Plan d’études

Master en Cybersécurité

2 0 2 1 - 2 0 2 2

arrêté par la direction de l'EPFL le 26 mai 2021

Directeur de section	**Prof. K. Aberer dès 01.01.2022** **Prof. A.-M. Kermarrec** de septembre à décembre 2021
Adjointe du directeur de section	**Mme E. Hazboun**
Conseillers d'études : **1ère année cycle master** **2ème année cycle master** **Projet de master**	**Prof. B. Faltings**
Coordinatrice des stages d’ingénieur	**Mme E. Hazboun**
Secrétaire du Master	**Mme E. van Eijs**

Aux cycles bachelor et master, selon les besoins pédagogiques, les heures d’exercices mentionnées dans le plan d’études pourront être intégrées dans les heures de cours ; les scolarités indiquées représentent les nombres moyens d’heures de cours et d’exercices hebdomadaires sur le semestre

2021-2022 INFORMATIQUE - CYBERSÉCURITÉ - Obligatoire

Cycle Master

Code	Matières	Enseignants sous réserve de modification	Sections	depth requirement**	Semestres						Crédits	Période des épreuves *	Type examen *
					MA1			MA2					
					c	e	p	c	e	p			
	Groupe "breadth requirement et depth requirement and options"										**72**		
	Groupe 1 "breadth requirement"										**min. 30**		
CS-450	Advanced algorithms	Kapralov/Svensson	IN					**4**	**3**		7	E	écrit
CS-470	Advanced computer architecture	Ienne	IN					**3**		**2**	6	E	écrit
COM-401	Cryptography and security	Vaudenay	SC	x	**4**	**2**					7	H	écrit
CS-422	Database systems	Ailamaki	IN					**3**	**2**	**2**	7	E	écrit
CS-438	Decentralized systems engineering	Ford	IN		**2**	**2**	**2**				6	H	oral
CS-451	Distributed algorithms	Guerraoui	SC		**3**	**2**	**1**				6	H	écrit
CS-452	Foundations of software	Odersky	IN		**2**	**2**					4	H	écrit
COM-402	Information security and privacy	Hubaux/Pyrgelis	SC	x	**3**	**1**	**2**				6	H	écrit
CS-433	Machine learning	Jaggi/Flammarion	IN		**4**	**2**					7	H	écrit
COM-407	TCP/IP networking	Le Boudec	SC		**2**	**2**	**2**				6	H	écrit
ETHZ	ETHZ courses counting as breadth requirement												
	Groupe 2 "depth requirement and options"	**(la somme des crédits des groupes 1 et 2 doit être de 72**			←					→			
	Bloc "Projet et SHS" :										**18**		
CS-496	Semester project in Cyber security	Divers enseignants	IN		←			**12**		→	12	sem A ou P	
HUM-nnn	SHS : introduction au projet	Divers enseignants	SHS		**2**		**1**				3	sem A	
HUM-nnn	SHS : projet	Divers enseignants	SHS							**3**	3	sem P	
	Total des crédits du cycle master :										**90**		

Remarque :

* Se référer à l'art. 3 al. 4 du règlement d'application

** se référer à l'art. 7 al. 2 du règlement d'application

Stage d'ingénieur :

Voir les modalités dans le règlement d'application

2021-2022 **INFORMATIQUE - CYBERSÉCURITÉ - Options** **Cycle Master**

Code	Matières	Enseignants sous réserve de modification	Sections	other security oriented options	depth requirement**	Semestres MA1 c	MA1 e	MA1 p	MA2 c	MA2 e	MA2 p	Crédits	Nbre places	Période des épreuves *	Type examen*	Cours biennaux donnés en
	Groupe 2 "depth requirement and options"															
CS-420	Advanced compiler construction	Schinz	IN						2		2	4		sem P		
CS-440	Advanced computer graphics	Jakob	IN						2	1		6		sem P		
COM-501	Advanced cryptography	Vaudenay	SC		x				2	2		4		E	écrit	
CS-471	Advanced multiprocessor architecture	Falsafi	IN			4						6		sem A		2021-2022
COM-417	Advanced probability and applications	Lévêque	SC						3	2		6		E	écrit	
CS-523	Advanced topics on privacy enhancing technologies	Lueks	IN		x				3	1	2	7		E	écrit	
EE-431	Advanced VLSI design	Burg	EL	x					2	2		4		E	écrit	
MATH-493	Applied biostatistics	Goldstein	MA						2	2		5		sem P		
CS-401	Applied data analysis	West	IN			2		2				6		H	écrit	
CS-456	Artificial neural networks	Gerstner	IN						2	2		5		E	écrit	
EE-554	Automatic speech processing	Magimai Doss	EL			2	1					3		H	écrit	
BIO-465	Biological modeling of neural networks	Gerstner	IN						2	2		4		E	écrit	
EE-512	Biomedical signal processing	Vesin	EL			4		2				6		H	écrit	
CS-490	Business design for IT services	Wegmann	SC						3			3		E	oral	
BIO-105	Cellular biology and biochemistry for engineers	Zufferey	SV			2	2					4		H	écrit	
CS-524	Computational complexity	Göös	IN			3	1					4		sem A		
CS-413	Computational photography	Süsstrunk	SC						2		2	5		sem P		
CS-442	Computer vision	Fua	IN						2	1		4		E	écrit	
CS-453	Concurrent algorithms	Guerraoui	SC			3	1	1				5		H	écrit	
COM-480	Data visualization	Vuillon	SC						2		2	4		sem P		
EE-559	Deep learning	Fleuret	EL						2	2		4	500	E	écrit sans retrait	
CS-472	Design technologies for integrated systems	De Micheli	IN			3		2				6		sem A		
CS-411	Digital education & learning analytics	Dillenbourg/Jermann	IN			2		2				4		H	oral	
CS-423	Distributed information systems	Aberer	SC			2	1					4		H	écrit	
ENG-466	Distributed intelligent systems	Martinoli	SIE						2	3		5		E	écrit	
COM-502	Dynamical system theory for engineers	Thiran P.	SC						2	1		4		E	écrit	
CS-473	Embedded systems	Beuchat	IN			2		2				4		H	oral	
CS-491	Enterprise and service-oriented architecture	Wegmann	SC						6			6		E	oral	
CS-489	Experience design	Huang	IN			2		4				6		sem A		
CS-550	Formal verification	Kuncak	IN		x	2	2	2				6		sem A		
EE-429	Fundamentals of VLSI design	Burg	EL	x		3	1					4		sem A		
MATH-483	Gödel and recursivity (pas donné en 2021-2022)	Duparc	MA			2	2					5		H	écrit	2022-2023
MICRO-511	Image processing I	Unser/Van De Ville	MT			3						3		H	écrit	
MICRO-512	Image processing II	Unser/Van de Ville/Liebling/Sa	MT						3			3		E	écrit	
CS-487	Industrial automation	Tournier/Sommer	SC						2		1	3		E	oral	
COM-404	Information theory and coding	Telatar	SC			4	2					7		H	écrit	
COM-406	Foundations of Data Science	Urbanke	SC			4	2					6		H	écrit	
CS-430	Intelligent agents (pas donné en 2021-2022)	Faltings	IN			3	3					6		sem A		
CS-486	Interaction design	Pu	IN						2	1	1	4		sem P		
CS-431	Introduction to natural language processing	Rajman/Chappelier	IN			2	2					4		H	écrit	
CS-526	Learning theory	Macris/Urbanke	SC						2	2		4		E	écrit	
CS-421	Machine learning for behavioral data	Käser	IN						2		2	4		E	écrit	
COM-516	Markov chains and algorithmic applications	Lévêque/Macris	SC			2	2					4		H	écrit	
COM-514	Mathematical foundations of signal processing	Simeoni/Behar Haro	SC			3	2					6		H	écrit	
COM-405	Mobile networks	Hubaux	SC	x					2	1		4		E	écrit	
COM-430	Modern digital communications: a hands-on approach	Chiurtu	SC			2		2				6		sem A		
COM-512	Networks out of control	Thiran P./ Grossglauser	SC						2	1		4		E	écrit	2021-2022
MATH-489	Number theory in cryptography	Jetchev	MA						2	2		5		E	écrit	
CS-439	Optimization for machine learning	Jaggi/Flammarion	IN						2	2	1	5		E	écrit	
CS-596	Optional project in computer science	Divers enseignants	IN			←			2		→	8		sem A ou P		
CS-522	Principles of computer systems	Argyraki/Candea	SC/IN	x		4						7		H	écrit	
MATH-467	Probabilistic methods in combinatorics **	Marcus	MA			2	2					5		H	écrit	2021-2022
CS-476	Real-time embedded systems	Beuchat	IN						2		2	4		sem P		
EE-511	Sensors in medical instrumentation	Aminian	EL						2	1		3		E	écrit	
MATH-318	Set theory	Duparc	MA						2	2		5		H	écrit	
EE-472	Smart grids technologies	Paolone / Le Boudec	EL/SC						2	1	2	5		E	écrit	
EE-593	Social media	Gillet/Vonèche	EL						1		1	2	45	sem P	sans retrait	
CS-412	Software security	Payer	IN		x				3	2	1	6		sem P		
COM-500	Statistical signal and data processing through applications	Ridolfi	SC						3	2		6		E	écrit	
COM-506	Student seminar: security protocols and applications	Vaudenay	SC	x					2			3		E	écrit	
CS-448	Sublinear algorithms for big data analysis	Kapralov	IN			2	1					4		sem P		2021-2022
CS-410	Technology ventures in IC (pas donné en 2021-2022)	Bugnion	IN						2		2	4		sem P		
CS-455	Topics in theoretical computer science (pas donné en 2021-2022)	Kapralov	IN			3	1					4		sem A		2022-2023
CS-444	Virtual reality	Boulic	IN						2	1		4		sem P		
ETHZ	ETHZ courses counting as options															
ETHZ	ETHZ courses counting as depth requirement				x											

Remarque :
* Se référer à l'art. 3 al. 4 du règlement d'application

** se référer à l'art. 7 al. 2 du règlement d'application

2021-2022

Cyber security
Mineur disciplinaire

Section d'Informatique
Responsable : Prof. C. Troncoso

Les enseignants, les crédits et la période des cours sont indiqués sous réserve de modification. **82** **crédits offerts**
Les cours déjà suivis au bachelor ou au master ne peuvent pas être pris également dans un mineur.

Codes	Matières (liste indicative)	Enseignants	Livret des cours	Crédits	Période des cours	
CS-450	Advanced algorithms	Kapralov/Svensson	IN	7		P
CS-470	Advanced computer architecture	Ienne	IN	6		P
COM-501	Advanced cryptography*	Vaudenay	SC	4		P
CS-101	Advanced information, computation, communication I	Aberer	SC	7	A	
EE-431	Advanced VLSI design	Burg	EL	4		P
MATH-310	Algebra	Lachowska	MA	3	A	
CS-250	Algorithms	Svensson	IN	6	A	
COM-208	Computer networks	Argyraki	SC	5	A	
COM-301	Computer security	Troncoso	IN	4	A	
COM-401	Cryptography and security*	Vaudenay	SC	7	A	
EE-429	Fundamentals of VLSI Design	Burg	EL	4	A	
COM-402	Information security and privacy	Hubaux/Pyrgelis	SC	6	A	
COM-405	Mobile networks*	Hubaux	SC	4		P
CS-412	Software security	Payer	IN	6		P
COM-506	Student seminar: security protocols and applications*	Vaudenay	SC	3		P
COM-407	TCP/IP Networking	Le Boudec	SC	6	A	

Crédits obligatoires
*pour le Mineur en Cyber Security, au moins 17 crédits parmi ces cours doivent obligatoirement être acquis.
** For the Minor in Information Security it will be mandatory to accumulate at least 17 credits from these courses.*

Légende :
A = automne, P = printemps
1 semestre comprend 14 semaines.

RÈGLEMENT D'APPLICATION DU CONTRÔLE DES ÉTUDES DE LA SECTION D'INFORMATIQUE POUR LE MASTER EN INFORMATIQUE - CYBERSÉCURITÉ pour l'année académique 2021-2022 du 26 mai 2021

La direction de l'École polytechnique fédérale de Lausanne

vu l'ordonnance sur la formation menant au bachelor et au master de l'EPFL du 14 juin 2004,
vu l'ordonnance sur le contrôle des études menant au bachelor et au master à l'EPFL du 30 juin 2015,
vu le plan d'études de la section d'informatique pour le master en Informatique - Cybersécurité.

arrête:

Article premier - Champ d'application

Le présent règlement fixe les règles d'application du contrôle des études de master de la section d'informatique pour le master en Informatique - Cybersécurité qui se rapportent à l'année académique 2020-2021.

Art. 2 – Étapes de formation

Le master en Informatique - Cybersécurité est composé de deux étapes successives de formation :
- le cycle master d'une durée de 3 semestres dont la réussite implique l'acquisition de 90 crédits, condition pour effectuer le projet de master.
- le projet de master, d'une durée de 17 semaines à l'EPFL ou à l'ETHZ, ou de 25 semaines hors EPFL (industrie ou autre haute école) et dont la réussite se traduit par l'acquisition de 30 crédits. Il est placé sous la responsabilité d'un professeur ou MER affilié à la section d'informatique ou de systèmes de communication et doit être fait dans le domaine de la Cybersécurité.

Art. 3 – Sessions d'examen

1. Les branches d'examen sont examinées par écrit ou par oral pendant les sessions d'hiver ou d'été. Elles sont mentionnées dans le plan d'études avec la mention H ou E.

2. Les branches de semestre sont examinées pendant le semestre d'automne ou le semestre de printemps. Elles sont mentionnées dans le plan d'études avec la mention sem A ou sem P.

3. Une branche annuelle, c'est à dire dont l'intitulé tient sur une seule ligne dans le plan d'étude, est examinée globalement pendant la session d'été (E).

4 Pour les branches de session, la forme écrite ou orale de l'examen indiquée pour la session peut être complétée par des contrôles de connaissances écrits ou oraux durant le semestre, selon indications de l'enseignant.

Art. 4 – Prérequis

Certains enseignements peuvent exiger des prérequis qui sont mentionnés dans la fiche de cours concerné. Le cours prérequis est validé si les crédits correspondants ont été acquis pour le cours ou par moyenne du bloc.

Art. 5 – Conditions d'admission

1. Les étudiants issus du Bachelor EPFL en Informatique ou en Systèmes de communication, et les étudiants issus du Bachelor ETHZ en Informatique, sont admis automatiquement.

2. Les étudiants issus du Bachelor EPFL en Informatique ou en Systèmes de communication qui n'auront pas suivi les cours prérequis durant leur cycle Bachelor devront les prendre en parallèle à leur cycle Master.

3. Pour les autres étudiants, l'admission s'effectue sur dossier.

4. Un candidat refusé à l'ETHZ ne peut pas être admis à l'EPFL.

Art. 6 - Organisation

1. Les enseignements liés à ce master sont dispensés par l'EPFL et l'ETHZ. Le premier semestre du cycle master se déroule à l'EPFL et un des autres semestres se déroule à l'ETHZ. Durant le semestre passé à l'ETHZ, l'étudiant doit obtenir entre 20 et 35 ECTS parmi une liste de cours ETHZ établie par la section d'Informatique. Les crédits obtenus sont validés par le délégué à la mobilité.

2. Si l'étudiant n'obtient pas les 20 crédits minimums selon l'alinéa 1, il devra se réinscrire à des cours ETHZ et valider les crédits manquant avant la fin de son cycle Master.

3. Les étudiants ayant fait leur Bachelor à l'EPFL peuvent se réinscrire dans leur section d'origine en cas d'échec dans l'obtention des crédits à l'ETHZ

4. Les enseignements du cycle master sont répartis en deux groupes et un bloc dont les crédits doivent être obtenus de façon indépendante.

5. Le groupe 1 « breadth requirement » est composé des cours de la liste du groupe 1 du plan d'études.

6 Le groupe 2 « depth requirement and options » est composé
- des cours de la liste du groupe 2 du plan d'études ;
- des crédits surnuméraires obtenus dans le groupe 1 ;
- d'un projet optionnel de 8 crédits ;
- de cours hors plan d'études suivant l'alinéa 9.

7. Le bloc « Projets et SHS » est composé d'un projet de 12 crédits et de l'enseignement SHS.

8. Le projet du bloc « Projets et SHS » et le projet optionnel du groupe 2 ne peuvent être effectués dans le même semestre.

9. Des cours, comptant pour un maximum de 15 crédits au total, peuvent être choisis en dehors de la liste des cours du plan d'études. Le choix de ces cours doit être accepté

préalablement par le directeur de la section qui peut augmenter le maximum de 15 crédits si la demande est justifiée.

Art. 7 - Examen du cycle master

1. Le groupe 1 « breadth requirement » est réussi lorsque **30 crédits** sont obtenus.

2. La condition « depth requirement » est remplie lorsque 30 crédits sont obtenus dans la liste des cours avalisés « depth requirement ».

3. Le groupe « breadth requirement et depth requirement and options », composé du groupe 1 et du groupe 2 est réussi lorsque **72 crédits** sont obtenus.

4. Le bloc « Projets et SHS » est réussi lorsque **18 crédits** sont obtenus.

Art. 8 - Enseignement SHS

Les deux branches SHS donnent chacune lieu à 3 crédits. L'enseignement du semestre d'automne introduit à la réalisation du projet du semestre de printemps. Pour autant qu'il considère que le motif est justifié, le Collège des Humanités peut déroger à cette organisation. Il peut également autoriser à ce qu'un étudiant réalise son projet sur un semestre qui ne suit pas immédiatement celui dans lequel a lieu l'enseignement d'introduction.

Art. 9 – Stage d'ingénieur

1. Les étudiants commençant leur cycle master doivent effectuer un stage d'ingénieur durant leur master :
- soit un stage d'été de minimum 8 semaines
- soit un stage de minimum 6 mois en entreprise (en statut stage durant un semestre). Durant la période du COVID-19, la durée du stage peut-être adaptée.
- soit un projet de master de 25 semaines en entreprise (au sens de l'Art. 2)

2. En règle générale, pour les étudiants issus du Bachelor IC, le stage peut être effectué dès le 2ème semestre du cycle master, mais avant le projet de master (sauf si le stage est effectué sous la forme d'un projet de master). Sur demande de l'étudiant, la section peut l'autoriser à effectuer son stage avant ou pendant le 1er semestre du cycle Master.

3. L'étudiant ne peut pas faire de cours/projet en parallèle à son stage

4. Le responsable du stage de la section évalue le stage, par l'appréciation « réussi » ou « non réussi ». Sa réussite est une condition pour l'admission au projet de master. En cas de non réussite, il peut être répété une fois, en règle générale dans une autre entreprise.

5. Il est validé avec les 30 crédits du projet de master.

6. Les modalités d'organisation et les critères de validation du stage font l'objet d'une directive interne à la section.

Au nom de la direction de l'EPFL

Le président, M. Vetterli
Le vice-président académique, J. S. Hesthaven

Lausanne, le 26 mai 2021

2021-2022 **INFORMATIQUE / CYBERSECURITE** **Passerelle HES**

Code	Matière	Enseignants sous réserve de modification	Sections	Semestre AUT c	AUT e	AUT p	PRI c	PRI e	PRI p	Crédits	Période des épreuves	Type examen
	Proposition de cours 60 crédits du Bachelor pour passer au Master :											
	Branches de bases									**33**		
CS-250	Algorithms	Svensson	IN	**4**	**2**					6	H	écrit
MATH-203b	Analyse III	Colombo	MA	**2**	**2**					4	H	écrit
CS-208	Computer architecture	Stojilovic	IN	**2**		**2**				4	H	écrit
COM-208	Computer networks	Argyraki	SC	**2**	**2**					5	H	écrit
PHYS-114	General physics : electromagnetism	Shchutska	PH	**2**	**2**					4	H	écrit
MATH-232	Probabilities and statistics	Berthier/Abbé	MA				**4**	**2**		6	E	écrit
CS-251	Theory of computation	Göös	IN				**2**	**2**		4	E	écrit
	Branches d'approfondissement									**26**		
CS-210	Functional programming	Kuncak / Odersky	IN	**2**	**2**					5	sem A	
CS-322	Introduction to database systems	Ailamaki / Koch	IN				**2**	**1**	**1**	4	E	écrit
CS-323	Introduction to operating systems	Kashyap / Payer	IN	**2**	**1**	**2**				5	sem A	
CS-206	Parallelism and concurrency	Kashyap / Odersky	IN				**1**	**1**	**2**	4	sem P	
CS-305	Software engineering	Candea	IN	**2**	**1**	**1**				4	sem A	
CS-306	Software development project	Candea	IN			**4**			**4**	4	sem P	
	Totaux			**18**	**12**	**9**	**9**	**6**	**7**	**59**		
	Totaux par semaine				**39**			**22**				

Légende :

colonnes c/e/p : nb d'heures par semaine

1 semestre comprend 14 semaines.

type examination : voir règlement d'application

RÈGLEMENT D'APPLICATION DU CONTRÔLE DES ÉTUDES CONCERNANT LA PASSERELLE HES-EPFL
pour l'année académique 2021-2022
du 26 mai 2021

La direction de l'École polytechnique fédérale de Lausanne,

Vu l'art. 9 de l'ordonnance du Conseil des hautes écoles sur la coordination de l'enseignement du 29 novembre 2019 ;
Vu l'art. 11 de l'ordonnance concernant l'admission à l'EPFL du 8 mai 1995 ;
vu les art. 1 et 8 de la directive sur les programmes de master et les mineurs, du 17 octobre 2005 ;
vu l'ordonnance sur la formation menant au bachelor et au master de l'EPFL du 14 juin 2004 ;
vu l'ordonnance sur le contrôle des études menant au bachelor et au master à l'EPFL du 30 juin 2015 ;

arrête :

Art. 1 - Passerelle HES-EPFL

1. Le présent règlement fixe les règles spécifiques à l'admission à la formation de master de l'EPFL sur la base d'un titre de bachelor HES (passerelle HES-EPFL ; ci-après la passerelle) qui se rapportent à l'année académique 2021-2022. S'appliquent au surplus les règles d'études générales à l'EPFL, en particulier celles figurant dans son ordonnance sur le contrôle des études.

2. Le bachelor HES avec une moyenne minimale correspondant à la notation de 5.0 de l'EPFL permet l'admission à un master EPFL dans la discipline correspondante, avec condition de réussite de la passerelle.

3. La passerelle complète la formation HES par l'obtention à l'EPFL de 57 à 60 crédits en sciences de base, en ingénierie ou en architecture, suivant le master suivi.

4. Les branches permettant l'obtention des crédits de la passerelle sont divisées en un bloc de branches de base et un bloc de branches d'approfondissement. Chacun des deux blocs comprend entre 25 et 35 crédits.

5. Aux branches permettant d'acquérir les crédits de la passerelle, peuvent s'ajouter les éventuelles branches prérequises pour les branches du master suivi, conformément au livret de cours correspondant.

6. La réussite de la passerelle permet l'admission définitive au master. Elle ne donne lieu à aucun titre.

Art. 2 - Inscription anticipée au master

Pour s'inscrire aux branches de master, au moins 30 crédits doivent être acquis dans les branches de la passerelle (branches prises individuellement).

Art. 3 - Conditions de réussite de la passerelle

1. La passerelle est réussie lorsque ses crédits sont obtenus dans un délai de deux ans au maximum. Ces crédits sont obtenus par une moyenne des branches égale ou supérieure à 4,00 pour chacun des deux blocs de la passerelle.

2. L'obtention de moins de 30 crédits dans les branches de la passerelle (branches prises individuellement) au terme des examens de la première année entraîne un échec définitif.

Art. 4 - Règles applicables en deuxième année

1. Celui qui doit obtenir des crédits manquants sur une deuxième année demeure soumis au règlement de passerelle qui se rapporte à sa première année (année d'admission à la passerelle).

2. La répétition d'une branche est exécutée conformément aux règles de la branche pour l'année de la répétition.

Art. 5 - Période des cours et épreuves

1. Les cours de la passerelle débutent à la rentrée du semestre d'automne. L'entrée en cours d'année est exclue.

2. Conformément aux règles de l'EPFL,
   - les branches de session sont examinées aux sessions d'examens d'hiver ou d'été correspondantes avec d'éventuelles épreuves de semestre,
   - les branches de semestre sont examinées pendant le semestre correspondant, et
   - les branches annuelles sont examinées à la session d'examens d'été ponctuant l'année académique.

Au nom de la direction de l'EPFL

Le président, M. Vetterli
Le vice-président académique, J. S. Hesthaven

Lausanne, le 26 mai 2021

EE-431

Advanced VLSI design

Burg Andreas Peter

Cursus	Sem.	Type
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Opt.
Génie électrique et électronique	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

In this project-based course, students collect hands-on experience with designing full-custom digital VLSI circuits in dynamic logic. They learn to carry out the design and optimization on transistor level, including logic and clock tree, the verification, and the layout.

Content

Introduction to dynamic logic:
An alternative logic style derived from CMOS, used for high-speed logic, as basis for the project
Introduction to fast adder circuits:
Fast adder structures as basic building block of computer arithmetic
Layout and floorplanning:
Practical guidelines for full-custom layout of custom digital circuits
PROJECT (covers 80% of the course):
Build a 1GHz 64 Bit Parallel Prefix Adder in a 90nm technology on transistor level, including logic design, schematic entry, clock tree design, simulation, parasitic estimation, layout, and verification.

