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Special theme:

Human-Robot Interaction

Also in this issue:

Research and Innovation:

Corpus Conversion Service:

A Machine Learning Platform to Ingest Documents at Scale

ERCIM News is the magazine of ERCIM. Published quarterly, it reports on joint actions of the ERCIM partners, and aims to reflect the contribution made by ERCIM to the European Community in Information Technology and Applied Mathematics. Through short articles and news items, it provides a forum for the exchange of information between the institutes and also with the wider scientific community. This issue has a circulation of about 6,000 printed copies and is also available online.

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BP 93, F-06902 Sophia Antipolis Cedex, France
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EVENTS, IN BRIEF

Guest Editorial

by Jos Baeten

Recently, I attended a lecture by Cathy O'Neil, author of the book "Weapons of Math Destruction". Clearly, she demonstrated the destructive power of proprietary predictive algorithms that learn from possibly biased data sets.

I think we need to be able to appeal against decisions by such algorithms, the software implementing these algorithms should be open source, and the underlying data sets should be open for inspection by an authority. Apart from this, each individual should be able to control his/her data, and should have the right to be informed, the right to inspect and correct.

I shudder to think of a world where we are constantly monitored, guided, even ruled by an internet of interacting AIs, without recourse to human intervention.

More in general, all of us as researchers concerned with the digital domain have a moral obligation to speak out when we feel things are not going right or certain threats come about. Of course, we should always speak from our expertise, and not get caught up in a hype. Again and again, general opinion tends to go overboard, and people say for instance that the quantum computer can solve all problems, or that a normal computer can learn to solve all problems. Then we should also speak out, and temper expectations.

Jos Baeten
General Director, CWI
ERCIM President

Video Tutorials on Virtual Research Environments

VRE4EIC, an H2020 European research project managed by ERCIM, has released a series of video tutorials. Short online videos are explaining how to build a Virtual Research Environment (VRE) or to enhance an existing VRE. VRE4EIC has developed a reference architecture and software components for building VREs.

This software developed in the frame of VRE4EIC, called e-VRE, provides a comfortable, homogeneous interface for users by virtualising access to the heterogeneous datasets, software services and resources of the e-RIs, and provides collaboration/communication facilities for users to improve research communication. It also has the capability of bridging across existing e-RIs (e-Research Infrastructures).

With a series of tutorial videos, scientists and engineers can now learn how to build a VRE or enhance the functionalities of an existing VRE. Experts explain in a way easy to understand the different items and aspects of e-VRE: Keith Jeffery from ERCIM gives an introduction "What is a Virtual Research Environment". Carlo Meghini from CNR gives insight in e-VRE architecture design & implementation", explaining the architecture as well as set of software systems and tools of e-VRE. Laurent Remy from euroCRIS teaches how to manage metadata in Virtual Research Environments. Maria Theodoridou, FORTH, presents the VRE4EIC Metadata Portal. The first part of her tutorial introduces the core components and explains how to construct a basic query. The second part demonstrates advanced features of the portal: how to use the geographical map, how to expand basic into complex queries, and how to store and load queries. Further videos explain how to use e-VRE to enhance an existing VRE. Daniele Bailo from the Italian National Institute for Geophysics and Volcanology (INGV) explains how building blocks (software tools) provided by VRE4EIC are enhancing an existing Research Infrastructure such as the European Plate Observation System (EPOS). Zhiming Zhao from University of Amsterdam (UvA) presents how the ENVRIPLUS community uses e-VRE architecture and building blocks for enhancing research infrastructures from different environmental and earth science domains (the video will be available in July).

Screenshot from the tutorial video on architecture design and implementation.

Link: https://www.vre4eic.eu/tutorials

ERCIM Workshop on Blockchain Engineering: Papers, Research Questions and Interests

by Wolfgang Prinz (Fraunhofer FIT)

The ERCIM blockchain Working Group [L1] organised a workshop in Amsterdam on 8-9 June in conjunction with the ERCIM spring meetings. The purpose of this workshop was to look at what the general excitement about blockchain technologies means for computer science research and to identify the major research challenges in this area.

Ten papers covering basic technologies, applications and methods have been selected for presentation. The papers are available in the EUSSET Digital Library [L2].

Prof. dr. J.C. van de Pol (left) presents the first research agenda on blockchain by the Dutch Blockchain Coalition to the coalitions' ambassador Rob van Gijzel. Source: Roy Borghouts Fotografie.

More than 40 participants from different research organisations and universities particicpated in the workshop. In discussions after the paper presentations and during a discussion session we have identified the following research questions:

Design, Privacy and Applications
- How we can combine development frameworks with design thinking?
- How can the (newly established) certification processes of the GDPR be used to implement compliant applications in the market?
- How to protect privacy per se and without creating an overhead?
- How to select application-specific parameters for platform selection and design?
- How can we include social science & economist in the community to discuss trust?
- How to build governance & busines models for Blockchain?

Technology and Development
- What is a Reference Architecture for Blockchain?
- How can we create a general framework for Blockchain development?
- How do we manage multiple Blockchains and Cross Blockchain Applications?
- What are Atomic operations across multiple blockchains?
- How can we realize the desirable properties of blockchain in other settings?

Some of these aspects can also be found in the first research agenda on blockchain by the Dutch Blockchain Coalition that was presented to Rob van Gijzel, who is ambassador of the Dutch Blockchain Coalition by Prof. dr. J.C. van de Pol.

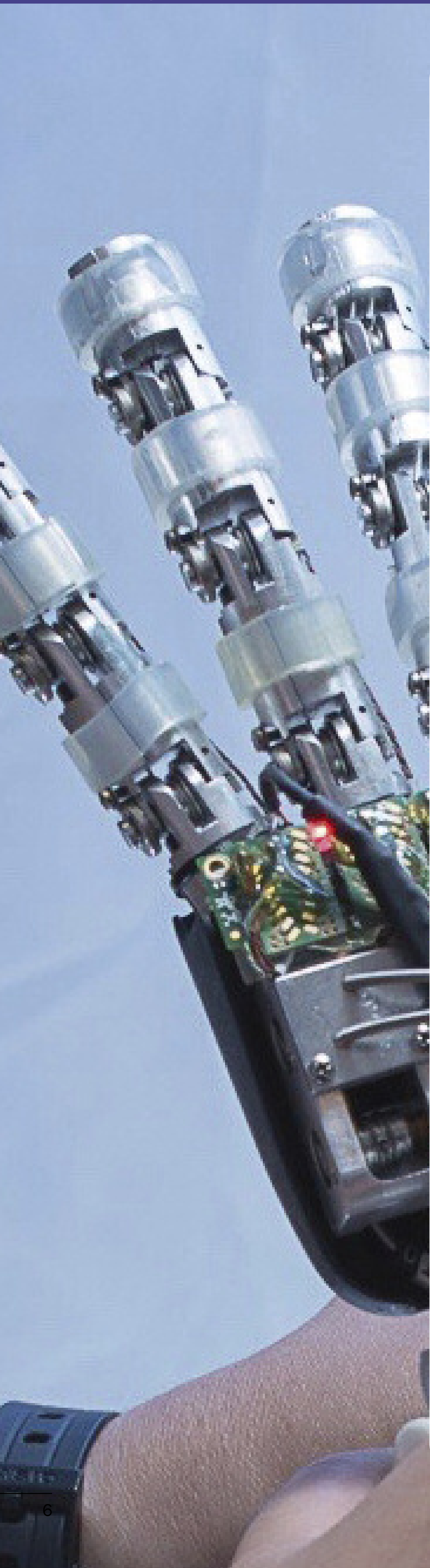
Research interests of the participating institutions

During the workshop we collected the research interest of the participating institutions. Please note that the following list can only provide a snapshot of the participates and can not reflect the full research spectrum of each organsitions.

- *CWI:* Immutability/Security Aspects of Blockchain; Dezentralized Decision Making; Intelligent Agents.
- *Fraunhofer FIT:* Methods of Use Case Analyse; Business relevance; Application development: Education, Energy, Automotive, IoT, Industrie 4.0, Media; Formal Modelling; Governance; Blockchain Patterns; Process Modelling/Additional Role of Intermediaries; Network Governance & Responsabilities; Incentives; Governance Design
- *IBM:* Crazy Blockchain Ideas; Multichain Network; Interoperability of Blockchain; AI for Puzzles
- *INESTEC Portugal:* Blockchain Appl. Supply Chain/ Smart Grid
- *Inria:* Formal Verification, Smart Contract
- *TU Delft*: Identity, Replace Passport: Delft Univ.; Reputation Systems, Valuable Use of Computing Power for PoW; Tribler; Hybrid Model of POW & BYZFT INESC; Game theory Aspects and transaction distribution
- *Theo Mensen/Maastricht:* Blockchain 4 Education
- *Univ. Appl. Science Salzburg:* Energy Provider; Tracking of Local Energy; Green Energy Certificates; ERP Systems Integration; Interest free mutial credit system
- *Univ. Göttingen:* DAO for Social Network; Power to the users
- *Univ. of Luxemburg:* Privacy of Blockchain
- *Univ. Lyon:* Green IT/Teaching Material for Blockchain; Energy Consumption of Smart Contracts
- *Univ. Speyer:* Legal/Data Protection
- *Univ. of Twente:* Formal Veritification/Methods; Verification Smart Contracts.

Links:
[L1] https://wiki.ercim.eu/wg/BlockchainTechnology/
[L2] https://dl.eusset.eu/handle/20.500.12015/3155

Please contact:
Wolfgang Prinz, Fraunhofer-FIT
ERCIM blockchain Working Group chair
wolfgang.prinz@fit.fraunhofer.de



Introduction to the Special Theme

Human-Robot Interaction

by the guest editors Serena Ivaldi (Inria) and Maria Pateraki (ICS-FORTH)

This special theme addresses the state of the art of human-robot interaction (HRI), discussing the current challenges faced by the research community for integrating both physical and social interaction skills into current and future collaborative robots.

Recent years have seen a proliferation of applications for robots interacting physically with humans in manufacturing and industry, from bimanual cooperation in assembly with cobots (i.e., industrial manipulators for collaboration) to physical assistance with exoskeletons. These applications have driven research in many fundamental topics for collaboration, such as shared task allocation, synchronisation and coordination, control of contacts and physical interaction, role estimation and adaptive role allocation during collaboration, learning by demonstrations, safe control, etc. All the developments in these areas contribute to the success of the “Industry 4.0”, whose elite platforms are essentially cobots and exoskeletons.

At the same time, research in social robotics has made tremendous progress in understanding the behaviour and the intricacy of verbal and non-verbal signals exchanged by robots and humans during interaction, highlighting critical aspects such as trust, mutual awareness and turn-taking. These studies were initially motivated by the increased assistance and service robotics application, ranging from the introduction of robots in malls and shops to hospitals and homes, but are now becoming crucial for the acceptance of new intelligent robotics technologies in other industrial domains, such as manufacturing.

The human-robot-interaction (HRI) research community is thus advancing both physical and social interaction skills for robots. The proof of the convergence of both skills are the new industrial robots such as Baxter and Sawyer, where compliant arms such as in cobots are coupled with a face emulating referential gaze and social behaviour, to facilitate collaboration with humans.

The European Commission’s Strategic Research Agenda for Robotics acknowledges the importance of robotics. With their increased awareness and ease of use, robots represent the dawn of a new era as ubiquitous helpers improving competitiveness for business and quality of life for individuals. Their role is expected to continuously expand beyond their traditional role in the manufacturing industry, providing significant short to medium term opportunities in areas such as agriculture, healthcare, security and transport, while in the longer term robots are expected to enter almost all areas of human activity, including the home. Along this line, the European Commission highlights HRI as one of the key technology areas in robotics with greatest impact guaranteeing project funding of 66 million EUR for 2018-2020. A large number of national and European projects are active in this area and a selection of these can be found referenced in the articles on these issue. Besides some of the current challenges in human-robot interaction and the approaches to tackle these challenges in real applications are presented in this special issue.

Key challenges on human robot collaboration are discussed in several papers. Buoncompagni et al. (page 8) addresses main research questions for HRC in smart factories, advocating an AI-based approach to develop intelligent collaborative robots and Ivaldi (page 9) is focused on the prediction of the human partner, currently developed within the EU-funded H2020 project AnDy.

Topics related to *conversational and dialog systems* are addressed in Agirre et al. (page 12) presenting relevant research work in dialog systems for industry aiming to improve the natural language interaction between humans and robots. On the same topic Schindler et al. (page 13) describe a conversational system that faciltates HRI thanks to a context-aware approach based on audio-analysis, which has been successfully exploited in various application areas.

Manufacturing-oriented papers such as those by Kaiser (page 17) and Horvath (page 15) aim to support HRC scenarios in their respective areas. Kaiser used simulation tools to design collaborative assembly systems and to support the planning tasks, whereas Horvath describes a context-aware multimodal interface effectively utilised within SYMBIO-TIC H2020 project.

Assistive robots and healthcare applications within the context of HRI are discussed in Cesta et al. (page 18), Hindriks et al (page 20) and Efthimiou et al (page 21). Cesta et al. present a cognitive architecture combining human perception and AI techniques to infer knowledge about the status of a user and the environment and plan personalised assistive robot actions for elderly people. Hindriks et al. report on their first experiments on a social robot that supports collection of patient data in a hospital, to reduce the workload of nurses. Efthimiou et al. are developing a multimodal user-centred HRI solution that encourages trust and acceptance of assistive robots for elderly people.

State-of-the art *research in social HRI* is presented in Schellen et al. (page 23), Evers (page 24), Mokios et al. (page 26) and Ribino et al (page 28). Schellen et al. highlight the importance of social attunement in interactions with artificial agents, exploiting methods from experimental psychology and cognitive neuroscience to study social cognitive mechanisms during HRI. The research is partially funded by the starting ERC grant InStance. Evers designs socially intelligent robots for several applications, from service to education. As part of EU-funded FET projects TimeStorm and Entiment, Mokios et al. address the open challenge of time perception in HRI to enable fluent HRI. Ribino et al. argue that robots acting with humans following social norms may improve their acceptance and the dynamics of HRI by proactively reasoning in dynamic normative situations.

The articles in this special theme not only provide a panorama of the ongoing European research in the field, but highlight the intrinsic multidisciplinarity of the theme. Even in industrial sectors such as manufacturing, it is clear that the problem of introducing collaborative robots cannot be merely reduced to the problem of ensuring safety and controlling their physical interaction with the humans. A multitude of sub-problems must be taken into account for collaborative robots to be accepted and widely adopted: from rethinking the whole system software and hardware architecture to enabling natural communication. The diversity of challenges and topics addressed in the special theme illustrates the several challenges for human-robot interaction and collaboration.

References:

[1] A. M. Zanchettin, E. Croft, H. Ding and M. Li: "Collaborative Robots in the Workplace", in IEEE Robotics & Automation Magazine, Vol. 25, N. 2, pp. 16-17, 2018.

[2] A. Ajoudani, A. M. Zanchettin, S. Ivaldi, A. Albu-Schaeffer, K. Kosuge, O. Khatib: "Progress and Prospects of the Human-Robot Collaboration", in Autonomous Robots, Vol. 42, Issue 5, pp. 957–975, 2018.

[3] A. Thomaz, G. Hoffman and M. Cakmak: "Computational Human-Robot Interaction", in Foundations and Trends in Robotics, Vol. 4, N. 2-3, pp. 105-223, 2016.

Please contact:

Serena Ivaldi
Inria, France
+33 (0)354958475
serena.ivaldi@inria.fr
https://members.loria.fr/SIvaldi/

Maria Pateraki
ICS-FORTH, Greece
+30 2810 391719
pateraki@ics.forth.gr
http://www.mpateraki.org

From Collaborative Robots to Work Mates: A New Perspective on Human-Robot Cooperation

by Luca Buoncompagni, Alessio Capitanelli, Alessandro Carfì, Fulvio Mastrogiovanni (University of Genoa)

The introduction of collaborative robots in next-generation factories is expected to spark debates about ethical, social, and even legal matters. Research centres, universities and manufacturing companies, as well as technology providers, must help society understand how it can benefit from this transition, and possibly accelerate it. We frame the problem in the context of the trade-off between Artificial Intelligence and Intelligence Augmentation, and we pose four questions that research in human-robot cooperation must address.

The Industry 4.0 paradigm aims at integrating human knowledge and know-how with intelligent and flexible robots. This opens up ethical, social and legal issues, spanning academic debates and involving themes of general public interest. Manufacturing has made increasing use of robot-based technology in the past 30 years. At the same time, silently and pervasively, research in Artificial Intelligence (AI) has produced commercial products with unprecedented capabilities, which are now used by everybody. The scope of intelligent systems has reached cars, homes, wearable devices, digital assistants, and robot co-workers in factories.

These advances in Robotics and AI raise major concerns about the kind of society we are creating for future generations. The division between AI-based systems aimed at replacing humans in certain situations and the Intelligence Augmentation (IA) based approach for extending human intelligence originated by seminal scientific research by [1], seems of the utmost relevance today.

The use of robot co-workers in next-generation factories involves the integration of critical technologies, such as intelligent, intrinsically safe robots, as well as algorithms and technologies for human activity recognition (also making use of wearable devices), and requires a clear understanding of not-so-obvious issues such as privacy and data protection in the workplace.

We argue that collaboration between humans and robot co-workers in factories must be based on the IA-based approach to the development of intelligent systems as advocated by [1], i.e., robots must be designed to empower and augment the possibilities of human operators. Such collaborative robots are expected to improve new performance indicators taking into account both robot-centred and human-centred needs, and enforcing a positive attitude towards robots [2]. We believe that, in order to increase the likelihood that robots are accepted as “work mates” rather than tools “taking the jobs of human workers” and human dignity, robot co-workers should be designed with three related requirements in mind:

1. Robots should be “aware” of the fatigue and stress levels of human operators working alongside robots, and be programmed to behave in such a way as to reduce these stress levels, as if robots were friendly mates in the workplace.
2. Since more intelligence means more autonomy, robot behaviour should be designed to be easily understandable by human operators, i.e., there is a trade-off between a concept of “optimality” and “efficiency” for robot behaviour and its acceptance by humans.
3. Robot behaviour should be designed to be intrinsically safe, not only in terms of a “reactive” (and quite limited) notion of safety, but above all having a safety-by-design approach in terms of standard development workflows, and compliance with high level regulations, such as existing ISO standards like the ISO 10218:2011, as well as new standards like the technical specification TS 15066 for robots, robot devices, and collaborative robots.

IA proposes that technology should extend human capabilities. If we focus on the workplace, technology should contribute to the empowerment of human workers at different levels.

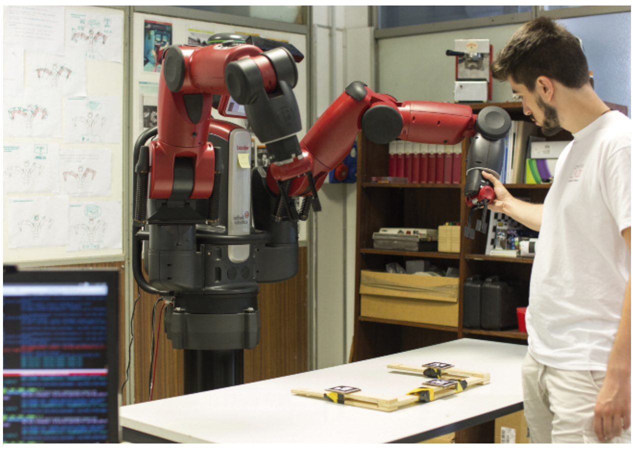


Figure 1: Collaborative robots may be the mediators between production criteria and operators’ wellbeing.

Figure 2: Robots should be capable of detecting human operators’ fatigue and stress levels.

These include taking control of tasks to be carried out, and receiving support by intelligent robots when needed. To this end, collaborative robots provided with human-like capabilities in understanding human activities, mood, fatigue and stress levels, can effectively trade-off between duties and the human operator's wellbeing.

On the one hand, we argue that if human operators are supposed to interact with robots in the future, robots may be good mediators for improved wellbeing in the workplace. It is necessary to design collaborative robots integrating two perspectives – which, up until now, have been separated: the human operators' (human-centred perspective) and the stakeholders' (automation-centred perspective). Major concerns are related to the quality of the working environment, which must be addressed by informed research activities, i.e., the wellbeing of human operators, and negative perception of robots. Concerns typically raised by human operators depend on the tasks, geographical location, culture and gender, but all focus on safety, fatigue and stress levels.

On the other hand, the need for safe-by-design robot systems, also taking into consideration aspects of ergonomics, is rapidly emerging ([3]). Traditional ISO standards, such as the well-known ISO 10218:2011, are quite limited in indicating how to deal with cases where robots and humans share their workspace. Although more recent technical specifications, such as the TS 15066 (Robots and Robotic Devices-Collaborative Robots), try to amend certain limitations, collaborative robot design at the behaviour level is still in its infancy.