Keywords

VLSI, CMOS, transistor level, layout, adder, dynamic logic

Learning Prerequisites

Required courses

EE-429 Fundamentals of VLSI design
EE-490(b) Lab in EDA based design (or experience with CADENCE Virtuoso)

Learning Outcomes

By the end of the course, the student must be able to:

- Compose a transistor-level integrated circuit
- Analyze its performance
- Anticipate layout effects
- Design its layout

Teaching methods

Project based course with few lectures

CS-450

Advanced algorithms

Kapralov Mikhail, Svensson Ola Nils Anders

Cursus	Sem.	Type
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Obl.
Data Science	MA2, MA4	Obl.
Informatique et communications		Opt.
Informatique	MA2, MA4	Obl.
Mineur en Data science	E	Opt.
Mineur en Informatique	E	Opt.
Robotique, contrôle et systèmes intelligents		Opt.
SC master EPFL	MA2, MA4	Obl.
Science et ing. computationelles	MA2, MA4	Opt.

Language	English
Credits	7
Session	Summer
Semester	Spring
Exam	Written
Workload	210h
Weeks	14
Hours	**7 weekly**
Lecture	4 weekly
Exercises	3 weekly
Number of positions	

Summary

A first graduate course in algorithms, this course assumes minimal background, but moves rapidly. The objective is to learn the main techniques of algorithm analysis and design, while building a repertory of basic algorithmic solutions to problems in many domains.

Content

Algorithm analysis techniques: worst-case and amortized, average-case, randomized, competitive, approximation. Basic algorithm design techniques: greedy, iterative, incremental, divide-and-conquer, dynamic programming, randomization, linear programming. Examples from graph theory, linear algebra, geometry, operations research, and finance.

Keywords

See content.

Learning Prerequisites

Required courses

An undergraduate course in Discrete Structures / Discrete Mathematics, covering formal notation (sets, propositional logic, quantifiers), proof methods (derivation, contradiction, induction), enumeration of choices and other basic combinatorial techniques, graphs and simple results on graphs (cycles, paths, spanning trees, cliques, coloring, etc.).

Recommended courses

An undergraduate course in Data Structures and Algorithms.
An undergraduate course in Probability and Statistics.

Important concepts to start the course

Basic data structures (arrays, lists, stacks, queues,trees) and algorithms (binary search; sorting; graph connectivity); basic discrete mathematics (proof methods, induction, enumeration and counting, graphs); elementary probability and statistics (random variables, distributions, independence, conditional probabilities); data abstraction.

Learning Outcomes

By the end of the course, the student must be able to:

- Use a suitable analysis method for any given algorithm
- Prove correctness and running-time bounds
- Design new algorithms for variations of problems studied in class
- Select appropriately an algorithmic paradigm for the problem at hand
- Define formally an algorithmic problem

Teaching methods

Ex cathedra lecture, reading

Assessment methods

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes
Others	For details, see the course web page.

Resources

Bibliography

See web page for the course.

Ressources en bibliothèque

- Randomized Algorithms / Motwani
- Approximation Algorithms / Vazirani
- Quantum Computation and Quantum Information / Nielsen
- Algebraic Complexity Theory / Buergisser
- Computational Complexity / Papadimitrou

Notes/Handbook

Class notes and references for the running semester will be provided as needed within a few days after each lecture.

Websites

- http://theory.epfl.ch/courses/AdvAlg/

CS-420

Advanced compiler construction

Schinz Michel

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Informatique	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

Students learn several implementation techniques for modern functional and object-oriented programming languages. They put some of them into practice by developing key parts of a compiler and run time system for a simple functional programming language.

Content

Part 1: implementation of high-level concepts

- functional languages: closures, continuations, tail call elimination,
- object-oriented languages: object layout, method dispatch, membership test.

Part 2: optimizations

- compiler intermediate representations (RTL, SSA, CPS),
- inlining and simple optimizations,
- register allocation,
- instruction scheduling.

Part 3: run time support

- interpreters and virtual machines,
- memory management (including garbage collection).

Keywords

compilation, programming languages, functional programming languages, object-oriented programming languages, code optimization, register allocation, garbage collection, virtual machines, interpreters, Scala.

Learning Prerequisites

Recommended courses

Computer language processing

Important concepts to start the course

Excellent knowledge of Scala and C programming languages

Learning Outcomes

By the end of the course, the student must be able to:

- Assess / Evaluate the quality of a compiler intermediate representation
- Design compilers and run time systems for object-oriented and functional programming languages
- Implement rewriting-based compiler optimizations
- Implement efficient virtual machines and interpreters
- Implement mark and sweep or copying garbage collectors

Teaching methods

Ex Cathedra, mini-project

Assessment methods

Continuous control (mini-project 80%, final exam 20%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Ressources en bibliothèque

- Engineering a Compiler / Cooper
- Compiling with continuations / Appel
- The garbage collection handbook : the art of automatic memory management / Jones
- Modern Compiler Implementation in Java / Appel

Websites

- https://cs420.epfl.ch/

EPFL

CS-470 **Advanced computer architecture**

Ienne Paolo

Cursus	Sem.	Type
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Obl.
Génie électrique et électronique	MA2, MA4	Opt.
Informatique	MA2, MA4	Obl.
Mineur en Informatique	E	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Project	2 weekly
Number of positions	

Summary

The course studies techniques to exploit Instruction-Level Parallelism (ILP) statically and dynamically. It also addresses some aspects of the design of domain-specific accelerators. Finally, it explores security challenges based on microarchitectural features and hardware isolation techniques.

Content

Pushing processor performance to its limits:

- Principles of Instruction Level Parallelism (ILP)
- Register renaming techniques
- Prediction and speculation
- Simultaneous multithreading
- VLIW and compiler techniques for ILP
- Dynamic binary translation

Domain specific architectures and accelerators:

- Specificities of embedded vs. general computing processors
- Overview of DSPs and related compilation challenges
- High-Level Synthesis and accelerators

Hardware security:

- Information leakage through the microarchitecture
- Trusted Execution Environments
- Physical side-channel attacks

Keywords

Processors, Instruction Level Parallelism, Systems-on-Chip, Embedded Systems, High-Level Synthesis, Hardware Security.

Learning Prerequisites

Required courses

- CS-208 Architecture des ordinateurs or Computer Architecture I

Recommended courses

- CS-209 Architecture des systèmes-on-chip or Computer Architecture II

Important concepts to start the course

Undergraduate knowledge of digital circuit design and of computer architecture

Learning Outcomes

By the end of the course, the student must be able to:

- Design strategies to exploit instruction level parallelism in processors.
- Contrast static and dynamic techniques for instruction level parallelism.
- Design effective processor (micro-)architectures for which efficient compilers can be written.
- Develop hardware accelerators competitive to best commercial processors
- Defend against security threats based on microarchitectural processor features

Teaching methods

Courses, labs, and compulsory homeworks.

Assessment methods

Labs, homeworks, and final exam.

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

- John L. Hennessy and David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufman, 6th edition, 2017.

Ressources en bibliothèque

- Computer Architecture / Hennessy

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=15017

Prerequisite for

CS-471 Advanced Multiprocessor Architecture

CS-440

Advanced computer graphics

Jakob Wenzel

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Humanités digitales	MA2, MA4	Opt.
Informatique	MA2, MA4	Opt.
Mineur en Informatique	E	Opt.
Mineur en Systèmes de communication	E	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	During the semester
Workload	180h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course covers advanced 3D graphics techniques for realistic image synthesis. Students will learn how light interacts with objects in our world, and how to recreate these phenomena in a computer simulation to create synthetic images that are indistinguishable from photographs.

Content

This is a project-based course: students will initially receive a basic software package that lacks most rendering-related functionality.
Over the course of the semester, we will discuss a variety of concepts and tools including the basic physical quantities, how light interacts with surfaces, and how to solve the resulting mathematical problem numerically to create realistic images. Advanced topics include participating media, material models for sub-surface light transport, and Markov Chain Monte Carlo Methods.
Each major topic is accompanied by an assignment so that students can implement solution algorithms and obtain practical experience with these techniques within their own software framework.
Towards the end of the course, students will realize a self-directed final project that extends their rendering software with additional features of their own choosing. The objective of the final project is to create a single image of both technical and artistic merit that is entered into a rendering competition and judged by an independent panel of computer graphics experts.

Learning Prerequisites

Required courses

Nothing

Recommended courses

Introduction to Computer Graphics

Important concepts to start the course

We will rely on calculus, linear algebra and use basic concepts of algorithms and data structures. Students are expected to be familiar with the C++ programming language that is used in the programming assignments.

Learning Outcomes

By the end of the course, the student must be able to:

- Recognize and understand the physical quantities of light transport and be able to perform basic computations using pencil+paper

- Explain a range of surface and subsurface material models
- Explain the rendering and radiative transfer equation and show how to construct Monte Carlo methods to solve them
- Design and implement an advanced rendering system based on Monte Carlo integration
- Assess / Evaluate the performance and conceptual limits of the implemented simulation code

Teaching methods

Lectures, interactive demos, theory and programming exercises, programming project, project tutoring

Expected student activities

The student are expected to study the provided reading material and actively participate in class. They should prepare and resolve the exercises, prepare and carry out the programming project.

Assessment methods

Intermediate assignments (60%), final project (40%)

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

A list of books will be provided at the beginning of the class

Ressources en bibliothèque

- Physically Based Rendering: From Theory to Implementation / Pharr

Notes/Handbook

Slides and online resources will be provided in class

Websites

- https://rgl.epfl.ch/courses/ACG22

COM-501

Advanced cryptography

Vaudenay Serge

Cursus	Sem.	Type
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Mineur en Data science	E	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course reviews some failure cases in public-key cryptography. It introduces some cryptanalysis techniques. It also presents fundamentals in cryptography such as interactive proofs. Finally, it presents some techniques to validate the security of cryptographic primitives.

Content

1. **The cryptograhic zoo**: definitions, cryptographic primitives, math, algorithms, complexity
2. **Cryptographic security models:** security notions for encryption and authentication, game reduction techniques, RSA and Diffie-Hellman security notions
3. **Public-key cryptanalysis:** side channels, low RSA exponents, discrete logarithm, ElGamal signature
4. **Interactive proofs:** NP-completeness, interactive systems, zero-knowledge
5. **Symmetric-key cryptanalysis:** differential and linear cryptanalysis, hypothesis testing, decorrelation
6. **Proof techniques:** random oracles, leftover-hash lemma, Fujisaki-Okamoto transform

Keywords

cryptography, cryptanalysis, interactive proof, security proof

Learning Prerequisites

Required courses

- Cryptography and security (COM-401)

Important concepts to start the course

- Cryptography
- Mathematical reasoning
- Number theory and probability theory
- Algorithmics
- Complexity

Learning Outcomes

By the end of the course, the student must be able to:

- Assess / Evaluate the security deployed by cryptographic schemes

- Prove or disprove security
- Justify the elements of cryptographic schemes
- Analyze cryptographic schemes
- Implement attack methods
- Model security notions

Teaching methods

ex-cathedra

Expected student activities

- active participation during the course
- take notes during the course
- do the exercises during the exercise sessions
- complete the regular tests and homework
- read the material from the course
- self-train using the provided material
- do the midterm exam and final exam

Assessment methods

Mandatory continuous evaluation:

- homework (30%)
- regular graded tests (30%)
- midterm exam (40%)

Final exam averaged (same weight) with the contiuous evaluation, but with final grade between final_exam-1 and final_exam+1.

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	Lecturers and assistants are available upon appointment.

Resources

Bibliography

- Communication security: an introduction to cryptography. Serge Vaudenay. Springer 2004.
- A computational introduction to number theory and algebra. Victor Shoup. Cambridge University Press 2005.
- Algorithmic cryptanalysis. Antoine Joux. CRC 2009.

Ressources en bibliothèque

- Algorithmic cryptanalysis / Joux
- A computational introduction to number theory and algebra / Shoup
- Communication security / Vaudenay

Websites

- http://lasec.epfl.ch/teaching.shtml

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=13913

CS-471

Advanced multiprocessor architecture

Falsafi Babak

Cursus	Sem.	Type
Cybersecurity	MA1, MA3	Opt.
Génie électrique et électronique	MA1, MA3	Opt.
Informatique et communications		Obl.
Informatique	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.
Science et ing. computationelles	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**4 weekly**
Lecture	4 weekly
Number of positions	

Remark

Cours biennal donné une année sur deux les années impaires

Summary

Multiprocessors are now the defacto building blocks for all computer systems. This course will build upon the basic concepts offered in Computer Architecture I to cover the architecture and organization of modern multiprocessors from mobile and embedded platforms to servers, data centers and cloud computing platforms.

Content

Introduction to multiprocessor systems, parallel programming models including Pthreads, MPI, hardware and software transactional memory, synchronization primitives, memory consistency mdels, cache coherence, on-chip shared cache architectures, on-chip interconnects, multi-chip interconnects, multi-chip bus-based and general-purpose interconnect-based shared-memory systems, clusters.
The course will include weekly readings, discussions, and student reviews and reports on publications (besides the text book) of seminal and recent contributions to the field of computer architecture. Student reviews, class discussions, and an independent research project will account for a significant fraction of the grade. Feedback on performance will be given only upon request by a student. There will be no recitation classes.
The course will also include an independent and original research project, in which students study, improve, and evaluate multiprocessor innovations using a software simulation infrastructure. There will be a list of project ideas given out, but students can suggest and work on their own ideas with potentials for advancing the state of the art.

Learning Prerequisites

Recommended courses

Computer Architecture I, basic C/C++ systems programming.

Learning Outcomes

By the end of the course, the student must be able to:

- Design and evaluate parallel computer organizations
- Develop parallel programs and benchmarks for parallel systems
- Design the basic components of modern parallel systems including multiple processors, cache hierarchies and networks
- Quantify performance metrics for parallel systems
- Interpret and critique research papers
- Plan , propose and conduct a research project empirically

- Present research contributions

Teaching methods

Lectures, homeworks, and a research project

Assessment methods

Continuous control :
Homework : 30 %, Project 15 %, Midterm test : 20 %,
End term test : 35 %

Resources

Websites

- https://parsa.epfl.ch/course-info/cs471/

COM-417

Advanced probability and applications

Lévêque Olivier

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Génie électrique		Opt.
Informatique et communications		Obl.
Informatique	MA2, MA4	Opt.
Mineur en Data science	E	Opt.
Robotique, contrôle et systèmes intelligents		Opt.
SC master EPFL	MA2, MA4	Obl.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Exercises	2 weekly
Number of positions	

Summary

In this course, various aspects of probability theory are considered. The first part is devoted to the main theorems in the field (law of large numbers, central limit theorem, concentration inequalities), while the second part focuses on the theory of martingales in discrete time.

Content

- sigma-fields, random variables
- probability measures, distributions
- independence, convolution
- expectation, characteristic function
- random vectors and Gaussian random vectors
- inequalities, convergences of sequences of random variables
- laws of large numbers, applications and extensions
- convergence in distribution, central limit theorem and applications
- moments and Carleman's theorem
- concentration inequalities
- conditional expectation
- martingales, stopping times
- martingale convergence theorems

Keywords

probability theory, measure theory, martingales, convergence theorems

Learning Prerequisites

Required courses

Basic probability course
Calculus courses

Recommended courses

complex analysis

Important concepts to start the course

This course is NOT an introductory course on probability: the students should have a good understanding and practice of basic probability concepts such as: distribution, expectation, variance, independence, conditional probability.
The students should also be at ease with calculus. Complex analyisis is a plus, but is not required.
On the other hand, no prior background on measure theory is needed for this course: we will go through the

basic concepts one by one at the beginning.

Learning Outcomes

By the end of the course, the student must be able to:

- understand the main ideas at the heart of probability theory

Teaching methods

Ex cathedra lectures + exercise sessions

Expected student activities

active participation to exercise sessions

Assessment methods

graded homeworks 10%
midterm 20%
final exam 70%

Resources

Bibliography

Sheldon M. Ross, Erol A. Pekoz, A Second Course in Probability,1st edition, www.ProbabilityBookstore.com, 2007.
Jeffrey S. Rosenthal, A First Look at Rigorous Probability Theory,2nd edition, World Scientific, 2006.
Geoffrey R. Grimmett, David R. Stirzaker, Probability and Random Processes,3rd edition, Oxford University Press, 2001.
Richard Durrett, Probability: Theory and Examples, 4th edition, Cambridge University Press, 2010.
Patrick Billingsley, Probability and Measure, 3rd edition, Wiley, 1995.

Ressources en bibliothèque

- Sheldon M. Ross, Erol A. Pekoz, A Second Course in Probability, 1st ed
- Patrick Billingsley, Probability and Measure, 3rd ed
- Richard Durrett, Probability: Theory and Examples, 4th ed
- Jeffrey S. Rosenthal, A First Look at Rigorous Probability Theory, 2nd ed
- Probability and Random Processes

Notes/Handbook

available on the course website

Websites

- https://moodle.epfl.ch/course/view.php?id=14557

Prerequisite for

Advanced classes requiring a good knowledge of probability

CS-523

Advanced topics on privacy enhancing technologies

Lueks Wouter

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Informatique et communications		Obl.
Informatique	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	7
Session	Summer
Semester	Spring
Exam	Written
Workload	210h
Weeks	14
Hours	**6 weekly**
Lecture	3 weekly
Exercises	1 weekly
Project	2 weekly
Number of positions	

Summary

This advanced course will provide students with the knowledge to tackle the design of privacy-preserving ICT systems. Students will learn about existing technologies to protect privacy, and how to evaluate the protection they provide.

Content

The course will cover the following topics:

- Privacy definitions and concepts.
- Privacy-preserving cryptographic solutions: anonymous credentials, zero-knowledge proofs, secure multi-party computation, homomorphic encryption, Private information retrieval (PIR), Oblivious RAM (ORAM)
- Anonymization and data hiding: generalization, differential privacy, etc
- Machine learning and privacy
- Protection of metadata: anonymous communications systems, location privacy, censorpship resistance.
- Online tracking and countermeasures
- Privacy engineering: design and evaluation (evaluation metrics and notions)
- Legal aspects of privacy

Keywords

Privacy, anonymity, homomorphic encryption, secure multi-paty computation, anonymous credentials, ethics

Learning Prerequisites

Required courses

COM-402 Information Security and Privacy
COM-301 Computer Security

Recommended courses

COM-401 Cryptography

Important concepts to start the course

Basic programming skills; basics of probabilities and statistics; basics of cryptography

Learning Outcomes

By the end of the course, the student must be able to:

- Select appropriately privacy mechanisms
- Develop privacy technologies
- Assess / Evaluate privacy protection
- Reason about privacy concerns

Teaching methods

Lectures and written exercises to deepen understanding of concepts

Programming-oriented assignments to practice use of privacy technologies

Expected student activities

Participation in the lectures. Active participation is encouraged.
Participation in exercise session and complete the exercises regularly
Completion of programming assignments

Assessment methods

Final exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

EPFL

MATH-493

Applied biostatistics

Goldstein Darlene

Cursus	Sem.	Type
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Génie civil & environnement		Opt.
Informatique	MA2, MA4	Opt.
Ing.-math	MA2, MA4	Opt.
Ingénierie des sciences du vivant	MA2, MA4	Opt.
Mathématicien	MA2	Opt.
Mineur en Data science	E	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	During the semester
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

This course covers topics in applied biostatistics, with an emphasis on practical aspects of data analysis using R statistical software. Topics include types of studies and their design and analysis, high dimensional data analysis (genetic/genomic) and other topics as time and interest permit.

Content

- Types of studies
- Design and analysis of studies
- R statistical software
- Reproducible research techniques and tools
- Report writing
- Exploratory data analysis
- Liniear modeling (regression, anova)
- Generalized linear modeling (logistic, Poission)
- Survival analysis
- Discrete data analysis
- Meta-analysis
- High dimensional data analysis (genetics/genomics applications)
- Additional topics as time and interest permit

Keywords

Data analysis, reproducible research, statistical methods, R, biostatistical data analysis, statistical data analysis

Learning Prerequisites

Required courses

This course will be very difficult for students with no previous course or experience with statistics. **Previous experience with R is neither assumed nor required.**

Recommended courses

Undergraduate statistics course

Important concepts to start the course

It is useful to review statistical hypothesis testing.

Learning Outcomes

By the end of the course, the student must be able to:

- Interpret analysis results
- Justify analysis plan
- Plan analysis for a given dataset
- Analyze various types of biostatistical data
- Synthesize analysis into a written report
- Report plan of analysis and results obtained

Transversal skills

- Write a scientific or technical report.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.
- Take feedback (critique) and respond in an appropriate manner.
- Use a work methodology appropriate to the task.

Teaching methods

Lectures and practical exercises using R. Typically, each week covers an analysis method in the lecture and then the corresponding exercise session consists of an R proactical showing how to implement the methods using R. In each practical, students use R to carry out analyses of the relevant data type for that week.

Expected student activities

Students are expected to participate in their learning by attending lectures and practical exercise sessions, posing questions, proposing topics of interest, peer reviewing of preliminary reports, and interacting with teaching staff regarding their understanding of course material. In addition, there will be a number of short activities in class aimed at improving English for report writing.

Assessment methods

Evaluation is based on written reports of projects analyzing biostatistical data.
Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

EPFL

CS-401

Applied data analysis

West Robert

Cursus	Sem.	Type
Civil & Environmental Engineering		Opt.
Computational Neurosciences minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Obl.
Data science minor	H	Opt.
Digital Humanities	MA1, MA3	Obl.
Electrical Engineering		Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Energy Science and Technology	MA1, MA3	Opt.
Financial engineering	MA1, MA3	Opt.
Internet of Things minor	H	Opt.
Learning Sciences		Obl.
Life Sciences Engineering	MA1, MA3	Opt.
Managmt, tech et entr.	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.
UNIL - Sciences forensiques	H	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

This course teaches the basic techniques, methodologies, and practical skills required to draw meaningful insights from a variety of data, with the help of the most acclaimed software tools in the data science world: pandas, scikit-learn, Spark, etc.

Content

Thanks to modern software tools that allow to easily process and analyze data at scale, we are now able to extract invaluable insights from the vast amount of data generated daily. As a result, both the business and scientific world are undergoing a revolution which is fueled by one of the most sought after job profiles: the data scientist.
This course covers the fundamental steps of the data science pipeline:
Data wrangling

- Data acqusition (scraping, crawling, parsing, etc.)
- Data manipulation, array programming, dataframes
- The many sources of data problems (and how to fix them): missing data, incorrect data, inconsistent representations
- Data quality testing with crowdsourcing

Data interpretation

- Statistics in practice (distribution fitting, statistical significance, etc.)
- Working with "found data" (design of observational studies, regression analysis)
- Machine learning in practice (supervised and unsupervised, feature engineering, more data vs. advanced algorithms, curse of dimensionality, etc.)
- Text mining: vector space model, topic models, word embedding
- Social network analysis (influencers, community detection, etc.)

Data visualization

• Introduction to different plot types (1, 2, and 3 variables), layout best practices, network and geographical data

• Visualization to diagnose data problems, scaling visualization to large datasets, visualizing uncertain data

Reporting

• Results reporting, infographics

• How to publish reproducible results

The students will learn the techniques during the ex-cathedra lectures and will be introduced, in the lab sessions, to the software tools required to complete the homework assignments and the in-class quizzes.
In parallel, the students will embark on a semester-long project, split in agile teams of 3-4 students. The project consists of two parts: (1) replication of a data analysis pipeline from a published scientific paper, (2) a "free-style" component where students propose and execute their own extension of part 1. The outcome of this team effort will be a project portfolio that will be made public (and available as open source).
At the end of the semester, students will also take a 3-hour final exam in a classroom with their own computer, where they will be asked to complete a data analysis pipeline (both with code and extensive comments) on a dataset they have never worked with before.

Keywords

data science, data analysis, data mining, machine learning

Learning Prerequisites

Required courses

The student must have passed an introduction to databases course, OR a course in probability & statistics, OR two separate courses that include programming projects.

Recommended courses

• CS-423 Distributed Information Systems

• CS-433 Machine Learning

Important concepts to start the course

Algorithms, (object-oriented) programming, basic probability and statistics

Learning Outcomes

By the end of the course, the student must be able to:

• Construct a coherent understanding of the techniques and software tools required to perform the fundamental steps of the data science pipeline

• Perform data acquisition (data formats, dataset fusion, Web scrapers, REST APIs, open data, big data platforms, etc.)

• Perform data wrangling (fixing missing and incorrect data, data reconciliation, data quality assessments, etc.)

• Perform data interpretation (statistics, correlation vs. causality, knowledge extraction, critical thinking, team discussions, ad-hoc visualizations, etc.)

• Perform result dissemination (reporting, visualizations, publishing reproducible results, ethical concerns, etc.)

Transversal skills

- Give feedback (critique) in an appropriate fashion.
- Demonstrate the capacity for critical thinking
- Write a scientific or technical report.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.

Teaching methods

- Physical in-class recitations and lab sessions
- Homework assignments
- In-class quizzes
- Course project

Expected student activities

Students are expected to:

- Attend the lectures and lab sessions
- Complete 2-3 homework assignments
- Complete 3 in-class quizzes (held during lab sessions)
- Conduct the class project
- Read/watch the pertinent material before a lecture
- Engage during the class, and present their results in front of the other colleagues

Assessment methods

- 30% continuous assessment during the semester (homework)
- 30% final exam, data analysis task on a computer (3 hours)
- 25% final project, done in groups of 4
- 15% regular online quizzes

Supervision

Others	http://ada.epfl.ch

CS-456

Artificial neural networks

Gerstner Wulfram

Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Computational Neurosciences minor	E	Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
Electrical Engineering		Opt.
Financial engineering	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Since 2010 approaches in deep learning have revolutionized fields as diverse as computer vision, machine learning, or artificial intelligence. This course gives a systematic introduction into the main models of deep artificial neural networks: Supervised Learning and Reinforcement Learning.