We believe that research in human-robot cooperation, specifically framed in the context of factory automation, should address and provide answers to the following questions:

1. Is human-robot cooperation a viable solution to mediate between stakeholders' need for automation and compliance with industrial and regulatory standards (automation-centred metrics) and the needs of the future workforce (human-centred criteria)?
2. Can intelligent, yet supportive, and proactive collaborative robots limit alienation in the workplace and support wellbeing?
3. Can collaborative robots act as mediators of automation-centred metrics to provide human operators in factories with more meaningful work?
4. Can we identify and overcome technological, social and psychological barriers to adopt collaborative robots in next-generation factories?

With the Industry 4.0 paradigm likely to be adopted by a large number of manufacturing players, and the number of collaborative robots in operation to increase, it would understandable for workers to adopt a negative perception of robots that are "taking their jobs". Whilst increasing automation is unavoidable, the effort of research centres, universities and automation companies must be to (i) find ways of managing the transition that minimises negative impacts on workers and thus facilitates acceptance of robots by human operators in factories, and (ii) educate new professional staff to achieve competence in the use of novel robot platforms, including collaborative robots.

References

[1] Douglas .C. Engelbart: "Augmenting human intellect: a conceptual framework", SRI Summary Report AFOSR-3223, October, 1962.

[2] S. Strohkorb, B. Scassellati: "Promoting collaboration with social robots", Proc. of HRI'16, Christchurch, New Zealand, 2016

[3] E. Hollnagel: "Resilience engineering and the built environment", Building Research and Information, vol. 42, pages 221-228, 2014.

Please contact:

Luca Buoncompagni, Alessio Capitanelli, Alessandro Carfì, Fulvio Mastrogiovanni
University of Genoa, Italy
luca.buoncompagni@edu.unige.it
alessio.capitanelli@dibris.unige.it
alessandro.carfi@dibris.unige.it
fulvio.mastrogiovanni@unige.it

Intelligent Human-Robot Collaboration with Prediction and Anticipation

by Serena Ivaldi (Inria)

Collaborative robots need to safely control their physical interaction with humans. However, in order to provide physical assistance to humans, robots need to be able to predict their intent, future behaviour and movements. We are currently tackling these questions in our research within the European H2020 Project AnDy. [L1].

Collaborative robotics technologies are rapidly spreading in manufacturing and industry, in the lead platforms of cobots and exoskeletons. The former are the descendants of industrial manipulators, capable of safely interacting and "co-existing" (i.e., sharing the same workspace) with operators, while the latter are wearable robotics devices that assist the operators in their motions. The introduction of these two technologies has changed the way operators may perceive interaction with robots at work: robots are no longer confined to their own areas; instead, they are sharing space with humans, modifying workstations, and influencing gestures at work (see Figure 1).

The major concern when introducing these technologies was to ensure safety during physical interaction. Most of the research in co-botics over recent decades has focused on collision avoidance, human-aware planning and re-planning of robot motions, control of contact, safe control of physical collaboration and so on.. This research has been funded by the European Commission in several projects, such as SAPHARI [L2] and CODYCO [L3], and contributed to the formulation of ISO norms on safety for collaborative robots, such as the ISO/TS 15066:2016 [L4].

With the introduction of the new collaborative technologies at work, however, it has become clear that the problem of collaboration cannot be merely reduced to the problem of controlling the physical interaction between the human and the robot. The transition from robots to cobots, motivated largely by economic factors (increased productivity and flexibility) and health factors (reduction of physical stress and musculo-skeletal diseases), raises several issues from psychological and cognitive perspectives. First, there is the problem of technology acceptance and trust in the new technologies on the part of the operators. Second, there is the problem of achieving a more advanced form of interaction, realised with a multi-modal system that takes into account human cues, movements and intentions in the robot control loop, that is able to differentiate between work-related intentional and non-intentional human gestures, make appropriate decisions together with the human, and adapt to the human.

If we observe two humans collaborating, we quickly realise that their synchronous movements, almost like a dance, are the outcome of a complex mechanism that combines perfect motor control, modelling and prediction of the human partner and anticipation of our collaborator's actions and reactions. While this fluent exchange is straightforward for us humans, with our ability to "read" our human partners, it is extremely challenging for robots.

Take, for example, two humans collaborating to move a big, bulky, heavy couch. How do the two partners synchronise to lift the couch at the same time, in a way that does not result in a back injury? Typically, the two assume an ergonomically efficient posture, ensure a safe haptic interaction, then use a combination of verbal and non-verbal signals, to synchronise their movement and move the couch towards the new desired location. While this collaborative action could be done in principle exclusively exchanging haptic cues, humans leverage their other signals to communicate their intent and make the partner aware of their status, intention and their upcoming actions. Visual feedback is used to estimate the partner's current posture and effort, non-verbal cues such as directed gaze are used to communicate the intended direction of movement and the final position, speech is used to provide high-level feedback and correct eventual mistakes.

In other words, collaboration undoubtedly needs a good physical interaction, but it also needs to leverage social interaction: it is a complex bidirectional process that efficiently works if both humans have a good idea of the model of their partner and are able to predict his/her intentions, future movements and efforts. Such a capacity is a hallmark of the human central nervous system that uses internal models to plan accurate actions as well as to recognise the partner's.

But how can these abilities be translated into a collaborative robotic system? This is one of the questions that we are currently addressing in our research, funded by the European H2020 project AnDy. AnDy involves several European research institutes (IIT in Italy, Inria in France, DLR in Germany, JSI in Solvenia) and companies (XSens Technologies, IMK automotive GmbH, Otto Bock Healthcare GmbH, AnyBody Technology). The main objective of the AnDy project is to create new hardware and software technologies that enable robots not only to estimate the motion of humans, but to fully describe and predict the whole-body dynamics of the interaction between humans and robots. The final goal is to create anticipatory robot controllers that take into account the prediction of human dynamics during collaboration to provide appropriate physical assistance.

Three different collaborative platforms are studied in AnDy: industrial cobots, exoskeletons and humanoid robots. The three platforms allow researchers to study the problem of collaboration from different angles, with platforms that are more critical in terms of physical interaction (e.g., exoskeletons) and more critical in terms of cognitive interaction (e.g., cobots and humanoids).

The main objective of exoskeletons is to provide physical assistance and reduce the risk of work-related musculo-skeletal diseases. It is critical that an exoskeleton is safe, assistive when needed, and "transparent" when not required. One of the challenges for an exoskeleton is the detection of current and future human activity and the onset of the kind of activity that requires assistance. While in the laboratories this can be easily detected by using several sensors (e.g., EMG sensors, motion tracker markers), it is more difficult to achieve in the field with a reduced set of sensors. Challenges for the acceptance of this kind of technology include a systematic evaluation of the effects of the exoskeleton on the human body, in terms of movement, efforts, ergonomics, but also on the perceived utility, trust towards the device and cognitive effort in using it. In a recent paper [1], we listed the ethical issues related to the acceptance of this technology.

For a collaborative robot (manipulator or more complex articulated robot such as a humanoid), the problems are similar in terms of physical interaction and safety. The cobot needs to be able to interact safely with the human and provide assistance when needed. Typically, cobots provide strength and endurance (e.g., they can be used to lift heavy tools and end-effectors) that complement human dexterity, flexibility and cognitive abilities in solving complex tasks. In AnDy we are focusing on the type of assistance that can help improve the ergonomics of the human operator at work. To provide suitable assistance, here the robot needs to be able to perceive human posture and efforts, to estimate the current task performed by the operator and predict future movements and efforts. Again, this is easily achieved in laboratory settings with RGB-D cameras, force plates and EMG sensors, but it is more challenging, if not impossible, to do in real working conditions such as in manufacturing lines with several occlusions and reduced external sensing. In AnDy, we exploited wearable sensors for postural estimation and activity recognition, which was also possible in a real manufacturing line [2]. For the problem of predicting the future intended movement, we proposed describing the problem as an inference over a probabilistic skill model given early observations of the action. At first we leveraged haptic information, but rapidly developed a multi-modal approach to the

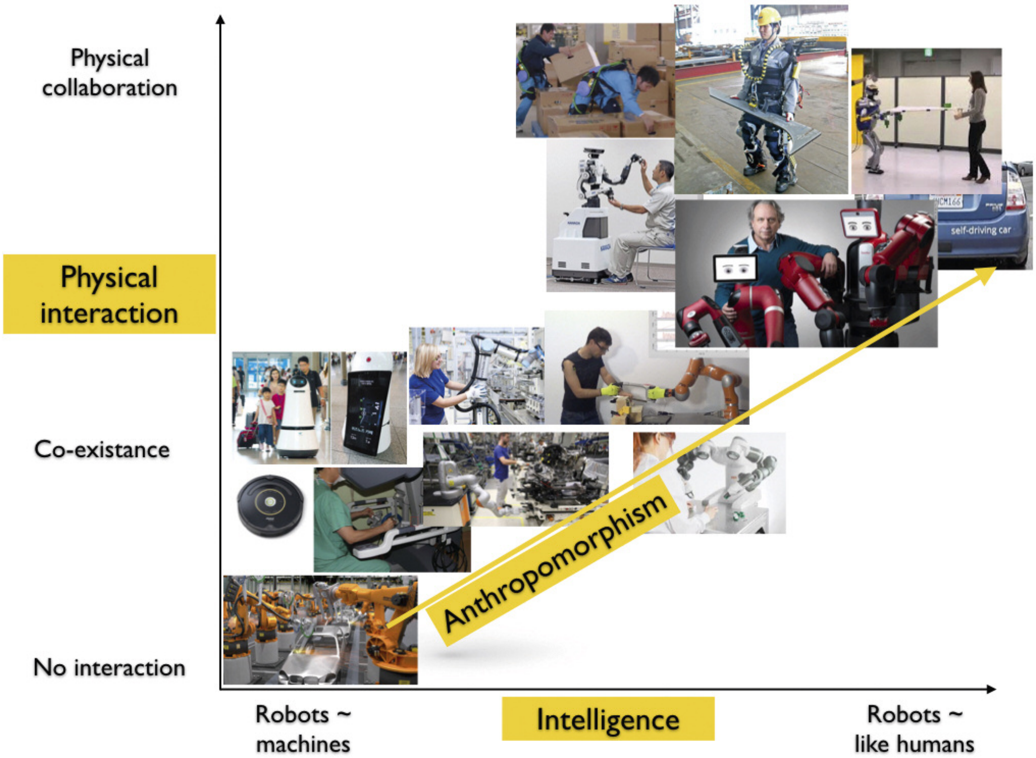


Figure 1: The recent trend in collaborative robotics technologies in industry: from industrial robots working separately from humans, to cobots able to co-exist and safely interact with operators. The advanced forms of cobots are exoskeletons, wearable devices that provide physical assistance at whole-body level, and more "anthropomorphic" collaborative robots that combine physical interaction with advanced collaborative skills typical of social interaction.

problem of predicting human intention [3]. Inspired by the way humans communicate during collaboration, we realised that anticipatory directed gaze is used to signal the target location for goal-directed actions, while haptic information is used to start the cooperative movement and eventually provide corrections. This information is being used as input to the robot controller, to take into account the prediction of human intent in the planned robot motions.

This research was performed with the humanoid robot iCub, an open-source platform for research in intelligent cognitive systems. iCub is equipped with several sensors, that make it valuable for conducting human-robot interaction studies. Humanoid platforms such as iCub may seem far from industrial applications; however, many collaborative robots are now being equipped with a "head" and sometimes have two arms, which makes them more and more anthropomorphic and very close to a humanoid (see Figure 1). In this sense, operators may be driven to interact with them in a different manner than from the one they use with cobots or manipulators: the simple addition of a head with a face displaying information about the robot status, or moving along with the human, may create the illusion of a more "intelligent" form of human-robot interaction that goes beyond physical assistance. Expectations may increase, both in terms of the complexity of the interaction and the capacity of the system to properly react to the human and communicate its status. When such interactions occur, and they involve collaborative tasks or decision-making tasks, we believe that it is important to take a human-centred approach and make sure that the operators trust the system, learn how to use it, provide feedback and finally evaluate the system. As roboticists, we often imagine that humans wish to interact with intelligent systems that are able to anticipate and adapt, but our recent experiments show that when humans see the robot as a cognitive and social agent they tend to mistrust it [4]. Our take-home message is that we need to develop collaborative robotics technologies that are co-designed and validated by the end-users, otherwise we run the risk of developing robots that will fail to gain acceptance and adoption.

Links:

[L1] www.andy-project.eu
[L3] www.codyco.eu
[L2] www.saphari.eu/
[L4] https://kwz.me/htK

References:

[1] P. Maurice, et al: "Ethical and Social Considerations for the introduction of Human-Centered Technologies at Work", IEEE ARSO, 2018.
[2] A. Malaisé, et al: "Activity recognition with multiple wearable sensors for industrial applications", in Proc. 11th Int. Conf. on Advances in Computer-Human Interactions (ACHI), 2018.
[3] O. Dermy, F. Charpillet, S. Ivaldi: "Multi-modal Intention Prediction with Probabilistic Movement Primitives", in: F. Ficuciello, F. Ruggiero, A. Finzi A. (eds) "Human Friendly Robotics", Springer Proc. in Advanced Robotics, vol 7. Springer, 2019.
[4] I. Gaudiello et al.: "Trust as indicator of robot functional and social acceptance. An experimental study on user conformation to the iCub's answers", Computers in Human Behavior, vol. 61, pp. 633-655, 2016.

Please contact:

Serena Ivaldi
Inria, France
+33 (0)354958475
serena.ivaldi@inria.fr
https://members.loria.fr/SIvaldi/

LIHLITH: Improving Communication Skills of Robots through Lifelong Learning

by Eneko Agirre (UPV/EHU), Sarah Marchand (Synapse Développement), Sophie Rosset (LIMSI), Anselmo Peñas (UNED) and Mark Cieliebak (ZHAW)

Dialogue systems are a crucial component when robots have to interact with humans in natural language. In order to improve these interactions over time, the system needs to be able to learn from its experience, its mistakes and the user's feedback. This process – fittingly called lifelong learning – is the focus of LIHLITH, an EU project funded by CHIST-ERA.

Artificial Intelligence is a field that is progressing rapidly in many areas, including dialogues with machines and robots. Examples include speaking to a gadget to request simple tasks like turning on the radio or asking for the weather, but also more complex settings where the machine calls a restaurant to make a reservation [L1], or where a robot assists customers in a shop. LIHLITH [L2] is a project focusing on human-machine dialogues. It aims to improve the self-learning capabilities of an artificial intelligence. More specifically, LIHLITH will devise dialogue systems which learn to improve themselves based on their interactions with humans.

LIHLITH ("Learning to Interact with Humans by Lifelong Interaction with Humans") is a three-year high risk / high impact project funded by CHIST-ERA [L3] that started in January 2018. Participating partners (Figure 1) are researchers from University of the Basque Country (UPV/EHU), Computer Science Laboratory for Mechanics and Engineering Sciences (LIMSI), Universidad Nacional de Educación a Distancia in Spain (UNED), Zurich University of Applied Sciences (ZHAW), and Synapse Développement in France.

Current industrial chatbots are based on rules which need to be hand-crafted carefully for each domain of application. Alternatively, systems based on machine learning use manually annotated data from the domain to train the dialogue system. In both cases, producing rules or training data for each dialogue domain is very time consuming, and limits the quality and widespread adoption of chatbots. In addition, companies need to monitor the performance of the dialogue system after being deployed, and re-engineer it to respond to user needs. Throughout the project, LIHLITH will explore the paradigm of life-long learning in human-machine dialogue systems with the aim of improving their quality, lowering the cost of maintenance, and reducing efforts for deployment in new domains.

Main goal: continuous improvement of dialogue systems

The main goal of life-long learning systems [1] is to continue to learn after being deployed. In the case of LIHLITH, the dialogue system will be developed as usual, but it will include machinery to continue to improve its capabilities based on its interaction with users. The key idea is that dialogues will be designed to get feedback from users, while the system will be designed to learn from this continuous feedback. This will allow the system to keep improving during its lifetime, quickly adapting to domain shifts that occur after deployment.

LIHLITH will focus on goal-driven question-answering dialogues, where the user has an information need and the system will try to satisfy this need as it chats with the user. The project has been structured in three research areas: lifelong learning for dialogue; lifelong learning for knowledge induction and question answering; and evaluation of dialogue improvement. All modules will be designed to learn from available feedback using deep learning techniques.

The goal regarding lifelong learning for dialogue will be to obtain a method to produce a dialogue management module that learns from previous dialogues. The project will explore autonomous reconfiguration of dialogue strategies based on user feedback. We will also give proactive capabilities to the system, which will be used to ask the user for new knowledge and for performance feedback. This will be triggered, for instance, when the past reactions have been rejected, when the user interaction is too ambiguous, when the possible answers are too numerous, or if they have too similar confidence scores.

Regarding knowledge induction and question answering, the goal is to improve the domain knowledge, which includes the representation of utter-

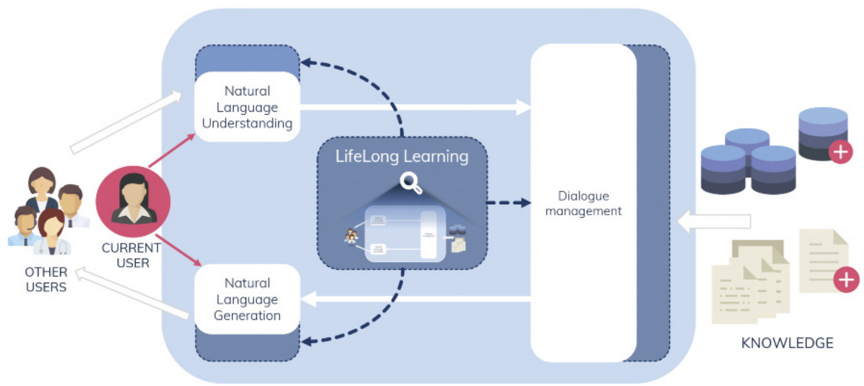


Figure 1: Schema of a standard dialogue system in white boxes. The innovative lifelong learning module is able to improve all modules (in blue) based on past interactions and the interaction with the current user, updating the domain knowledge accordingly.

ances and the question answering performance based on the dialogue feedback obtained by the dialogue management module. The representation of utterances and knowledge base will be based on low-dimensional representations. The question answering system will leverage both the information in background texts and domain ontologies. The feedback will be used to provide supervised signal in these learning systems, and thus tune the parameters of the underlying deep learning systems.

Evaluation of dialogue systems is still challenging, with reproducibility and comparability issues. LIHLITH will produce benchmarks for lifelong learning in dialogue systems, which will be applied in an international shared task to explore capabilities of existing solutions. In addition, the research in LIHLITH will be transferred to the industrial dialogue system of Synapse.

To carry out this research, LIHLITH combines machine learning, knowledge representation and linguistic expertise. The project will build on recent advances in a number of research disciplines, including natural language processing, deep learning, knowledge induction, reinforcement learning and dialogue evaluation, to explore their applicability to lifelong learning.

Links:
[L1] https://kwz.me/htg
[L] http://ixa2.si.ehu.es/lihlith/
[L3] http://www.chistera.eu/

Reference:
[1] Z. Chen and B. Liu. Lifelong Machine Learning. Morgan Clayton. 2016

Please contact:
Eneko Agirre
University of the Basque Country (UPV/EHU), Spain
e.agirre@ehu.eus

Contextualised Conversational Systems

by Alexander Schindler and Sven Schlarb (AIT Austrian Institute of Technolog)

Conversational systems allow us to interact with computational and robotic systems. Such approaches are often deliberately limited to the context of a given task. We apply audio analysis to either broaden or to adaptively set this context based on identified surrounding acoustic scenes or events.

Research on conversational systems dates back to the 1950s when a chatbot called ELIZA was intended to emulate a psycho-therapist. These early systems were generally based on pattern matching where input text messages are mapped to a predefined dictionary of keywords. Using associated response rules, these keywords are mapped to response templates which are used to create the system's answer. While pattern matching is still one of the most used technologies in chatbots, dialog systems extensively harness advances from research fields which are now associated with the domain of artificial intelligence – in particular, natural language processing tasks such as sentence detection, part of speech tagging, named entity recognition and intent recognition. In these tasks, new approaches based on deep neural networks have shown outstanding improvements. Additional advances in speech recognition systems brought conversational systems into our homes and daily lives with virtual personal assistants such as Amazon Echo, Google Home, Microsoft Cortana and Apple Homepod.

Although these systems are highly optimised to excel as a product, their degree of complexity is limited to simple patterns of user commands. The components of such systems often include: speech recognition (speech to text), natural language processing (NLP), including the sub-tasks part-of-speech detection (PoS), named entity recognition (NER) and recognition of intent, as well as components for dialog management, answer generation and vocalisation (text to speech). Based on the identified intents and involved entities, the dialog manager decides, commonly based on a set of rules, which actions to take (e.g., query for information, execute a task) and uses templates to generate the answer. Recent systems use recurrent neural networks (RNN) to generate sequences of words embedded into a statistical representation of words generated from a large corpus of related question answer pairs. Most state-of-the-art approaches and products are restricted to the context of the intended use-case and the user needs to learn and use a limited vocabulary with a predefined syntax.

Beyond voice commands

To enable a system to interact with its environment – especially in human robot interaction (HRI) for the purposes of entertainment, teaching, comfort and assistance – reacting to voice commands is not sufficient. Conversational commands are frequently related to environmental events and the execution of tasks may depend on environmental states. Thus, we research combined multi-modal approaches to conversational systems where we add audio analysis to the language processing stack.

We analyse the surrounding acoustic scene to add this information as context to the conversational system. We apply a custom neural network architecture using parallel stacks of Convolutional Neural Network (CNN) layers which captures timbral and rhythmic patterns and adapts well to small datasets [1]. These models were developed and evaluated in the context of the annual evaluation campaign Detection and Classification of Acoustic Scenes and Events (DCASE). By identifying acoustic scenes such as Home, Office, Kitchen, Bathroom or Restaurant, the semantic scope of the conversational system can be adaptively reduced to the environmental context. Additionally we apply audio event detection to identify acoustic events such as our task leading contribution to domestic audio tagging (DCASE 2016) to identify acoustic events such as child or adult/male/

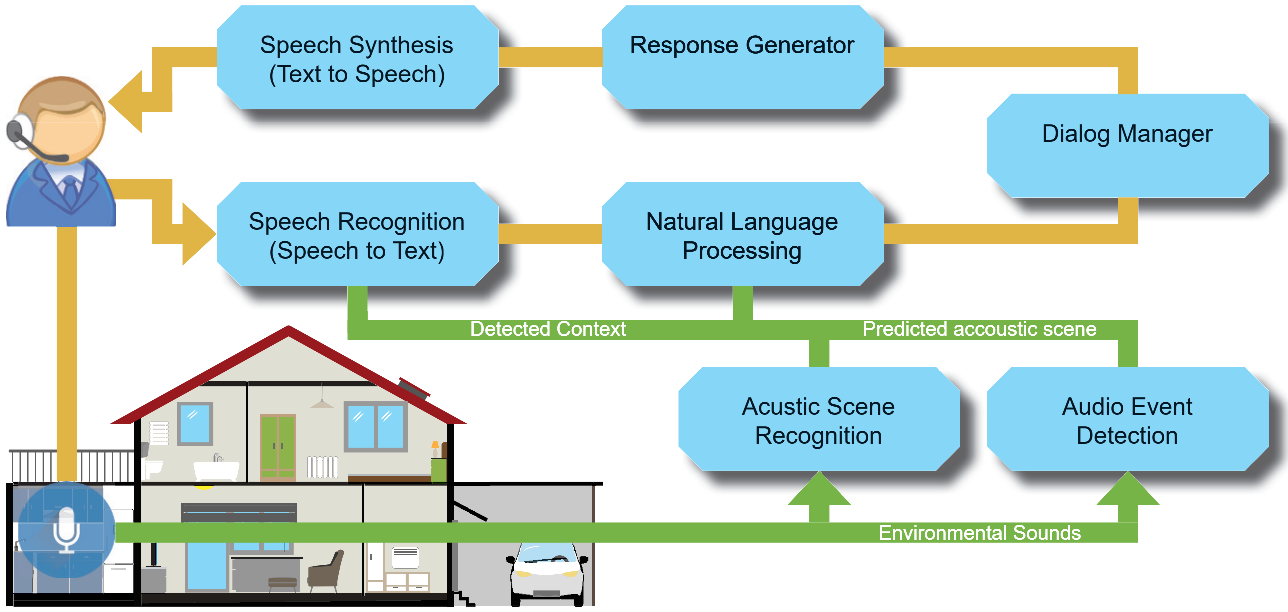


Figure 1: Illustration of the processing pipeline. Predictions of domestic soundscapes and acoustic events are added as contextual information to the conversational workflow. This context directly influences the models for speech recognition and the semantic interpretation of recognized words.

female speech, percussive sound (e.g., knock, footsteps) but also Page Turning to assess the presence of individuals.

This research was successfully applied in cultural heritage projects Europeana Sounds [L1] as well as the security related projects FLORIDA [L2], VICTORIA [L3] to identify acoustic events such as gunshots or explosions. Our work on natural language processing will be applied and extended in the upcoming security related project COPKIT (H2020). For future work we intend to further extend the range of contexts to our other research tasks such as identifying environmental acoustic events [2] or emotion expressed by music or speakers [3]. Finally we intend to extend this approach to include further modalities based on our experience in audio-visual analytics [4] to provide even more contextual input.

Links:
[L1] http://www.eusounds.eu/
[L2] http://www.florida-project.de/
[L3] https://www.victoria-project.eu/

References:

[1] A. Schindler, T. Lidy and A. Rauber: “Multi-Temporal Resolution Convolutional Neural Networks for Acoustic Scene Classification”, in Proc. of DCASE 2017, 2017.
[2] B. Fazekas, et al: “A multi-modal deep neural network approach to bird-song identification”, LifeCLEF 2017 working notes, Dublin, Ireland
[3] T. Lidy and A. Schindler: “Parallel convolutional neural networks for music genre and mood classification”, Technical report, MIREX 2016, 2016.
[4] A. Schindler and A. Rauber: “Harnessing Music related Visual Stereotypes for Music Information Retrieval”, ACM Transactions on Intelligent Systems and Technology (TIST) 8.2 (2016): 20.

Please contact:

Alexander Schindler
AIT Austrian Institute of Technology
alexander.schindler@ait.ac.at

Sven Schlarb
AIT Austrian Institute of Technology
sven.schlarb@ait.ac.at

Multi-Modal Interfaces for Human–Robot Communication in Collaborative Assembly

by Gergely Horváth, Csaba Kardos, Zsolt Kemény, András Kovács, Balázs E. Pataki and József Váncza (MTA SZTAKI)

Human–Robot Collaboration (HRC) in production—especially in assembly— offers, on one hand, flexibility and a solution for maintaining competitiveness. On the other hand, there are still numerous challenges that have to be answered to allow the realization of HRC. Beyond the essential problems of safety, the efficient sharing of work and workspace between human and robot requires new interfaces for communication as well. As a part of the SYMBIO-TIC H2020 project, a dynamic context-aware and bi-directional, multi-modal communication system is introduced and implemented for supporting human operators in collaborative assembly.

The main goal of the SYMBIO-TIC H2020 project is to provide a safe, dynamic, intuitive and cost effective working environment, hosting immersive and symbiotic collaboration between human workers and robots [L1]. In such a dynamic environment, a key to boosting the efficiency of human workers is supporting them with context-dependent work instructions, delivered via communication modalities that suit the actual context. Workers, in turn, should be able to control the robot or other components of the production system by using the most convenient modality, thus lifting the limitations of traditional interfaces such as push buttons installed at fixed locations. As part of the SYMIBIO-TIC project, we are developing a system that addresses these needs.

Context-awareness in human-robot collaboration

To harness the flexibility of an HRC production environment, it is essential that the worker assistance system delivers information to the human worker that suits the actual context of production. In order to gather the information describing the context, data related to both the worker (individual properties, location, activity) and to the process under execution is required. This information is provided to the worker assistance system by three connected systems, which together form the HRC ecosystem, namely (1) the workcell-level task execution and control (unit controller, UC), (2) the shopfloor-level scheduling (cockpit), and (3) the mobile worker identification (MWI) systems [1].

The process execution context is defined by the state of the task execution in the UC. The identification and location of the worker by the MWI is essential in order to trigger the worker assistance system and to properly utilise the devices around the worker. Actions of the worker have to be captured either directly by devices available to the worker, or the sensors deployed in the

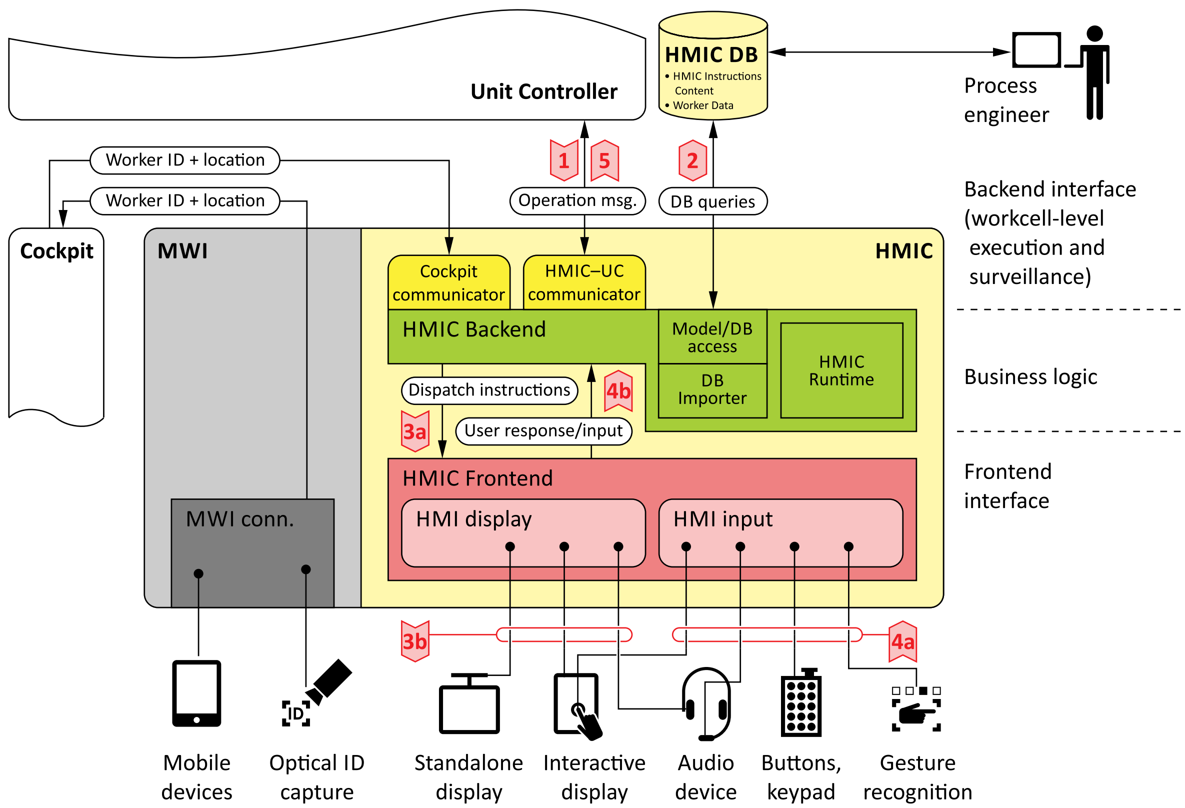


Figure 1. Schematic architecture of the HMIC implementation and its immediate environment in the production system.

workcell, registering the worker's activity context. The properties of the worker, such as skills or preferences of instruction delivery, define the final format of the instructions delivered.

Automatically generated work instructions

The complexity of managing work instructions in production environments characterised by shortening product life cycles and increasing product variety, as well as the requirement to fully exploit the available context data in customised instructions, calls for the automated generation of human work instructions. A method for this, relying on a feature-based representation of the assembly process [2], computer-aided process planning (CAPP) techniques, and a hierarchical template for the instructions, has been proposed in [3]. The method generates textual work instructions (with potential audio interpretation using text-to-speech tools) and X3D animations of the process tailored to the skill level and the language preferences of the individual worker. The presentation of the instruction can be further customised in real time by the instruction delivery system: e.g., the selection of the modality and the device, as well as the font size and the sound volume, can be adjusted according to the current context.

Multi-modal communication

Traditionally, worker assistance is provided by visual media, mostly in the form of text or images. The currently prevailing digital assistance systems hence focus on delivering visual instructions to the workers. However, in a HRC setting, it is also necessary to provide bi-directional interfaces that allow the workers to control the robots and other equipment participating in the production process.

The worker assistance system that we have developed is designed to deliver various forms of visual work instructions, such as text, images, static and animated 3D content and videos. Audio instructions are also supported: by using text-to-speech software, the textual instructions can be transformed as well. Instruction delivery is implemented as an HTML5 webpage, which supports embedding multi-media content and also allows multiple devices to be used for both visual and audio content, such as smartphones, AR-glasses, computer screens, or tablets.

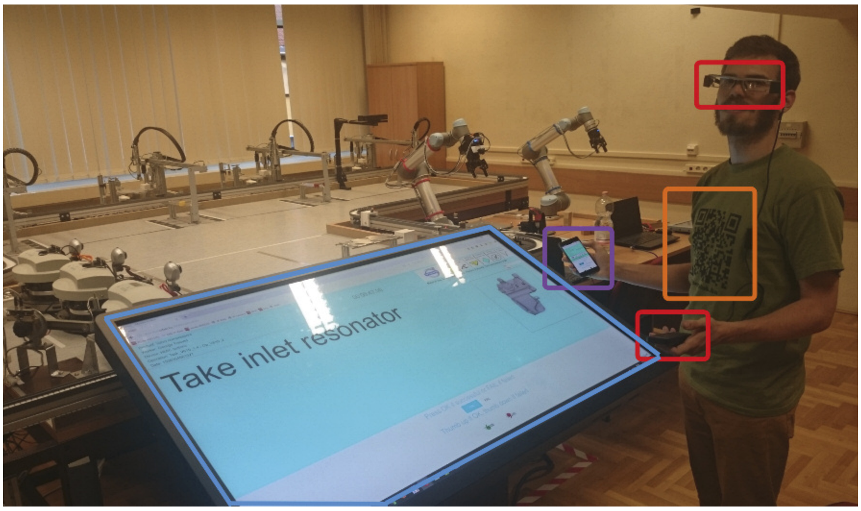


Figure 2. Demonstration of an automotive assembly case study using the HMIC system. The devices available for the user are a large touchscreen, a smartphone and an AR-glass.

Our web-based solution for input interfaces provide the classic button-like input channels, which are still required in most industrial scenarios. Potentially promising contactless technologies are also integrated into the system. Interpreting audio commands shows great potential as it is not only contactless, but also hands-free. However, in a noisy industrial environment, it could be challenging and therefore the application of two hand gesture-based technologies is also supported, one using point-cloud data registered by depth cameras and the other using a special interpreter glove that measures the relative displacement of the hand and fingers.

Implementation and use case

A complete server–client-based solution for the human–machine interface system was implemented in accordance with the aforementioned requirements and technologies. The system is named Human Machine Interface Controller (HMIC). Figure 1 shows its major structure (backend/frontend design) and its connections to other elements of the ecosystem. The implemented HMIC system was successfully demonstrated in the laboratory simulation of an automotive assembly use case, where 29 parts were assembled in 19 tasks (see Figure 2). The research project is now in its closing phase, where the focus is on the development of demonstrator case studies and the evaluation of the perceived work experience with the use of the generated content and the multi-modal content delivery system.

This research has been supported by the EU H2020 Grant SYMBIO-TIC No. 637107 and by the GINOP-2.3.2-15-2016-00002 grant on an "Industry 4.0 research and innovation center of excellence".

Link:
[L1] http://www.symbio-tic.eu

References:
[1] Cs. Kardos, et al.: "Context-dependent multimodal communication in human–robot collaboration", 51st CIRP International Conference on Manufacturing Systems, 2018.
[2] Cs. Kardos, A. Kovács, J. Váncza: "Decomposition approach to optimal feature-based assembly planning", CIRP Annals – Manufacturing Technology, 66(1):417-420, 2017.
[3] Cs. Kardos, A. Kovács, A.; B.E. Pataki, J. Váncza: "Generating human work instructions from assembly plans", 2nd ICAPS Workshop on User Interfaces and Scheduling and Planning (UISP2018), 2018.

Please contact:
Csaba Kardos
MTA SZTAKI: Institute for Computer Science and Control, Hungarian Academy of Sciences
+ 36 1 279 6189
csaba.kardos@sztaki.mta.hu

Wholistic Human Robot Simulation for Efficient Planning of HRC Workstations

by Marcus Kaiser (IMK-Automotive)

The planning of assembly workplaces with direct human-robot collaboration (HRC) is a complex task owing to the variety of target criteria that must be considered. The lack of a digital simulation tool for the wholistic planning and safeguarding of HRC-scenarios, as well as a lack of adequate training and qualification concepts for companies, are currently inhibiting the implementation of HRC. We are developing a new way to digitally design collaborative assembly systems to help companies embrace HRC systems.

In the context of globalisation, manufacturing companies face new challenges. A growing diversity of variants of industrial components, shorter product life cycles and fluctuating demands require versatile production systems in order to secure the competitiveness of companies in high-wage countries in the future. Cost-effective assembly is an important lever for economic efficiency. Since investment-intensive and sometimes inflexible fully automated solutions are often limited in their ability to enhance productivity and efficiency, the topic of human-robot collaboration (H RC) is becoming increasingly important. The aim is to combine the strengths of the human (flexibility, intuition, creativity) with those of the robot (strength, endurance, speed, precision) to use resources efficiently and thus to increase productivity.

Previous implementations of HRC have failed to take full advantage of the potential for humans and robots to cooperate, owing partly to the complexity of the processes to be planned and partly to a lack of suitable methods and tools [1]. Simulation tools make it possible to visualise complex issues in advance and make them plausible, for example, in terms of feasibility, accessibility and space requirements without the use of costly prototypes. Various systems already exist in the market, which focus either on the simulation of manual workstations with digital human models or on the simulation of automated workplaces with partly manufacturer-specific robotic libraries. A few systems support the prototypical usage of a human model in simulation software for robotic systems for individual tasks. In order to meet the requirements for a wholistic HRC simulation for the various fields of activity of assembly, a combination of both simulation systems is necessary – but this is not supported by available software solutions [2].

The goal of the collaborative research project KoMPI [L1] is to develop a new method for the integrated planning and implementation of collaborative workplace systems in assembly with different product scenarios. This essentially comprises three components shown in Figure 1. The main part is the development of a wholistic, digital planning tool. On the basis of a potential analysis of the work system carried out in advance, the automation, technical and economic suitability, ergonomics and safety can be simulated and evaluated. The second component comprises developing a concept for the participation and qualification of the involved employees in order to integrate them early in the planning process and thus to ensure their acceptance. The third component is the implementation of HRC application scenarios for the respective partners to use and the associated validation of the planning tool.

The main task of the development of the performance-based, digital tool is the integration of human model and robot simulation systems. The human behaviour simulation is done using the software Editor of Manual Work Activities (called “ema”) [L2] developed by imk automotive GmbH. It is a wholistic planning method based on a digital human model, which autonomously executes work instructions based on MTM-UAS. An interface between ema and the open source software framework Robot Operating System (ROS) will enable ema to simulate robots, sensors and their environment with the help of a wide range of drivers [3].

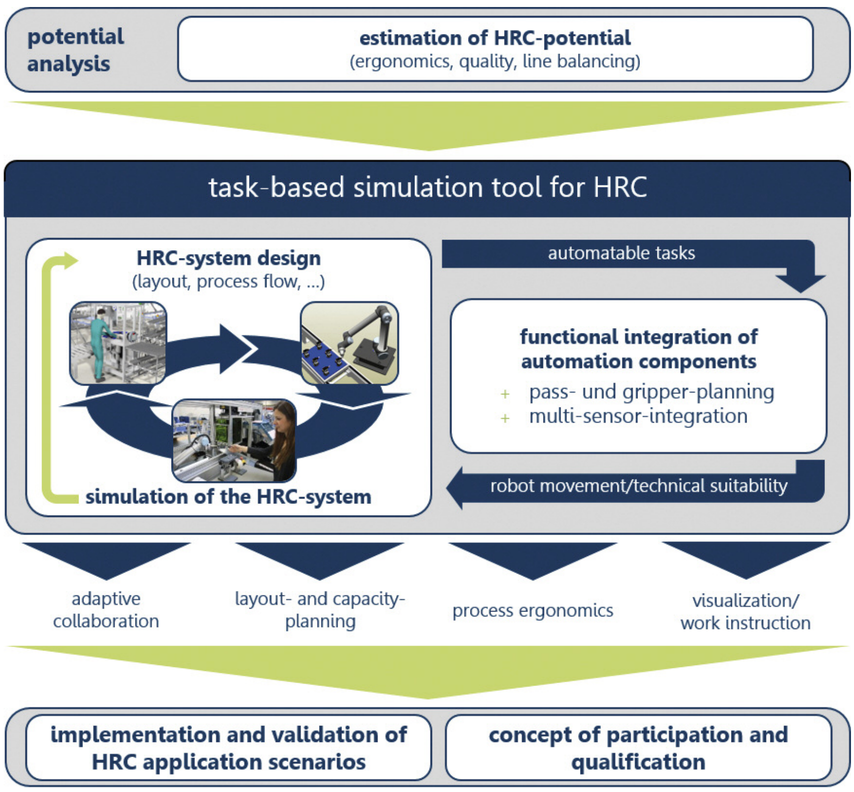


Figure 1: Three stage implementation procedure of the proposed HRC system.