Content

- *General Introduction: Deep Networks versus Simple perceptrons*

- *Reinforcement Learning 1: Bellman equation and SARSA*
- *Reinforcement Learning 2: variants of SARSA, Q-learning, n-step-TD learning*
- *Reinforcement Learning 3: Policy gradient*

- *Deep Networks 1: BackProp and Multilayer Perceptrons*
- *Deep Networks 2: Regularization and Tricks of the Trade in deep learning*
- *Deep Networks 3: Error landscape and optimization methods for deep networks*
- *Deep Networks 4: Statistical Classification by deep networks*
- *Deep Networks 5: Convolutional networks*

- *Deep reinforcement learning 1: Exploration*
- *Deep reinforcement learning 2: Actor-Critic networks*
- *Deep reinforcement learning 3: Atari games and robotics*
- *Deep reinforcement learning 4: Board games and planning*
- *Deep reinforcement learning 5: Sequences, recurrent networks, partial observability*

Keywords

Deep learning, artificial neural networks, reinforcement learning, TD learning, SARSA,

Learning Prerequisites

Required courses

CS 433 Machine Learning (or equivalent)
Calculus, Linear Algebra (at the level equivalent to first 2 years of EPFL in STI or IC, such as Computer Science, Physics or Electrical Engineering)

Recommended courses

stochastic processes
optimization

Important concepts to start the course

- *Regularization in machine learning,*
- *Training base versus Test base, cross validation.*
- *Gradient descent. Stochastic gradient descent.*
- *Expectation, Poisson Process, Bernoulli Process.*

Learning Outcomes

- Apply learning in deep networks to real data
- Assess / Evaluate performance of learning algorithms
- Elaborate relations between different mathematical concepts of learning
- Judge limitations of algorithms
- Propose algorithms and models for learning in deep networks
- Apply Reinforcement Learning

Transversal skills

- Continue to work through difficulties or initial failure to find optimal solutions.
- Access and evaluate appropriate sources of information.
- Write a scientific or technical report.
- Manage priorities.

Teaching methods

ex cathedra lectures and miniproject. Every week the ex cathedra lectures are interrupted for at least one in-class exercise which is then discussed in classroom before the lecture continues. Additional exercises are given as homework or can be disussed in the second exercise hour.

Expected student activities

work on miniproject
solve all exercises
attend all lectures and take notes during lecture, participate in quizzes.
If you cannot attend a lecture, then you must read the recommended book chapters

Assessment methods

written exam (70 percent) and miniproject (30 percent)

Supervision

Office hours	Yes

Assistants	Yes
Forum	Yes
Others	TAs are available during exercise sessions. Every week one of the exercises is run as 'integrated exercise' during the lecture. Choice between two different exercise sessions

Resources

Bibliography

- Textbook: Deep Learning by Goodfellow, Bengio, Courville (MIT Press)
- Textbook: Reinforcement Learning by Sutton and Barto (MIT Press)

Pdfs of the preprint version for both books are availble online

Ressources en bibliothèque

- Reinforcement Learning by Sutton and Barto
- Deep Learning by Goodfellow, Bengio, Courville

Websites

- http://for videos and lecture slides https://lcnwww.epfl.ch/gerstner/VideoLecturesANN-Gerstner.html
- http://main web page is moodle

Videos

- http://yes, for most session.

EE-554

Automatic speech processing

Magimai Doss Mathew

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Digital Humanities	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

The goal of this course is to provide the students with the main formalisms, models and algorithms required for the implementation of advanced speech processing applications (involving, among others, speech coding, speech analysis/synthesis, and speech recognition).

Content

1. Introduction: Speech processing tasks, language engineering applications.

2. Basic Tools: Analysis and spectral properties of the speech signal, linear prediction algorithms, statistical pattern recognition, dynamic programming.

3. Speech Coding: Human hearing properties, quantization theory, speech coding in the temporal and frequency domains.

4. Speech Synthesis: Morpho-syntactic analysis, phonetic transcription, prosody, speech synthesis models.

5. Automatic Speech Recognition: Temporal pattern matching and Dynamic Time Warping (DTW) algorithms, speech recognition systems based on Hidden Markov Models (HMMs).

6. Speaker recognition and speaker verification: Formalism, hypothesis testing, HMM based speaker verification.

7. Linguistic Engineering: state-of-the-art and typical applications

Keywords

speech processing, speech coding, speech analysis/synthesis, automatic speech recognition, speaker identification, text-to-speech

Learning Prerequisites

Required courses

Basis in linear algebra, signal processing (FFT), and statistics

Important concepts to start the course

Basic knowledge in signal processing, linear algebra, statistics and stochastic processes.

Learning Outcomes

By the end of the course, the student must be able to:

- speech signal properties
- Exploit those properties to speech codign, speech synthesis, and speech recognition

Transversal skills

- Use a work methodology appropriate to the task.
- Access and evaluate appropriate sources of information.
- Use both general and domain specific IT resources and tools

Teaching methods

Lecture + lab exercises

Expected student activities

Attending courses and lab exercises. Read additional papers and continue lab exercises at home if necessary. Regulary answer list of questions for feedback.

Assessment methods

Written exam without notes

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Ressources en bibliothèque

- Traitement de la parole / Boite

Websites

- http://lectures.idiap.ch/

EPFL

BIO-465 **Biological modeling of neural networks**

Gerstner Wulfram

Cursus	Sem.	Type
Auditeurs en ligne	E	Opt.
Biocomputing minor	E	Opt.
Biomedical technologies minor	E	Opt.
Computational Neurosciences minor	E	Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Electrical Engineering		Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Neuroprosthetics minor	E	Opt.
Neuroscience		Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

In this course we study mathematical models of neurons and neuronal networks in the context of biology and establish links to models of cognition. The focus is on brain dynamics approximated by determinstic or stochatic differnetial equations.

Content

I. Models of single neurons 1. Introduction: brain vs computer and a first simple neuron model 2. Models on the level of ion current (Hodgkin-Huxley model) 3./4. Two-dimensional models and phase space analysis ***II. Neuronal Dynamics of Cognition*** 5./6. Associative Memory and Attractor Dynamics (Hopfield Model) 7. Neuronal Populations and networks 8. Continuum models and perception 9. Competition and models of Decision making ***III. Noise and the neural code*** 10. Noise and variability of spike trains (point processes, renewal process, interval distribution) 11: Variance of membrane potentials and Spike Response Models **IV. Plasticity and Learning** 12. Synaptic Plasticity and Long-term potentiation and Learning (Hebb rule, mathematical formulation) 13. Summary: Fitting Neural Models to Data

Keywords

neural networks, neuronal dynamics, computational neuroscience, mathematical modeling in biology, applied mathematics, brain, cognition, neurons, memory, learning, plasticity

Learning Prerequisites

Required courses

undergraduate math at the level of electrical engineering or physics majors
undergraduate physics.

Recommended courses

Analysis I-III, linear algebra, probability and statistics
For SSV students: Dynamical Systems Theory for Engineers or "Mathematical and Computational Models in Biology"

Important concepts to start the course

Differential equations, stochastic processes,

Learning Outcomes

By the end of the course, the student must be able to:
- Analyze two-dimensional models in the phase plane
- Solve linear one-dimensional differential equations
- Develop a simplified model by separation of time scales
- Analyze connected networks in the mean-field limit
- Formulate stochastic models of biological phenomena
- Formalize biological facts into mathematical models
- Prove stability and convergence
- Apply model concepts in simulations
- Predict outcome of dynamics
- Describe neuronal phenomena

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Collect data.
- Write a scientific or technical report.

Teaching methods

Classroom teaching, exercises and miniproject. One of the two exercise hours is integrated into the lectures.

Expected student activities

- participate in ALL in-class exercises.
- do all homework exercises (paper-and-pencil)
- study video lectures if you miss a class
- study suggested textbook sections for in-depth understanding of material
- submit miniprojects

Assessment methods

Written exam (70%) & miniproject (30%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	The teacher is available during the breaks of the class. Some exercises are integrated in class in the presence of the teacher and the teaching assistants.

Resources

Bibliography

Gerstner, Kistler, Naud, Pansinski : Neuronal Dynamics, Cambridge Univ. Press 2014

Ressources en bibliothèque

- Neuronal Dynamics / Gerstner

Notes/Handbook

The textbook is online at: http://neuronaldynamics.epfl.ch/

Videos

- http://lcn.epfl.ch/~gerstner/NeuronalDynamics-MOOC1.html
- http://lcn.epfl.ch/~gerstner/NeuronalDynamics-MOOC2.html

EE-512

Biomedical signal processing

Vesin Jean-Marc

Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Project	2 weekly
Number of positions	

Summary

The goal of this course is to introduce the techniques most commonly used for the analysis of biomedical signals, and to present concrete examples of their application for diagnosis purposes.

Content

1. Generalities on biomedical signal processing
2. Digital signal processing - basics

- sampling
- Fourier transform
- filtering
- stochastic signals correlation, and pwoer spectral density

3. Time-frequency analysis

- short-term Fourier transform
- time-frequency distributions, Cohen's class
- wavelet transform

4. Linear modeling

- autoregressive models
- linear prediction
- parametric spectral estimation
- criteria for model selection

5. Adaptive filtering

- adaptive prediction
- adaptive estimation of transfert functions
- adaptive interference cancellation

6. Miscellaneous

- polynomial models
- singular value decomposition
- principal component analysis

Keywords

signal processing, biomedical engineering, signal modeling, spectral analysis, adaptive filtering

Learning Prerequisites

Recommended courses

Signal processing for telecommunications COM-303
Signal processing EE-350

Important concepts to start the course

basics of discrete-time signal analysis

Teaching methods

lectures, lab sessions using Matlab

Assessment methods

1 point for lab/exercise sessions reports
2 exams: end of November 2points - final exam 3 points

Supervision

Office hours	Yes
Assistants	Yes

CS-490

Business design for IT services

Wegmann Alain

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Summary

In this course, students practice designing digital business services. The students learn to apply the principles of technical sales while developing their own projects. Through this process, students gain insight into the co-creation of relationships between a company and its customers.

Content

This course is for engineers who are interested in creating a better relationship with the users of the engineers'technology. The experience the students gain is useful especially in the context of startups. This is also relevant for intrapreneur (engineers who seek to bring innovation in companies) and for anyone who seeks to establish and evolve their business relationships.

The course participants begin their projects by *exploring* an area that interests them. They *evaluate* with whom they can establish a company/customer relationship. They *engage* in a concrete relationship with someone interested in their idea. They *establish* the relationship by developing, delivering, and measuring the service. And they *evolve* these relationships through the digitalization of these services. These are not necessarily chronological stages of journey that the engineer needs to progress through.They are the five *experiences* that the students practice in the course.

To complete this journey, we provide the tools to help the course participants to develop the four following capabilities: (i) the *curiosity* - the receptivity to uncovering the unexpected, (ii) the *awareness* - the capacity to assess a reality in order to optimize solutions (iii) the *service understanding* - the capacity to represent what the company exchanges with its customers, (iv) *the actions* planning - *the* capacity *to* make the result concrete through *actions*.

Indeed, this is the SEAM method. We began developing it 1997, at EPFL. SEAM is a system thinking method that reconciles multiple theories from various disciplines from business engineering. SEAM is an open method.

Come *practice* with us! It might be uncomfortable and difficult, yet fun and interesting. By transcending this, you will learn new tools to reframe problems that are apparently impossible to solve.

Keywords

Entrepreneurial motivation, information inquiry, ecosystem analysis, competitor analysis.

Business definition, business services, IT services, segmentation, lead, prospect, opportunity, qualification, value proposition, quotation, break-even model.

The SEAM canvas, customer-relation management tool.

Learning Outcomes

By the end of the course, the student must be able to:

- Create a precise and detailed description for a new business design
- Analyze environmental as well as organizational factors in a business design
- Design a business model in details (service, value, finance)
- Assess / Evaluate alternative business strategies
- Synthesize multiple marketing theories (from seminal publications)
- Represent the key concepts of a business design (ecosystem, value, finance)
- Interpret evidences collected through extensive interviews
- Investigate innovative views of a business design

Transversal skills

- Collect data.
- Access and evaluate appropriate sources of information.
- Write a scientific or technical report.
- Make an oral presentation.
- Summarize an article or a technical report.

Teaching methods

Experiential learning + individual work

EPFL

BIO-105

Cellular biology and biochemistry for engineers

Zufferey Romain

Cursus	Sem.	Type
Biomedical technologies minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Neuroprosthetics minor	H	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Basic course in biochemistry as well as cellular and molecular biology for non-life science students enrolling at the Master or PhD thesis level from various engineering disciplines. It reviews essential notions necessary for a training in biology-related engineering fields.

Content

The course gives basic knowledge on various phenoma taking place within a cell, and among cells within tissues and organs. The course gives an integrated view of various molecular mechanisms (rather in the second half of the class). It should therefore allow engineering students involved in future projects touching on biomedical problems to better integrate the constraints of a biological system and to enable them to communicate with specialists in both fields.
This course is not available to students who had already taken basic cell biology or biochemistry classes during their Bachelor studies at EPFL or elsewhere. This applies for example to the course BIO-109 "Introduction to Life Sciences for Information Sciences" and MSE 212 "Biology for engineers"

Keywords

The course contains chapters on the following subjects:
1.Cells and Organs
2.Chemical components of cells
3.Proteins, Enzymes
4.Energy, Metabolism
5.DNA, Chromosomes, Replication
6.Gene expression
7.Recombinant techniques
8.Membrane and Transport
9.Intracellular trafficking
10.Cytoskeleton
11.Cell division, Mitosis
12.Genetics, Meiosis
13.Cell communication, Signaling
14.Tissue, Tissue regeneration

Learning Prerequisites

Required courses

Bachelor degree in engineering or other non-life science discipline

Recommended courses

Some basic knowledge in chemistry can help, but not required

Important concepts to start the course

Curiosity about how biological systems work, willingness to acquire a certain amount of facts and details necessary to understand and discuss the various molecular mechanisms present in cells or related to modern biology

Learning Outcomes

By the end of the course, the student must be able to:

- Describe the basic components and functions found in cells
- Draw schemes explaining essential cellular phenomena
- Explain which are the important metabolic pathways
- Translate information from genetic code
- Verify statements about specific cellular mechanisms
- Integrate knowledge from different cellular mechanisms

Transversal skills

- Access and evaluate appropriate sources of information.

Teaching methods

2 hours of ex cathedra-type of lecture
2 hours of exercises: the instructor gives out appr. 10 questions out (through Moodle and in the beginning of the session). The questions have different formats, and can in some cases just retrieve the acquired facts, in others have a more integrative problem-based learning approach.

Expected student activities

- review regularly the presented lectures.
- participate actively in the exercise sessions when the questions and problems are discussed altogether

Assessment methods

- a written exam at the winter exam session

Supervision

Office hours	Yes
Assistants	Yes
Forum	No
Others	- the teacher can always be reached through Email or phone to fix a one-to-one discussion about specific subjects

Resources

Bibliography

The lecture is aligned to selected chapters in the following book (recommended although not required): "Essential Cell Bioogy" by B Alberts et al. , 3rd edition, Garland Science Taylor & Francis Group

Ressources en bibliothèque

- Essential Cell Biology / Alberts

CS-524

Computational complexity

Göös Mika

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	3 weekly
Exercises	1 weekly
Number of positions	

Summary

In computational complexity we study the computational resources needed to solve problems and understand the relation between different types of computation. This course advances the students knowledge of computational complexity, and develop an understanding of fundamental open questions.

Content

- Complexity classes (time, space, nondeterminism)
- Space complexity (Logspace, L=NL)
- Boolean circuits and nonuniform computation
- Power of randomness (interactive proofs, IP=PSPACE)
- Lower bounds for concrete models of computation: Decision trees, communication protocols, propositional proofs.

Keywords

theoretical computer science
computational complexity

Learning Prerequisites

Recommended courses

Theory of computation (CS-251)
Algorithms (CS-250)

Learning Outcomes

By the end of the course, the student must be able to:

- Demonstrate an understanding of computational complexity and the P vs NP problem
- Formalize and analyze abstractions of complex scenarios/problems
- Express a good understanding of different concepts of proofs
- Prove statements that are similar to those taught in the course
- Use and understand the role of randomness in computation

- Explain recent exciting developments in theoretical computer science
- Compare different models of computation

Transversal skills

- Demonstrate the capacity for critical thinking
- Summarize an article or a technical report.

Teaching methods

Lecturing and exercises

Expected student activities

Actively attending lectures and exercise sessions. Also homeworks and exam.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Sanjeev Arora and Boaz Barak: *Computational Complexity: A Modern Approach, Cambridge University Press.*
Stasys Jukna: *Boolean Function Complexity, Springer*

Ressources en bibliothèque

- Computational Complexity: A Modern Approach / Arora
- Boolean Function Complexity / Stasys

Websites

- http://theory.epfl.ch/courses/complexity/

CS-413 **Computational photography**

Süsstrunk Sabine

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	During the semester
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

The students will gain the theoretical knowledge in computational photography, which allows recording and processing a richer visual experience than traditional digital imaging. They will also execute practical group projects to develop their own computational photography application.

Content

Computational photography is the art, science, and engineering of creating a great (still or moving) image. Information is recorded in space, time, across visible and invisible radiation and from other sources, and then post-processed to produce the final - visually pleasing - result.
Basics: Human vision system, Light and illumination, Geometric optics, Color science, Sensors, Digital camera systems.
Generalized illumination: Structured light, High dynamic range (HDR) imaging, Time-of-flight.
Generalized optics: Coded Image Sensing, Coded aperture, Focal stacks.
Generalized sensing: Low light imaging, Depth imaging, Plenoptic imaging, Light field cameras.
Generalized processing: Super-resolution, In-painting, Compositing, Photomontages, Panoramas, HDR imaging, Multi-wavelength imaging, Dynamic imaging.
Generalized display: Stereoscopic displays, HDR displays, 3D displays, Mobile displays.
Deep Learning for image resoration and image enhancement.

Keywords

Computational Photography, Coded Image Sensing, Non-classical image capture, Multi-Image & Sensor Fusion, Mobile Imaging, Machine Learning

Learning Prerequisites

Required courses

- A basic Signal Processing, Image Processing, and/or Computer Vision course.
- Linear Algebra.

Recommended courses

- Introduction to Computer Vision.
- Signal Processing for Communications.
- Machine Learning.

Important concepts to start the course

• Basic signal/image processing.
• Basic computer vision.
• Basic programming (Python, iOS, Android).

Learning Outcomes

• Identify the main components of a computational photography system.
• Contextualise the main trends in computational optics, sensing, processing, and displays.
• Create a computational photography application.
• Design a computational photography solution to solve a particular imaging task.
• Assess / Evaluate hardware and software combinations for their imaging performance.
• Formulate computational photography challenges that still need to be resolved.

Transversal skills

• Evaluate one's own performance in the team, receive and respond appropriately to feedback.
• Continue to work through difficulties or initial failure to find optimal solutions.

Teaching methods

The course consists of 2 hours of lectures per week that will cover the theoretical basics. An additional 2 hours per week are dedicated to a group project designing, developing, and programming a compuational photography application on a mobile plateform (iOS, Android).

Expected student activities

The studens is expected to attend the class and actively participate in the practical group project, which requires coding on either Android or iOS plateform. The student is also required to read the assigned reading material (book chapters, scientific articles).

Assessment methods

The theoretical part will be evaluated with an oral exam at the end of the semester, and the practical part based on the students’ group projects.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

- Selected book chapters
- Course notes (on moodle)
- Links to relevant scientific articles and on-line resources will be given on moodle.

EPFL

CS-442

Computer vision

Fua Pascal

Cursus	Sem.	Type
Communication systems minor	E	Opt.
Computer science minor	E	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Data science minor	E	Opt.
Digital Humanities	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Computer Vision aims at modeling the world from digital images acquired using video or infrared cameras, and other imaging sensors. We will focus on images acquired using digital cameras. We will introduce basic processing techniques and discuss their field of applicability.

Content

Introduction

- History of Computer Vision
- Human vs Machine Vision
- Image formation

Extracting 2D Features

- Contours
- Texture
- Regions

3D Shape Recovery

- From one single image
- From multiple images

Learning Outcomes

By the end of the course, the student must be able to:

- Choose relevant algorithms in specific situations
- Perform simple image-understanding tasks

Teaching methods

Ex cathedra lectures and programming exercises using matlab.

Assessment methods

With continuous control

Resources

Bibliography

• R. Szeliski, Computer Vision: Computer Vision: Algorithms and Applications, 2010.
• A. Zisserman and R. Hartley, Multiple View Geometry in Computer Vision, Cambridge University Press, 2003.

Ressources en bibliothèque

• Computer Vision: Algorithms and Applications / Szeliski
• Multiple View Geometry in Computer Vision / Zisserman

Websites

• http://cvlab.epfl.ch/

Moodle Link

• http://moodle.epfl.ch/course/view.php?id=472

CS-453

Concurrent algorithms

Guerraoui Rachid

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Exercises	1 weekly
Practical work	1 weekly
Number of positions	

Summary

With the advent of multiprocessors, it becomes crucial to master the underlying algorithmics of concurrency. The objective of this course is to study the foundations of concurrent algorithms and in particular the techniques that enable the construction of robust such algorithms.

Content

Model of a parallel system
A multicore architect
Processes and objects
Safety and liveliness

Parallel programming
Automatic parallelism
Mutual exclusion and locks
Non-blocking data structures

Register Implementations
Safe, regular and atomic registers
General and limited transactions
Atomic snapshots

Hierarchy of objects
The FLP impossibility
The consensus number
Universal constructions
Transactional memories
Transactional algorithms
Opacity and obstruction-freedom

Keywords

Concurrency, parallelism, algorithms, data structures

Learning Prerequisites

Required courses

ICC, Operatings systems

Recommended courses

This course is complementary to the Distributed Algorithms course.

Important concepts to start the course

Processes, threads, datas structures

Learning Outcomes

By the end of the course, the student must be able to:

- Reason in a precise manner about concurrency
- Design a concurrent algorithm
- Prove a concurrent algorithm
- Implement a concurrent system

Teaching methods

Lectures, exercises and practical work

Expected student activities

Midterm and final exam
Project

Assessment methods

With continuous control, midterm final exams and project

Supervision

Office hours	Yes
Assistants	Yes
Forum	No

Resources

Notes/Handbook

Concurrent Algorithms, R. Guerraoui and P. Kouznetsov

Websites

- http://lpd.epfl.ch/site/education

EPFL

COM-401

Cryptography and security

Vaudenay Serge

Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computer and Communication Sciences		Opt.
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cyber security minor	H	Opt.
Cybersecurity	MA1, MA3	Obl.
Data Science	MA1, MA3	Opt.
Financial engineering	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	7
Session	Winter
Semester	Fall
Exam	Written
Workload	210h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

This course introduces the basics of cryptography. We review several types of cryptographic primitives, when it is safe to use them and how to select the appropriate security parameters. We detail how they work and sketch how they can be implemented.

Content

1. **Ancient cryptography**: Vigenère, Enigma, Vernam cipher, Shannon theory
2. **Diffie-Hellman cryptography**: algebra, Diffie-Hellman, ElGamal
3. **RSA cryptography**: number theory, RSA, factoring
4. **Elliptic curve cryptography**: elliptic curves over a finite field, ECDH, ECIES, pairing
5. **Symmetric encryption**: block ciphers, stream ciphers, exhaustive search
6. **Integrity and authentication**: hashing, MAC, birthday paradox
7. **Public-key cryptography**: cryptosystem, digital signature, post-quantum cryptography
8. **Trust establishment**: password-based cryptography, secure communication, trust setups
9. **Case studies**: WiFI, bitcoin, mobile telephony, WhatsApp, EMV, Bluetooth, biometric passport, TLS

Keywords

cryptography, encryption, secure communication

Learning Prerequisites

Required courses

- Algebra (MATH-310)
- Probabilities and statistics (MATH-232)
- Algorithms (CS-250)

Recommended courses

- Computer security (COM-301)

Important concepts to start the course

- Mathematical reasoning
- Probabilities

- Algebra, arithmetics
- Algorithmics

Learning Outcomes

By the end of the course, the student must be able to:

- Choose the appropriate cryptographic primitive in a security infrastructure
- Judge the strength of existing standards
- Assess / Evaluate the security based on key length
- Implement algorithms manipulating big numbers and use number theory
- Use algebra and probability theory to analyze cryptographic algorithms
- Identify the techniques to secure the communication and establish trust

Teaching methods

ex-cathedra

Expected student activities

- active participation during the course
- take notes during the course
- do the exercises during the exercise sessions
- complete the regular tests and homework
- read the material from the course
- self-train using the provided material
- do the midterm exam and final exam

Assessment methods

Mandatory continuous evaluation:

- homework (30%)
- regular graded tests (30%)
- midterm exam (40%)

Final exam averaged (same weight) with the contiuous evaluation, but with final grade between final_exam-1 and final_exam+1.

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	Lecturers and assistants are available upon appointment.

Resources

Bibliography

- Communication security: an introduction to cryptography. Serge Vaudenay. Springer 2004.
- A computational introduction to number theory and algebra. Victor Shoup. Cambridge University Press

2005.

Ressources en bibliothèque

- A computational introduction to number theory and algebra / Shoup
- Communication security / Vaudenay

Websites

- http://lasec.epfl.ch/teaching.shtml

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=13671

Prerequisite for

- Advanced cryptography (COM-401)
- Student seminar: security protocols and applications (COM-506)

EPFL

COM-480

Data visualization

Vuillon Laurent Gilles Marie

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Data science minor	E	Opt.
Digital Humanities	MA2, MA4	Opt.
Electrical Engineering		Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Learning Sciences		Obl.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

Understanding why and how to present complex data interactively in an effective manner has become a crucial skill for any data scientist. In this course, you will learn how to design, judge, build and present your own interactive data visualizations.