The software called ema, enhanced with appropriate functionalities, will form the basis of a system that will help with the wholistic planning of HRC workplaces. In addition to the functions for the human model, parametrisable tasks for automation components are developed, which allow a flexible allocation of work tasks between human and robot. In addition to the libraries for human models, robots, sensors and environment objects, a grasp library is also implemented in order to make a statement about the feasibility of the automation tasks. The interface to ROS also enables collision-free path planning, taking into account human movements and the entire environment [4]. The design and safety guidelines of ISO TS 15066 are also taken into account. Including all HRC operating modes (safety-rated monitored stop, hand guiding, speed and separation monitoring, power and force limiting), a sensor library and the logical link to objects, taking the corresponding safety distances into account, allowing the creation of a safety concept. For example, the output of collision and contact forces as well as the maximum valid speed limits of the robot support the planner in the risk assessment. In order to meet the requirements of the planning task, decisive information on the economic, ergonomic and safe operation of a HRC system can be generated before implementation.

The research and development project "KoMPI" is funded by the German Federal Ministry of Education and Research (BMBF) within the Framework Concept "Research for Tomorrow's Product ion" (fund number 02P15A060).

Links:
[L1] www.kompi.org
[L2] www.imk-ema.com

References:
[1] W. Bauer et al.: "Leichtbauroboter in der manuellen Montage- einfach einfach anfangen", Stuttgart: Fraunhofer IAO.
[2] P. Glogowski et al.: "Task-based Simulation Tool for Human-Robot Collaboration within Assembly Systems", in Tagungsband des Kongresses Montage Handhabung Industrieroboter, Springer Vieweg, 2017.
[3] M. Quigley, B. Gerkey, W. Smart: "Programming Robots with ROS", O'Reilly Media.
[4] K. Lemmerz et al: "Functional Integration of a Robotics Software Framework into a Human Simulation System", in ISR 2018.

Please contact:
Alfred Hypki
Ruhr-Universität Bochum, Germany
+49 234 32 26304
hypki@lps.rub.de

A Cognitive Architecture for Autonomous Assistive Robots

by Amedeo Cesta, Gabriella Cortellessa, Andrea Orlandini and Alessandro Umbrico (ISTI-CNR)

Effective human-robot interaction in real-world environments requires robotic agents to be endowed with advanced cognitive features and more flexible behaviours with respect to classical robot programming approach. Artificial intelligence can play a key role enabling suitable reasoning abilities and adaptable solutions. This article presents a reseach initiative that pursues a hybrid control approach by integrating semantic technologies with automated planning and execution techniques. The main objective is to allow a generic assistive robotic agent (for elderly people) to dynamically infer knowledge about the status of a user and the environment, and provide personalised supporting actions accordingly.

Recent advances in robotic technologies are fostering new opportunities for robotic applications. Robots are entering working and living environments, sharing space and tasks with humans. The co-presence of humans and robots in increasingly common situations poses new research challenges related to different fields, paving the way for multidisciplinary research initiatives. On the one hand, a higher level of safety, reliability, robustness and flexibility is required for robots interacting with humans in environments typically designed for them. On the other hand, a robot must be able to interact with humans at different levels, i.e., behaving in a "human-compliant way" (social behaviours) and collaborating with humans to carry out tasks with shared goals.

Artificial intelligence (AI) techniques play an important role in such contexts providing suitable methods to support tighter and more flexible interactions between robot and humans. In this very wide area, there are several research trends, including social robots, assistive robots and human-robot collaboration, which focus on the co-presence and non-trivial interactions of robots and humans by taking into account different perspectives and objectives.

The Planning and Scheduling Technology (PST) Laboratory [L1] at the CNR Institute for Cognitive Science and Technologies (ISTC-CNR), has considerable know-how on this important research topic. The group has worked on several successful research projects that represented good opportunities to investigate innovative AI-based techniques for a flexible and safe human-robot interaction. Specifically, two research projects warrant a mention: (i) GiraffPlus [1, L2] is a research project (2012-2014) aimed at the development of innovative services for long-term and continuous monitoring of senior people using sensor networks, intelligent software and a telepresence robot (the Giraff robot). PST developed novel techniques to provide personalised healthcare services through the system to support seniors with different needs directly in their home. (ii) FourByThree [2, L3] is a recently ended H2020 research project [2014-2017] whose aim was to develop novel software and hardware solutions (from low

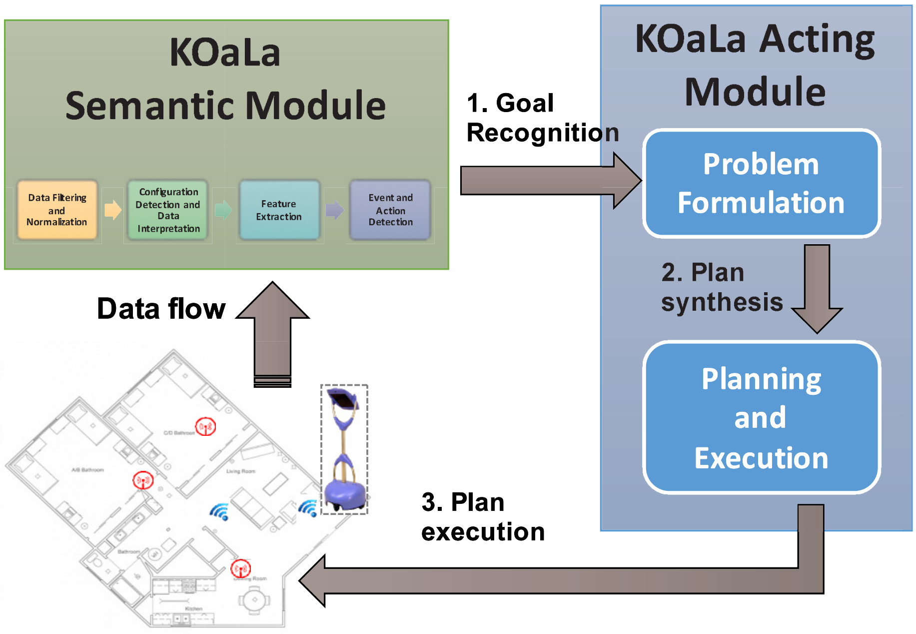


Figure 1: The KOaLa control approach.

level contro to multi-modal interaction) for safe human-robot collaboration in manufacturing scenarios. In this project, the PST group developed and successfully applied a planning and execution framework called PLATINUm [3] for coordinating collaborative assembly processes between a lightweight robot and a human worker in a fence-less robotic cell.

Building on top of such experience, PST-ers started a research initiative called KOaLa (Knowledge-based cOntinuous Loop) to enhance the capabilities and the autonomy of an assistive robot, such as the Giraff robot. Targeting the GiraffPlus scenarios, a sensor network monitors the activities inside a senior's house and provides a continuous flow of data about both environmental features and some physiological parameters of a person that the carers would like to monitor. Such a rich set of data can be used to detect the activities a person is performing or the events occurring inside the house. KOaLa aims to make use of semantic technologies and Web Ontology Language (OWL) to endow an assistive robot with the cognitive capabilities needed to reason on the available data. Semantic technologies allow an assistive robot to build an internal abstraction of the environment which can be dynamically analysed to understand what is happening inside the house and make decisions accordingly.

Figure 1 depicts the KOaLa approach. It proposes a cognitive architecture capable of integrating two types of knowledge inside a unified hybrid control process: (i) knowledge about the environment and the events or activities that can be recognised; (ii) knowledge about the functional capabilities of a robot that determine the actions a robot can perform inside the considered environment. The envisaged hybrid control approach integrates knowledge reasoning, automated planning and execution technologies to allow a robot to autonomously analyse the environment and proactively execute actions. Specifically, the semantic module is in charge of interpreting sensor data and processing the resulting information to infer knowledge about the environment. It leverages a dedicated ontology (the KOaLa ontology) which defines a clear semantics for data coming from the environment. The KOaLa ontology is defined by evolving the standard Semantic Sensor Network ontology (SSN) and the foundational DOLCE Ultra Light ontology (DUL). The acting module is in charge of synthesising and executing the robot actions to achieve a desired caring objective. A goal triggering process puts the semantic module in contact with the acting module operating as a background process which continuously analyses the knowledge about the environment in order to recognize relevant situations requiring a proactive execution of tasks (i.e., implementing goals that respond to specific user needs) by the Giraff robot.

The key point of KOaLa is the integration of heterogeneous AI techniques within a unified monitoring and control process. The pursued tight integration of these AI techniques provides a robot with the cognitive capabilities needed to generate knowledge from sensing functions and reason on such knowledge to make decisions and dynamically adapt its behaviours.

Links:
[L1] http://www.istc.cnr.it/it/group/pst
[L2] http://www.giraffplus.eu/
[L3] http://fourbythree.eu/

References:

[1] Coradeschi et al.: "GiraffPlus: Combining social interaction and long term monitoring for promoting independent living", 6th International Conference on Human System Interactions (HSI), Sopot, 2013, pp. 578-585, 2013 doi: 10.1109/HSI.2013.6577883

[2] I. Maurtua et al.: "FourByThree: Imagine humans and robots working hand in hand", IEEE 21st International Conference on Emerging Technologies and Factory Automation (ETFA), Berlin, pp. , 2016,. doi: 10.1109/ETFA.2016.7733583

[3] A. Umbrico et al.: "PLATINUm: A New Framework for Planning and Acting", in: F. Esposito et al. (eds) AI*IA 2017 Advances in Artificial Intelligence. , AI*IA 2017. Springer LNCS, vol 1064, 2017.

Please contact:

Amedeo Cesta, ISTC-CNR, Italy
amedeo.cesta@istc.cnr.it

An Interview Robot for Collecting Patient Data in a Hospital

by Koen V. Hindriks (Delft University of Technology), Roel Boumans (Delft University of Technology and Radboud university medical center), Fokke van Meulen (Radboud university medical center), Mark Neerincx (Delft University of Technology), Marcel Olde Rikkert (Radboud university medical center)

We are designing a social robot to collect patient data in hospitals by interviewing patients. This task is crucial for improving and providing value-based care. Currently, professional caretakers administer self-reported outcome questionnaires called patient reported outcome measures (PROMs) to collect this data. By delegating this task to a robot, time spent on administration is significantly reduced.

Social robots are finding applications in many domains but are particularly interesting for addressing healthcare related problems [1]. We are researching and developing a social robot as an interview robot for administering PROMs [2]. The Radboud university medical center (Radboudumc) Alzheimer Center [L1] and Delft University of Technology Interactive Intelligence Group [L2] have joined forces, combining their expertise on patient measures and providing value-based aged care with complementary expertise on social interaction between robots with patients. The design of the robot is evaluated in the actual care setting where patients are treated at the Radboudumc.

The quality of health care has significantly increased over recent decades as evidenced by the increase in average life expectancy and the high quality of life of elderly people today. Value-based healthcare has been vital in shifting the focus from the medical interventions performed to the value, i.e., the quality of life, that is delivered. Patient reported outcome measures (PROMs) have been crucial for assessing the quality of life of patients, supporting physicians and nurses in delivering personalised healthcare, and institutions in monitoring the effectiveness and efficiency of their services. However, in practice, the administration of PROMs requires considerable effort on the part of healthcare professionals and thus puts a large burden on the healthcare system. Efforts to have patients fill out paper questionnaires or use tablets have not worked well and in practice also require assistance from caretakers. We are evaluating the hypothesis that a social humanoid robot that interacts using voice will be able to autonomously, reliably, and comfortably provide more fitting support to help patients complete PROMs.

Figure 1: Using the Pepper as interview robot, self-reported patient outcomes can be collected autonomously, reliably, and efficiently at the Vlietland hospital. Source: RTV Rijnmond.

Autonomous here means that the robot is capable of administering questionnaires without any intervention or support from a caretaker. Reliable data collection means that the answers the robot collects from patients match those that would have been collected by a caretaker. Comfort, or more broadly acceptance, means that the robot is easy to use and patients feel comfortable while being interviewed by it. A user-centred methodology called situated cognitive engineering has been used to design our interview robot, taking into account both human factors and operational demands. Our approach moreover has been informed by the current social practices in the hospital. Our aim is to provide a context that is as natural as possible and provides a setting that is as realistic as possible for deployment of the robot. In the scenario we designed, a healthcare professional receives patients, introduces, and performs a handover to the robot.

Our focus in the design of the robot has been on integrating various dialogue components for asking PROM questions, asking for confirmation, allowing patients flexibility by skipping questions that do not apply to them, and by integrating a patient-initiated explanation component in case patients need help with a question. The robot welcomes patients by name and explains the interview procedure. The questions asked by the robot are also displayed on the robot's tablet, and the robot repeats a question if too much time passes before an answer is received. Because reliability is essential, the robot recorded answers are replayed and also displayed on the tablet for confirmation. Explanations are based on advice and experience of professional caretakers. Upon completion, the robot sends the answers to the caretaker by mail. Variation in the dialogue (e.g., for introducing the next question) has been achieved by including minor variations to avoid the dialogue from becoming monotone.

We evaluated the first prototype of our interview robot with participants aged 70+. Patients were interviewed in a hospital examination room twice: once by the robot and once by a nurse. A counterbalanced design to control for order effects was used and the interviews were scheduled with two-week intervals in between. After completion of the robot interviews the nurse returned and performed a post-interview with the patient, to obtain insight into acceptance of the robot. We found that bias of the interview robot compared with the nurse was low using Bland-Altman plots and reliability overall was acceptable. The robot takes longer to administer a PROM but efficiency is acceptable too. Overall, patients indicated that they felt comfortable interacting with the robot but also that there is room for improvement.

Key next steps are to improve the robot's responsiveness, for example, to additional clarifications that patients share voluntarily. We aim to extend dialogue capabilities to allow for such digressions. Another limitation of the robot is that it is not sensitive to emotional responses of patients who are being questioned about their quality of life. We plan to add emotion detection capabilities to improve the robot's handling of these situations. It will be very challenging to get this completely right though, thus a key issue will be how we can make the robot aware of its limitations in these situations and provide it with the capability to handover to a caretaker.

Links:
[L1] https://kwz.me/hty
[L2] https://kwz.me/htH

References:

[1] J. Broekens, et al.: "Assistive social robots in elderly care: a review", Gerontechnology 8:2, 94–103. 2009.
[2] C.B. Forrest: "Digitization of patient reported outcomes", Value Health, 16:4, 459–460, 2013.

Please contact:

Koen Hindriks
TU Delft, The Netherlands
+31 15 2782523
k.v.hindriks@tudelft.nl

ComBox – a Multimodal HRI Strategy for Assistive Robots

by Eleni Efthimiou and Stavroula-Evita Fotinea (Athena RC)

ComBox incorporates a multimodal user-centred intelligent human-robot interaction (HRI) framework that uses different technologies and user modalities to create à-la-carte HRI solutions. Appropriate HRI approaches are likely to encourage user trust and acceptance of assistive robotic devices.

ComBox is a methodological framework for developing multimodal human-machine interaction environments. It is being developed in the framework of multimodal interaction and robotics research at ILSP/Athena RC, and introduces a customable suite of user-centred HCI/HRI tools, enabling interaction via text, haptic, avatar and voice technology. Assistive robotics provides a major integration framework for ComBox, since the latter proposes an innovative model of user-centred human-machine interaction exploiting a set of modules that can be embedded to different product/service platforms in order to address different accessibility abilities and preferences [1]. Research on ComBox development is crucially directed by the growing geriatric population needs and the associated increased demands for managed healthcare in developed societies, conditions which are driving research in a range of domains, combining assistive robotics, the internet of things (IoT) and smart environments for the elderly.

In this context, human-like interaction has been identified as a critical factor for user acceptance and user trust of robotic devices. To serve the ComBox spectrum of interaction goals, we have been focusing on developing an intelligent multimodal dialogue management system, which is currently under development, that incorporates speech input/output technologies, sensorial data of behavioural patterns and affect features on conversational agent performance, enabling a closer to natural human-machine interaction adaptable to specific use contexts. Thus, ComBox advances the current state of the art in HRI, incorporating in its design cognitive support mechanisms and affect features, in combination with human behavioural patterns, to create more human-like interactions.

ComBox builds upon many years' experience in building advanced accessible Human-Computer Interaction (HCI) environments and significant effort gathering and annotating multimodal interaction data of elderly subjects in order to develop human-like HRI models, which have been positively validated by targeted user groups in real use environments, as in the case of the MOBOT [L1] rollator end-user evaluation [2]. Assistive robotic device evaluation/validation studies with the targeted user groups reveal a strong tendency for users to accept devices with human-like behavioural characteristics. Such characteristics are highly regarded, increasing user trust and willingness to use robotic products. Direct measurable benefits derived from regular device use include: better rehabilitation, reinforcement effects, socialisation support, help with daily activities and an increased ability to live independently. This happens because the aged user feels sup-

Figure 1: User navigating interaction during MOBOT rollator evaluation.

Figure 2: User audio-gestural interaction during MOBOT rollator evaluation.

ported in executing everyday tasks, receiving information or being reinforced while interacting with the robotic device in a manner resembling human communication.

Our long term vision is to provide highly naturalistic à-la-carte interaction solutions adaptable to the wide spectrum of assistive robotics and smart environments. ComBox provides a user-centred intelligent interaction framework that enables à-la-carte interaction solutions, exploiting different technologies and user modalities [3] – characteristics that frequently appear in wish lists but are absent from the majority of solutions that reach the market.

Market research and user evaluation measures reveal that, at this stage, few solutions integrate limited sign language features to support deaf accessibility worldwide, and even voice- and gesture- based communication is rarely found in devices addressing aging and/or rehabilitation.

The components of the ComBox tool suite for human-like HRI have been designed based on input from corpus research on multimodal human communication in various contexts, while several tools addressing different modalities of interaction and user group communication needs have undergone extensive end-user evaluation as independent modules in collaboration with the IRAL group at SECE-NTUA and DIAPLASIS rehabilitation centre.

The short-term goal of ComBox is to offer a multimodal dialogue management system which builds multimodal human-machine dialogues exploiting communication via text, speech and gesture for transmission of system messages and acquisition of user feedback, incorporating avatar technology for information presentation in suitable contexts (i.e., user psychological support via reinforcement or affect-rich messages, sign language messages, etc). GUIs entail screen design based on personalised accessibility facilities to cover different interaction needs.

The long term goal is to offer advanced user-centred HCI/HRI solutions suitable for mounting to various devices/services in the context of AAL, IoT and the Smart City, directing research towards integrated interaction solutions which opt to address seniors with mobility/cognitive impairments and other pathologies, their carers and specialised health professionals.

Link:
[L1]: http://www.mobot-project.eu/

References:

[1] M. Turk: "Multimodal interaction: A review", Pattern Recognition Letters, 36:189–195, 2014. DOI: 10.1016/j.patrec.2013.07.003

[2] Y. Koumpouros et al.: "User Evaluation of the MOBOT rollator type robotic mobility assistive device", Technologies, 5, 73, 2017; DOI:10.3390/technologies5040073 2.

[3] L. Garçon et al.: "Medical and Assistive Health Technology: Meeting the Needs of Aging Populations". Gerontologist, 56: 293–302, 2016.

Please contact:

Eleni Efthimiou, Athena RC, Greece
+302106875356, eleni_e@ilsp.gr

Social Cognition in Human-Robot Interaction: Putting the 'H' back in 'HRI'

by Elef Schellen, Jairo Pérez-Osorio and Agnieszka Wykowska (Istituto Italiano di Tecnologia)

The Social Cognition in Human-Robot Interaction (S4HRI) research line at the Istituto Italiano di Tecnologia (IIT) applies methods from experimental psychology and cognitive neuroscience to human-robot interaction studies. With this approach, we maintain excellent experimental control, without losing ecological validity and generalisability, and thus we can provide reliable results informing about robot design that best evokes mechanisms of social cognition in the human interaction partner.

A major goal in the field of Human-Robot Interaction (HRI) is determining the factors required for social attunement between a human and a robot agent. When socially attuned with others, humans employ specialised cognitive mechanisms leading to effective communication and cooperation. Eliciting attunement in interaction with artificial agents (robots, in this case) will therefore allow these mechanisms to be brought to bear on HRI, improving cooperation between humans and robots.

At present, HRI research gives more weight to external validity; introducing a robotic system into its intended environment (or a close approximation thereof), and relying on questionnaires and task efficiency as outcome variables. This approach is valuable in that it provides practical insights that aid the further development of a system; though, it seldom sheds light on the underlying neuro-cognitive mechanisms of the human during interaction with a robot [1].

The S4HRI research line emphasises the fundamental neuro-cognitive mechanisms (often implicit or automatic) that humans use to ensure efficient social interaction. These mechanisms include, for example, joint attention, where two agents attend to the same object or event in environment, or spatial perspective taking, where one represents space from the point of view of their interaction partner. The presence of mechanisms such as these contribute to a generalised attitude or stance that people take on when interacting with (artificial) agents. People can take on a stance toward another agent in which they assume that this agent has certain intentions, and use this to predict the agent's actions. This is known as the intentional stance [2], and is generally how humans interact with each other. We are interested in finding out whether taking on this attitude towards a robot will make interacting with it more natural and efficient.

One current line of research that is illustrative of our goals and methods examines predictive processing of robot's eye movements in the context of action expectations. For this series of studies, we designed an interactive protocol with the iCub [3] robot (Figure 1) by modifying an established experimental paradigm in cognitive psychology [4]. Similarly to previous findings [4], we observed that people engaged in joint attention with iCub by following its gaze. However, the level of engagement depended on whether iCub's behaviour confirmed participants' expectations or violated them (i.e., iCub either looked at an object that it was expected to manip-

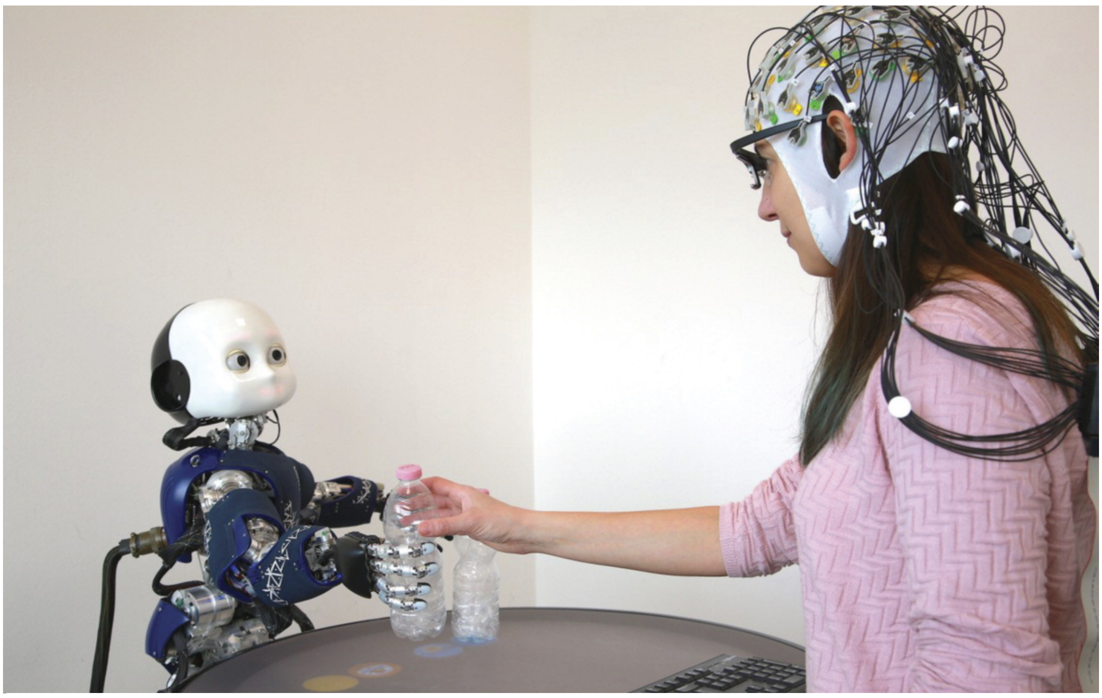


Figure 1. An example experimental setup where a participant is involved in an interaction with the humanoid robot iCub [3], while neuro-cognitive mechanisms are measured through performance data, as well as eye tracking and EEG.

ulate, or looked at an unexpected object). This example study serves as a proof of concept that well-established paradigms in experimental psychology can be implemented in more naturalistic HRI scenarios, while still maintaining excellent experimental control. In follow-up studies we will examine how violation of expectations, as well as other subtle behavioural characteristics of the robot, influence the adoption of intentional stance towards iCub.

S4HRI's research goes beyond just focusing on the behavioural parameters involved in HRI. With the aid of tools like electroencephalography (EEG) and eye-tracking, we are further able to investigate neuro-cognitive processes during HRI. We are currently using EEG to investigate the neural mechanisms underlying adoption of intentional stance as well as the engagement in joint attention with iCub. The methodology employed in the S4HRI research line emphasises high internal validity, creating highly controlled experiments designed to prevent from potential confounding factors that could otherwise influence the results. By using this approach, we can target and isolate very specific mechanisms that are relatively foundational in their role in social cognition, and that have a ripple effect for more complex social interaction. Consequently, fundamental findings resulting from our research can be used to inform practical design of future robotic systems.

To conclude, we highlight that despite the rapidly changing nature of the field, and the constant pushing the envelope in terms of technology, studying fundamental mechanisms of human information processing remains essential. We aim to provide insights into the fundamentals of social cognition as it pertains to robots, and with these results provide designers of future robotic systems with a solid understanding of the mechanisms of human information processing. This is applicable not only in social robotics but also in current industrial applications, with the rise of industrial robots that use social cues to communicate efficiently and intuitively with users.

The S4HRI research line [L1] is partially funded by the ERC starting grant "Intentional Stance for Social Attunement" (InStance), Grant Agreement No. ERC-2016-STG-715058, awarded to Agnieszka Wykowska [L2], and hosted at the Istituto Italiano di Tecnologia (IIT, Genova, Italy) [L3]. In order to meet the challenges of the interdisciplinary aims of the research line, we are collaborating closely with the iCub facility at IIT [L4].

Links:
[L1] https://kwz.me/htp
[L2] https://instanceproject.eu
[L3] https://www.iit.it
[L4] https://www.iit.it/research/lines/icub

References:
[1] Kachouie et al.: "Socially Assistive Robots in Elderly Care: A Mixed-Method Systematic Literature Review", International Journal of Human–Computer Interaction, 2014
[2] D.C. Dennett: "True believers: the intentional strategy and why it works", in: O'Connor, T., Robb, D. (Eds.) Philosophy of Mind: Contemporary Readings (Routledge, London) pp. 370-390, 2003.
[3] Metta et al.: "The iCub humanoid robot: An open-systems platform for research in cognitive development", Neural Networks, 2010.
[4] Perez-Osorio et al.: "Expectations regarding action sequences modulate electrophysiological correlates of the gaze-cueing effect", Psychophysiology, 2017.

Please contact:
Agnieszka Wykowska
Istituto Italiano di Tecnologia
+39 010 8172 242
agnieszka.wykowska@iit.it
https://www.iit.it/people/agnieszka-wykowska

Robots with Social Intelligence

by Vanessa Evers (University of Twente)

Since 2011, The Human Media Interaction Group at the University of Twente has been working on robots with social intelligence. This has led to the development of robots that can recognise human behaviour, interpret this behaviour and respond in a socially appropriate way. We have developed robots that can be used as guides at zoos or airports, and helping children with autism in understanding emotional expressions in faces.

Work started with the European FP7 project FROG [L1], the Fun Robotic Outdoor Guide. The FROG robot was an instantiation of a robot service in outdoor public places. We envisioned robotic information or other services in outdoor public places such as city squares, car parks at shopping malls and airports and leisure areas such as parks and zoos. The FROG robot was developed specifically to offer augmented reality information in places such as zoos or cultural heritage sites such as the Royal Alcazar in Seville, Spain.

FROG had to approach small groups of visitors, enquire whether they were interested in information or a short tour of the premises and would take the group along, offering them information along the way. To do this effectively, FROG tracked the visitors and their facial expressions and determined their interest. To show augmented reality information it had to autonomously navigate and position itself very precisely so that the augmented reality content would overlay the camera image of the scene behind the robot. When FROG detected people losing interest, it would change the type of information or the type of locations covered by the route.

In many iterations and real-world observation studies, we found the robot was able to capture people's interest accurately and offer them an interactive experience of the location that added to their experience. FROG was particularly effective for families with small children who were not the target audience for the tours given by professional guides. Of course the novelty of a large robot autonomously navigating a crowded a public place caused disruption. While FROG was able to navigate challenging environments like banquet chairs and guests everywhere, people wanted to take selfies with the robot and would "test" the robot by not allowing it to pass where it wanted to guide people. While the robot would adjust the route, the robot's tour group got frustrated at times because people outside their tour would hinder the robot. When people make use of a robot service they see the robot as "theirs" during that time.

A similar trend was observed in the SPENCER EU H2020 project [L2]. SPENCER was developed to guide airport passengers around the airside gate areas of Schiphol. The robot had to approach a group of people, engage them and take them to their newly assigned gate or other important location. While the robot had the technical ability to accurately track the people in the group it was guiding, know when to wait for a person and navigate the airport in a socially normative way (going around queues and families rather cut through), the robot was constantly stopped by other passengers for selfies or people would try to distract the robot, or prevent it from reaching its goal – to the frustration of the guided group. One participant in a test-run reported that he was happy when the robot seemed to ignore a person and kept going, acting like it was "their" robot.

Vanessa Evers at the University of Twente in the Netherlands, with a robot. Picture: Kees Bennema (http://www.bennema.nl/).

We are currently developing robots that have to analyse, understand and interact with children in a social context. The SQUIRREL EU H2020 project [L3] concerns a robot playing with small groups of children and engaging them in a game that leads to sorting and tidying the environment. The robot analyses clutter in the environment, plans a way to clean it up and invents a multi-player game to achieve this. As the children engage in the game, SQUIRREL analyses their collaborative play and adjusts the game to optimise pro-social activities and teamwork between the children.

In the DE-ENIGMA project [L4], a robot assists a therapist in teaching young children with autism emotion recognition skills. The target group of children are aged between four and eight years and are far on the spectrum of autism, which means that they are not high functioning and very young. This is a challenging group for therapists and very individual in nature, therefore a one size fits all solution is out of the question. The DE-ENIGMA robot functions as an intermediate between the therapist and the child. It has the capability to display intricate facial expressions and unlike a person, it can very systematically move and show isolated dynamic facial movements such as an eyebrow raise. This facilitates the child's learning process. Also, the DE-ENIGMA robot analyses the facial expressions of the children, it can minutely track facial features and through machine learning recognise the facial expressions in emotions. Therefore, the robot provides very detailed feedback over time to the therapist about how the children's use of their own facial expressions develops over time and where exercise may be needed.

The DE-ENIGMA project is a strong example of a robot enhancing current work-practices. Therapists are able to administer interventions in ways that they could not have done before. The robotic intervention allows them to reach a target group which was difficult to reach and it allows them to tailor their therapy to the individual. The novelty effect observed in the other robot applications seems to have limited impact here. The children are intrigued by the robot but see it as a game, a toy or a tool and relate to it accordingly, the novelty does not cause a break down in the flow as is the case for the robot in more public places.

As robot services become more common, we expect the unique value contributed by a robot intervention to be optimised. When robots are able to understand the social aspects of an environment and respond to people in a socially appropriate manner, only then can we hope to integrate robot services seamlessly in our everyday lives.

Links:
[L1] https://www.frogrobot.eu
[L2] http://www.spencer.eu/
[L3] http://www.squirrel-project.eu/
[L4] http://de-enigma.eu/

Please contact:
Vanessa Evers
University of Twente, The Netherlands
v.evers@utwente.nl

Time-informed Human-Robot Interaction: Combining Time, Emotions, Skills and Task Ordering

by Parmenion Mokios and Michail Maniadakis (ICS-FORTH)

Synergetic performance within human-robot teams might be significantly enhanced by consideration of the temporal aspects of multi-agent interaction. For a number of years, FORTH has been equipping robots with human-like artificial time perception thus contributing a unique robotic cognitive skill that drastically improves fluency in human-robot interaction (HRI). We present an overview of the relevant technologies, which are constantly being improved and tested in naturalistic multi-agent scenarios.

Most biological organisms possess an innate sense of time. For several decades, a sense of time was missing from contemporary robotic systems, and this had clear negative impacts on their integration into human environments.

Through the EU-funded TimeStorm and EnTiment projects, FORTH has systematically investigated the strong coupling of time and mind, emphasising both the implementation of human-like artificial time perception and the implementation of time-aware robotic cognition. Along this line, we have developed technology that enables robots to effectively perceive the three main temporal views that living organisms – and particularly humans – develop of the world, namely, the past [1], the present [2] and the future [3]. Relevant experiments demonstrate that the developed technology significantly supports symbiotic HRI that assumes the long-term, timely and fluent cooperation of humans and robots.

The prioritisation of jobs and their attribution to the most appropriate agents (humans and robots) may significantly improve multi-agent HRI in naturalistic setups. To this end, HRI systems should ideally consider and exploit:
- the emotional state of humans that is known to drastically affect their perception of time and thus the temporal aspects of their personal satisfaction criteria,
- the skills that each agent brings into the team, further analysed into the time requested by a human or robot to implement a job and the quality of the underlying job implementation,
- the ordering of tasks in association to the actual progress accomplished by each agent.

The newly introduced Daisy Planner can effectively address the above issues, effectively guiding and coordinating multi-agent activities. For example, in setups assuming several humans being served by a single robot, the planner exploits information about the emotional state of the individual humans in order to estimate the pace of their subjective time perception (i.e., fast or slow flow of time) and thus be able to effectively balance between the time pressure of humans and the expected completion time of the requested tasks. Following this approach, it is possible to prioritise human requests in a way

Figure 1: Human-robot interaction in prioritised meal serving.

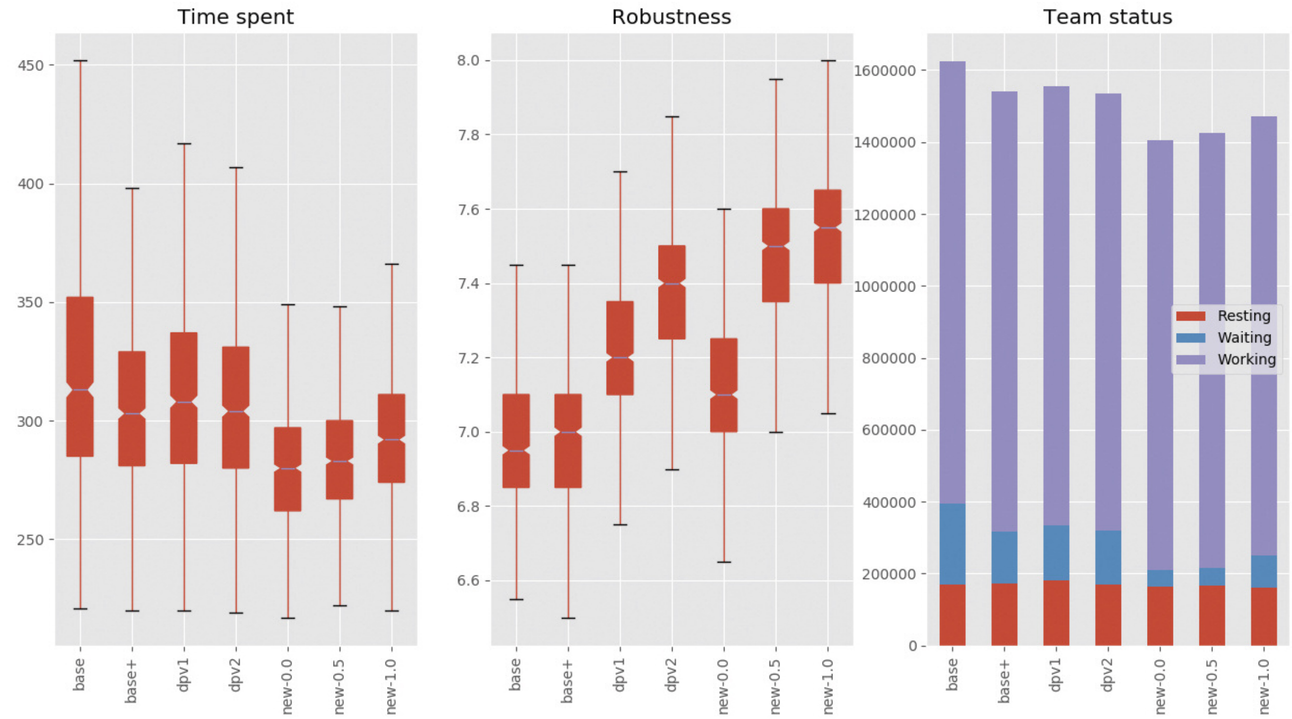


Figure 2: Daisy Planner-driven multi-agent collaboration based on different optimality criteria. The employed methods (from left to right) prioritise fully unconstrained tasks, promote the attribution of tasks with the fewest constraints, consider agent-task matching i.e., time + implementation quality, consider team benefit i.e., time + implementation quality, contrasts expected and maximum task value with emphasis on time, contrasts expected and maximum task value equally balancing between time and implementation quality, contrasts expected and maximum task value with emphasis on implementation quality.

that improves the composite level of satisfaction for the whole group of interacting humans. More specifically, the system guides the robot to prioritise service to individuals at high arousal state (i.e., those who are having trouble waiting) given that the completion time of their request is not very long, providing lower priority to people in a low arousal state (i.e., people who would tolerate a short delay).

Interestingly, in unstructured real-world environments the occurrence of unexpected events may temporally disturb multi-agent collaboration (e.g., while cooking, the baby may cry, or the phone may ring). In such cases, it is very practical to adopt a progressive, short-term planning of the composite behaviour, in line with the pragmatic unfolding of task execution. Following this approach, the Daisy Planner attributes tasks to the available agents, effectively guiding them towards the incremental accomplishment of the composite goal. The attribution of tasks to agents assumes a multi-criteria optimised local matching of agents and tasks, in order to effectively exploit the heterogeneous skills of the individual agents for the benefit of the team. A key issue in fluent human-robot interaction is the synchronicity of agents and their delegation to tasks which help other team members reduce their idle times.

We have examined various formulations of the same Daisy Planner using alternative time-informed multi-criteria measures to coordinate the activities of heterogeneous agents. As shown in Figure 2, the relevant measures can effectively balance between minimising the implementation time of the composite behaviour, improving the quality of task implementation and minimising the idle time of participating agents.

In order to accomplish the long-term goal of human-machine confluence, it is imperative that temporal aspects of human-robot interaction are investigated. FORTH will continue to systematically explore the temporal, short- and long-term aspects of symbiotic HRI, targeting the seamless integration of robots into the heavily time structured human society.

References:

[1] M. Sigalas, M. Maniadakis, and P. Trahanias, 2017. Episodic memory formulation and its application in long-term HRI, 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN 2017).

[2] E. Hourdakis and P. Trahanias, 2018. A robust method to predict temporal aspects of actions by observation. International Conference on Robotics Automation, (ICRA 2018).

[3] M. Maniadakis, E. Hourdakis, and P. Trahanias, 2016. Time-informed task planning in multi-agent collaboration. Cognitive Systems Research (2016).

Please contact:

Michail Maniadakis
ICS-FORTH, Greece
mmaniada@ics.forth.gr

Human-Robot Social Interactions: The Role of Social Norms

by Patrizia Ribino and Carmelo Lodato (ICAR-CNR)

Human interactions are fundamentally based on normative principles. Particularly in social contexts, human behaviours are affected by social norms. Individuals expect certain behaviours from other people, who are perceived to have an obligation to act according to the expected behaviour. Giving robots the ability to interact with humans, on human terms, is an open challenge. People are more willing to accept robotic systems in daily life when the robots engage in socially desirable behaviours with benevolent interaction styles. Furthermore, allowing robots to reason in social situations, which involve a set of social norms generating expectations, may improve the dynamics of human-robot interactions and the self-evaluation processes of robot's behaviours.

Human-robot social interactions play an essential role in extending the use of robots in daily life. It is widely discussed that, to be social, robots need the ability to engage in interactions with humans based on the same principles as humans do. Cognitive and social sciences assess that human interactions are fundamentally based on normative principles. Most human interactions are influenced by deep social and cultural standards, known as social norms [1]. Social norms are behavioural expressions of abstract social values (e.g., politeness and honesty) that underlie the preferences of a community. Social norms guide human behaviours and generate expectations of compliance that are considered to be legitimate. An open challenge is how to incorporate norm processing into robotic architectures [2].

At the Cognitive Robotics and Social SensingLab at ICAR-CNR [L1], we are working on a normative reasoning approach that takes advantage of goal-orientation, using high-level abstractions to implement appropriate algorithms that allow social robots to proactively reason about dynamic normative situations. A tuple of mental concepts is the grounding of our normative reasoning, such as the state of the world, goals, capabilities, qualitative goals, social norms, and expectations. In particular, a state of the world represents conditions or set of circumstances in which a robot operates at a specific time. A goal describes a desired state of affairs a robot wants to achieve. Capabilities are abstract descriptions about abilities of a robot that can be used to reach its objectives. A qualitative goal is a goal for which satisfaction criteria are not defined in a clear-cut way. It allows us to model the pursuit of a social value that cannot be described in terms of a clear condition to be reached. A social robot continuously performs actions that give positive contributions to sustaining that social value. The actions to be performed are prescribed by the social norms. They are defined using desirability operators that represent preferences about acceptable behaviours. Let us consider a society where politeness is considered a social value to be pursed, then the norm "it is desirable that a guy gives up his seat if an elderly person is standing up" prescribes an acceptable behaviour within the community. Finally, the Expectations are motivators for pursuing social values. Just like a human, a robot may comply with a social norm in the presence of relevant expectations, but it may decide not to follow the norm in the absence of such expectations, thus reviewing its beliefs.