Content

Tentative course schedule
Week 1: Introduction to Data visualization Web development
Week 2: Javascript
Week 3: More Javascript
Week 4: Data Data driven documents (D3.js)
Week 5: Interaction, filtering, aggregation (UI /UX). Advanced D3 / javascript libs
Week 6: Perception, cognition, color Marks and channels
Week 7: Designing visualizations (UI/UX) Project introduction Dos and don’ts for data-viz
Week 8: Maps (theory) Maps (practice)
Week 9: Text visualization
Week 10: Graphs
Week 11: Tabular data viz Music viz
Week 12: Introduction to scientific visualisation
Week 13: Storytelling with data / data journalism Creative coding
Week 14: Wrap-Up

Keywords

Data viz, visualization, data science

Learning Prerequisites

Required courses

CS-305 Software engineering (BA)
CS-250 Algorithms (BA)
CS-401 Applied data analysis (MA)

Recommended courses

EE-558 A Network Tour of Data Science (MA)
CS-486 Interaction design (MA)
CS-210 Functional programming (BA)

Important concepts to start the course

Being autonomous is a prerequisite, we don't offer office hours and we won't have enough teaching assistants (you've been warned!).
Knowledge of one of the following progrmaming language such as C++, Python, Scala.
Familiarity with web-development (you already have a blog, host a webiste). Experience with HTML5, Javascript is a strong plus for the course.

Learning Outcomes

By the end of the course, the student must be able to:

- Judge visualization in a critical manner and suggest improvements.
- Design and implement visualizations from the idea to the final product according to human perception and cognition
- Know the common data-viz techniques for each data domain (multivariate data, networks, texts, cartography, etc) with their technical limitations
- Create interactive visualizations int he browser using HTM5 and Javascript

Transversal skills

- Communicate effectively, being understood, including across different languages and cultures.
- Negotiate effectively within the group.
- Resolve conflicts in ways that are productive for the task and the people concerned.

Teaching methods

Ex cathedra lectures, exercises, and group projects

Expected student activities

- Follow lectures
- Read lectures notes and textbooks
- Create an advanced data-viz in groups of 3.
- Answer questions assessing the evolution of the project.
- Create a 2min screencast presentation of the viz.
- Create a process book for the final data viz.

Assessment methods

- Data-viz (35%)
- Technical implementation (15%)
- Website, presentation, screencast (25%)
- Process book (25%)

Supervision

Office hours	No
Assistants	No
Forum	No

Resources

Bibliography

Visualization Analysis and Design by Tamara Munzner, CRC Press (2014). Free online version at EPFL.
Interactive Data Visualization for the Web by Scott Murray O'Reilly (2013) - D3 - Free online version.
The Truthful Art: Data, Charts, and Maps for Communication by Cairo, Alberto. Royaume-Uni, New Riders, (2016).
Data Visualisation: A Handbook for Data Driven Design by Kirk, Andy. Royaume-Uni, SAGE Publications, (2019).

Ressources en bibliothèque

- Interactive Data Visualization for the Web / Murray
- Visualization Analysis and Design / Munzner
- Data Visualisation / Kirk
- The Truthful Art / Cairo

Notes/Handbook

Lecture notes

Websites

- https://www.kirellbenzi.com

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=15487

EPFL

CS-422

Database systems

Ailamaki Anastasia

Cursus	Sem.	Type
Computer and Communication Sciences		Obl.
Computer science minor	E	Opt.
Computer science	MA2, MA4	Obl.
Cybersecurity	MA2, MA4	Obl.
Digital Humanities	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	7
Session	Summer
Semester	Spring
Exam	Written
Workload	210h
Weeks	14
Hours	**7 weekly**
Lecture	3 weekly
Exercises	2 weekly
Project	2 weekly
Number of positions	

Summary

This course is intended for students who want to understand modern large-scale data analysis systems and database systems. It covers a wide range of topics and technologies, and will prepare students to be able to build such systems as well as read and understand recent research publications.

Content

- Database systems
- Online analytics; data stream processing
- Column stores
- Decision support systems and data warehouses
- Large-scale data analytics infrastructure and systems
- Transaction processing. OLTP systems and concurrency control algorithms
- Distributed data management systems
- Query optimization; database tuning
- Logging and recovery
- Modern storage hierarchies

Learning Prerequisites

Required courses

- CS-107: Introduction to programming
- CS-322: Introduction to database systems
- CS-323: Introduction to operating systems
- CS-452: Foundations of software

Recommended courses

Learning Outcomes

By the end of the course, the student must be able to:

- Design big data analytics systems using state-of-the-art infrastructures for horizontal scaling, e.g., Spark
- Implement algorithms and data structures for streaming data analytics
- Decide between different storage models based on the offered optimizations enabled by each model and on the expected query workload
- Compare concurrency control algorithms, and algorithms for distributed data management
- Identify performance culprits, e.g., due to concurrency control

Teaching methods

Lectures, project, homework, exercises

Expected student activities

During the semester, the students are expected to:

- attend the lectures in order to ask questions and interact with the professor,
- attend the exercise sessions to solve and discuss exercises about the recently taught material,
- work on projects, which cover the practical side of the taught material,
- take a midterm,
- take a final exam,
- read scientific papers related to the course material

Assessment methods

- project
- exams

Supervision

Office hours	Yes
Others	Office hours on request. Q&A sessions in lectures and exercises.

Resources

Bibliography

J. Hellerstein & M. Stonebraker, Readings in Database Systems, 4th Edition, 2005
R. Ramakrishnan & J. Gehrke: "Database Management Systems", McGraw-Hill, 3rd Edition, 2002.
A. Rajaraman & J. Ullman: "Mining of Massive Datasets", Cambridge Univ. Press, 2011.

Ressources en bibliothèque

- Database Management Systems / Ramakrishnan
- Mining of Massive Datasets / Rajaraman
- Readings in Database Systems / Hellerstein

CS-438

Decentralized systems engineering

Ford Bryan Alexander

Cursus	Sem.	Type
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cybersecurity	MA1, MA3	Obl.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Oral
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	2 weekly
Exercises	2 weekly
Project	2 weekly
Number of positions	

Summary

A decentralized system is one that works when no single party is in charge or fully trusted. This course teaches decentralized systems principles while guiding students through the development and testing of their own decentralized system incorporating messaging, encryption, and blockchain concepts.

Content

Topics this course covers include:

- Addressing, Forwarding, Routing. Peer-to-peer communication.
- Information gossip. UseNet: technical, security, and social lessons. Randomized rumor-mongering and anti-entropy algorithms.
- Communicating Securely: Basic Cryptographic Tools. Symmetric-key encryption. Hash functions, message authentication. Diffie-Hellman key exchange. Public-key encryption, digital signatures.
- Trust and Reputation. Authorities, trust networks. Sybil attacks and defenses.
- Naming and search. Request flooding. Hierarchical directories, landmark structures. Self-certifying identities. Distributed hash tables.
- Distributed consensus, distributed ledgers (blockchains), and cryptocurrencies.
- Anonymous Communication. Onion routing, mix networks. Dining cryptographers. Voting, verifiable shuffles, homomorphic encryption. Anonymous disruption.
- Fireproofing Alexandria: Decentralized Storage. Replication. Parity, erasure coding. Renewal. Digital preservation.
- Content Distribution. Opportunistic caching (FreeNet). Content integrity: hash trees, hash file systems. Convergent encryption. Swarming downloads: BitTorrent. Free-riding, incentives.
- Gaining perspective. Spam, malicious content. Review/moderation and reputation systems. Leveraging social networks (Peerspective). Balancing local and global viewpoints.
- Decentralized Collaboration. Network file systems, version management. Consistency.
- Consistency Models. Disconnected operation, eventual consistency, conflict resolution.
- Distributed Consensus. Paxos. Accountability (PeerReview). Byzantine fault tolerance.
- Mobile Code. Smart contract systems. Privacy: trusted computing, fully homomorphic encryption. Decentralized virtual organizations.

Keywords

distributed systems, decentralized systems, security, privacy, anonymity, cryptography, gossip, consensus, swarming, blockchain, cryptocurrency

Learning Prerequisites

Required courses

- COM-208Computer networks

Recommended courses

- CS-206 Parallelism and concurrency
- COM-301 Computer security
- CS-323 Introduction to operating systems

Important concepts to start the course

Students must already be highly competent at programming and debugging in a high-level systems programming language such as Java, C#, or Go. Programming exercises will be in Go, but students already well-versed and experienced in programming with comparable systems languages should be able to pick up Go during the course.
Students should have both solid foundational knowledge of how networks function, and some experience actually writing network programs, e.g., TCP/IP programming using the Sockets API.

Learning Outcomes

By the end of the course, the student must be able to:

- Implement systems via hands-on coding, debugging, and interoperability testing
- Design practical distributed and decentralized systems

Teaching methods

Lectures: The course's lectures will present and discuss challenges, known techniques, and open questions in decentralized system design and implementation. Lectures will often be driven by examination of real decentralized systems with various purposes in widespread use the past or present, such as UseNet, IRC, FreeNet, Tor, BitTorrent, and Bitcoin. Throughout the course we will explore fundamental security and usability challenges such as decentralized identification and authentication, denial-of-service and Sybil attacks, and maintenance of decentralized structures undergoing rapid changes (churn).
Labs: During the semester, students will develop a small but usable peer-to-peer communication application that reflects a few of the important design principles and techniques to be explored in the course, such as gossip, social trust networks, distributed hash tables, consensus algorithms, and cryptocurrencies. The labs will designed so that solutions can initially be tested individually on private, virtual networks running on one machine, then tested collectively by attempting to make different students' solutions interoperate on a real network.
Warning: This course is extremely programming-intensive. Students should be strong and confident in their programming skills in general, and be willing to spend substantial time outside of class debugging difficult distributed concurrency bugs and other challenges. TAs will be available to help at the exercise sessions, but *they will not solve your problems or debug your code for you*.

Expected student activities

Students will be expected to attend lectures to understand the concepts needed for the course, but the main workload will be actual hands-on programming assignments, which the students will perform on their own during the first part of the course and optionally in small teams during the final project-oriented part of the course.

Assessment methods

• Lecture attendance: 10%
• Programming assignment grading (evaluating both function and student documentation): 50%
• Final project grading (accounting for both scope, appropriateness, and follow-through in implementation quality and documentation): 40%

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Moodle Link

• https://moodle.epfl.ch/course/view.php?id=15483

EE-559

Deep learning

Fleuret François

Cursus	Sem.	Type
Civil & Environmental Engineering		Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Data science minor	E	Opt.
Digital Humanities	MA2, MA4	Opt.
Electrical Engineering		Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Financial engineering	MA2, MA4	Opt.
Learning Sciences		Obl.
Life Sciences Engineering	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	**500**

Summary

The objective of this course is to provide a complete introduction to deep machine learning. How to design a neural network, how to train it, and what are the modern techniques that specifically handle very large networks.

Content

The course aims at providing an overview of existing processings and methods, at teaching how to design and train a deep neural network for a given task, and at providing the theoretical basis to go beyond the topics directly seen in the course.

It will touch on the following topics:

- What is deep learning, introduction to tensors.
- Basic machine-learning, empirical risk minimization, simple embeddings.
- Linear separability, multi-layer perceptrons, back-propagation.
- Generalized networks, autograd, batch processing, convolutional networks.
- Initialization, optimization, and regularization. Drop-out, batchnorm, resnets.
- Deep models for Computer Vision.
- Analysis of deep models.
- Auto-encoders, embeddings, and generative models.
- Recurrent and attention models, Natural Language Processing.

Concepts will be illustrated with examples in the PyTorch framework (http://pytorch.org).

Keywords

machine learning, neural networks, deep learning, computer vision, python, pytorch

Learning Prerequisites

Required courses

• Linear algebra (vector, matrix operations, Euclidean spaces).
• Differential calculus (Jacobian, Hessian, chain rule).
• Python programming.
• Basics in probabilities and statistics (discrete and continuous distributions, normal density, law of large numbers, conditional probabilities, Bayes, PCA)

Recommended courses

• Basics in optimization (notion of minima, gradient descent).
• Basics in algorithmic (computational costs).
• Basics in signal processing (Fourier transform, wavelets).

Teaching methods

Ex-cathedra with exercise sessions and mini-projects. Possibly invited speakers.

Assessment methods

Mini-projects by groups of students, and one final written exam.

Resources

Notes/Handbook

Not mandatory: http://www.deeplearningbook.org/

Websites

• https://fleuret.org/ee559/

EPFL

CS-472

Design technologies for integrated systems

De Micheli Giovanni

Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
MNIS	MA3	Obl.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Project	2 weekly
Number of positions	

Summary

Hardware compilation is the process of transforming specialized hardware description languages into circuit descriptions, which are iteratively refined, detailed and optimized. The course presents algorithms, tools and methods for hardware compilation and logic synthesis.

Content

The course will present the most outstanding features of hardware compilation, as well as the techniques for optimizing logic representations and networks. The course gives a novel, uptodate view of digital circuit design. Practical sessions will teach students the use of current design tools.Syllabus1) Modeling languages and specification formalisms;2) High-level synthesis and optimization methods (scheduling, binding, data-path and control synthesis);3) Representation and optimization of combinational logic functions (encoding problems, binary decision diagrams);4) Representation and optimization of multiple-level networks (algebraic and Boolean methods, "don't care" set computation, timing verification and optimization);5) Modeling and optimization of sequential functions and networks (retiming);6) Semicustom libraries and library binding.

Keywords

Hardware, VLSI, Synthesis, Optimization, Algorithms

Learning Prerequisites

Required courses

No specific course

Recommended courses

Good knowledge of digital design, algorithm design and programming.

Important concepts to start the course

Good knowledge of digital design, algorithm design and programming.

Learning Outcomes

By the end of the course, the student must be able to:

- Recognize important problems in digital design
- Examine and evaluate available design tools and methods
- Decide upon a design tool flow to perform a digital design

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.

Assessment methods

Continuous control :
Homework : 30 %, Project 10 %, Midterm test : 25 %,
End term test : 35 %

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

G. De Micheli, Synthesis and Optimization of Digital Circuits, McGraw'Hill.

Ressources en bibliothèque

- Synthesis and Optimization of Digital Circuits / De Micheli

Notes/Handbook

Copies of the slides used for lectures will be given in class and posted.

Websites

- http://lsi-www.epfl.ch/dtis/

CS-411

Digital education & learning analytics

Dillenbourg Pierre, Jermann Patrick

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Digital Humanities	MA1, MA3	Opt.
Learning Sciences		Obl.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

This course addresses the relationship between specific technological features and the learners' cognitive processes. It also covers the methods and results of empirical studies on this topic: do student actually learn due to technologies?

Content

- *Learning theories and learning processes.*
- *Types of learning technlogies*
- *Instructional design: methods, patterns and principles.*
- *On-line education.*
- *Effectiveness of learning technologies.*
- *Methods for empirical research.*

Keywords

learning, pedagogy, teaching, online education, MOOCs

Learning Outcomes

By the end of the course, the student must be able to:

- Describe the learning processes triggered by a technology-based activity
- Explain how a technology feature influences learning processes
- Elaborate a study that measures the learning effects of a digital environment
- Select appropriately a learning technology given the target audience and the expected learning outcomes
- Apply machine learning methods to educational traces

Transversal skills

- Set objectives and design an action plan to reach those objectives.

Teaching methods

The course will combine participatory lectures with a project around learning analytics

Expected student activities

The project will include several milestones to be delivered along the semester.

Assessment methods

- Project + exam
- 50 / 50

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=14248

EPFL

CS-451

Distributed algorithms

Guerraoui Rachid

Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cybersecurity	MA1, MA3	Obl.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	3 weekly
Exercises	2 weekly
Practical work	1 weekly
Number of positions	

Summary

Computing is often distributed over several machines, in a local IP-like network, a cloud or in a P2P network. Failures are common and computations need to proceed despite partial failures of machines or communication links. The foundations of reliable distributed computing will be studied.

Content

Reliable broadcast
Causal Broadcast
Total Order Broadcast
Consensus
Non-Blocking Atomic Commit
Group Membership, View Synchrony
Terminating Reliable Broadcast
Shared Memory in Message Passing Systems
Byzantine Fault Tolerance
Self Stabilization
Population protocols (models of mobile networks)
Bitcoin, Blockchain
Distributed Machine Learning
Gossip

Keywords

Distributed algorithms, checkpointing, replication, consensus, atomic broadcast, ditributed transactions, atomic commitment, 2PC, Machine Learning

Learning Prerequisites

Required courses

Basics of Algorithms, networking and operating systems

Recommended courses

The lecture is orthogonal to the one on concurrent algorithms: it makes a lot of sense to take them in parallel.

Learning Outcomes

By the end of the course, the student must be able to:

- Choose an appropriate abstraction to model a distributed computing problem
- Specify the abstraction
- Present and implement it
- Analyze its complexity
- Prove a distributed algorithm
- Implement a distributed system

Teaching methods

Ex cathedera
Lectures, exercises and practical work

Assessment methods

Midterm and final exams
Project

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Ressources en bibliothèque

- Introduction to reliable and secure distributed programming / Cachin

Notes/Handbook

Reliable and Secure Distributed Programming
Springer Verlag
C. Cachin, R. Guerraoui, L. Rodrigues

Websites

- http://lpdwww.epfl.ch/education

CS-423

Distributed information systems

Aberer Karl

Cursus	Sem.	Type
Biocomputing minor	H	Opt.
Civil & Environmental Engineering		Opt.
Communication systems minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Digital Humanities	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Energy Management and Sustainability	MA1, MA3	Opt.
Environmental Sciences and Engineering	MA1, MA3	Opt.
Learning Sciences		Obl.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course introduces the key concepts and algorithms from the areas of information retrieval, data mining and knowledge bases, which constitute the foundations of today's Web-based distributed information systems.

Content

Information Retrieval

1. Information Retrieval - Introduction
2. Text-Based Information Retrieval (Boolean, Vector space, probabilistic)
3. Inverted Files
4. Distributed Retrieval
5. Query Expansion
6. Embedding models (LSI, word2vec)
7. Link-Based Ranking

Mining Unstructured Data

1. Association Rule Mining
2. Document Classification (knn, Naive Bayes, Fasttext, Transformer models)
3. Recommender Systems (collaborative filtering, matrix factorization)
4. Mining Social Graphs (modularity clustering, Girvan-Newman)

Knowledge Bases

1. Semantic Web
2. Keyphrase extraction
3. Named entity recognition
4. Information extraction
5. Taxonomy Induction
6. Entity Disambiguation
7. Label Propagation
8. Link Prediction
9. Data Integration

Learning Prerequisites

Recommended courses

Introductory courses to databases and machine learning are helpful, but not required.
Programming skills in Python are helpful, but not required.

Learning Outcomes

By the end of the course, the student must be able to:

- Characterize the main tasks performed by information systems, namely data, information and knowledge management
- Apply collaborative information management models, like crowd-sourcing, recommender systems, social networks
- Apply knowledge models, their representation through Web standards and algorithms for storing and processing semi-structured data
- Apply fundamental models and techniques of text retrieval and their use in Web search engines
- Apply main categories of data mining techniques, local rules, predictive and descriptive models, and master representative algorithms for each of the categories

Teaching methods

Ex cathedra + programming exercises (Python)

Assessment methods

25% Continuous evaluations with bonus system during the semester
75% Final written exam (180 min) during exam session

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

ENG-466

Distributed intelligent systems

Martinoli Alcherio

Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Energy Management and Sustainability	MA2, MA4	Opt.
Energy Science and Technology	MA2, MA4	Opt.
Environmental Sciences and Engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Oral
Workload	150h
Weeks	14
Hours	**5 weekly**
Lecture	2 weekly
Exercises	3 weekly
Number of positions	

Summary

The goal of this course is to provide methods and tools for modeling distributed intelligent systems as well as designing and optimizing coordination strategies. The course is a well-balanced mixture of theory and practical activities.

Content

- Introduction to key concepts such as self-organization and tools used in the course
- Examples of natural, artificial and hybrid distributed intelligent systems
- Modeling methods: sub-microscopic, microscopic, macroscopic, multi-level; spatial and non-spatial; mean field, approximated and exact approaches
- Machine-learning methods: single- and multi-agent techniques; expensive optimization problems and noise resistance
- Coordination strategies and distributed control: direct and indirect schemes; algorithms and methods; performance evaluation
- Application examples in distributed sensing and action

Keywords

Artificial intelligence, swarm intelligence, distributed robotics, sensor networks, modeling, machine-learning, control

Learning Prerequisites

Required courses

Fundamentals in analysis, probability, and programming for both compiled and interpreted languages

Recommended courses

Basic knowledge in statistics, programming language used in the course (C, Matlab, Python), and signals and systems

Learning Outcomes

By the end of the course, the student must be able to:

- Design control algorithms
- Formulate a model at different level of abstraction for a distributed intelligent system
- Analyze a model of a distributed intelligent system
- Analyze a distributed coordination strategy/algorithm
- Design a distributed coordination strategy/algorithm
- Implement code for single robot and multi-robot systems
- Carry out systematic performance evaluation of a distributed intelligent system
- Apply modeling and design methods to specific problems requiring distributed sensing and action
- Optimize a controller or a set of possibly coordinated controllers using model-based or data-driven methods

Transversal skills

- Demonstrate a capacity for creativity.
- Access and evaluate appropriate sources of information.
- Collect data.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Write a scientific or technical report.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.

Teaching methods

Ex-cathedra lectures, assisted exercises, and homework in team

Expected student activities

Attending lectures, carrying out exercises and the course project, and reading handouts.

Assessment methods

Oral exam (60%) with continuous assessment during the semester (40%).

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Lecture notes, selected papers and book chapters distributed at each lecture.

Websites

- https://disal.epfl.ch/teaching/distributed_intelligent_systems/

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=15472

Prerequisite for

R&D activities in engineering

EPFL

COM-502

Dynamical system theory for engineers

Thiran Patrick

Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Computational Neurosciences minor	E	Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Opt.
Systems Engineering minor	E	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Linear and nonlinear dynamical systems are found in all fields of science and engineering. After a short review of linear system theory, the class will explain and develop the main tools for the qualitative analysis of nonlinear systems, both in discrete-time and continuous-time.

Content

- **Introduction:** Dynamics of linear and non linear systems. Definitions; Unicity of a solution; Limit Sets, Attractors.
- **Linear Systems:** Solutions; Stability of autonomous systems, Geometrical analysis, connection with frequency domain analysis.
- **Nonlinear Systems:** Solutions; Examples. Large-scale notions of stability (Lyapunov functions). Hamiltonian systems, gradient systems. Small-scale notions of stability (Linearization; stability and basin of attraction of an equilibrium point, stability of periodic solutions, Floquet Multipliers). Graphical methods for the analysis of low-dimensional systems. Introduction to structural stability, Bifurcation theory. Introduction to chaotic systems (Lyapunov exponents).
- The class is methodology-driven. It may present some limited examples of applications, but it is not application-driven.

Keywords

Dynamical Systems, Attractors, Equilibrium point, Limit Cycles, Stability, Lyapunov Functions, Bifurcations, Lyapunov exponents.

Learning Prerequisites

Required courses

- Linear algebra (MATH 111 or equivalent).
- Analysis I, II, III (MATH 101, 106, 203 or equivalent).
- Circuits & Systems II (EE 205 or equivalent) or a Systems & Signals class (MICRO 310/311 or equivalent).

Recommended courses

- A first-year Probabilty class, such as MATH-232, MATH-231, MATH-234(b), MATH-234(c), or equivalent.

- Analysis IV (MATH 207 or equivalent)

Important concepts to start the course

- Linear Algebra (vector spaces, matrix operations, including inversion and eigendecomposition).
- Calculus (linear ordinary differential equations; Fourier, Laplace and z-Transforms).
- Basic notions of topology.
- Basic notions of probability.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze a linear or nonlinear dynamical system.
- Anticipate the asymptotic behavior of a dynamical system.
- Assess / Evaluate the stability of a dynamical system.
- Identify the type of solutions of a dynamical sytem.

Teaching methods

- Lectures (blackboard), 2h per week
- Exercise session, 1h per week.

Expected student activities

Exercises in class and at home (paper and pencil, and Matlab)

Assessment methods

1. Mid-term 20% (conditionally on the Covid situation allowing for it to be taken at EPFL).
2. Final exam 80%

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Course notes; textbooks given as reference on the moodle page of the course.

Notes/Handbook

Course notes, exercises and solutions provided on the moodle page of the course.

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=303

Prerequisite for

Classes using methods from dynamical systems.

CS-473

Embedded systems

Beuchat René

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Oral
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

The main topics of this course are understanding and designing embedded system on a programmable circuit (FPGA). Students will be able to design a camera or a LCD controller on an FPGA in VHDL and will use their controller through a softcore processor.

Content

- Microcontrollers and their associated programmable interfaces (GPIO, Timer, SPI, A/D, PWM, interrupts)
- Hardcore/softcore processors (ie. NIOS II, ARM)
- Memory organizations, little/big endian
- Synchronous busses, dynamic bus sizing (ie. Avalon Bus in Memory Mapped mode)
- Processor busses, busses realized in a FPGA
- Serial busses(ie. UART, SPI, i2c, ...)
- How an LCD graphical screen and a CMOS camera work
- FPGA-based conception of Embedded Systems
- Embedded systems with processors on FPGAs

Laboratories provide knowledge & practice to develop an embedded system based on an FPGA device.