Figure 1 shows the architectural schema we implemented for incorporating norm reasoning into a robotic framework. The conceptual layer is responsible for manifesting a uniform way of representing the mental concepts that are the basis for the reasoning process. It uses AgentSpeak, a powerful programming language for building rational agents based on the belief-desire-intention paradigm.

The logical layer provides high-level decision making based on declarative knowledge coming from the conceptual level. It consists of a set of components for normative reasoning, goal deliberation and means-end reasoning implemented in Jason. Its outcome is a declarative representation of tasks a robot has to perform to fulfil the deliberated goal according to the context it is operating.

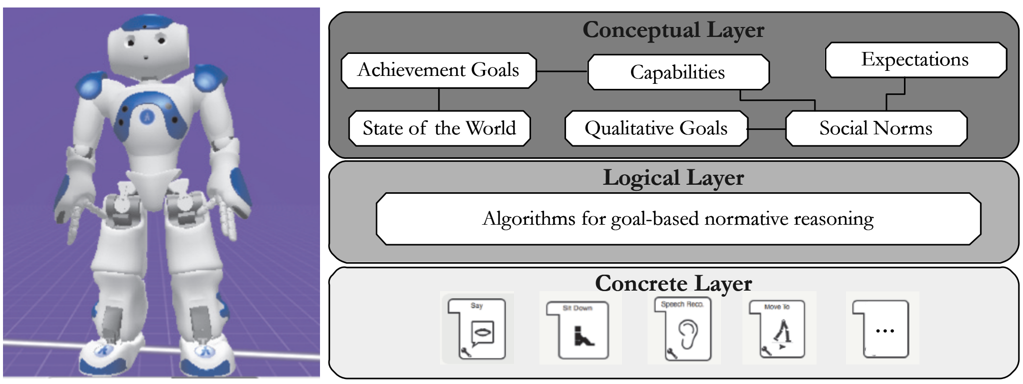
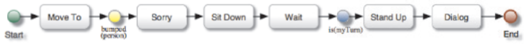


Figure 1: Architectural schema for incorporating norm reasoning into robotic framework.

Initial Behaviour

Execution

```
Task: Move to postal office
Unexpected Event: bumped(person)
Applicable norm: norm(position(_),state(be_social), state(sorry),condition(
    bumped(person)),type(desirable))
Update Behaviour:
```




```
Task: Say Sorry
Unexpected Event: said(person,"Not at all")
Task: Sit Down
Unexpected Event: is(person,old)
Applicable norm: norm(position(_),state(be_social), state(standup),condition(
    and([is(person,old),state(sitting)])),type(desirable))
Update Behaviour:
```


```
Task: Stand up
Unexpected Event: said(person,"Thanks")
Task: Wait
Expected Event: is(MyTurn)
Task: Dialog
```

Figure 2: The robot dynamically assumes the most suitable behaviour according to different social situations performing the actions prescribed by social norms.

Finally, the concrete layer provides the procedural knowledge for performing declarative tasks coming from the upper level. It consists of a set of Python modules that implement concrete tasks a robot may perform.

Figure 2 shows a scenario that involves social norms. A robot is committed to taking a packet at a post office. It knows that it is desirable to offer a polite greeting when s(he) meets someone (N1), to say “I’m sorry” if it bumps into someone (N2) and to be kind to the elderly, giving up own seat (N3). The first workflow in Figure 2 represents the initial behaviour orchestrated by the robot for reaching its goal. At the post office, it bumps into someone, an event that triggers the norm N2. Thus the robot changes its planned behaviour by performing the task for apologising. Then, when it arrives at the post office, it sees a free chair, and sits down. A senior arrives at the postal office. The robot changes its plan by following the norm N3.

Our approach allows robots to dynamically assume the most suitable behaviour according to different social situations by changing the generated plan by introducing/deleting desirable/undesirable actions prescribed by social norms.

Link:
[L1] https://kwz.me/htr

References:

[1] C.Bicchieri and R. Muldoon: “Social norms”, in Edward N. Zalta, (ed.), The Stanford Encyclopedia of Philosophy. Metaphysics Research Lab, Stanford University, spring 2014 ed., 2014.

[2] B. F Malle, M. Scheutz, and J. L Austerweil: “Networks of social and moral norms in human and robot agents”, in A world with robots, pages 3–17, 2017.

Please contact:

Patrizia Ribino, ICAR-CNR, Italy
+39 091 8031069
patrizia.ribino@icar.cnr.it

Conferences related to the theme “Human-Robot Interaction”

IEEE Int. Conference on Robotics and its Social Impact (ARSO 2018)
Genova, Italy, September 27th-28th, 2018
ARSO is a single track workshop to discuss advanced robotics R&D and its implications to economic and social systems, ARSO 2018 will focus in particular on the impact of AI and AI empowered autonomous systems.
http://www.arso2018.eu/

Collaborative Robotics and Ergonomics Workshop – held during International Ergonomics Association Conference (IEA 2018)
Florence, Italy – August 26th, 2018
This workshop gathers researchers and industrials from the different domains related to occupational health, wearable motion and force measurement, ergonomic and musculoskeletal modeling, and assistive robotics.
http://crews.loria.fr/

ACM/IEEE International Conference on Human-Robot Interaction (HRI 2019)
Daegu, South Korea, March 11-14, 2019,
The HRI conference is a highly selective annual international conference that aims to showcase the very best interdisciplinary and multidisciplinary research in human-robot interaction. The theme of HRI 2019 is “Collaborative HRI”.
http://humanrobotinteraction.org/2019/

IEEE Int. Conference on Robotics and Automation (ICRA 2019)
Montreal, Canada, May 20-24, 2019
ICRA is the flagship conference of the IEEE Robotics and Automation Society and will bring together the world’s top researchers and most important companies to share ideas and advances in field of robotics and automation. The role of industry-centered activities will be a critical aspect of the conference.
https://www.icra2019.org/

synERGY: Detecting Advanced Attacks Across Multiple Layers of Cyber-Physical Systems

by Florian Skopik, Markus Wurzenberger and Roman Fiedler (AIT Austrian Institute of Technology)

Today's security solutions usually address only single architectural layers, and are unable to take account of the full picture. This leads to a system operator having only a limited view regarding the root cause of a cyberattack, which can reduce the overall availability of cyber-physical systems (CPS). Particularly for complex and stealthy multi-stage attacks, an approach is required that correlates information from all CPS layers, including the field area, the SCADA backend, the enterprise IT and the WAN (in the case of large-scale CPS) to promptly react to emerging malicious activities.

The degree of sophistication of modern cyber-attacks has increased in recent years, and in the future these attacks will increasingly target cyber-physical systems (CPS). Unfortunately, today's security solutions that are used for enterprise IT infrastructures are not sufficient to protect CPS, which have largely different properties, involve heterogeneous technologies, and have an architecture that is very much shaped to specific physical processes. Furthermore, many best practice security techniques clash with the stringent safety requirements in CPS [1], e.g., weekly software updates might be acceptable in an enterprise IT environment, but certainly not in a safety-critical environment with certified equipment. The chances of unwanted side-effects are enormous. As a consequence, detective security techniques must be applied to CPS [2], which rely upon the ability to detect attacks in a timely and accurate manner.

Therefore, the objective of the project synERGY is to develop new methods, tools and processes for cross-layer anomaly detection (AD) to enable the early discovery of both cyber- and physical-attacks, which will have an impact on the security of CPS. To achieve this, synERGY develops a novel behaviour-based anomaly detection approach that leverages machine learning to understand a system's normal behaviour by investigating network flows as well as events on endpoints reflected in log data, and detect consequences of security issues as deviations from the norm. While common anomaly detection concepts usually fail for enterprise environments, because of their complex behavioural patterns, these approaches are very promising for CPS that have a rather deterministic behaviour. The solution proposed by synERGY flexibly adapts itself to specific CPS layers (e.g., automatically applies more sensitive behaviour deviation thresholds to more deterministic system areas, and is less strict for other parts), thus improving its detection capabilities. Moreover, synERGY interfaces with various organisational data sources, such as asset databases, configuration management, and risk data (the latter is especially of interest for flexible monitoring of the most threatened components).

The aim is to facilitate the semi-automatic interpretation of detected anomalies, which can help to reduce false positives and increase the utility of the system to an operator. The synERGY approach is evaluated in real smart grid vendor environments – a societally important CPS [3]. As a "by-product" of this evaluation, we plan to make raw CPS data sets available (in compliance with synERGY's data management plan) to other research groups working on new anomaly detection methods. Because of the modular approach taken in the project, we propose that the synERGY results will be readily applicable to a wide range of CPS in value networks, and will thus result in broader impact on future CPS security solutions.

synERGY Technical Objectives

The main technical research goal of synERGY is to develop a novel anomaly detection system – based on cross-layer monitoring from embedded field devices to enterprise IT – which can be applied to a wide range of CPS operating in different application domains. The abstract concept with its four focus areas (FA) is depicted in Figure 1. This means that synERGY offers the ability to adapt the monitoring layer to specific CPS environments predefined by the combination of ICT infrastructure and physical/industrial processes of an organisation (FA I). Eventually, synERGY should have the capability to detect a priori unspecified errors, anomalies and misuse (for which no predefined signatures exist), e.g., potential consequences of security incidents, with more accuracy than existing products (FA II). Furthermore, synERGY supports the analysis and interpretation of detected anomalies using end-user specific organisational context, information from existing security mechanisms, such as firewalls, antivirus programs, IDSs, etc. and open/external information about threat intelligence, provided by mailing lists, vulnerability databases and online platforms (FA III). This is vital to assess a given security situation quicker and – in course of the organisational security processes (FA IV) – enable CPS providers to deploy counter measures earlier than with today's solutions.

The Project synERGY and its Consortium

In order to attain these ambitious goals and finally ensure the wide applicability of developed tools and procedures, the project consortium consists of a vital mix of academics with deep knowledge in cyber security (Austrian Institute of Technology, TU Wien, Universitaet Klagenfurt) and security solution vendors from the industry (Huemer iT-Solutions). In addition to the development of scientific methods, the proper demonstration of the applicability of synERGY's results in a real-world environment is of paramount importance in order to test and evaluate the planned system. Thus, two electrical utility providers are involved as end users (Linz AG, Energie AG). Furthermore, the involvement of economic experts (MOOSMOAR Energies) and national stakeholders (Ministry of Defence) is essential to account for vital non-technical aspects and ensure the later adoption of synERGY in real application environments. synERGY is a 30-month national research project running from 2017 to 2019 and is funded by the Austrian FFG Research Program "ICT of the Future".

Link:
https://synergy.ait.ac.at/

References:

[1] S.K. Khaitan and J.D.McCalley: "Design Techniques and Applications of Cyberphysical Systems: A Survey", in Systems Journal, IEEE , vol.9, no.2, pp.350-365, June 2015.
[2] R. Mitchell and I.R. Chen: "A survey of intrusion detection techniques for cyberphysical systems". ACM Comput. Surv. 46, 4, Article 55, 2014.
[3] F. Skopik and P. Smith: "Smart Grid Security – Innovative Solutions for a Modernized Grid", Elsevier Science Publishing, 2015, ISBN: 978-0-12-802122-4.

Please contact:

Florian Skopik, AIT Austrian Institute of Technology, Center for Digital Safety & Security, Austria
+43 664 8251495, florian.skopik@ait.ac.at

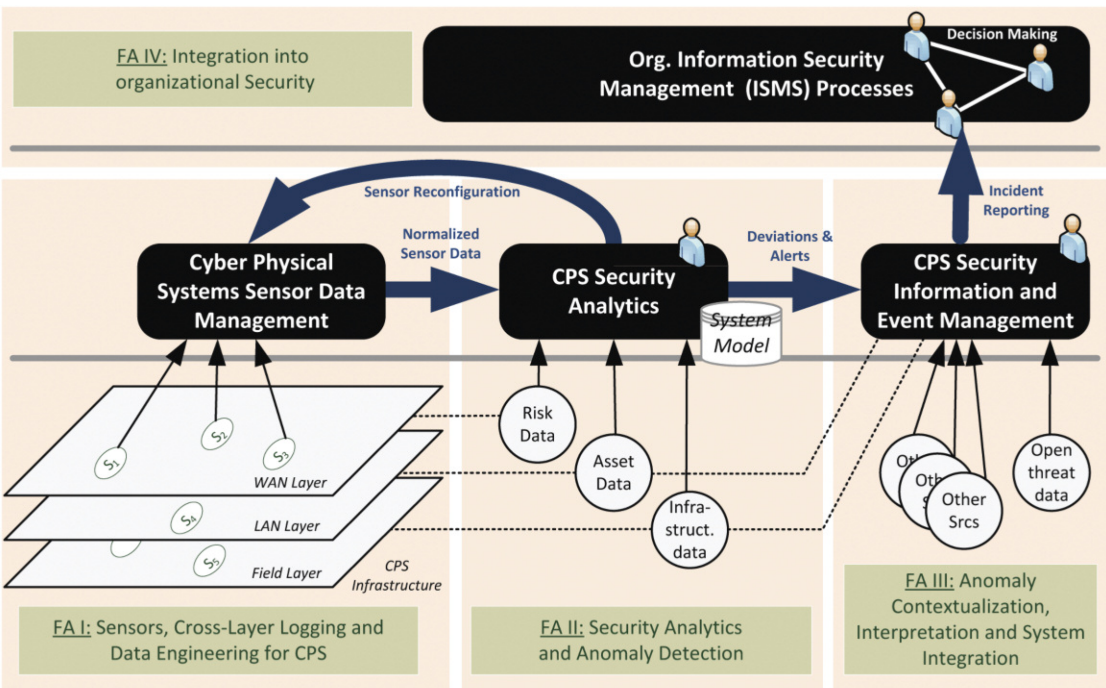


Figure 1: The synERGY concept and four main focus areas (FA).

Secure and Robust Multi-Cloud Storage for the Public Sector

byThomas Lorünser (AIT Austrian Institute of Technology) Eva Munoz and (ETRA Investigación y Desarrollo) and Marco Decandia Brocca (Lombardia Informatica)

Distributing trust among many different players is a common approach in security. In the case of storage, many protocols are known for secure fragmentation of data, however, relatively little research has addressed the aspects relevant for real deployment in cloud based systems, i.e., how to satisfy the underlying trust assumption.

In this work we report findings encountered during the design and deployment of multi-cloud storage solutions based on secure fragmentation (secret sharing) and solutions developed within the project PRISMACLOUD [1]. It was interesting to see that major inhibitors for adoption were not the technical barriers, but human factors.

Nowadays cloud storage can be considered a commodity product. Thanks to de-facto industry standards like S3 (Amazon Simple Storage Interface) and SWIFT (Open Stack Storage) provider lock-in is no longer a problem and a prosperous market is developing. Although the cloud storage service level agreement (SLA) offered by cloud service providers (CSP) differ in many details, consumers already have access to a large and diverse cloud storage market which opens up many new opportunities for IT operators, from small to large enterprises. The natural next step would be to combine the offerings into intercloud and multi-cloud settings to gain in flexibility, availability, confidentiality as well as price. However, adoption of fragmented multi-cloud storage has not yet taken off, and we have identified two main reasons for this. Firstly, the cloud storage market is still very dynamic and no comprehensive archive exists to enable people to compare offerings. Secondly, almost all IT professionals interviewed felt overwhelmed with the many configuration options possible. The selection of suitable choices for configuration parameters combined with the selection of non-colluding sets of providers turned out to be too complex and time consuming for administrators.

These findings led us to an in-depth analysis of the decision process for the configuration of secure and cost efficient multi-cloud storage systems on the basis of Archistar [2] technology. It was important to understand how cloud customers rate the trustworthiness of providers and their likelihood to collude. It was also important to consider legal aspects, i.e., especially requirements given by the general data protection regulation (GDPR), which basically require that all personal data reside in EU or countries which provide the same level of protection. Additionally, business needs had to be considered which require strongest protection for critical assets even beyond compliance requirements.

One important feedback from industry was that the non-collusion assumption would be specifically appealing in semi-trusted environments. By semi-trusted environments we mean infrastructure pooled by communities who are following the same practices and standards, and who also trust each other to a high level, however, they would still not entrust company data to be stored in plaintext on peer server. This is typically the case for public authorities or governmental organisations sharing some common communication infrastructure but still maintaining their own data centres and wanting to maintain control over their data.

Based on this result we've developed two interesting use cases and demonstrators leveraging secure multi-cloud storage and data sharing in a community setting. Lombardia Informatica S.p.A. developed an eGovernment pilot for secure cloud based backup and archiving where data can be flexibly dispersed over a data centre of municipalities and public clouds. The system enables resilient and secure backup of citizen data in a cost effective and flexible way [3]. Instead of requiring remote backup data centres for each municipality by pooling resources, all operators have access

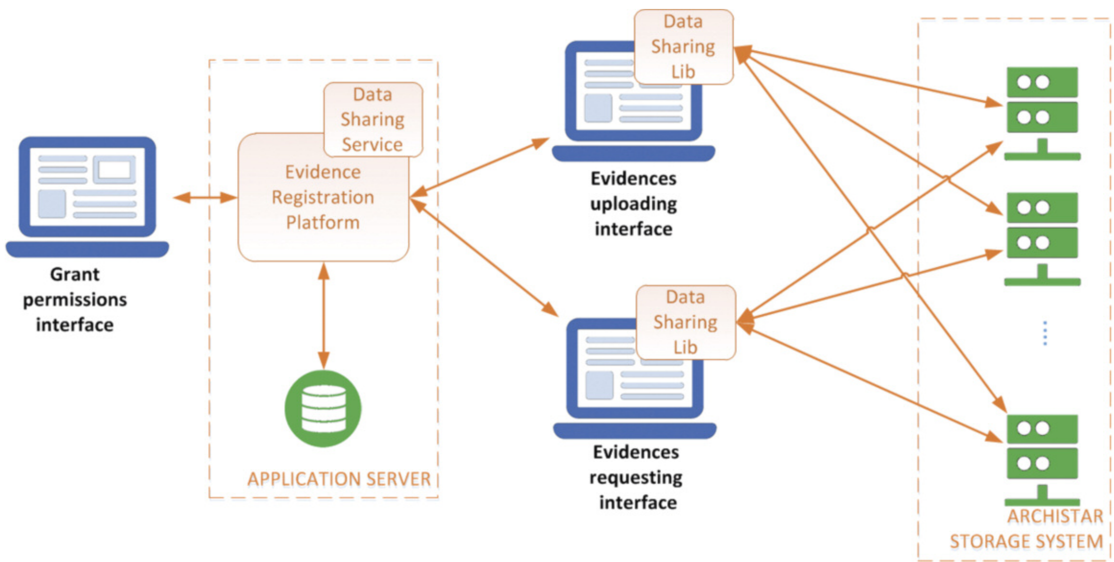


Figure 1: Evidence registration platform architecture.

to a large distributed storage network where data can be fragmented and stored.

On the very same principle, ETRA Investigación y Desarrollo S.A. developed a smart city application for law enforcement agencies to gather and share digital evidence, e.g. CCTV video material or images of car number plates in a parking garage, in a trustworthy way. The idea of the system is that storage nodes are operated by different authorities and build a storage network without a single point of trust or failure. A key component of this platform is the Data Sharing Lib which encodes the file in secret shares which are then sent to different storage nodes. The system allows parking/traffic managers to upload the files upon request, and the law enforcement officer to access the files only if there is an authorisation for it. A data protection officer role is crucial to approve / reject the operations that take place in this system. Once the officer is allowed to download the file, the Data Sharing Lib requests the secret shares to the remote nodes in the Archistar Storage System and once received, it decrypts and joints them in a single file again. The combination of the methods presented result in a secure and resilient distributed system, which provides a trustworthy, controlled and transparent access to sensitive data.

Links:
https://prismacloud.eu
https://at.linkedin.com/in/prismacloud
Twitter: @prismacloud, http://twitter.com/prismacloud
http://cordis.europa.eu/project/rcn/194266_en.html

References:
[1] T. Lorünser, D. Slamanig, T. Länger, and H. C. Pöhls: „PRISMACLOUD Tools: A Cryptographic Toolbox for Increasing Security in Cloud Services," ARES 2016, pp. 733-741, http://dx.doi.org/10.1109/ARES.2016.62
[2] T. Lorünser, A. Happe, and D. Slamanig: "ARCHISTAR: Towards Secure and Robust Cloud Based Data Sharing," IEEE 7th International Conference on Cloud Computing Technology and Science, CloudCom 2015, IEEE, 2015, https://doi.org/10.1109/CloudCom.2015.71
[3] A. Happe, F. Wohner, T. Lorünser: „The Archistar Secret-Sharing Backup Proxy," ARES 2017, pp. 88:1--88:8, https://doi.org/10.1145/3098954.3104055

Please contact:
Thomas Lorünser
AIT Austrian Institute of Technology GmbH
+43 664 8157857
Thomas.Loruenser@ait.ac.at

Strengthening the Cybersecurity of Manufacturing Companies: A Semantic Approach Compliant with the NIST Framework

by Gianfranco E. Modoni, Marco Sacco (ITIA-CNR) and Alberto Trombetta (University of Insubria)

In order to face the challenge of strengthening its cybersecurity, a manufacturing company can follow the approach of aligning cybersecurity-related goals with its specific business objectives.

Cybersecurity represents one of the biggest challenges for modern manufacturing companies. At the same time as these companies are striving to take advantage of recent advances in ICT, they are also facing an increasing number of threats and vulnerabilities, which can jeopardise cybersecurity of their information systems. In particular, data confidentiality, integrity, and availability are at risk. Hence, it is essential to identify new security measures that mitigate the risk of internal and external attacks against the systems to an acceptable level, thus protecting the information processed by those systems. To this end, several high profile international organisations have been conducting various cybersecurity initiatives. One of the most relevant is the National Institute of Standards and Technology's (NIST) "Framework for Improving Critical Infrastructure Cybersecurity" (CSF) [1], which provides guidance for any organisation to assess and manage cybersecurity risks.

However, a framework such as the CSF is only useful to a manufacturing company if its application is framed within the business context of the particular organisation. A process of alignment of the core activities provided by the NIST CSF with the business model could greatly help an organisation to analyse and assess their cybersecurity issues. A potential definition and workflow for this alignment, using an IDEF0 model, is represented in Figure 1. The input of the alignment activity is a virtual image of the factory, representing the evolution of its products, processes, and production systems [2]. The constraints of the alignment consist of a list of conditions that the company has to meet in order to be compliant with the CSF, while the configuration consists of a list of known threats and vulnerabilities that are widely acknowledged in the literature. The output of the alignment process is the cybersecurity posture of the company. The resulting output posture can then be compared with the target posture, thus highlighting the gap that needs to be filled for the organisation to reach compliance with the NIST CSF.

The current state of the art shows that cybersecurity information models are typically decoupled and separated from business process information models – an approach that fragments the efforts that an organisation is making to strengthen

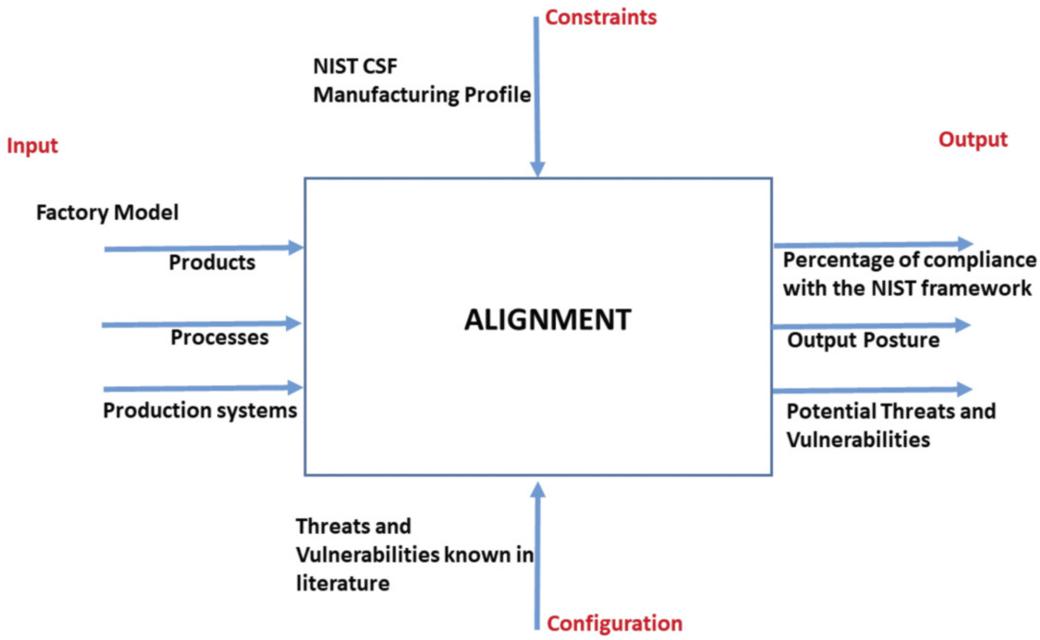


Figure 1: IDEF0 diagram for the alignment activity.

cybersecurity. We propose the introduction of a semantic-based data model to harmonise the involved information and overcome this fragmentation. This model overlaps and correlates core concepts provided by the NIST CSF with the business dynamics behind any given manufacturing company. In this way, it mediates and reconciles concepts of different knowledge domains (Figure 2), allowing the integration of cybersecurity within the context of an organisation's business model. Thus, this approach can help the organisation to allocate investments towards specific objectives compliant with the NIST CSF. On top of this model, an ontology expressing complex relationships (and which will serve as basis for the reasoning tool) is defined using OWL; the ontology is then processed using SWRL rules that encode the set of conditions that the factory has to meet in order to comply with the NIST CSF. A good starting point for implementing the required conceptual models is the Enterprise Core Ontology [3], an existing model that represents the dynamics behind the factory world.

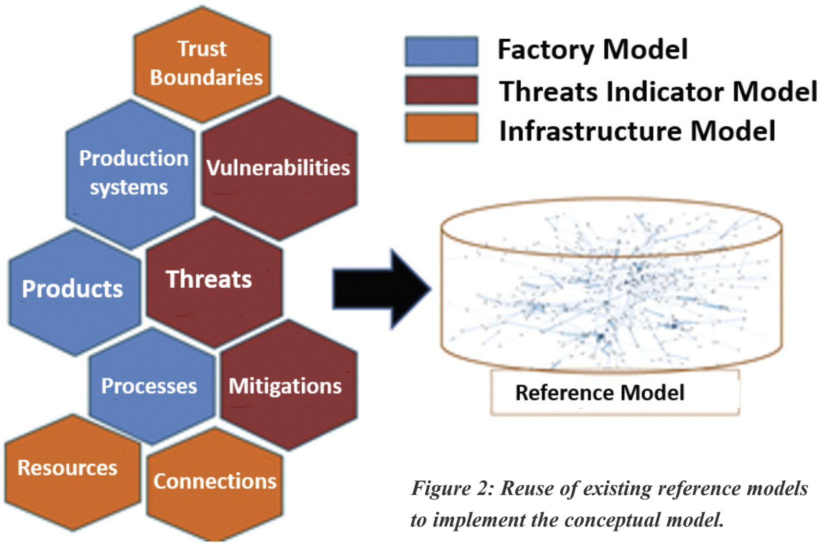


Figure 2: Reuse of existing reference models to implement the conceptual model.

Ongoing and future developments will address three main goals. First, an automated way to measure the compliance of a specific business scenario with CSF has to be conceived and developed, taking into account the model previously defined. Second, the proposed conceptual model will be used as pillar to design and develop a new software tool to support a company's technicians to identify and manage cybersecurity priorities. Third, an empirical evaluation of the proposed approach in a real-world case study is needed, in order to test its correctness and effectiveness.

References:
[1] NIST: "Framework for Improving Critical Infrastructure Cybersecurity", 2014.
[2] G. E. Modoni, et al.: "A telemetry-driven approach to simulate data-intensive manufacturing processes". Procedia CIRP, 57, 281-285, 2016.
[3] G. E. Modoni, et al.: "Enhancing factory data integration through the development of an ontology: from the reference models reuse to the semantic conversion of the legacy models", International Journal of Computer Integrated Manufacturing, Ed. Taylor & Francis, 2016.

Please contact:
Gianfranco E. Modoni, ITIA-CNR, Italy
gianfranco.modoni@itia.cnr.it

Corpus Conversion Service: A Machine Learning Platform to Ingest Documents at Scale

by Michele Dolfi, Christoph Auer, Peter W J Staar and Costas Bekas (IBM Research Zurich)

Over recent decades, the number of scientific articles and technical publications have been increasing exponentially, and as a consequence there is a great need for systems that can ingest these documents at scale and make their content discoverable. Unfortunately, both the format of these documents (e.g. the PDF format or bitmap images) as well as the presentation of the data (e.g. complex tables) make the extraction of qualitative and quantitative data extremely challenging. We have developed a platform to ingest documents at scale which is powered by machine learning techniques and allows the user to train custom models on document collections.

There are roughly 2.5 trillion PDFs in circulation, such as scientific publications, manuals, reports, contracts and more. However, content encoded in PDF is by its nature reduced to streams of printing instructions purposed to faithfully present a visual layout. The task of automatic content reconstruction and conversion of PDF documents into structured data files has been an outstanding problem for over three decades. We have developed a solution to the problem of document conversion, which at its core, uses trainable, machine learning algorithms. The central idea is that we avoid heuristic or rule-based conversion algorithms, using instead generic machine learning algorithms, which produce models based on gathered ground-truth data. In this way, we eliminate the continuous tweaking of conversion rules and let the solution simply learn how to correctly convert documents by providing enough training data. This approach is in stark contrast to current state-of-the-art conversion systems (both open-source and proprietary), which are all rule-based.

While a machine learning approach might appear very natural in the current era of AI, it has serious consequences with regard to the design of such a solution. First, one should think at the level of a whole document collection (or a corpus of documents) as opposed to individual documents, since an ML model for a single document is not very useful. Second, one needs efficient tools to gather ground-truth via human annotation. These annotations can then be used to train the ML models. Hence, one has to provide the ability to store a collection of documents, annotate these documents, store the annotations, train models and ultimately apply these models to unseen documents. This implies that our solution cannot be a monolithic application, rather it was built as a cloud-based platform, which consists of micro-services that execute the previously mentioned tasks in an efficient and scalable way. We call this platform Corpus Conversion Service (CCS).

Using a micro-services architecture, the CCS platform implements the pipeline depicted in Figure 1. The micro-services are grouped into five components: (1) the parsing of documents, (2) applying the ML model(s), (3) assembling the document(s) into a structured data format, and additionally it provides the (optional) lower branch which allows (4) annotating the parsed documents and (5) training the models from these annotations. If a trained model is available, only the first three components are needed to convert the documents.

In the parsing phase of the pipeline, we focus on the following straightforward but non-trivial task: Find the bounding boxes of all text-snippets (named cells) that appear on each pdf-page. In Figure 2 we show the cells obtained from the title-page of a paper. The job of the subsequent components is to associate certain semantic classes (called

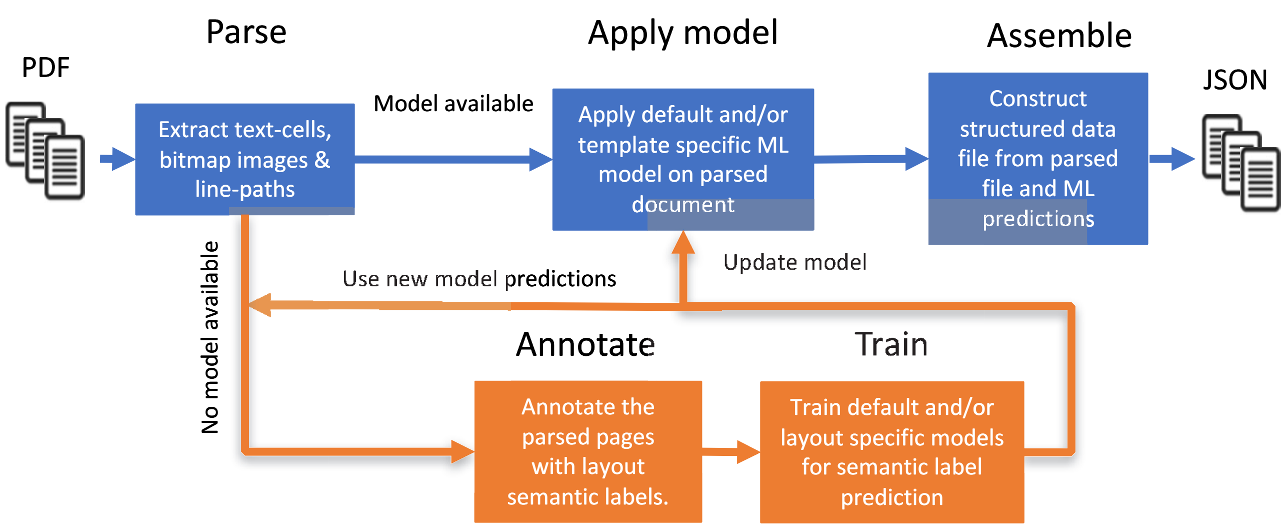


Figure 1: A sketch of the Corpus Conversion Service platform for document conversion. The main conversion pipeline is depicted in blue and allows you to process and convert documents at scale into a structured data format. The orange section is (optionally) used for training new models based on human annotation.

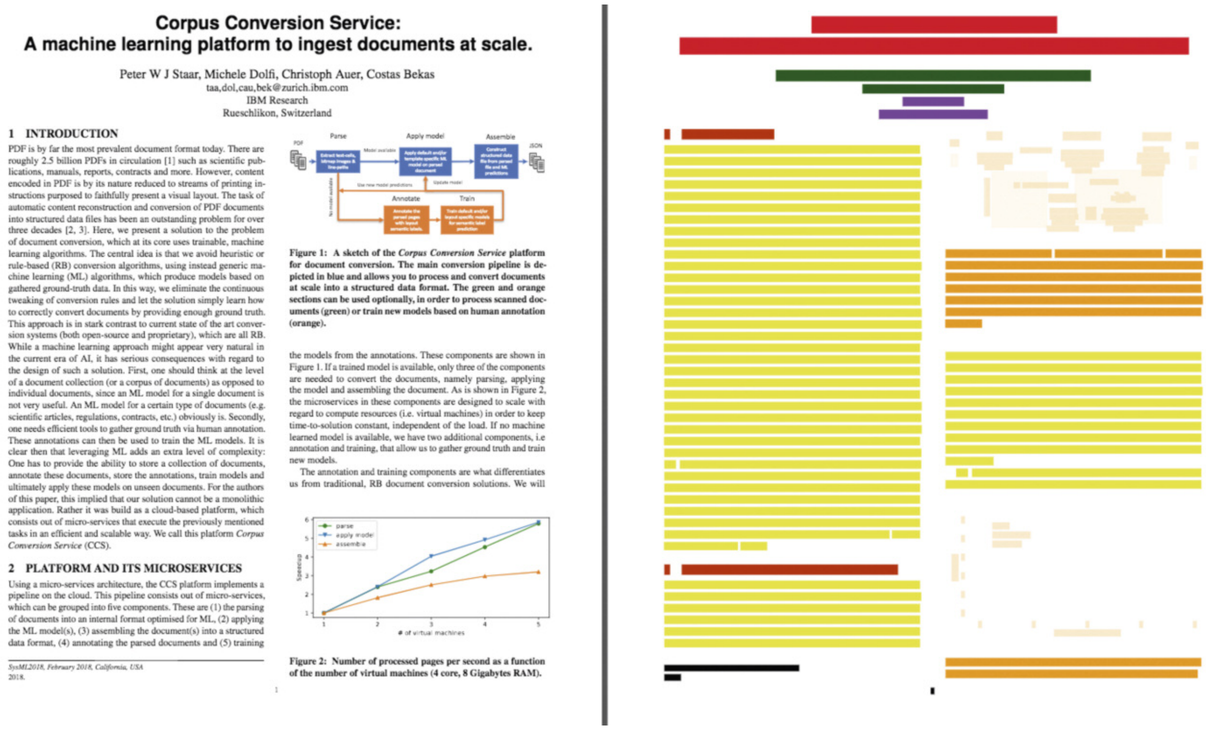


Figure 2: The annotated cells obtained for a published paper. Here, the title, authors, affiliation, subtitle, main-text, caption and picture labels are represented respectively as red, green, purple, dark-red, yellow, orange and ivory.

labels) to these cells, e.g. we want to identify the cells that belong to the same paragraph, or that constitute a table. More examples of labels are: Title, Abstract, Authors, Subtitle, Text, Table, Figure, etc.

The annotation and training components are what differentiates our method from traditional, rule-based document conversion solutions. They allow the user to obtain a highly accurate and very customisable output, for instance some users want to identify authors and affiliations, whilst others will discard these labels.

This level of customisation is obtained thanks to the possibility of enriching the ML models by introducing custom human annotations in the training set. The page annotator visualises one PDF page at the time on which the (human) annotator is requested to paint the text cells with the colour representing a certain label. This is a visual and very intuitive task; hence it is suited for large annotation campaigns that can be performed by non-qualified personnel. Various campaigns have demonstrated that the average annotation time per document was reduced by at least one order of magnitude, corresponding to a ground-truth annotation rate of 30 pages per minute.

Once enough ground-truth has been collected, one can train ML models on the CCS platform. We have the ability to train two types of models: default models, which use state-of-the-art deep neural networks [1, 2] and customised models using random forest [3] in combination with the default models. The aim of the default models is to detect objects on the page such as tables, images, formulas, etc. The customised ML models are classification models, which assign/predict a label for each cell on the page. In these customised models, we typically use the predictions of the default models as additional features to our annotation-derived features.

The approach taken for the CCS platform has proven to scale in a cloud environment and to provide accuracies above 98 % with a very limited number of annotated pages. Further details on the cloud architecture and the ML models are available in our paper for the ACM KDD'18 conference [4].

Link:
https://www.zurich.ibm.com

References:
[1] Ross Girshick, Fast R-CNN. In Proceedings of the 2015 IEEE International Conference on Computer Vision (ICCV) (ICCV '15). IEEE Computer Society, Washington, DC, USA, 1440–1448, 2015. https://doi.org/10.1109/ICCV.2015.169
[2] Joseph Redmon, et al., You Only Look Once: Unified, Real-Time Object Detection. In IEEE Conference on Computer Vision and Pattern Recognition (CVPR) (2016), 779–788, 2016.
[3] Leo Breiman, Random Forests. In Machine Learning 45, 1 (01 Oct 2001), 5–32, 2001. https://doi.org/10.1023/A:1010933404324
[4] P. Staar et al., Corpus Conversion Service: A machine learning platform to ingest documents at scale. In KDD '18, ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, 2018. https://doi.org/10.1145/3219819.3219834

Please contact:
Michele Dolfi, IBM Research Zurich, Switzerland
dol@zurich.ibm.com

TRUSTEE – Data Privacy and Cloud Security Cluster Europe

by Justina Bieliauskaite (European DIGITAL SME Alliance), Agi Karyda, Stephan Krenn (AIT Austrian Institute of Technology), Erkuden Rios (Tecnalia) and George Suciu Jr (BEIA Consult)

While highly secure and privacy-friendly solutions for sensitive domains are being developed by numerous publicly funded projects, many of them never make it into the real world. TRUSTEE is a network of projects that aims at increasing the visibility of leading-edge technologies by providing interested customers with a single contact point.

Over the last two decades, cloud services have made their way into all domains in information and communication technologies, and are still one of the major growing areas in that market. However, for sensitive domains like eHealth, eGovernment, or eFinance, the as-a-service outsourcing paradigm comes with intrinsic security and privacy problems, including: secure message transfer, secure storage, data processing, and (metadata) privacy, identity and access management and secure hardware and infrastructures.

Many national and transnational research initiatives – including but not limited to the European Commission's FP7 or H2020 research programmes – are actively supporting a huge variety of research and innovation projects dedicated to developing solutions to these challenges. However, many of the solutions have not yet made it into the real world; in fact, even promising and mature approaches often do not achieve the visibility and prevalence they might deserve.

The reasons for this state of affairs are multifold, including the complexity and lack of standardisation of many techniques, the large amount of background knowledge that is required to correctly deploy them, and the "hidden" added value of security solutions, which are usually non-functional [1]. Furthermore, the skills and competences are spread across a large number of experts, without a central contact point that potential customers could consult with their needs, interests, and challenges. Even more, the service offers by different, potentially competing, research initiatives are often not accessible in a centralised way, making it hard to even get an idea of the available solutions, techniques, methods, and their maturity levels.

The ambition of TRUSTEE (daTa pRivacy and cloUd SecuriTy clustEr Europe) [L1] is to consolidate the distributed and fragmented nature of ongoing European research initiatives and to serve as a central contact point for software vendors, customers, research colleagues, and decision makers who are interested in leading-edge security technologies and solutions. TRUSTEE is a network of 11 research projects funded by the European Union that was established within the Common Dissemination Booster initiative. The cluster is coordinated by AIT Austrian Institute of Technology GmbH, and currently consists of the following projects: CREDENTIAL, MUSA, PRISMACLOUD, SecureCloud, SERECA, SPECS, SUNFISH, SWITCH, TREDISEC, UNICORN, and WITDOM, which are all performing cutting-edge research and innovation in different domains of cloud security and privacy, ranging from secure and privacy-friendly authentication over encrypted and distributed solutions for data sharing and cloud storage to data integrity, authenticity, and availability. Overall, TRUSTEE subsumes and results from more than 90 partners in 23 countries within Europe and beyond.