Keywords

microprocessors, microcontroller, FPGA, embedded systems, SoC, programmable interface

Learning Prerequisites

Required courses

Introduction to computing systems, Logic systems, Computer architecture

Recommended courses

Electronic, Programming (C/C++), Project System On Chip

Important concepts to start the course

- Computer architecture (processor, memory, programmable interfaces)
- Processor Architecture (PC, registers, ALU, instruction decoding, instruction execution)
- Knowledge of C programming language

- Knowledge of VHDL

Learning Outcomes

By the end of the course, the student must be able to:

- Design an embedded system on an FPGA
- Analyze a specific problem to be solved and propose an FPGA-based system to solve it
- Implement a solution to the given problem
- Realize and simulate the design
- Test the developed solution on an FPGA
- Use complex development tools and hardware debugging tools such as a logic analyzer and an oscilloscope

Transversal skills

- Use a work methodology appropriate to the task.
- Negotiate effectively within the group.
- Set objectives and design an action plan to reach those objectives.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Use both general and domain specific IT resources and tools
- Make an oral presentation.

Teaching methods

Ex cathedra and exercises, laboratories by specific sub-topics, final mini-project

Expected student activities

- Reading and deepening of course concepts
- Preparation of exercises performed in the laboratory
- Writing reports on different labs
- Realization of a final mini-project by group with oral presentation, report and demonstration

Assessment methods

With continuous control.
all labs 30%, mini-projet 20%, oral exam 50%

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	Course on Moodle with forum

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Teaching notes and suggested reading material on moodle
Specialized datasheets (micro-controllers, FPGA) and standards(ie, SPI, i2c, Amba, Avalon, etc)

Notes/Handbook

Documents and slides provided on moodle

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=1231

Prerequisite for

CS-476 Real-time embedded systems

CS-491

Enterprise and service-oriented architecture

Regev Gil

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	Oral
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	6 weekly
Number of positions	

Summary

This course is an introduction to the alignment of enterprise needs with the possibilities offered by Information Technology (IT). Using a simulated business case, we explore how to define the requirements for an IT service that matches stakeholders implicit wishes.

Content

Target Audience

EPFL Engineers who want to become

- Business Analysts
- Requirements Engineers
- Project Managers
- Management and IT consultants
- Product Owners

Content

Technological and societal changes are pressuring enterprise IT departments to hire engineers with excellent technical and business skills. Their roles are called business analysts, requirements engineers, or product owners. Their skills enable the bidirectional alignment of business needs and IT capabilities. With IT becoming the most important enabler of enterprise strategy, these roles are becoming crucial in many organizations, large and small, private or public.

We use experiential learning beginning with concrete experience, followed by reflection and abstraction to encourage collaborative learning by doing. You will be part of a small team that needs to understand and solve a business case through fast-paced role-playing with the teaching staff. This is interspersed with lectures on the nature of organizations, business analysis and the role of enterprise IT. Several external speakers from industry illustrate what we see in class.

We will explore the following subjects:

- The nature of organizations
- Problems and solutions
- Requirements elicitation
- Enterprise modeling
- Low-code prototyping
- Creating a request for tender

Keywords

Ethnography, interviews, contextual inquiry, business service, business process, IT service, business analysis, requirements engineeing, SEAM service modeling, SEAM motivation modeling, interpretivism, homeostasis, appreciation, resilience, low-code development, request for tender

Learning Outcomes

By the end of the course, the student must be able to:

- Elicit requirements with business stakeholders
- Analyze business stakeholder perceptions and motivations

- Assess / Evaluate business processes
- Define requirements for business and IT services
- Present problems and solutions to management
- Implement a prototype in a low-code platform

Transversal skills

- Demonstrate a capacity for creativity.
- Communicate effectively with professionals from other disciplines.
- Take feedback (critique) and respond in an appropriate manner.

Teaching methods

Experiential learning and teamwork

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Beyer, H. and K. Holtzblatt (1999). "Contextual design." interactions 6(1): 32-42.
Markus M.L., Keil M. (1994). If We Build It, They Will Come: Designing Information Systems that People Want to use, Sloan Management Review; Summer 1994; 35, 4; ABI/INFORM Global pg. 11
Regev, G. et al.(2013) What We Can Learn about Business Modeling from Homeostasis, Lecture Notes in Business Information Processing, 142, 1-15, 2003
Zachman, J. A. (1987). "A framework for information systems architecture." IBM Syst. J. 26 (3): 276-292.

Ressources en bibliothèque

- Contextual design / Beyer

EPFL

CS-489

Experience design

Huang Jeffrey

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	2 weekly
Project	4 weekly
Number of positions	

Summary

As we move towards a design economy, the success of new products, systems and services depend increasingly on the excellence of personal experience. This course introduces students to the notion and practice of experience design following a hands-on, studio-based approach.

Content

Experience design in practice encompasses the collection, analysis and design of users experiences based on a deep understanding of the context concerned. We will examine these processes using a series of mini-workshops, to rapidly iterate on multiple design experience options. The goal is to create a meaningful, interactive, data-driven (and possibly AI-assisted) digital interface and physical prototypes for new experiences.
We explore questions at the intersection of physical and digital architecture through an experience design approach, involving: (1) a mapping of the social dynamics surrounding an experience; (2) a critical analysis of the geographical and temporal flows (experience journeys); and (3) a detailed evaluation of the experience touch points. Based on this experience diagnosis, we propose alternative designs of experience blueprints that combine physical and digital touch points which in turn will constitute the elements of future typologies.
Our particular focus will be on information intensive typologies in the contemporary city, such as museums, libraries, airports, banks, boutiques, governments, hospitals and homes. Each year, we will investigate a different typology. Digital interfaces and augmented artifacts will be considered as possible alternatives to reconfigure the senses of perception, redistribute time, and reorchestrate the configuration of social, emotional and spatial experiences.
The seminar will combine students from both IC and ENAC to work together in a real interdisciplinary process.

Keywords

User Experience (UX) Design, Design Thinking, Journey Mapping, Optioneering, Critical Prototyping, Value Proposition

Learning Prerequisites

Required courses

Bachelor in Computer Science or equivalent

Learning Outcomes

By the end of the course, the student must be able to:

- Identify issues of experience design in relation to an actual design project
- Perform rigorous analysis of the problem space and map the design opportunities
- Develop alternative design concepts for future artifacts

- Translate design concepts into meaningful experiences through iterative prototyping at appropriate scales and levels of granularity
- Create convincing arguments for the design propositions and persuasive visual and tangible evidence

Teaching methods

Workshops, Design reviews, Presentations, Group projects

Expected student activities

Group discussion, Case studies, Design Reviews, Pin-Up, Desk Crits

Assessment methods

Grading will be based upon the quality of the projects in the preliminary workshops (30%), intermediary reviews (20%) and in the final review (50%). Projects will be reviewed and assessed based on their conceptual strength, the coherence of their translation into prototypes, their narrative clarity and experiential power, and the persuasiveness of their communication, both orally and through the presented artifacts.

Supervision

Office hours	Yes
Assistants	Yes

Resources

Bibliography

To be made available during the course

CS-550

Formal verification

Kuncak Viktor

Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	2 weekly
Exercises	2 weekly
Practical work	2 weekly
Number of positions	

Summary

We introduce formal verification as an approach for developing highly reliable systems. Formal verification finds proofs that computer systems work under all relevant scenarios. We will learn how to use formal verification tools and explain the theory and the practice behind them.

Content

Topics may include (among others) some of the following:

- Importance of Reliable Systems. Methodology of Formal Verification. Soundness and Completeness in Modeling and Tools. Successful Tools and Flagship Case Studies
- Review of Sets, Relations, Computability, Propositional and First-Order Logic Syntax, Semantics, Sequent Calculus.
- Completeness and Semi-Decidability for First-Order Logic. Inductive Definitions and Proof Trees. Higher-Order Logic and LCF Approach.
- State Machines. Transition Formulas. Traces. Strongest Postconditions and Weakest Preconditions.
- Hoare Logic. Inductive Invariants. Well-Founded Relations and Termination Measures
- Linear Temporal Logic. System Verilog Assertions. Monitors
- SAT Solvers and Bounded Model Checking
- Model Checking using Binary Decision Diagrams
- Loop Invariants. Hoare Logic. Statically Checked Function Contracts. Relational Semantics and Fixed-Point Semantics
- Symbolic Execution. Satisfiability Modulo Theories
- Abstract Interpretation and Predicate Abstraction
- Information Flow and Taint Analysis
- Verification of Security Protocols
- Dependent and Refinement Types

Learning Prerequisites

Recommended courses

Computer Language Processing / Compilers

Important concepts to start the course

Discrete Mathematics

Learning Outcomes

By the end of the course, the student must be able to:

- Formalize specifications
- Synthesize loop invariants
- Specify software functionality
- Generalize inductive hypothesis
- Critique current software development practices

Teaching methods

Instructors will present lectures and exercises and supervise labs on student laptops.

Expected student activities

Follow the course material and complete and explain projects during the semester.

Assessment methods

The grade is based on the code, documentation, and explanation of projects during the semester.
There are no written exams.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

- **Harrison, J. (2009). *Handbook of Practical Logic and Automated Reasoning*. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511576430**
- **Aaron Bradley and Zohar Manna: The Calculus of Computation - Decision Procedures with Applications to Verification, Springer 2007.**
- Michael Huth and Mark Rayan: Logic in Computer Science - Modelling and Reasoning about Systems. Cambridge University Press 2004.
- Handbook of Model Checking, https://www.springer.com/de/book/9783319105741 Springer 2018. Including Chapter Model Checking Security Protocols by David Basin.
- Tobias Nipkow, Gerwin Klein: Concrete Semantics with Isabelle/HOL. http://concrete-semantics.org/concrete-semantics.pdf
- Nielson, Flemming, Nielson, Hanne R., Hankin, Chris: Principles of Program Analysis. ISBN 978-3-662-03811-6. Springer 1999.
- Peter B. Andrews: An Introduction to Mathematical Logic and Type Theory (To Truth Through Proof), Springer 2002.
- http://logitext.mit.edu/tutorial

Ressources en bibliothèque

- Handbook of model checking / Clarke

- Introduction to mathematical logic and type theory / Andrews
- Principles of Program Analysis / Flemming
- The Calculus of Computation / Bradley
- Logic in Computer Science / Huth
- Handbook of model checking : Model Checking Security Protocols / Bassin

Notes/Handbook

- https://lara.epfl.ch/w/fv

Websites

- https://lara.epfl.ch/w/fv

Videos

- https://tube.switch.ch/channels/f2d4e01d

Prerequisite for

MSc thesis in the LARA group

EPFL

COM-406

Foundations of Data Science

Gastpar Michael C., Urbanke Rüdiger

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Computer and Communication Sciences		Obl.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Obl.
Data science minor	H	Opt.
Digital Humanities	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

We discuss a set of topics that are important for the understanding of modern data science but that are typically not taught in an introductory ML course. In particular we discuss fundamental ideas and techniques that come from probability, information theory as well as signal processing.

Content

This class presents basic concepts of Information Theory and Signal Processing and their relevance to emerging problems in Data Science and Machine Learning.
A tentative list of topics covered is:

1. Information Measures
2. Signal Representations
3. Detection and Estimation
4. Multi-arm Bandits
5. Distribution Estimation, Property Testing, and Property Estimation
6. Exponential Families
7. Compression and Dimensionality Reduction
8. Information Measures and Generalization Error

Keywords

Information Theory, Signal Processing, Statistical Signal Processing, Machine Learning, Data Science.

Learning Prerequisites

Required courses

COM-300 Modèles stochastiques pour les communications

Recommended courses

Statistics

Important concepts to start the course

Solid understanding of linear algebra and probability as well as real and complex analysis.

Learning Outcomes

By the end of the course, the student must be able to:

- Formulate the fundamental concepts of signal processing such as basis representations and sampling
- Formulate the fundamental concepts of information theory such as entropy and mutual information

- Analyze problems in statistical settings using fundamental bounds from information theory
- Formulate problems using robust and universal techniques

Teaching methods

Ex cathedra lectures, exercises, and small projects.

Expected student activities

Follow lectures; independent work on problems (homework and small projects).

Assessment methods

Written final exam during the exam session.
Homework Problem Sets during the semester.
10% homework, 30% midterm, 60% final exam; (if for some reason the course has to be given over zoom then we will skip the midterm and the course will be evaluated by 10% homework and 90% final)

Resources

Bibliography

Cover and Thomas, Elements of Information Theory (Second Edition), Wiley, 2006.

Ressources en bibliothèque

- Elements of Information Theory / Cover

Notes/Handbook

Lectures notes will be available on the course web page.

CS-452

Foundations of software

Odersky Martin

Cursus	Sem.	Type
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cybersecurity	MA1, MA3	Obl.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The course introduces the foundations on which programs and programming languages are built. It introduces syntax, types and semantics as building blocks that together define the properties of a program part or a language. Students will learn how to apply these concepts in their reasoning.

Content

- simple types, lambda-calculus
- normalization, references, exceptions
- subtyping
- recursive types
- polymorphism
- advances features of the Scala type system

Learning Prerequisites

Recommended courses

Advanced topics in programming, Compiler construction

Important concepts to start the course

Functional programming
Basic knowledge of formal languages

Learning Outcomes

By the end of the course, the student must be able to:

- Argue design decisions of programming languages
- Assess / Evaluate soundness of type systems
- Compose higher-order functions
- Verify progress and preservation in type systems
- Work out / Determine operational equivalences
- Carry out projects of 2-3 weeks duration
- Distinguish valid from invalid proofs
- Implement type systems and operational semantics

Transversal skills

- Assess progress against the plan, and adapt the plan as appropriate.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.
- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.
- Manage priorities.

Teaching methods

Ex cathedra, practical exercises

Assessment methods

With continuous control

Resources

Ressources en bibliothèque

-

Websites

- http://lampwww.epfl.ch/teaching/index.html.en

EE-429

Fundamentals of VLSI design

Burg Andreas Peter

Cursus	Sem.	Type
Cyber security minor	H	Opt.
Cybersecurity	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
MNIS	MA3	Obl.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	3 weekly
Exercises	1 weekly
Number of positions	

Summary

The course introduces the fundamentals of digital integrated circuits and the technology aspects from a designers perspective. It focuses mostly on transistor level, but discusses also the extension to large digital semicustom designs.

Content

Introduction:
History/milestones, methodology, technology, design objectives & principles
Digital CMOS Fundamentals (Inverter):
DC characteristics, delay, rise/fall time, noise-margins, impact of sizing
Basic CMOS logic gates:
Constructing basic logic gates, transistor sizing, gate delay considerations
Custom digital logic:
Logical effort model, sizing of gates, inverter chains
Parasitic effects:
Routing capacitance, wire resistance, Elmore delay model
Technology considerations:
Technology scaling, impact on parasitics, variabiity
Low-power design:
Power consumption basics (leakage, dynamic), voltage-scaling, basic low-power design principles
Memories:
Embedded SRAM (6T bit-cell, organization, peripherals), SRAM stability (noise margins)
DRAM (briefly)
Fundamentals of Semicustom design:
Design flow, design abstraction, IP components, standard-cells (layout, characterization, lib, lef)
Semicustom design flow:
Logic synthesis, place & route, clock distribution, verification

Learning Prerequisites

Required courses

EE-490(b) Lab in EDA based design (can be attended in parallel in same semester)

Recommended courses

EE-334 Digital system design (can be attended in parallel in same semester)

Learning Outcomes

By the end of the course, the student must be able to:

- Construct digital logic gates
- Analyze the performance of digital gates
- Optimize digital logic
- Explain the operation of embedded memories
- Anticipate the impact of parasitics and technology scaling
- Implement a semicustom integrated circuit from a given RTL code to layout
- Link simplified abstract models to detailed computer simulations

Teaching methods

Ex-cathedra lectures with computer labs using industry-standard IC design tools

Resources

Notes/Handbook

Slides & course notes

Prerequisite for

EE-431 Advanced VLSI design (highly recommended)

MATH-483

Gödel and recursivity

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Remark

Cours donné en alternance tous les deux ans (pas donné en 2021-22)

Summary

Gödel incompleteness theorems and mathematical foundations of computer science

Content

Gödel's theorems:
Peano and Robinson Arithmetics. Representable functions. Arithmetic of syntax. Incompleteness, and undecidability theorems.

Recursivity :
Turing Machines and variants. The Church-Turing Thesis. Universal Turing Machine. Undecidable problems (the halting and the Post-Correspondance problems). Reducibility. The arithmetical hierarchy. Relations to Turing machines. Turing degrees.

Keywords

Gödel, incompleteness theorems, Peano arithmetic, Robinson arithmetic, decidability, recursively enumerable, arithmetical hierarchy, Turing machine, Turing degrees, jump operator, primitive recursive functions, recursive functions, automata, pushdown automata, regular languages, context-free languages, recursive languages, halting problem, universal Turing machine, Church thesis.

Learning Prerequisites

Recommended courses

Mathematical logic (or equivalent). A good understanding of 1st order logic is required - in particular the relation between syntax and semantics.

Important concepts to start the course

1st order logic: syntax, semantics, proof theory, completeness theorem, compactness theorem, Löwenheim-Skolem theorem.

Learning Outcomes

By the end of the course, the student must be able to:

- Estimate whether a given theory, function, language is recursive or no
- Decide the class that a language belongs to (regular, context-free, recursive,...)

• Elaborate an automaton
• Design a Turing machine
• Formalize a proof in Peano arithmetic
• Sketch the incompleteness theorems
• Propose a non-standard model
• Argue why Hilbert program failed

Teaching methods

Ex cathedra lecture and exercises

Assessment methods

Written: 3 hours
Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Set Theory:
• Thomas Jech: Set theory, Springer 2006
• Kenneth Kunen: Set theory, Springer, 1983
• Jean-Louis Krivine: Theory des ensembles, 2007
• Patrick Dehornoy: Logique et théorie des ensembles; Notes de cours, FIMFA ENS: http://www.math.unicaen.fr/~dehornoy/surveys.html
• Yiannis Moschovakis: Notes on set theory, Springer 2006
• Karel Hrbacek and Thomas Jech: Introduction to Set theory, (3d edition), 1999

Recursion Theory :
• Micheal Sipser: Introduction to the Theory of Computation, Thomson Course Technology Boston, 2006
• Piergiorgio Odifreddi: Classical recursion theory, vol. 1 and 2, Springer, 1999
• Robert I. Soare: Recursively Enumerable Sets and Degres, A Study of Computable Functions and Computably Generated Sets, Springer-Verlag 1987
• Nigel Cutland: Computability, an introduction to recursive function theory, 1980
• Raymond M. Smullyan: recursion theory for methamathematics, Oxford, 1993

Proof theory :
• Wolfram Pohlers: Proof Theory, the first step into impredicativity, Springer, 2008
• A. S. Troelstra, H. Schwichtenberg, and Anne S. Troelstra: Basic proof theory, Cambridge, 2000
• S.R. Buss: Handbook of proof theory, Springer, 1998

Gödel's results :

- Raymond M. Smullyan: Gödel's incompleteness theorems, Oxford, 1992
- Peter Smith: An introduction to Gödel's theorems, Cambridge, 2008
- Torkel Franzen: Inexhaustibility, a non exhaustive treatment, AK Peteres, 2002
- Melvin Fitting: Incompleteness in the land of sets, King's College, 2007
- Torkel Franzen: Gödel's theorem: an incomplete guide to its use and abuse, AK Peters, 2005

Ressources en bibliothèque

- Théorie des ensembles / Krivine
- Introduction to Set theory / Hrbacek
- Proof Theory / Pohlers
- Notes on theory / Moschovakis
- Basic proof theory / Troelstra
- Introduction to the Theory of Computation / Sipser
- Handbook of proof theory / Buss
- Set theory / Jech
- Classical recursion theory / Odifreddi
- Recursion theory for methamathematics / Smullyan
- Set theory / Kunen
- Incompleteness in the land of sets / Fitting
- Recursively Enumerable Sets and Degres / Soare
- Gödel's theorem / Franzen
- Computability, an introduction to recursive function theory / Cutland
- Logique et théorie des ensembles / Dehornoy
- Gödel's incompleteness theorems / Smullyan
- An introduction to Gödel's theorems / Smith
- Inexhaustibility, a non exhaustive treatment / Franzen

Websites

- http://www.hec.unil.ch/logique/enseignement/recursivity

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=14569

EPFL

MICRO-511

Image processing I

Unser Michaël, Van De Ville Dimitri

Cursus	Sem.	Type
Biocomputing minor	H	Opt.
Computational Neurosciences minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Digital Humanities	MA1, MA3	Opt.
Environmental Sciences and Engineering	MA1, MA3	Opt.
Life Sciences Engineering	MA1, MA3	Opt.
Microtechnics	MA1, MA3	Opt.
Neuroprosthetics minor	H	Opt.
Photonics minor	H	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	3
Session	Winter
Semester	Fall
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Summary

Introduction to the basic techniques of image processing. Introduction to the development of image-processing software and to prototyping in JAVA. Application to real-world examples in industrial vision and biomedical imaging.

Content

- Introduction. Image processing versus image analysis. Applications. System components.
- Characterization of continuous images. Image classes. 2D Fourier transform. Shift-invariant systems.
- Image acquisition. Sampling theory. Acquisition systems. Histogram and simple statistics. Linear and Max-Lloyd Quantization.
- Characterization of discrete images and linear filtering. z-transform. Convolution. Separability. FIR and IIR filters.
- Image-processing operations. Point operators (thresholding, histogram modification). Spatial operators (smoothing, enhancement, nonlinear filtering). Morphological operators.
- Introduction to image analysis and computer vision. Segmentation, edge detection, objet detection, image comparison.

Learning Prerequisites

Required courses

Signals and Systems I & II (or equivalent)

Important concepts to start the course

1-D signal processing: convolution, Fourier transform, z-transform

Learning Outcomes

By the end of the course, the student must be able to:

- Exploit the multidimensional Fourier transform
- Select appropriately Hilbert spaces and inner-products
- Optimize 2-D sampling to avoid aliasing
- Formalize convolution and optical systems
- Design digital filters in 2-D
- Analyze multidimensional linear shift-invariant systems
- Apply image-analysis techniques
- Construct image-processing software
- Elaborate morphological filters

Transversal skills

- Use a work methodology appropriate to the task.
- Manage priorities.
- Use both general and domain specific IT resources and tools

MICRO-512

Image processing II

Liebling Michael, Sage Daniel, Unser Michaël, Van De Ville Dimitri

Cursus	Sem.	Type
Biocomputing minor	E	Opt.
Computational Neurosciences minor	E	Opt.
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Neuroprosthetics minor	E	Opt.
Photonics minor	E	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	3 weekly
Number of positions	

Summary

Study of advanced image processing; mathematical imaging. Development of image-processing software and prototyping in JAVA; application to real-world examples in industrial vision and biomedical imaging.

Content

- **Review of fundamental notions.** Multi-dimensional Fourier transform. Convolution. z-transform. Digital filters.
- **Continuous representation of discrete data.** Splines. Interpolation. Geometric transformations. Multi-scale decomposition (pyramids and wavelets).
- **Image transforms.** Karhunen-Loève transform (KLT). Discrete cosine transform (DCT). JPEG coding. Image pyramids. Wavelet decomposition.
- **Reconstruction from projections.** X-ray scanners. Radon transform. Central slice theorem. Filtered backprojection. Iterative methods.
- **Deconvolution.** Inverse and Wiener filtering. Matrix formulations. Iterative techniques (ART).
- **Statistical pattern classification.** Decision making. Bayesian classification. Parameter estimation. Supervised learning. Clustering.
- **Image analysis.** Pixel classification. Contour extraction and representation. Shape. Texture. Snakes and active contours.

Learning Prerequisites

Required courses

Image Processing I

Recommended courses

Signals and Systems I & II, linear algebra, analysis

Important concepts to start the course

Basic image processing and related analytical tools (Fourier transform, z-tranform, etc.)

Learning Outcomes

By the end of the course, the student must be able to:

- Construct interpolation models and continuous-discrete representations
- Analyze image transforms
- Design image-reconstruction algorithms
- Formalize multiresolution representations using wavelets
- Design deconvolution algorithms
- Perform image analysis and feature extraction
- Design image-processing software (plugins)
- Synthesize steerable filters

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Manage priorities.
- Access and evaluate appropriate sources of information.
- Use both general and domain specific IT resources and tools

CS-487

Industrial automation

Sommer Philipp Alexander, Tournier Jean-Charles

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Energy Science and Technology	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Oral
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Project	1 weekly
Number of positions	

Remark

This course can be taken by students of all engineering sections.

Summary

This course consists of two parts: 1) architecture of automation systems, hands-on lab 2) handling of faults and failures in real-time systems, including fault-tolerant computing

Content

Trends like digitalization and internet of things affect the way industrial plants are designed, deployed and operated. Industrial Automation comprises the control, communication and software architecture in (real-time) automation systems: factories, energy production and distribution, vehicles and other embedded systems.

Keywords

1. Processes and plants, automation system architecture
2. Instrumentation, Programmable Logic Controllers and embedded computers
3. Industrial communication networks, field busses
4. Field device access protocols and application program interfaces
5. Human interface and supervision
6. Dependability (Reliability, Availability, Safety, ...)
6. Real-time response and performance analysis

Learning Prerequisites

Recommended courses

Communication networks

Learning Outcomes

By the end of the course, the student must be able to:

- Characterize the (software) architecture of a automation system
- Apply methods and trade-offs in real-time systems
- Analyze a plant
- Propose suitable automation solutions meeting the requirements
- Analyze the reliability, availability, safety of a system

Transversal skills

- Write a scientific or technical report.
- Use both general and domain specific IT resources and tools
- Communicate effectively with professionals from other disciplines.
- Keep appropriate documentation for group meetings.
- Access and evaluate appropriate sources of information.

Teaching methods

Oral presentation aided by slides, exercises as part of the lecture, practical work (workshop at Siemens and group assignment).

Expected student activities

- Understand material presented during lectures by asking questions and/or independent (online) searches
- Attend Siemens workshop (one full day on Siemens premises in Renens based on availability)
- Work on group assignment
- Hand-in artifacts for assignment on time

Assessment methods

Assignment 25% and final oral exam 75%

Resources

Bibliography

Nussbaumer, Informatique Industrielle (EPFL)
Olsson, Gustav & Rosen, Christian - industrial automation,Dept. of Industrial Electrical Engineering and Automation, Lund University, Lund, Sweden.
Introduction to Industrial Automation, Stamatios Manesis & George Nikolakopoulos, CRC Press, 2018

Ressources en bibliothèque

- Informatique Industrielle / Nussbaumer

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=14114

COM-402

Information security and privacy

Hubaux Jean-Pierre, Pyrgelis Apostolos

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Computer and Communication Sciences		Opt.
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cyber security minor	H	Opt.
Cybersecurity	MA1, MA3	Obl.
Data Science	MA1, MA3	Obl.
Data science minor	H	Opt.
Financial engineering	MA1, MA3	Opt.
Learning Sciences		Obl.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	3 weekly
Exercises	1 weekly
Project	2 weekly
Number of positions	

Summary

This course provides an overview of information security and privacy topics. It introduces students to the knowledge and tools they will need to deal with the security/privacy challenges they are likely to encounter in today's Big Data world. The tools are illustrated with relevant applications.

Content

- Overview of cyberthreats
- Exploiting vulnerabilities
- Authentication, access control, compartmentalization
- Basic applied cryptography
- Operational security practices and failures
- Machine learning and privacy
- Data anonymization and de-anonymization techniques
- Privacy enhancing technologies
- Blockchain and decentralization

Keywords

security, privacy, protection, intrusion, anonymization, cryptography

Learning Prerequisites

Required courses

COM-301 Computer security
Basic Python programming or better
Basic networking knowledge

Learning Outcomes

By the end of the course, the student must be able to:

- Understand the most important classes of information security/privacy risks in today's "Big Data" environment
- Exercise a basic, critical set of "best practices" for handling sensitive information
- Exercise competent operational security practices
- Understand the key technical tools available for security/privacy protection

Expected student activities

Attending lectures, solving assigned problems and "hands-on" exercises, reading and demonstrating understanding of provided materials.

Assessment methods

- continuous control : 30% of the grade
- final exam : 70% of the grade

EPFL

COM-404 **Information theory and coding**

Telatar Emre

Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computer and Communication Sciences		Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	7
Session	Winter
Semester	Fall
Exam	Written
Workload	210h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

The mathematical principles of communication that govern the compression and transmission of data and the design of efficient methods of doing so.

Content

1. Mathematical definition of information and the study of its properties.
2. Source coding: efficient representation of message sources.
3. Communication channels and their capacity.
4. Coding for reliable communication over noisy channels.
5. Multi-user communications: multi access and broadcast channels.
6. Lossy source coding : approximate representation of message sources.
7. Information Theory and statistics

Learning Outcomes

By the end of the course, the student must be able to:

- Formulate the fundamenal concepts of information theory such as entropy, mutual information, channel capacity
- Elaborate the principles of source coding and data transmission
- Analyze source codes and channel codes
- Apply information theoretic methods to novel settings

Teaching methods

Ex cathedra + exercises

Assessment methods

With continuous control

Resources

Ressources en bibliothèque

- Elements of Information Theory / Cover

Websites

- http://moodle.epfl.ch/enrol/index.php?id=14593

EPFL

CS-430 **Intelligent agents**

Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Computer science minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Data science minor	H	Opt.
Energy Management and Sustainability	MA1, MA3	Opt.
Financial engineering minor	H	Opt.
Financial engineering	MA1, MA3	Opt.
Learning Sciences		Obl.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	3 weekly
Exercises	3 weekly
Number of positions	

Remark

pas donné en 2021-22

Summary

Software agents are widely used to control physical, economic and financial processes. The course presents practical methods for implementing software agents and multi-agent systems, supported by programming exercises, and the theoretical underpinnings including computational game theory.

Content

The course contains 4 main subject areas:

1) Basic models and algorithms for individual agents:
Models and algorithms for rational, goal-oriented behavior in agents: reactive agents, reinforcement learning, exploration-exploitation tradeoff, AI planning methods.
2) Multi-agent systems:
multi-agent planning, coordination techniques for multi-agent systems, distributed algorithms for constraint satisfaction.
3) Self-interested agents:
Models and algorithms for implementing self-interested agents motivated by economic principles: elements of computational game theory, models and algorithms for automated negotiation, social choice, mechanism design, electronic auctions and marketplaces.
4) Implementing multi-agent systems:
Agent platforms, ontologies and markup languages, web services and standards for their definition and indexing.

Learning Prerequisites

Recommended courses

Intelligence Artificielle or another introductory course to AI

Learning Outcomes

By the end of the course, the student must be able to:

- Choose and implement methods for rational decision making in software agents, based on decision processes and AI

planning techniques
• Choose and implement methods for efficient rational decision making in teams of multiple software agents
• Model scenarios with multiple self-interested agents in the language of game theory
• Evaluate the feasibility of achieving goals with self-interested agents using game theory
• Design, choose and implement mechanisms for self-interested agents using game theory
• Implement systems of software agents using agent platforms

Teaching methods

Ex cathedra, practical programming exercises

Expected student activities

Lectures: 3 hours
Reading: 3 hours
Assignments/programming: 4 hours

Assessment methods

Mini-projects and exercises 40%, final exam 60%

Resources

Bibliography

Michael Wooldridge : An Introduction to MultiAgent Systems - Second Edition, John Wiley & Sons, 2009
Stuart Russell and Peter Norvig: Artificial Intelligence: A Modern Approach (2nd/3rd Edition), Prentice Hall Series in Artificial Intelligence, 2003/2009.

Ressources en bibliothèque

- Artificial Intelligence: A Modern Approach / Russell
- An Introduction to MultiAgent Systems / Wooldridge

Websites

- http://liawww.epfl.ch/
- http://moodle.epfl.ch/

EPFL

CS-486

Interaction design

Pu Pearl

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	1 weekly
Project	1 weekly
Number of positions	

Summary

This course focuses on goal-directed design and interaction design, two subjects treated in depth in the Cooper book (see reference below). To practice these two methods, we propose a design challenge, which is to be carried out by a team of three students.

Content

Design methods for HCI
What is HCI: its aims and goals
Design thinking
Goal-directed Design
Mental model and different types of users
Qualitative research and user interviews
User modeling: persona and empathy diagram
Scenarios, requirements and framework design
Visual design
Information Visualization design
Basic prototyping methods for HCI
Storyboarding
Context scenario
Interactive prototype
Video prototype
Human computer interaction evaluation methods
Cognitive walkthrough
Heuristic evaluation
Evaluation with users

Keywords

Interaction design, design thinking, design for playfulness, rapid prototyping techniques, evaluation with users.

Learning Prerequisites

Required courses

Introduction to Visual Computing

Recommended courses

Open to students enrolled in the Master and PhD programs in IC.

Important concepts to start the course

Goal-direction design

Learning Outcomes

By the end of the course, the student must be able to:

- Interview users and elicit their needs using the goal-directed design method
- Design and implement interfaces and intearctions
- Project management: set objectives and device a plan to achieve them
- Group work skills: discuss and identify roles, and assume those roles including leadership
- Communication: writing and presentation skills

Teaching methods

Lectures, exercises, hands-on practice, design review

Expected student activities

Lectures, readings, design project, quiz

Assessment methods

Group project, presentation, mid-term exam

Resources

Bibliography

About Face 3: The Essentials of Interaction Design by Alan Cooper et al. (available as e-book at NEBIS)

Ressources en bibliothèque

- About Face 3

CS-594 **Internship credited with Master Project (master in Cybersecurity)**

Profs divers *

Cursus	Sem.	Type
Cybersecurity	MA1, MA2, MA3, MA4, PME, PMH	Obl.

Language	English
Credits	0
Session	Winter, Summer
Semester	Fall
Exam	Term paper
Workload	0h
Weeks	
Practical work	320 weekly
Number of positions	

Summary

The engineering internship is an integral part of the curriculum for master's students. They join companies in Switzerland or abroad to carry out an internship or their master's project in a field of activity where the skills of the futur Engineer are highlighted.

Content

Internships represent an important experience for students, allowing them to achieve the following goals :
- Immerse themselves in the professional world
- Highlight the importance of teamwork
- Consider the imperatives of a companyin its processes
- Put into practice the knowledge acquired from the study plan

The following three forms of internship are possible as part of the master's study plan :
- 8 weeks internship during the summer only
- 6 months (long) internship. The student is on leave for one semester
- Master project in the industry (25 weeks)

Learning Prerequisites

Required courses

- Have completed one full semester for students who have obtained their Bachelor EPFL
- Have completed two full semesters for students coming from another university

Learning Outcomes

By the end of the course, the student must be able to:

- Be aware of the importance of legal procedures and the ethical code of the profession
- Communicate effectively and be understood
- Self-assess the level of acquired skills and plan the next goals
- Manage the priorities
- Receive and give feedback (criticism) and respond appropriately

Expected student activities

The student agrees to do this internship with the professionalism

Assessment methods

- Short internship (8 weeks) : electronic evaluation at the end of the internship
- Long internship (6 months) : electronic evaluation at the end of the internship
- Master's project in the industry : see the master's project course book

Supervision

Others	Industry supervisor EPFL supervisor

Resources

Websites

- https://www.epfl.ch/schools/ic/internships/
- https://www.epfl.ch/about/recruiting/recruiting/internships/

CS-431

Introduction to natural language processing

Chappelier Jean-Cédric, Rajman Martin

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Data science minor	H	Opt.
Digital Humanities	MA1, MA3	Opt.
Learning Sciences		Obl.
SC master EPFL	MA1, MA3	Opt.
UNIL - Sciences forensiques	H	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The objective of this course is to present the main models, formalisms and algorithms necessary for the development of applications in the field of natural language information processing. The concepts introduced during the lectures will be applied during practical sessions.

Content

Several models and algorithms for automated textual data processing will be described: (1) morpho-lexical level: electronic lexica, spelling checkers, ...; (2) syntactic level: regular, context-free, stochastic grammars, parsing algorithms, ...; (3) semantic level: models and formalisms for the representation of meaning, ...
Several application domains will be presented: Linguistic engineering, Information Retrieval, Text mining (automated knowledge extraction), Textual Data Analysis (automated document classification, visualization of textual data).

Keywords

Natural Language Processing; Computationnal Linguisitics; Part-of-Speech tagging; Parsing

Learning Outcomes

By the end of the course, the student must be able to:

- Compose key NLP elements to develop higher level processing chains
- Assess / Evaluate NLP based systems
- Choose appropriate solutions for solving typical NLP subproblems (tokenizing, tagging, parsing)
- Describe the typical problems and processing layers in NLP
- Analyze NLP problems to decompose them in adequate independant components

Teaching methods

Ex cathedra ; practical work on computer

Expected student activities

attend lectures and practical sessions, answer quizzes.

Assessment methods

4 quiz during semester 25%, final exam 75%

Supervision

Office hours	No
Assistants	No
Forum	No

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

1. M. Rajman editor, "*Speech and Language Engineering*", EPFL Press, 2006.
2. Daniel Jurafsky and James H, Martin, "*Speech and Language Processing"*, Prentice Hall, 2008 (2nd edition)
3. Christopher D. Manning and Hinrich Schütze, "*Foundations of Statistical Natural Language Processing*", MIT Press, 2000
4. Christopher D. Manning, Prabhakar Raghavan and Hinrich Schütze, *Introduction to Information Retrieval*, Cambridge University Press. 2008
5. Nitin Indurkhya and Fred J. Damerau editors, "*Handbook of Natural Language Processing*", CRC Press, 2010 (2nd edition)

Ressources en bibliothèque

- Handbook of Natural Language Processing / Indurkhya
- Introduction to Information Retrieval / Manning
- Speech and Language Processing / Jurafsky
- Speech and Language Engineering / Rajman
- Foundations of Statistical Natural Language Processing / Manning

Websites

- http://coling.epfl.ch

CS-526

Learning theory

Macris Nicolas, Urbanke Rüdiger

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Machine learning and data analysis are becoming increasingly central in many sciences and applications. This course concentrates on the theoretical underpinnings of machine learning.

Content

- Basics : statistical learning framework, Probably Approximately Correct (PAC) learning, learning with a finite number of classes, Vapnik-Chervonenkis (VC) dimension, non-uniform learnability, complexity of learing.
- Neural Nets : representation power of neural nets, learning and stability, PAC Bayes bounds.
- Graphical model learning.
- Non-negative matrix factorization, Tensor decompositions and factorization.
- Learning mixture models.

Learning Prerequisites

Recommended courses

- Analysis I, II, III
- Linear Algebra
- Machine learning
- Probability
- Algorithms (CS-250)

Learning Outcomes

By the end of the course, the student must be able to:

- Explain the framework of PAC learning
- Explain the importance basic concepts such as VC dimension and non-uniform learnability
- Describe basic facts about representation of functions by neural networks
- Describe recent results on specific topics e.g., graphical model learning, matrix and tensor factorization, learning mixture models

Teaching methods

- Lectures
- Exercises

Expected student activities

- Attend lectures
- Attend exercises sessions and do the homework

Assessment methods

Final exam and graded homeworks

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes
Others	Course website

CS-433

Machine learning

Flammarion Nicolas, Jaggi Martin

Cursus	Sem.	Type
Biocomputing minor	H	Opt.
Civil & Environmental Engineering		Opt.
Communication systems minor	H	Opt.
Computational Neurosciences minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer and Communication Sciences		Opt.
Computer science minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cybersecurity	MA1, MA3	Obl.
Data Science	MA1, MA3	Obl.
Data science minor	H	Opt.
Digital Humanities	MA1, MA3	Opt.
Electrical Engineering		Opt.
Electrical and Electronical Engineering	MA1, MA3	Opt.
Financial engineering	MA1, MA3	Opt.
Learning Sciences		Obl.
Life Sciences Engineering	MA1, MA3	Opt.
Managmt, tech et entr.	MA1, MA3	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	7
Session	Winter
Semester	Fall
Exam	Written
Workload	210h
Weeks	14
Hours	**6 weekly**
Lecture	4 weekly
Exercises	2 weekly
Number of positions	

Summary

Machine learning methods are becoming increasingly central in many sciences and applications. In this course, fundamental principles and methods of machine learning will be introduced, analyzed and practically implemented.

Content

1. *Basic regression and classification concepts and methods: Linear models, overfitting, linear regression, Ridge regression, logistic regression, k-NN, SVMs and kernel methods*
2. *Fundamental concepts: cost-functions and optimization, cross-validation and bias-variance trade-off, curse of dimensionality.*
3. *Neural Networks: Representation power, backpropagation, activation functions, CNN, regularization, data augmentation, dropout*
4. *Unsupervised learning: k-means clustering, gaussian mixture models and the EM algorithm. Basics of self-supervised learning*
5. *Dimensionality reduction: PCA and matrix factorization, word embeddings*
6. *Advanced methods: Adversarial learning, Generative adversarial networks*

Keywords

- *Machine learning, pattern recognition, deep learning, neural networks, data mining, knowledge discovery, algorithms*

Learning Prerequisites

Required courses

• Analysis I, II, III
• Linear Algebra
• Probability and Statistics (MATH-232)
• Algorithms (CS-250)

Recommended courses

• *Introduction to machine learning (CS-233)*
• *...or similar bachelor lecture from other sections*

Important concepts to start the course

• *Basic probability and statistics (conditional and joint distribution, independence, Bayes rule, random variables, expectation, mean, median, mode, central limit theorem)*
• *Basic linear algebra (matrix/vector multiplications, systems of linear equations, SVD)*
• *Multivariate calculus (derivative w.r.t. vector and matrix variables)*
• *Basic Programming Skills (labs will use Python)*

Learning Outcomes

By the end of the course, the student must be able to:

• Define the following basic machine learning models: Regression, classification, clustering, dimensionality reduction, neural networks, time-series analysis
• Explain the main differences between them
• Implement algorithms for these machine learning models
• Optimize the main trade-offs such as overfitting, and computational cost vs accuracy
• Implement machine learning methods to real-world problems, and rigorously evaluate their performance using cross-validation. Experience common pitfalls and how to overcome them
• Explain and understand the fundamental theory presented for ML methods
• Conduct a real-world interdisciplinary machine learning project, in collaboration with application domain experts

Teaching methods

• Lectures
• Lab sessions
• Course Projects

Expected student activities

Students are expected to:

• attend lectures
• attend lab sessions and work on the weekly theory and coding exercises
• work on projects using the code developed during labs, in small groups

Assessment methods

• Written final exam
• Continuous control (Course projects)

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

• Christopher Bishop, Pattern Recognition and Machine Learning
• Kevin Murphy, Machine Learning: A Probabilistic Perspective
• Shai Shalev-Shwartz, Shai Ben-David, Understanding Machine Learning
• Michael Nielsen, Neural Networks and Deep Learning
• (Jerome Friedman, Robert Tibshirani, Trevor Hastie, The elements of statistical learning : data mining, inference, and prediction)

Ressources en bibliothèque

• Linear algebra and learning from data
• The elements of statistical learning : data mining, inference, and prediction / Friedman
• Understanding Machine Learning / Shalev-Shwartz
• Neural Networks and Deep Learning / Nielsen
• Machine Learning: A Probabilistic Perspective / Murphy
• Pattern Recognition and Machine Learning / Bishop

Notes/Handbook

https://github.com/epfml/ML_course

Websites

• https://www.epfl.ch/labs/mlo/machine-learning-cs-433/

EPFL

CS-421

Machine learning for behavioral data

Käser Tanja

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

Computer environments such as educational games, interactive simulations, and web services provide large amounts of data, which can be analyzed and serve as a basis for adaptation. This course will cover the core methods of user modeling and personalization, with a focus on educational data.

Content

The users of computer environments such as intelligent tutoring systems, interactive games, and web services are often very heterogeneous and therefore it is important to adapt to their specific needs and preferences.
This course will cover the core methods of adaptation and personalization, with a focus on educational data. Specifically we will discuss approaches to the task of accurately modeling and predicting human behavior within a computer environment. Furthermore, we we will also discuss data mining techniques with the goal to gain insights into human behavior. We will cover the theories and methodologies underlying the current approaches and then also look into the most recent developments in the field.

1. ‘Cycle’ of adaptation : representation, prediction, intervention (e.g. recommendation)
2. Data Processing and Interpretation (missing data, feature transformations, distribution fitting)
3. Performance evaluation (cross-validation, error measures, statistical significance, overfitting)
4. Representation & Prediction (probabilistic graphical models, recurrent neural networks, logistic models, clustering-classification approaches)
5. Recommendation (collaborative filtering, content-based recommendations, multi-armed bandits)
6. Stealth Assessment (seemless detection of user traits)
7. Multimodal analytics (represent & analyze data from non-traditional sources. i.e. sensors, classroom analytics, human-robot interaction)

Learning Prerequisites

Required courses

The student must have passed a course in probability and statistics and a course including a programming project

Recommended courses

- CS-433 Machine learning or
- CS-233a / CS-233b Introduction to machine learning

Important concepts to start the course

Probability and statistics, basic machine learning knowledge, algorithms and programming, Python

Learning Outcomes

By the end of the course, the student must be able to:

• Explain the main machine learning approaches to personalization, describe their advantages and disadvantages and explain the differences between them
• Implement algorithms for these machine learning models
• Apply them to real-world data
• Assess / Evaluate their performance
• Explain and understand the fundamental theory underlying the presented machine learning models

Teaching methods

- Lectures
- Weekly lab sessions
- Course project

Expected student activities

- Attend the lectures
- Attend the lab sessions and work on the homework assignments
- Project work

Assessment methods

- Project work (50%)
- Final exam (50%)

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

COM-516

Markov chains and algorithmic applications

Lévêque Olivier, Macris Nicolas

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Electrical Engineering		Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The study of random walks finds many applications in computer science and communications. The goal of the course is to get familiar with the theory of random walks, and to get an overview of some applications of this theory to problems of interest in communications, computer and network science.

Content

Part 1: Markov chains (~6 weeks):
- basic properties: irreducibility, periodicity, recurrence/transience, stationary and limiting distributions,
- ergodic theorem: coupling method
- detailed balance
- convergence rate to the equilibrium, spectral gap, mixing times
- cutoff phenomenon

Part 2: Sampling (~6 weeks)
- classical methods, importance and rejection sampling
- Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, Glauber dynamics, Gibbs sampling
- applications: function minimization, coloring problem, satisfiability problems, Ising models
- coupling from the past and exact simulation

Keywords

random walks, stationarity, ergodic, convergence, spectral gap, mixing time, sampling, Markov chain Monte Carlo, coupling from the past

Learning Prerequisites

Required courses

Basic probability course
Basic linear algebra and calculus courses

Recommended courses

Stochastic Models for Communications (COM-300)

Important concepts to start the course

Good knowledge of probability and analysis.
Having been exposed to the theory of Markov chains.

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze the behaviour of a random walk
- Assess / Evaluate the performance of an algorithm on a graph
- Implement efficiently various sampling methods

Teaching methods

ex-cathedra course

Expected student activities

active participation to exercise sessions and implementation of a sampling algorithm

Assessment methods

midterm (20%), mini-project (20%), final exam (60%)

Resources

Bibliography

Various references will be given to the students during the course, according to the topics discussed in class.

Ressources en bibliothèque

- Probability and random processes / Grimmett

Notes/Handbook

Lecture notes will be provided

Websites

- https://moodle.epfl.ch/course/view.php?id=15016

Prerequisite for

This course is not so to speak a prerequisite for other courses, but could complement well the course COM-512 on Networks out of control, as well as other courses in statistics.

COM-514

Mathematical foundations of signal processing

Bejar Haro Benjamin, Fageot Julien René Pierre, Simeoni Matthieu

Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computational science and Engineering	MA1, MA3	Opt.
Computer and Communication Sciences		Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA1, MA3	Opt.
Systems Engineering minor	H	Opt.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Exercises	2 weekly
Number of positions	

Summary

Signal processing tools are presented from an intuitive geometric point of view which is at the heart of all modern signal processing techniques. The student will develop the mathematical depth and rigor needed for the study of advanced topics in signal processing and approximation theory.

Content

Sequences, Discrete-Time Systems, Functions and Continuous-Time Systems (review of discrete-time Fourier transform; DFT; Fourier transform and Fourier series).
From Euclid to Hilbert: Linear Algebra Fundamentals for Representation Theory (vector spaces; Hilbert spaces; approximations, projections and decompositions; bases and frames; linear operators; adjoint; generalized inverses; matrix representations; computational aspects)
Sampling and Interpolation (sampling and interpolation with normal and non orthogonal vectors, sequences and functions; sampling and interpolation of bandlimited sequences and functions)
Polynomial and Spline Approximation (Legendre and Chebyshev polynomials; Lagrange interpolation; minimax approximation; Taylor expansions; B-splines)
Regularized Inverse Problems (regularized convex optimisation; Tikhonov regularisation; penalised basis pursuit; proximal algorithms; pseudo-differential operators and L-splines; representer theorems for continuous inverse problems with Tikhonov penalties)

Learning Prerequisites

Required courses

Signal processing for communications (or Digital signal processing on Coursera)
Linear Algebra I and II (or equivalent).

Recommended courses

Signals and Systems

Important concepts to start the course

Good knowledge of linear algebra concepts. Basics of Fourier analysis and signal processing. Good knowledge of Python and its scientific packages (Numpy, Scipy).

Learning Outcomes

By the end of the course, the student must be able to:

- Master the right tools to tackle advanced signal and data processing problems
- Develop an intuitive understanding of signal processing through a geometrical approach
- Get to know the applications that are of interest today
- Learn about topics that are at the forefront of signal processing research
- Identify and implement the algorithm best suited to solve a given convex optimisation problem
- Assess the computational cost and numerical stability of a numerical solver

Transversal skills

- Collect data.
- Write a scientific or technical report.
- Use a work methodology appropriate to the task.
- Demonstrate the capacity for critical thinking
- Use both general and domain specific IT resources and tools

Teaching methods

Ex cathedra with exercises, homeworks and practicals.

Expected student activities

Attending lectures, completing exercises.

Assessment methods

homeworks and project assignement 50%, final exam (written) 50%

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

M. Vetterli, J. Kovacevic and V. Goyal, *"Signal Processing: Foundations"*, Cambridge U. Press, 2014.
Available in open access at http://www.fourierandwavelets.org

Ressources en bibliothèque

- Signal Processing: Foundations / Vetterli

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=13431

COM-405

Mobile networks

Hubaux Jean-Pierre

Cursus	Sem.	Type
Communication systems minor	E	Opt.
Computer science	MA2, MA4	Opt.
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Obl.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

This course provides a detailed description of the organization and operating principles of mobile communication networks.

Content

Introduction to wireless networks
Organization of the MAC layer
Wireless Local Area Networks - WiFi
Cellular networks
Mobility at the network and transport layers
Security and privacy in mobile networks

Keywords

Communication networks, protocols, mobility

Learning Prerequisites

Required courses

COM-208 Computer Networks

Recommended courses

COM-302 Principles of Digital Communications
COM-301 Computer security

Important concepts to start the course

Operating principles of communication protocols and layer organization.

Learning Outcomes

By the end of the course, the student must be able to:

- Synthesize the way a mobile network operates
- Interpret the behavior of such networks
- Propose evolutions to existing protocols
- Identify weaknesses, bottlenecks and vulnerabilities

Teaching methods

Ex cathedra lectures
Weekly quizzes
Exercise sessions
Hands-on exercises

Expected student activities

Class participation, quizzes, homework, hands-on exercises

Assessment methods

Quizzes + final exam

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Bibliography

Handouts, recommended books (see course URL)

Ressources en bibliothèque

- Fundamentals of Mobile Data Networks / Miao

COM-430

Modern digital communications: a hands-on approach

Chiurtu Nicolae

Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	During the semester
Workload	180h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Practical work	2 weekly
Number of positions	

Summary

This course complements the theoretical knowledge learned in PDC with more advanced topics such as OFDM, MIMO, fading chancels, and GPS positioning. This knowledge is put into practice with hands-on exercises based on Matlab or Python (at choice) and on a software-defined radio platform.

Content

1. Software radio : key concepts.
2. Matlab/Python implementation of the signal processing chain to the level of detail in Principles of Digital Communications.
3. Channel modeling, estimation, equalization.
4. Implementation of a basic wireless communication system using a software-defined radio testbed.
5. Fading and diversity.
6. OFDM and MIMO : theory and implementation.
7. CDMA in the context of a GPS system.
8. Decoding of a GPS signal and positioning.

Keywords

Wireless, OFDM, Diversity, Coding, GPS, CDMA, MMSE, Rayleigh fading, software-defined radio, channel estimation.

Learning Prerequisites

Required courses

COM-302 Principles of digital communication or equivalent

Important concepts to start the course

Solid understanding of linear algebra and probability as well as real and complex analysis.

Learning Outcomes

By the end of the course, the student must be able to:

- Design and implement and advanced digital communication system (data rate, spectral bandwidth, energy requirements, error probability, implementation complexity)
- Model physical properties of wired and wireless communication channels
- Implement various parts of a "physical-layer" digital communication system
- Understand what software-defined radio is all about

Teaching methods

Ex cathedra lectures and small projects

Expected student activities

Follow lectures; guided as well as independent work on projects

Assessment methods

Written and practical midterm and final exam during the semester.
40% midterm exam, 60% final exam.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Notes/Handbook

Lecture notes

COM-512 Networks out of control

Grossglauser Matthias, Thiran Patrick

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Data science minor	E	Opt.
Electrical Engineering		Opt.
SC master EPFL	MA2, MA4	Opt.
Systems Engineering minor	E	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	Written
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours biennal

Summary

The goal of this class is to acquire mathematical tools and engineering insight about networks whose structure is random, as well as learning and control techniques applicable to such network data.

Content

- Random graph models: Erdös-Renyi, random regular, geometric, percolation, small worlds, stochastic block model
- Learning graphs from data: centrality metrics, embeddings, Hawkes processes, network alignment
- Control of processes on graphs: epidemics, navigation

Keywords

Random graphs, network data, machine learning, graph processes.

Learning Prerequisites

Required courses

Stochastic models in communication (COM-300), or equivalent.

Important concepts to start the course

Basic probability and stastistics; Markov chains; basic combinatorics.

Teaching methods

Ex cathedra lectures, exercises, mini-project

Expected student activities

Attending lectures, bi-weekly homeworks, mini-project incl. student presentation at the end of semester, final exam.

Assessment methods

1. Homeworks 10%
2. Mini-project 40%

3. Final exam 50%.

Supervision

Office hours	Yes
Assistants	Yes
Forum	No

Resources

Bibliography

- A. D. Barbour, L. Holst and S. Janson, Poisson Approximation, Oxford Science Publications, 1992.
- B. Bollobas, Random Graphs (2nd edition), Cambridge University Press, 2001.
- R. Durrett, Random Graph Dynamics, Cambridge University Press, 2006 (electronic version).
- D. Easley, J. Kleinberg. Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010 (electronic version).
- G. Grimmett, Percolation (2nd edition), Springer, 1999.
- S. Janson, T. Luczak, A. Rucinski, Random Graphs, Wiley, 2000.
- R. Meester and R. Roy, Continuum Percolation, Cambridge University Press, 1996.

Ressources en bibliothèque

- Random Graphs / Bollobas
- Random Graphs / Janson
- Continuum Percolation / Meester
- Random Graph Dynamics / Durrett
- Networks, Crowds and Markets / Easley
- Poisson Approximation / Barbour
- Percolation / Grimmett

Notes/Handbook

Class notes will be available on the course website.

Websites

- http://icawww1.epfl.ch/class-nooc/

MATH-489

Number theory in cryptography

Jetchev Dimitar

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Ing.-math	MA2, MA4	Opt.
Mathématicien	MA2	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The goal of the course is to introduce basic notions from public key cryptography (PKC) as well as basic number-theoretic methods and algorithms for cryptanalysis of protocols and schemes based on PKC.

Content

Basic notions and algorithms from public key cryptography such as RSA, ElGamal, key exchange protocols, zero knowledge proofs. Main topics may include, but are not limited to

- modular and finite field arithmetic
- primality testing
- polynomial and integer factorization algorithms
- index calculus and discrete logarithm-based schemes
- elliptic curve arithemtic and cryptography
- basic notions from lattice-based cryptography

Much of the course draws inspiration from the Math-489 (-2019) curriculum taught by Prof. Dimitar Jetchev.

Keywords

public key cryptography, key exchange, digital signatures, zero knowledge proofs, RSA, ElGamal, integer factorization, index calculus, elliptic curve cryptography

Teaching methods

lectures, exercises, additional references

Assessment methods

Homework assignments: Weekly problem sets focusing on number-theoretic and complexity-theoretic aspects. These will be complemented by programming exercises in SAGE which is a Python-based computer algebra system. No prior experience with SAGE or Python is required. A subset of the homework will be handed in and graded, counting for 40% of the final grade.
The written **final exam** counts for 60% of the final grade. There will be no graded midterm since the class is online. The final exam will test theoretical understanding as well as understanding of the algorithms and protocols. The exam will include no SAGE programming exercises. If needed, algorithms could be presented with pseudo-code. The exact final exam format will be adapted to the epidemiological situation and resulting guidelines.

Dans le cas de l¿art. 3 al. 5 du Règlement de section, l¿enseignant décide de la forme de l¿examen qu¿il communique aux étudiants concernés.

CS-439

Optimization for machine learning

Flammarion Nicolas, Jaggi Martin

Cursus	Sem.	Type
Computational science and Engineering	MA2, MA4	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Obl.
Data science minor	E	Opt.
Electrical Engineering		Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**5 weekly**
Lecture	2 weekly
Exercises	2 weekly
Practical work	1 weekly
Number of positions	

Summary

This course teaches an overview of modern optimization methods, for applications in machine learning and data science. In particular, scalability of algorithms to large datasets will be discussed in theory and in implementation.

Content

This course teaches an overview of modern optimization methods, for applications in machine learning and data science. In particular, scalability of algorithms to large datasets will be discussed in theory and in implementation.
Fundamental Contents:

- Convexity, Gradient Methods, Proximal algorithms, Stochastic and Online Variants of mentioned methods, Coordinate Descent Methods, Subgradient Methods, Non-Convex Optimization, Frank-Wolfe, Accelerated Methods, Primal-Dual context and certificates, Lagrange and Fenchel Duality, Second-Order Methods, Quasi-Newton Methods, Gradient-Free and Zero-Order Optimization.

Advanced Contents:

- Non-Convex Optimization: Convergence to Critical Points, Saddle-Point methods, Alternating minimization for matrix and tensor factorizations
- Parallel and Distributed Optimization Algorithms, Synchronous and Asynchronous Communication
- Lower Bounds

On the practical side, a graded **group project** allows to explore and investigate the real-world performance aspects of the algorithms and variants discussed in the course.

Keywords

Optimization, Machine learning

Learning Prerequisites

Recommended courses

- CS-433 Machine Learning

Important concepts to start the course

- Previous coursework in calculus, linear algebra, and probability is required.

• Familiarity with optimization and/or machine learning is useful.

Learning Outcomes

By the end of the course, the student must be able to:

- Assess / Evaluate the most important algorithms, function classes, and algorithm convergence guarantees
- Compose existing theoretical analysis with new aspects and algorithm variants.
- Formulate scalable and accurate implementations of the most important optimization algorithms for machine learning applications
- Characterize trade-offs between time, data and accuracy, for machine learning methods

Transversal skills

- Use both general and domain specific IT resources and tools
- Summarize an article or a technical report.

Teaching methods

- Lectures
- Exercises with Theory and Implementation Assignments

Expected student activities

Students are expected to:

- Attend the lectures and exercises
- Give a short scientific presentation about a research paper
- Read / watch the pertinent material
- Engage during the class, and discuss with other colleagues

Assessment methods

- Continuous control (course project)
- Final Exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Websites

- https://github.com/epfml/OptML_course

Videos

- https://www.youtube.com/playlist?list=PL4O4bXkI-fAeYrsBqTUYn2xMjJAqlFQzX

EPFL

CS-596 **Optional project in computer science**

Profs divers *

Cursus	Sem.	Type
Computer science minor	E, H	Opt.
Computer science	MA1, MA2, MA3, MA4	Opt.
Cybersecurity	MA1, MA2, MA3, MA4	Opt.

Language	English
Credits	8
Session	Winter, Summer
Semester	Fall
Exam	During the semester
Workload	240h
Weeks	14
Hours	**2 weekly**
Project	2 weekly
Number of positions	

Remark

for students doing a minor in Computer Science : Registration upon authorization of the section. Only for 2nd year Master students. Supervision by an IC professor

Summary

Individual research during the semester under the guidance of a professor or an assistant.

Content

Subject to be chosen among the themes proposed on the web site :
https://www.epfl.ch/schools/ic/education/master/computer-science/projects-lab-mcs/

Learning Outcomes

By the end of the course, the student must be able to:

- Organize a project
- Assess / Evaluate one's progress through the course of the project
- Present a project

Transversal skills

- Write a scientific or technical report.
- Write a literature review which assesses the state of the art.

Teaching methods

Individual and independant work, under the guidance of a professor or an assistant.

Expected student activities

Written report due within the allotted time.
Information on the format and the content of the report is provied by the project supervisor.

Assessment methods

Automn : The written report must be returned to the laboratory no later than **the Friday of the second week** after the end of classes.
Spring : The written report must be returned to the laboratory no later than **the Friday of the first week** after the end of

classes.
The oral presentation is organized by the laboratory.

Resources

Virtual desktop infrastructure (VDI)

Yes

Websites

- https://www.epfl.ch/schools/ic/education/master/semester-project-msc/

CS-522

Principles of computer systems

Argyraki Katerina, Candea George

Cursus	Sem.	Type
Computer and Communication Sciences		Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	7
Session	Winter
Semester	Fall
Exam	During the semester
Workload	210h
Weeks	14
Hours	**4 weekly**
Lecture	4 weekly
Number of positions	

Summary

This advanced graduate course teaches the key design principles underlying successful computer and communication systems, and shows how to solve real problems with ideas, techniques, and algorithms from operating systems, networks, databases, programming languages, and computer architecture.

Content

A modern computer system spans many layers: applications, libraries, operating systems, networks, and hardware devices. Building a good system entails making the right trade-offs (e.g., between performance, durability, and correctness) and understanding emergent behaviors. Great system designers make these trade-offs in a principled fashion, whereas average ones make them by trial-and-error. In this course we develop a principled framework for computer system design, covering the following topics:

- Modules and interfaces
- Names
- Layers
- Indirection and virtualization
- Redundancy and fault tolerance
- Client/server architectures
- Decentralized architectures
- Transactional building blocks

Learning Prerequisites

Required courses

The course is intellectually challenging and fast-paced, and it requires a solid background in operating systems, databases, networking, programming languages, and computer architecture. The basic courses on these topics teach how the elemental parts of modern systems work, and this course picks up where the basic courses leave off. To do well, a student must master the material taught in the following courses:

- COM-208 Computer networks
- CS-208/209 Computer architecture
- CS-210 Functional programming
- CS-305 Software engineering
- CS-322 Introduction to database systems
- CS-323 Introduction to operating systems

Recommended courses

The following EPFL courses cover material that significantly helps students taking this course, however they are not strictly required:

- CS-320: Computer language processing
- CS-470: Advanced computer architecture
- CS-422: Database systems
- COM-407: TCP/IP networking

Learning Outcomes

By the end of the course, the student must be able to:

- Design computer and communication systems that work well
- Make rational design trade-offs (e.g., performance vs. correctness, latency vs. availability)
- Anticipate emergent system behaviors (e.g., failure cascades, security vulnerabilities)
- Integrate multiple techniques, ideas, and algorithms from different fields of computing/communication into a working system

Teaching methods

- A combination of online and in-class lectures
- Interactive design sessions
- Reading assignments
- Homework assignments

Expected student activities

- Attend lectures and design sessions
- Complete the reading and writing assignments
- Participate actively in the course (physically and online)

Assessment methods

- 40% OPS + quizzes
- 50% Midterm + final exam
- 10% Presentations

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

See course website for the latest information and an up-to-date bibliography.

Ressources en bibliothèque

- Principles of computer system design : an introduction / Saltzer

Websites

- https://pocs.epfl.ch

EPFL

MATH-467 **Probabilistic methods in combinatorics**

Marcus Adam W.

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	5
Session	Winter
Semester	Fall
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

We develop a sophisticated framework for solving problems in discrete mathematics through the use of randomness (i.e., coin flipping). This includes constructing mathematical structures with unexpected (and sometimes paradoxical) properties for which no other methods of construction are known.

Content

- Linearity of expectation
- The second moment method
- Local lemma
- Random graphs and matrices
- Applications in combinatorics and graph theory

Keywords

random variable, expected value, probabilistic method, random graph

Learning Prerequisites

Required courses

Probability theory

Recommended courses

- Discrete Mathematics or Graph Theory
- Linear Algebra

Important concepts to start the course

Graph, random variable, expectation, variance, binomial coefficients, asymptotics, eigenvalues

Learning Outcomes

By the end of the course, the student must be able to:

- Define and explain basic concepts in probability and discrete mathematics
- Prove explain, and apply the first and second moment methods

- Prove explain, and apply the Local Lemma
- Solve exercises, design randomized algorithms
- Describe and explain the method of interlacing polynomials

Transversal skills

- Summarize an article or a technical report.
- Demonstrate the capacity for critical thinking
- Assess progress against the plan, and adapt the plan as appropriate.

Teaching methods

Lectures and exercises

Expected student activities

Attending the lectures, solving the exercises, reading sections from the textbook

Assessment methods

Exam written
Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

Resources

Bibliography

Noga Alon-Joel Spencer: The Probabilistic Method (Wiley)

Ressources en bibliothèque

- Noga Probabilistic method

EPFL

CS-476

Real-time embedded systems

Beuchat René

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Summary

A real time system is subject to important temporal constraints. This course is about understanding where processing time is spent and what a designer can do in order to achieve real-time processing systems. Some solutions are Multiprocessors, accelerators, custom instructions, specialized hardware.

Content

During this course, response time measurements of interrupts are studied in laboratories, such as for example: the influence of dynamic memories, cache memories, compilation flags. Interrupts response time measurements, task commutations and synchronizations primitives are carried out on an embedded system based on an FPGA.
The course includes the study of embedded systems management models through polling, interrupts and using a real time kernel with its task management and synchronization primitives.
Specialized programmable interfaces are implemented in VHDL to help with these measurements. A real time kernel is studied and used during the labs. An acquisition system is implemented and the gathered data is transmitted by a Web server. To ensure the real time acquisition and reading by the Web server, a multiprocessor system is developed and implemented on an FPGA.
An Accelerator designed in VHDL makes it possible to facilitate the optimization of functions through hardware on an FPGA. Cross development tools are used.
Each topic is treated by a theoretical course and an associated laboratory. The laboratories are realized on an FPGA board including a hardcore multiprocessor. A real time operating system is studied and used with the laboratories.

Keywords

Real Time, FPGA, SOC, microprocessor, hardware accelerator, custom instruction, Real Time OS

Learning Prerequisites

Required courses

Introduction to computing systems, Logic systems, Computer architecture

Recommended courses

Embedded Systems, Real time Programming

Important concepts to start the course

Programmable Logic Architecture (FPGA), Computer Architecture, VHDL, C programming, Real Times basic knowledge (semaphor, synchronization)

Learning Outcomes

By the end of the course, the student must be able to:
- Design a multiprocessor system on an FPGA
- Analyze the performance of a real time embedded system
- Use design tools for SOC conception on an FPGA
- Implement a complete real-time system based on a multiprocessor design on an FPGA
- Test the realized system
- Defend the choices during the design phases

Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Communicate effectively, being understood, including across different languages and cultures.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Make an oral presentation.
- Write a scientific or technical report.

Teaching methods

Ex cathedra, laboratories and a mini-project

Expected student activities

- 3 groups of laboratories on specific topics, with a report by group for each of them, 3-4 weeks/topic;
- A final mini-project to practically synthesize the content of the course, with the design of a multiprocessor system on an FPGA, including for example a Web-server, a camera controller, a specific algorithm to be implemented in an FPGA hardware accelerator, 3~4 weeks for this mini-project

Assessment methods

Continuous control with reports and oral presentation
all labs 50% + final mini-project 50%

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

Teaching notes and suggested reading material.
Specialized datasheets (ie.ex. FPGA et specific microcontrollers) and standards.

Notes/Handbook

Slides and documents on moodle

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=391

CS-496

Semester project in Cyber security

Profs divers *

Cursus	Sem.	Type
Cybersecurity	MA1, MA2, MA3, MA4	Obl.

Language	English
Credits	12
Session	Winter, Summer
Semester	Fall
Exam	During the semester
Workload	360h
Weeks	14
Hours	**2 weekly**
Project	2 weekly
Number of positions	

Summary

Individual research during the semester under the guidance of a professor or an assistant.

Content

Subject to be chosen among the themes proposed on the web site :
https://www.epfl.ch/schools/ic/education/master/cyber-security/projects-labs-cs/

Learning Outcomes

By the end of the course, the student must be able to:

- Organize a project
- Assess / Evaluate one's progress through the course of the project
- Present a project

Transversal skills

- Write a literature review which assesses the state of the art.
- Write a scientific or technical report.

Expected student activities

Written report due within the allotted time.
Information on the format and the content of the report is provided by the project supervisor.

Assessment methods

Autumn : The written report must be returned to the laboratory no later than **the Friday of the second week** after the end of the classes.
Spring : The written report must be returned to the laboratory no later thant **the Friday of the first week** after the end of the classes.
The oral presenation is organized by the laboratory.

Resources

Virtual desktop infrastructure (VDI)

No

Websites

- https://www.epfl.ch/schools/ic/education/master/semester-project-msc/

EE-511

Sensors in medical instrumentation

Aminian Kamiar

Cursus	Sem.	Type
Biomedical technologies minor	E	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Life Sciences Engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
Robotics	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

Fundamental principles and methods used for physiological signal conditioning. Resistive, capacitive, inductive, piezoelectric and optical techniques used to detect and convert physiological information's to electrical signals. Laboratory and ambulatory devices for monitoring and therapy.

Content

1. **Physiological Mesurands**
Biopotentials; bioimpedance; mechanical, acoustic and thermal signals
2. **Noise in medical instrumentation**
Source and nature of the noise; noise reduction; instrumentation amplifier for biopotential measurement
3. **Biopotential measurement**
Electrodes; ECG, EMG and EEG measurement
4. **Resistive sensors**
Thermistor and its biomedical applications; strain gage for the measurement of blood pressure; force and accelerations of the body
5. **Inductive sensors**
Simple and mutual inductance and its medical applications
6. **Capacitive sensors**
Respiratory flow measurement by the gradient of pressure
7. **Piezoelectric sensors**
Force platform, accelerometer, angular rate sensor for the measurement of tremors and body movements, ultrasound transducer : measurement of pressure and flow rate
8. **Optical sensors**
Photoplethysmography; pulsed oxymetry
9. **Example of applications**

Keywords

sensors, instrumentation, biomedical devices, physiological measurement, monitoring

Learning Prerequisites

Required courses

courses en electrical circuit, basic electronics

Recommended courses

measuring systems or electronics or sensors

Important concepts to start the course
basic electronics, basic physics

Learning Outcomes
By the end of the course, the student must be able to:
- Choose techniques detecting and convert physiological information's to electrical signals
- Exploit fundamental principles and methods used for physiological signal conditioning
- Design measuring devices
- Interpret error, noise in biomedical measuring systems

Transversal skills
- Use a work methodology appropriate to the task.
- Communicate effectively with professionals from other disciplines.

Teaching methods
Ex cathedra, with exercises

Expected student activities
home work, short quizzes during semester

Assessment methods
Written

Supervision
Office hours	Yes
Assistants	Yes
Forum	Yes

Resources
Bibliography
Medical Instrumentation : Application and design, JG Webster

Ressources en bibliothèque
- Medical Instrumentation / Webster

Notes/Handbook
Slides copies (to be completed during the lectures)
Polycopies (in French only)

Moodle Link
- http://moodle.epfl.ch/course/view.php?id=2571

Prerequisite for
Semester project and Master project

MATH-318

Set theory

Duparc Jacques

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Ing.-math	MA2, MA4	Opt.
Mathématicien	MA2	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

Set Theory as a foundational system for mathematics. ZF, ZFC and ZF with atoms. Relative consistency of the Axiom of Choice, the Continuum Hypothesis, the reals as a countable union of countable sets, the existence of a countable family of pairs without any choice function.

Content

Set Theory: ZFC. Extensionality and comprehension. Relations, functions, and well-ordering. Ordinals. Class and transfinite recursion. Cardinals. Well-founded relations, axiom of foundation, induction, and von Neumann's hierarchy. Relativization, absoluteness, reflection theorems. Gödel's constructible universe L. Axiom of Choice (AC), and Continuum Hypothesis inside L. Po-sets, filters and generic extensions. Forcing. ZFC in generic extensions. Cohen Forcing. Independence of the Continuum Hypothesis. HOD and AC: independence of AC. The reals without AC. Symmetric submodels of generic extensions. Applications of the symmetric submodel techinique (the reals as a countable union of countable sets, the reals not well-orderable, every ultrafilter on the integers is trivial). ZF with atoms and permutation models. Simultating permutation models by symmetric submodels of generic extensions.

Keywords

Set Theory, Relative consistency, ZFC, Ordinals, Cardinals, Transfinite recursion, Relativization, Absoluteness, Constructible universe, L, Axiom of Choice, Continuum hypothesis, Forcing, Generic extensions

Learning Prerequisites

Required courses

MATH-381 Mathematical Logic.
In particular ordinal numbers and ordinal arithmetic will be considered known and admitted.

Recommended courses

Mathematical logic (or any equivalent course on first order logic). Warning: without a good understanding of first order logic, students tend to get lost sooner orl later.

Important concepts to start the course

- 1st order logic
- basics of proof theory
- Basics of model theory
- Compacity theorem
- Löwenheim-Skolem

• Completeness theorem

Learning Outcomes

By the end of the course, the student must be able to:

- Specify a model of ZFC
- Prove consistency results
- Develop a generic extension
- Argue by transfinite induction
- Decide whether ZFC proves its own consistency
- Formalize the axioms of ZF, AC, CH, DC
- Sketch an inner model
- Justify the axiom of foundation

Teaching methods

Ex cathedra lecture and exercises

Expected student activities

- Attendance at lectures
- Solve the exercises

Assessment methods

- Writen exam (3 hours)
- Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

1. Kenneth Kunen: Set theory, Springer, 1983
2. Lorenz Halbeisen: Combinatorial Set Theory, Springer 2018
3. Thomas Jech: Set theory, Springer 2006
4. Jean-Louis Krivine: Theorie des ensembles, 2007
5. Patrick Dehornoy: Logique et théorie des ensembles; Notes de cours, FIMFA ENS: http://www.math.unicaen.fr/~dehornoy/surveys.html
6. Yiannis Moschovakis: Notes on set theory, Springer 2006
7. Karel Hrbacek and Thomas Jech: Introduction to Set theory, (3d edition), 1999

Ressources en bibliothèque

- Introduction to Set theory / Hrbacek
- Set theory / Jech
- Logique et théorie des ensembles / Dehorny
- Set theory / Kunen
- Notes on set theory / Moschovakis
- Theorie des ensembles / Krivine

Notes/Handbook

Lecture notes (350 pages).

Websites

- http://www.hec.unil.ch/logique/

Moodle Link

- http://moodle.epfl.ch/course/index.php?categoryid=72

EPFL

EE-472

Smart grids technologies

Le Boudec Jean-Yves, Paolone Mario

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Obl.
Energy Management and Sustainability	MA2, MA4	Opt.
Energy Science and Technology	MA2, MA4	Opt.
Energy minor	E	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	5
Session	Summer
Semester	Spring
Exam	Written
Workload	150h
Weeks	14
Hours	**5 weekly**
Lecture	2 weekly
Exercises	1 weekly
Practical work	2 weekly
Number of positions	

Summary

Learn the technologies and methodologies used in the context smart electrical grids and be able to deploy/implement/test them in a lab environment.

Content

1. Modern monitoring: phasor measurement units technology, synchrophasors extraction processes and time alignement
2. Smart grid communication; reliability, real time and security issues
3. Topology assessment and contingency analysis of power grids
4. Admittance matrix calculus, numerical solution of the load flow problem and state estimation
5. Energy management and dispatch plans, the optimal power flow problem
6. Demand response

Keywords

Smart grid, power systems

Learning Prerequisites

Required courses

Electric power systems, power distribution networks, TPC/IP Networking

Recommended courses

Signal processing, discrete optimization methods, model predictive control, industrial electronics.

Important concepts to start the course

Understanding of electrical grids and communication networks.

Learning Outcomes

By the end of the course, the student must be able to:

- Design monitoring and control platforms for smart grids
- Test a smart grid
- Implement a smart grid
- Analyze performance of a smart grid

Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Continue to work through difficulties or initial failure to find optimal solutions.
- Demonstrate the capacity for critical thinking
- Manage priorities.
- Use both general and domain specific IT resources and tools

Teaching methods

Ex cathedra, classroom integrated exercises and computer laboratory sessions.

Expected student activities

Attend lectures and labs
Do lab homeworks
Do online quizzes

Assessment methods

Written exam (50%) and graded lab reports (50%)

Prerequisite for

Master projects in the areas of power systems and energy conversion systems.

EE-593

Social media

Vonèche Cardia Isabelle, Gillet Denis

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Electrical and Electronical Engineering	MA2, MA4	Opt.
Learning Sciences		Obl.
SC master EPFL	MA2, MA4	Opt.
UNIL - HEC	E	Opt.

Language	English
Credits	2
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	60h
Weeks	14
Hours	**2 weekly**
Lecture	1 weekly
Project	1 weekly
Number of positions	**45**

Summary

The objective is to enable students to critically apprehend the Human Computer Interaction (HCI) challenges associated with the design and the exploitation of social media platforms.

Content

- Social media platforms and the long tail (definition and typology)
- Usability and adoption of social media platforms
- Web 2.0 features and adoption factors
- Privacy, trust and reputation models
- Identities, traces, and Web analytics
- Interplay, between platforms and communities (interdisciplinary perspective)
- Opportunities, requirements and constraints for organization and enterprises
- Participatory design methodologies
- Future ad hoc social applications

Learning Outcomes

By the end of the course, the student must be able to:

- Choose
- Design
- Critique
- Defend

Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Use a work methodology appropriate to the task.
- Communicate effectively, being understood, including across different languages and cultures.

- Communicate effectively with professionals from other disciplines.
- Evaluate one's own performance in the team, receive and respond appropriately to feedback.
- Negotiate effectively within the group.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.

Teaching methods

Lectures, invited speakers, individual work and teamwork

Assessment methods

One individual project and one teamwork with combined peer and expert assesment (reports and presentations)

Supervision

Office hours	No
Assistants	Yes
Forum	No

Resources

Bibliography

- Chris Anderson (2006) - The Long Tail: Why the Future of Business is Selling Less of More. New York, NY: Hyperion. ISBN 1-4013-0237-8.
- Joshua Porter - Designing for the Social Web
- Matthew A. Russel - Mining the Social Web: Analyzing Data from Facebook, Twitter, LinkedIn, and Other Social Media Sites. O¿Reilly 2011

Ressources en bibliothèque

- Designing for the Social Web / Porter
- Mining the Social Web / Russel
- The Long Tail / Anderson

CS-412 **Software security**

Payer Mathias

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	During the semester
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	3 weekly
Exercises	2 weekly
Practical work	1 weekly
Number of positions	

Summary

This course focuses on software security fundamentals, secure coding guidelines and principles, and advanced software security concepts. Students learn to assess and understand threats, learn how to design and implement secure software systems, and get hands-on experience with security pitfalls.

Content

This course focuses on software security fundamentals, secure coding guidelines and principles, and advanced software security concepts. Students will learn to assess and understand threats, learn how to design and implement secure software systems, and get hands-on experience with common security pitfalls.
Software running on current systems is exploited by attackers despite many deployed defence mechanisms and best practices for developing new software. In this course students will learn about current security threats, attack vectors, and defence mechanisms on current systems. The students will work with real world problems and technical challenges of security mechanisms (both in the design and implementation of programming languages, compilers, and runtime systems).

- Secure software lifecycle: design, implementation, testing, and deployment
- Basic software security principles
- Reverse engineering : understanding code
- Security policies: Memory and Type safety
- Software bugs and undefined behavior
- Attack vectors: from flaw to compromise
- Runtime defense: mitigations
- Software testing: fuzzing and sanitization
- Focus topic : Web security
-

Focus topic : Mobile security

Keywords

Software security, mitigation, software testing, sanitization, fuzzing

Learning Prerequisites

Required courses

- COM-402 Information security and privacy

Important concepts to start the course

Basic computer literacy like system administration, build systems, basic C/C++ programming skills, debugging, and development skills. Understanding of virtual machines and operating systems.

Learning Outcomes

By the end of the course, the student must be able to:

- Explain the top 20 most common weaknesses in software security and understand how such problems can be avoided in software.
- Identify common security threats, risks, and attack vectors for software systems.
- Assess / Evaluate current security best practices and defense mechanisms for current software systems. Become aware of limitations of existing defense mechanisms and how to avoid them.
- Identify security problems in source code and binaries, assess the associated risks, and reason about their severity and exploitability.
- Assess / Evaluate the security of given source code or applications.

Transversal skills

- Identify the different roles that are involved in well-functioning teams and assume different roles, including leadership roles.
- Keep appropriate documentation for group meetings.
- Summarize an article or a technical report.
- Access and evaluate appropriate sources of information.
- Write a scientific or technical report.
- Make an oral presentation.

Teaching methods

The lectures are denser early in the semester, then tapering off before the end. They may be peppered with occasional short surprise quizzes that are not mandatory but may earn points for successful participants. They are backed up by PDF files of all the lecture material, as well as a few textbook recommendations.
The exercises sessions start slowly early in the semester but pick up and occupy all time towards the end. They consist mostly of paper questions involving the analysis, critical review, and occasional correction of software. They include a reading, writing, and presentation assignment.

Expected student activities

Students are encouraged to attend lectures and exercise sessions. In addition to normal studying of the lecture and practice of the exercises, the reading assignment consists of analyzing a few suggested scientific papers on a large selection of topics; the presentation assignment consists of holding a 15-minute presentation on the selected topic; and the writing assignment of documenting what was learned in a term paper due at the end of the semester.

Assessment methods

The grade will continuously be evaluated through a combination of pracitcal assignments in the form of several labs and theoretical quizzes and assignments throughout the semester. The labs will account for 70%, the quizzes and assignments to 30%.

Supervision

Office hours	Yes
Assistants	Yes
Forum	No

Resources

Notes/Handbook

Software Security: Principles, Policies, and Protection (SS3P, by Mathias Payer)
http://nebelwelt.net/SS3P/

EPFL

COM-500 Statistical signal and data processing through applications

Ridolfi Andrea

Cursus	Sem.	Type
Communication systems minor	E	Opt.
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Obl.

Language	English
Credits	6
Session	Summer
Semester	Spring
Exam	Written
Workload	180h
Weeks	14
Hours	**5 weekly**
Lecture	3 weekly
Exercises	2 weekly
Number of positions	

Summary

Building up on the basic concepts of sampling, filtering and Fourier transforms, we address stochastic modeling, spectral analysis, estimation and prediction, classification, and adaptive filtering, with an application oriented approach and hands-on numerical exercises.

Content

1. Fundamentals of Statistical Signal and Data Processing: Signals and systems from the deterministic and the stochastic point of view; Processing and analysing signals and systems with a mathematical computing language.
2. Models, Methods, and Algorithms: Parametric and non-parametric signal models (wide sense stationary, Gaussian, Markovian, auto-regressive and white noise signals); Linear prediction and estimation (orthogonality principle and Wiener filter); Maximum likehood estimation and Bayesian a priori; Maximum a posteriori estimation.
3. Statistical Signal and Data Processing Tools for Spread Spectrum Wireless Transmission: Coding and decoding of information using position of pulses (annihilating filter approach); Spectrum estimation (periodogram, line spectrum methods, smooth spectrum methods, harmonic signals).
4. Statistical Signal and Data Processing Tools for the Analysis of Neurobiological Recordings: Poisson process for neurobiological spikes; Characterization of multiple state neurons (Markovian models and maximum likelihood estimation); Classifying firing rates of neuron (Mixture models and the EM algorithm); Hidden Markov models; Spike sorting and Principal Component Analysis.
5. Statistical Signal and Data Processing Tools for Echo Cancellation: Adaptive filtering (least mean squares and recursive least squares); Adaptive echo cancellation and denoising.

Keywords

Statistical tools, spectral analysis, prediction, estimation, annihilating filter, mixture models, principal component analysis, stochastic processes, hidden Markov models, adaptive filtering, mathematical computing language (Matlab, Python, or similar).

Learning Prerequisites

Required courses

Stochastic Models in Communications (COM-300), Signal Processing for Communications (COM-303).

Recommended courses

Mathematical Foundations of Signal Processing (COM-514).

Important concepts to start the course

Calculus, Algebra, Fourier Transform, Z Transform, Probability, Linear Systems, Filters.

Learning Outcomes

By the end of the course, the student must be able to:
- Choose appropriate statistical tools to solve signal processing problems;
- Analyze real data using a mathematical computing language;
- Interpret spectral content of signals;
- Develop appropriate models for observed signals;
- Assess / Evaluate advantages and limitations of different statistical tools for a given signal processing problem;
- Implement numerical methods for processing signals.

Teaching methods

Ex cathedra with exercises and numerical examples.

Expected student activities

Attendance at lectures, completing exercises, testing presented methods with a mathematical computing language (Matlab, Python, or similar).

Assessment methods

- 20% midterm
- 10% mini project
- 70% Final exam

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

Background texts

- P. Prandoni, *Signal Processing for Communications*, EPFL Press;
- P. Bremaud, *An Introduction to Probabilistic Modeling*, Springer-Verlag, 1988;
- A.V. Oppenheim, R.W. Schafer, *Discrete Time Signal Processing*, Prentice Hall, 1989;
- B. Porat, *A Course in Digital Signal Processing*, John Wiley & Sons,1997;
- C.T. Chen, *Digital Signal Processing*, Oxford University Press;
- D. P. Bertsekas, J. N. Tsitsiklis, *Introduction to Probability,* Athena Scientific, 2002 (excellent book on probability).

More advanced texts

- L. Debnath and P. Mikusinski, *Introduction to Hilbert Spaces with Applications*, Springer-Verlag, 1988;
- A.N. Shiryaev, *Probability*, Springer-Verlag, New York, 2nd edition, 1996;
- S.M. Ross, *Introduction to Probability Models*, Third edition, 1985;
- P. Bremaud, Markov Chains, Springer-Verlag, 1999;
- P. Bremaud, Mathematical Principles of Signal Processing, Springer-Verlag, 2002;
- S.M. Ross, *Stochastic Processes*, John Wiley, 1983;
- B. Porat, *Digital Processing of Random Signals*, Prentice Hall,1994;
- P.M. Clarkson, *Optimal and Adaptive Signal Processing*, CRC Press, 1993;
- P. Stoïca and R. Moses, *Introduction to Spectral Analysis*, Prentice-Hall, 1997.

Ressources en bibliothèque

- Probability / Shiryaev
- Stochastics Processes / Ross
- Discrete Time Signal Processing / Oppenheim
- Introduction to Spectral Analysis / Stoïca
- Digital Processing of Random Signals / Porat
- Introduction to Probability / Bertsekas
- Introduction to Probability Models / Ross
- Signal Processins for Communications / Prandoni
- An Introduction to Probabilistic Modeling / Bremaud
- A Course in Digital Signal Processing / Porat
- Optimal and Adaptive Signal Processing / Clarkson
- Digital Signal Processing / Chen
- Introduction to Hilbert Spaces with Applications / Debnath

Notes/Handbook

- Slides handouts;
- Collection of exercises.

Websites

- http://lcav.epfl.ch/cms/site/lcav/lang/en/teaching/statistical_sp_and_applications

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=422

EPFL

COM-506 Student seminar: security protocols and applications

Vaudenay Serge

Cursus	Sem.	Type
Cyber security minor	E	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	3
Session	Summer
Semester	Spring
Exam	Written
Workload	90h
Weeks	14
Hours	**2 weekly**
Lecture	2 weekly
Number of positions	

Summary

This seminar introduces the participants to the current trends, problems, and methods in the area of communication security.

Content

We will look at today's most popular security protocols and new kinds of protocols, techniques, and problems that will play an emerging role in the future. Also, the seminar will cover methods to model and analyze such security protocols. This course will be held as a seminar, in which the students actively participate. The talks will be assigned in the first meeting to teams of students, and each team will have to give a 45 minutes talk, react to other students' questions, and write a 3-4 pages summary of their talk.

Keywords

network security, security protocols, cryptography

Learning Prerequisites

Required courses

- Computer security (COM-301)
- Cryptography and security (COM-401)

Learning Outcomes

By the end of the course, the student must be able to:

- Synthesize some existing work on a security protocol
- Analyze a security protocol
- Present a lecture

Transversal skills

- Make an oral presentation.
- Summarize an article or a technical report.

Expected student activities

- prepare a lecture (presentation and a 4-page report)
- present the lecture
- attend to others' lectures and grade them
- do the final exam

Assessment methods

- lecture and attendance to others' lectures (50%)
- final exam (50%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes
Others	Lecturers and assistants are available upon appointment.

Resources

Websites

- http://lasec.epfl.ch/teaching.shtml

Moodle Link

- https://moodle.epfl.ch/course/view.php?id=13965

CS-448

Sublinear algorithms for big data analysis

Kapralov Mikhail

Cursus	Sem.	Type
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours biennal, donné les années impaires

Summary

In this course we will define rigorous mathematical models for computing on large datasets, cover main algorithmic techniques that have been developed for sublinear (e.g. faster than linear time) data processing. We will also discuss limitations inherent to computing with constrained resources.

Content

The tentative list of topics is:

Streaming: given a large dataset as a stream, how can we approximate its basic properties using a very small memory footprint? Examples that we will cover include statistical problems such as estimating the number of distinct elements in a stream of data items, finding heavy hitters, frequency moments, as well as graphs problems such as approximating shortest path distances, maximum matchings etc.;
Sketching: what can we learn about the input from a few carefully designed measurements (i.e. a `sketch') of the input, or just a few samples of the input? We will cover several results in sparse recovery and property testing that answer this question for a range of fundamental problems;
Sublinear runtime: which problems admit solutions that run faster than it takes to read the entire input? We will cover sublinear time algorithms for graph processing problems, nearest neighbor search and sparse recovery (including Sparse FFT);
Communication: how can we design algorithms for modern distributed computation models (e.g. MapReduce) that have low communication requirements? We will discuss graph sketching, a recently developed approach for designing low communication algorithms for processing dynamically changing graphs, as well as other techniques.

Keywords

streaming, sketching, sparse recovery, sublinear algorithms

Learning Prerequisites

Required courses

Bachelor courses on algorithms, complexity theory, and discrete mathematics

Important concepts to start the course

Discrete probability; mathematical maturity

Learning Outcomes

By the end of the course, the student must be able to:
- Design efficient algorithms for variations of problems discussed in class
- Analyze space/time/communication complexity of randomized algorithms
- Prove space/time/communication lower bounds for variations of problems discussed in class
- Choose an appropriate algorithmic tool for big data problem at hand

Teaching methods

Ex cathedra, homeworks, final

Assessment methods

Continuous control

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

COM-407

TCP/IP networking

Le Boudec Jean-Yves

Cursus	Sem.	Type
Communication systems minor	H	Opt.
Computer science	MA1, MA3	Obl.
Cyber security minor	H	Opt.
Cybersecurity	MA1, MA3	Obl.
Electrical and Electronical Engineering	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Obl.

Language	English
Credits	6
Session	Winter
Semester	Fall
Exam	Written
Workload	180h
Weeks	14
Hours	**6 weekly**
Lecture	2 weekly
Exercises	2 weekly
Practical work	2 weekly
Number of positions	

Summary

In the lectures you will learn and understand the main ideas that underlie and the way communication networks are built and run. In the labs you will exercise practical configurations.

Content

LECTURES: 1. The TCP/IP architecture 2. Layer 2 networking; Bridging. 3. The Internet protocol versions 4 and 6 4. The transport layer, TCP, UDP, sockets, QUIC. 5. Link state routing, OSPF, Distance Vector routing. Interdomain routing, BGP. 6. Congestion control principles. Application to the Internet. The fairness of TCP. Tunnels and hybrid architectures.
LABS: 1. Configuration of a network, virtual machines and mininet, packet captures 2. MAC; NATs and troubleshooting 3. Socket programming 4. OSPF routing 5. Congestion control and flow management 6. BGP

Keywords

TCP/IP
Computer Networks

Learning Prerequisites

Required courses

A first programming course

Learning Outcomes

By the end of the course, the student must be able to:

- Run and configure networks
- Understand the main ideas that underlie the Internet
- Write simple communicating programs
- Use communication primitives for internet and industrial applications.

Transversal skills

- Access and evaluate appropriate sources of information.
- Continue to work through difficulties or initial failure to find optimal solutions.

Teaching methods

Lectures with questionnaires.
Online quizzes.
Labs on student's computer and if required and if possible, in the Internet Engineering Workshop

Expected student activities

Participate in lectures
Participate in online quizzes
Make lab assignments (in the rule, every other week)

Assessment methods

Theory grade = final exam
Practice grade = average of labs
Final grade = mean of theory grade (50%) and practice grade (50%).
The research exercice may add a bonus of at most 0.5 points in 1-6 scale to the practice grade.

Supervision

Office hours	Yes
Assistants	Yes
Forum	Yes

Resources

Bibliography

"Computer Networking : Principles, Protocols and Practice", O. Bonaventure, open source textbook, http://inl.info.ucl.ac.be/CNP3

Ressources en bibliothèque

- Computer Networking / Bonaventure

Notes/Handbook

Slides are on moodle

Websites

- http://moodle.epfl.ch/course/view.php?id=523

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=523

Videos

- http://moodle.epfl.ch/course/view.php?id=523

EPFL

CS-410 **Technology ventures in IC**

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Project	2 weekly
Number of positions	

Remark

Pas donné en 2021-22

Summary

This hands-on class gives graduate students in IC interested in startups the opportunity to learn and put in practice the fundamental skills required to assess a technology concept in the context of a business opportunity. This class is focused only on business opportunities where high-technology

Content

Working in teams, students will learn the fundamentals of:

- *Opportunity assessement*
- *Customer development and validation*
- *Business model alternatives*
- *Intellectual Property*
- *Strategy and Financial planning*
- *Go-to-market, launch, and growth*

This is a hands-on class where students start the class with their own technology venture concept (e.g. the work done as part of their PhD, or some well-formed idea, maybe with a prototype). During the class, they convert their concept into a integrated business plan.

Keywords

Entrepreneurship, startups, technology transfer, intellectual property

Learning Prerequisites

Required courses

- *None – but available to MS and Ph.D. students only*

Learning Outcomes

By the end of the course, the student must be able to:

- Analyze a business plan
- Create a business plan

Teaching methods

- Short ex-cathedra presentations of each topic
- Hands-on seminar with many short student presentations
- Presentations from invited guests, in particluar industry executives and entrepeneurs
- Discussion and case studies

Assessment methods

- In-class participation (30%)
- In-class presentations (30%)
- Final pitch (40%)

Supervision

Office hours	Yes
Assistants	No
Forum	Yes

CS-455

Topics in theoretical computer science

Cursus	Sem.	Type
Computer science minor	H	Opt.
Computer science	MA1, MA3	Opt.
Cybersecurity	MA1, MA3	Opt.
Data Science	MA1, MA3	Opt.
SC master EPFL	MA1, MA3	Opt.

Language	English
Credits	4
Session	Winter
Semester	Fall
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	3 weekly
Exercises	1 weekly
Number of positions	

Remark

Cours biennal - pas donné en 2021-22

Summary

The students gain an in-depth knowledge of several current and emerging areas of theoretical computer science. The course familiarizes them with advanced techniques, and develops an understanding of fundamental questions that underlie some of the key problems of modern computer science.

Content

Examples of topics that will be covered include:

• Laplacians, random walks, graph sparsification: It is possible to compress graphs while approximately preserving their spectral properties (in particular, properties of random walks)? We will cover the main results from the recent influential line of work on spectral sparsification that provides such compression schemes.

• Laplacian system solvers: given a linear system Ax=b, how quickly can we find x? We will cover nearly linear time algorithms for solving Ax=b when A is a symmetric diagonally dominant matrix (a common scenario in practice) that crucially rely on spectral graph sparsification.

• Spectral clustering: given a graph, can we find a partition of the graph into k vertex disjoint parts such that few edges cross from one part to another? This is the fundamental graph clustering problem that arises in many applications. We will cover several results on spectral graph partitioning, where one first embeds vertices of the graph into Euclidean space using the bottom few eigenvectors of the graph Laplacian, and then employs Euclidean clustering primitives to find the partition.

• Local clustering with random walks: Given a very large graph and a seed node in it, can we find a small cut that separates the seed node from the rest of the graph, without reading the entire graph? We will cover local clustering algorithms, which identify such cuts in time roughly proportional to the number of vertices on the small side of the cut, by carefully analyzing distributions of random walks in the graph.

Keywords

spectral graph theory, sparsification, clustering, random walks

Learning Prerequisites

Required courses

Bachelor courses on algorithms and discrete mathematics, mathematical maturity.

Learning Outcomes

By the end of the course, the student must be able to:

- Design efficient algorithms for variations of problems discussed in class;
- Analyze approximation quality of spectral graph algorithms;

Teaching methods

Ex cathedra, homeworks, reading

Expected student activities

Attendance at lectures, completing exercises, reading written material

Assessment methods

- Continuous control

Supervision

Office hours	Yes
Assistants	Yes
Others	Electronique forum : Yes

Resources

Bibliography

There is no textbook for the course. Notes will be posted on the course website.

Ressources en bibliothèque

- Randomized Algorithms / Motwani

EPFL

CS-444 **Virtual reality**

Boulic Ronan

Cursus	Sem.	Type
Computer science	MA2, MA4	Opt.
Cybersecurity	MA2, MA4	Opt.
Data Science	MA2, MA4	Opt.
Digital Humanities	MA2, MA4	Opt.
Learning Sciences		Obl.
Robotics, Control and Intelligent Systems		Opt.
SC master EPFL	MA2, MA4	Opt.

Language	English
Credits	4
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**3 weekly**
Lecture	2 weekly
Exercises	1 weekly
Number of positions	

Summary

The goal of VR is to embed the users in a potentially complex virtual environment while ensuring that they are able to react as if this environment were real. The course provides a human perception-action background and describes the key techniques for achieving efficient VR applications.

Content

The first lectures focus more on the technical means (hw & sw) for acheiving the hands-on sessions:

- Visual display
- Interaction devices and sensors
- Software environment (UNITY3D)

The proportion of more theoretical VR and Neuroscience background increases over the semester:

- Key Human perception abilities, Cybersickness, Immersion, presence and flow
- Basic 3D interaction techniques: Magic vs Naturalism
- The perception of action
- Haptic interaction
- What makes a virtual human looking alive ?
- Motion capture for full-body interaction
- VR, cognitive science and true experimental design

Keywords

3D interaction, display, sensors, immersion, presence

Learning Prerequisites

Required courses

(CS 341) Introduction to Computer Graphics

Recommended courses

(CS 211) Introduction to Visual Computing

Important concepts to start the course

from Computer Graphics:
- perspective transformations
- representation of orientation

- 3D modelling hierarchy
- matrix algebra: translation, orientation, composition

Learning Outcomes

By the end of the course, the student must be able to:

- Describe how the human perception-action system is exploited in VR
- Apply the concepts of immersions, presence and flow
- Give an example of applications of VR in different industrial sectors
- Choose a method of immersion suited for a given 3D interaction context
- Explain the possible causes of cybersickness in a given VR system configuration
- Design a VR system involving 3D interactions

Transversal skills

- Set objectives and design an action plan to reach those objectives.
- Assess one's own level of skill acquisition, and plan their on-going learning goals.

Teaching methods

Ex cathedra + Hands-on sessions on VR devices in the first half of the semester,
A mini-project in groups of 2-3 persons will have to integrate various components of 3D real-time interaction. The group will submit their project proposal to the course responsible TAs who will assess whether it meets the key specifications and is original enough. The proposal will include the use of some VR devices that the IIG research group will lend during the mini-project period.

Expected student activities

exploit citation analysis tools to evaluate a scientific paper
combine 3D interaction components to produce an original 3D experience
experiment the hands-on practical work in the lab
synthesize the knowledge acquired in course and hands-on in the quizzes and final oral

Assessment methods

Throughout semester: 1 paper citation study (20%), 1 project (50%), 1 theoretical oral (30%)

Supervision

Office hours	No
Assistants	Yes
Forum	Yes

Resources

Virtual desktop infrastructure (VDI)

No

Bibliography

- Course notes will be updated and made available after each course, with links to key sites and on-line documents
- J. Jerald, The VR Book, ACM Press 2015
- Parisi, Learning Virtual Reality, O'Reilly 2015
- Le Traité de Réalité Virtuelle (5 vol.) Presses des Mines, ParisTech, 2006-2009, available on-line, free for student upon registration.

- Doug A. Bowman, Ernst Kruijff, Joseph J. LaViola, and Ivan Poupyrev. 2004. 3D User Interfaces: Theory and Practice. Addison Wesley Longman Publishing Co., Inc., Redwood City, CA, USA.

Ressources en bibliothèque

- 3D User Interfaces: Theory and Practice / Bowman
- Le Traité de Réalité Virtuelle / Fuchs
- The VR Book / Jerald
- Learning Virtual Reality / Parisi

Notes/Handbook

pdf of slides are made visible after the ex-cathedra courses

Websites

- http://www.thevrbook.net/

Moodle Link

- http://moodle.epfl.ch/course/view.php?id=6841