In contrast to related initiatives, such as the DPSP cluster on data protection, security, and privacy in the cloud [L2], or the service offer catalogues of European coordination and support actions like CloudWatch [L3] or Cyberwatching [L4], TRUSTEE does not aim at internally connecting the member projects or at providing a list of service offers per project. Rather, TRUSTEE's ultimate goal would be to offer customers a "one-stop shop" to address their cloud security and privacy demands. This will be achieved by presenting the projects' results by functionality and supporting customers in choosing the best option for their needs, as well as minimising the adoption pain for users through internal coordination to identify competing or mutually exclusive technologies.

In addition to making technology innovations more accessible to customers, TRUSTEE also aims at becoming a strong brand with sufficient visibility and acceptance to support the individual projects' communication and commercialisation efforts, and thereby increase the effectiveness and impact of European research and innovation actions in the fields of cryptography, privacy, and cyber security.

Links:
[L1] https://twitter.com/Trustee_EU
[L2] https://eucloudclusters.wordpress.com/data-protection-security-and-privacy-in-the-cloud/
[L3] http://www.cloudwatchhub.eu
[L4] https://www.cyberwatching.eu

References:
[1] T. Lorünser, S. Krenn, C. Striecks, T. Länger: "Agile cryptographic solutions for the cloud", E&I 134(7), 2017.

Please contact:
Agi Karyda, Stephan Krenn
AIT Austrian Institute of Technology GmbH
+43 50550 4123
agi.karyda@ait.ac.at, stephan.krenn@ait.ac.at

Educational Robotics Improves Social Relations at School

by Federica Truglio, Michela Ponticorvo and Franco Rubinacci (University of Naples “Federico II”)

Educational robotics is not only a useful tool to learn how program a robot, but it is. It can also be a powerful method to improve other skills, such as social ability. A lab has been set up to investigate whether educational robotics can help to improve social interaction at school.

Educational robotics, like coding, is an important tool to promote learning processes – and in recent years it has achieved an important role in the field of technologies for learning. It is a powerful tool to promote learning processes. Educational robotics is not only a useful method to learn how to build and program a robot, it also represents an opportunity to improve the life skills (i.e., the ability to solve problems and to plan a strategy, self-esteem, social skills and lateral thinking). Moreover, educational robotics brings the coding into the real world by the means of its physical and tangible models. Indeed, educational robotics requires the use of “robot construction kits”, that are the boxes containing both a hardware (i.e., small brick, set of sensors) and a software (a programming interface). Therefore, the robotics technologies have several advantages over coding: a bigger sensory involvement, a greater incentive to learn and more immediate error handling.

Educational robotics is also ideally suited to group works, stimulating collaboration and cooperation through lab activities. In particular, educational robotic labs enable group members to coordinate their efforts, to delegate tasks and to complete a job with an higher motivation, whilst taking other group members into consideration. As a consequence, educational robotics labs are innovative tools that can help improve social and communication skills and increase inclusion and cohesion within a group.

We set up an educational robotics lab in a secondary school (in Naples), with the aim of determining whether this type of lab can help to improve social relations. Our educational robotics lab was held during curricular hours and lasted two months (from September to November 2017). A class of 23 first-year students participated. Before the beginning of educational robotic lab, we applied the sociometric test to students, in order to assess the starting social relations in the class-group. Sociometric test is a self-report consisting of four questions (examples of two questions appearing in sociometric test: (i) write the names and surnames of those classmates who you would like as room-mates during a school trip. You can write as many names as you like. (ii) Write the names and surnames of those classmates who you would not want as room-mates during a school trip. You can write as many names as you like). It allows to determine the number of choices rejections by group members.

Pictures taken during the educational robotics lab. The students are building a robot in a group (the second activity).

The educational robotics lab was conducted during six weekly meeting, each lasting one or two hours (for a total of 10 hours). In every meeting, students have been divided in five different subgroups e have carried out various activities:
- In the first meeting, after learning some basics, each group of students produced posters about technologies, robotics and type of robot;
- In the second activity, the students have built the robots, in this way they have learned both how a robot is made and to work in a group;
- In the next meeting, after a short introduction about software to program, the students in group have formulated a string of information which has been hacked both in computer and in robot;
- In the fourth and fifth encounters, the students were asked to create road itineraries representing the environment that the robot has travelled. This was creative way of increasing their own connectivity territory;
- In the last meeting, the students have programmed with the software the robot, to make it follow the road itinerary correctly.

After the end of educational robotics lab we repeated the sociomatric test to determine whether there had been a discernible change in social relations among students following the lab sessions.

Statistical analysis of the sociometric test data (pre and post) indicated a substantial improvement in the social relations among students who took part in educational robotics lab (the number of choices among students doubled). This result might be due both to physical and tangible dimensions (the use of a tangible robot) of educational robotics and to the group work undertaken by the children.

In conclusion: educational robotics labs can offer an innovative means to support positive social relations among students. Further research need to: (i) repeat the experimental with students belonging to a different schools, and (ii) compare the educational robotic lab with a other creative and physical group activity (such as lab of creative arts or a lab about recycling). This comparison will allow us to determine if robotics labs specifically have this effect, or whether similar outcomes are achieved by physical group activities in general.

References:

[1] R. Didoni: "Il laboratorio di robotica. TD–Tecnologie Didattiche", (27), 29-35, 2002.

[2] F. Rubinacci, M. Ponticorvo, O. Gigliotta, O. Miglino: "Breeding Robots to Learn How to Rule Complex Systems", in Robotics in Education (pp. 137-142), Springer 2017.

[3] F. Truglio: "Tecnologie dell'apprendimento: la robotica educativa a supporto delle relazioni sociali nei gruppo classe", Master Degree Thesis, Università di Napoli "Federico II", 2018.

Please contact:

Federica Truglio, Michela Ponticorvo,
Franco Rubinacci, University of Naples "Federico II", Italy
trugliofederica.92@gmail.com,
michela.ponticorvo@unina.it, franco.rubinacci@unina.it

SMESEC: A Cybersecurity Framework to Protect, Enhance and Educate SMEs

by Jose Francisco Ruiz (Atos), Fady Copty (IBM) and Christos Tselios (Citrix)

Small to medium enterprises (SMEs) have benefited greatly from the digital revolution, but at the same time SMEs are particularly vulnerable to cyber-attacks. SMESEC is a cybersecurity framework designed specifically with SMEs in mind.

The digital revolution has benefited many businesses in Europe, creating opportunities and advantages, especially for small and medium enterprises (SMEs). Unfortunately, with this new paradigm, new problems have also appeared.

SMEs are an attractive target for malicious hackers. They have more digital assets and information than an individual, but less security than a large enterprise. Coupled with the fact that SMEs usually have no expertise or resources for cybersecurity, the outcome is a recipe for disaster. One study [1] found that 60 % of hacked SMEs go out of business because they do not know how to respond. Additionally, cybersecurity solutions are usually expensive for SMEs or do not provide a good solution for their needs. This problem is also a major inhibitor for start-up innovation in the EU. Cyber-security framework SMESEC [L1] aims to provide a solution that supports SMEs in these issues. The key pillars of SMESEC can be divided in three areas: i) to provide a state-of-the-art cybersecurity framework; ii) make the solution cost-effective and adaptive to SME needs; iii) offer cybersecurity awareness and training courses for SMEs.

The SMESEC use-cases offer great representative examples of the wide variety of SMEs that exist. These use-cases span different geographical locations, areas of innovation, SME size, organisational structure, and business models. Their main concerns about security solutions are maintaining security of their infrastructure, usability, cost, and privacy.

The SMESEC tools form a loosely coupled security framework. The main partners' concerns are orchestration between tools and getting feedback from the customer base to drive development based on customers' needs.

During the development of the SMESEC solution, we are continuously bearing in mind the need to provide a high

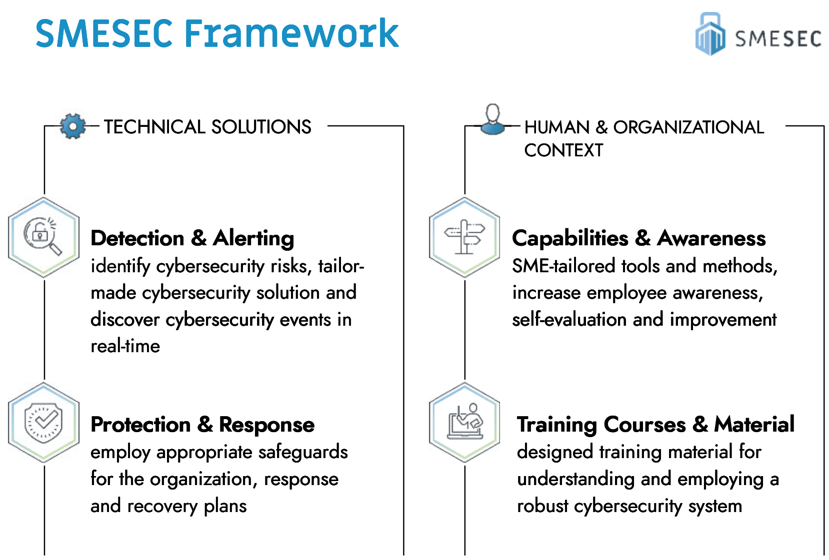


Figure 1. SMESEC Framework.

degree of usability and automation, an adequate degree of cyber situational awareness and control for end-users, incorporating the "human factor" in the design process, and following existing relevant best practices and adoption of standards, tailored to SMEs and individuals. This strategy to cover both areas can be seen in Figure 1.

To respond to the above technical and business requirements we have conducted a comprehensive market search and requirement gathering from SMESEC use-case partners, and to meet the needs of each use case partner, an innovation process was established. The main innovation expected from the SMESEC Framework is the integration of different solutions working in an orchestral approach. Future innovation directions of the SMESEC tools were collected and prioritised according to five criteria: increasing simplicity of security tools, increase protection level, cost-effectiveness, support training and awareness, and increasing interconnection.

The functional requirements can be categorised into threat defence and security management. Under threat defence we identified: protect, detect, monitor, alert, respond, and discover requirements. Under security management we identified: assess security level, suggest improvements, evaluate risk and consequences, and assess criticality. The non-functional requirements identified were: modularity of development and deployment, usability, confidentiality, load scalability, multi-tenancy, and expansibility of the framework.

To answer these requirements and concerns we have proposed a new security concept that extends the standard definition of a security event of adversary attacks detected with the following events: lack of user training, requirements mismatch, standards non-compliance, and recommendations not met. This concept of security event allows a comprehensive end-to-end security solution to be built, that solves all SME security concerns in one single security centre of operation.

Owing to the ever-increasing number of SMEs willing to address cyber-security issues and establish certain safeguards and defensive countermeasures, the SMESEC project needs to follow a specific set of actions towards providing a holistic security framework. The first set of action points comprises a thorough ecosystem analysis, paired with the development of a strategy to assemble the various components contributed by different partners into a unified solution. Immediately after comes the deployment, integration, evaluation and implementation phase upon which the SMESEC Framework will be deployed, obtaining new tailor-made features.

Therefore, our main objectives are: (i) creation of an automated cyber-security assessment engine, capable of high level personalisation and intelligent vulnerability categorisation and analysis, (ii) the aforementioned automated cyber-security assessment, including user behaviour monitoring and reputation analysis, will offer feedback to SMEs and users for any type of vulnerability or improper behaviour of users, (iii) the alignment of the SMESEC innovations with international links and standardisation bodies will eliminate decoupling between security solution development and the state of the art, resulting in inexpensive and effective security recommendations.

SMESEC brings together a set of distinguished partners with award-winning products and excellent backgrounds in innovative ICT solutions and cyber security. This consortium aims to provide a complete security framework carefully adjusted on the peculiarities of SMEs. A framework of this nature is particularly relevant since it will reduce the capital, operational and maintenance expenditures of SMEs, allowing for greater growth and innovation in the EU.

Link:
[L1] www.smesec.eu

Reference:
[1] https://www.csoonline.com/article/3267715/cyber-attacks-espionage/4-main-reasons-why-smes-and-smbs-fail-after-a-major-cyberattack.html

Please contact:
Jose Francisco Ruiz
Atos, Spain
+34 912148483
jose.ruizr.external@atos.net

Data Management in Practice – Knowing and Walking the Path

by Filip Kruse and Jesper Boserup Thestrup

Enter the matrix: Trials, tribulations – and successes – of doing an inter-institutional data management project in a matrix organization

"Neo, sooner or later you're going to realize just as I did that there's a difference between knowing the path and walking the path." (Morpheus, The Matrix, 1999)

The aim of the project Data Management in Practice was to establish a Danish infrastructure setup with services covering all aspects of the research data lifecycle: from application and initial planning, through discovering and selecting data and finally to the dissemination and sharing of results and data. Further, the setup should include facilities for training and education. Researchers' needs and demands from active projects – hence the "in Practice" – should form the basis of the services. Finally, the project should explore the role of research libraries regarding research data management.

The project can be described as a hybrid between a purely case-based project with individual institutions each working on their own sub-projects, and a thematic project with institutions working within one or more themes. Six themes were active: Data Management Planning; Data capture, storage and documentation; Data identification, citation and discovery; Select and deposit for long-term preservation; Training and marketing toolkits; and Sustainability. Each of the participating institutions worked on specific cases, such

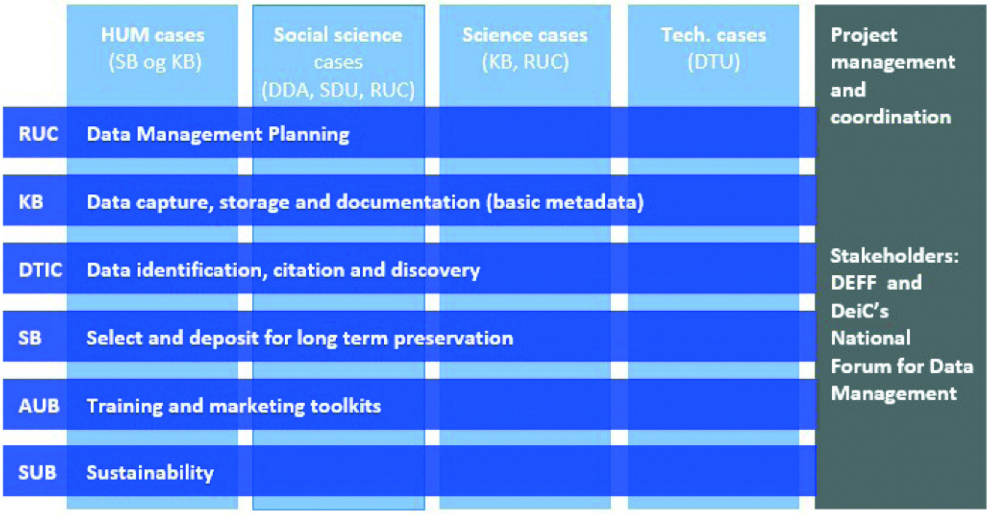


Figure 1: The Matrix Organization of the Project Data Management in Practice. RUC – Roskilde University, KB – The Royal Library (merged in 2017 with the State and University Library as The Royal Danish Library), DDA – Danish Data Archive, DTIC – DTU Library, Technical Information Center of Denmark, SB – State and University Library, now The Royal Danish Library, AUB – Aalborg University Library, SUB – University Library of Southern Denmark.

as ongoing research projects, well-defined data collections etc. The cases covered the main academic fields of Humanities, Social Sciences, Science and Technology.

The Humanities and Health cases spanned audio visual data collections, data on Danish web materials, and Soeren Kierkegaard's writings. The Social Science (SAM) cases consisted of survey data from local elections, and qualitative linguistic data, while the Health case (SUN) covered data on liver diseases (cirrhosis). The Science Technology cases dealt with data from the Kepler mission, on wind energy, and on the registration and preservation of artic flora and fauna. If we take the Humanities case of LARM (The Royal Danish Library's Sound Archive for Radio Media) as an example, on the one hand the result was a Danish operational version of the DCC's DMP online [L1], freely available via DeiC [L2] to Danish researchers. On the other hand, it turned up new challenges. Regarding Data identification, citation and discovery, sharing of the data encountered the problem that some of the data are sensitive or protected by copyright. This had two implications. Firstly, an additional facility for deposit of data with restricted access. This repository is at the moment awaiting decision for activation. Secondly, a requirement for a legal framework for handling data, leading to a model agreement on data management.

As the projects within the cases used different infrastructures already available on their respective mother institutions, the work on the second theme "Data capture, storage and documentation" produced no common results, but a wide array of local experiences. This unintended consequence demonstrated that an all-encompassing infrastructure able to cover the needs of research projects from all scientific areas is an impossibility, at least for now.

It was a requirement of the third theme "Data identification, citation and discover" that the different cases should deposit data in institutional repositories. These, however, were not readily available at the project institutions. Instead, the work led to the outline of recommendations based on the cases to facilitate the theme's objective – datasets should provide metadata based on the DataCite format, they should also have a DOI identifier and researchers should have an ORCID.

The fourth theme "Select and deposit for long-term preservation" led to the establishment of an open access data repository: Library Open Access Repository (LOAR) by The Royal Library, Aarhus. The work included assessment of PURE as a possible institutional repository concluding that PURE has many, but not all, of the features necessary for an institutional research repository.

The fifth theme "Training and marketing toolkits" developed the freely accessible DataflowToolkit [L3] in order to assist researchers in doing data management. This tool thus synthesises experiences gathered from the activities in the different cases.

The sixth and final theme of the project "Sustainability" addressed how (and if) infrastructure services developed as part of the work on the specific cases could continue after the termination of project.

The matrix organization of the project ensured both a high degree of adaptability to new conditions and an adherence to the project objectives. One might say that it overcame the difference between knowing and walking the path.

The project was funded evenly by DEFF, Denmark's Electronic Research Library [L4] and the participating institutions. The project period: March 2015 – June 2017, final report January 2018.

Links:
[L1] https://dmponline.dcc.ac.uk/
[L2] https://www.deic.dk/en
[L3] https://dataflowtoolkit.dk/
[L4] https://www.deff.dk/english/

Reference:
[1] Data Management in Practice, Results and Evaluation
http://ebooks.au.dk/index.php/aul/catalog/book/243

Please contact:
Filip Kruse, Jesper Boserup Thestrup, Royal Danish Library, Denmark,
fkr@kb.dk, jbt@kb.dk

Low Cost Brain-Controlled Telepresence Robot: A Brain-Computer Interface for Robot Car Navigation

by Cristina Farmaki and Vangelis Sakkalis (ICS-FORTH)

An innovative and reliable EEG brain-computer navigation system has been developed in the Computational Biomedicine Laboratory (CBML), at ICS-FORTH, in Crete, Greece. The implemented system is intended to enable patients suffering from neuromuscular paralysis to act independently, be able to make their own decisions and to some extent take part in social life. Using such a system challenges mental abilities in various ways and is expected to improve quality of life and benefit mental health.

A variety of neurological conditions can lead to severe paralysis, even to typical locked-in syndrome, where patients have retained their mental abilities and consciousness, but suffer from complete paralysis (quadriplegia and anarthria), except for eye movement control. Locked-in syndrome usually results from an insult to the ventral pons, most commonly a brainstem hemorrhage or infarct. Other potential causes that can affect this part of the brainstem can include trauma, such as stroke, encephalitis, as well as neurodegenerative diseases of motor neurons, such as Amyotrophic Lateral Sclerosis in which the patient gradually loses muscle control and, consequently, the ability to communicate.

As these patients maintain their mental functions unaffected, their motor impairment often results in social exclusion, usually leading to depression and resignation. As a consequence, providing even minimal means of communication and control can substantially improve the quality of life of both patients and their families. To this end, we have been developing brain-computer interfaces (BCIs), which constitute a direct communication pathway between the human brain and the external world. A BCI system relies only on brain signals, without the use of peripheral nerves, and therefore can provide communication and control for patients suffering from severe neuromuscular paralysis. BCIs capture brain signals using the electroencephalography (EEG) technique, due to its rather low cost, non-invasiveness, portability and good temporal resolution.

Bearing this in mind, our team, under the supervision of Dr. Vangelis Sakkalis, has designed and implemented an integrated EEG brain-computer interface for the navigation of a robot car, using a low-cost smartphone camera, in order for a patient to “move” (virtually) to remote and non-distant environments. Our BCI system is based on the SSVEP (steady-state visual evoked potentials) stimulation protocol, according to which, when a user attends a light source (LED or, as in our case, reversing screen patterns) that flashes at frequencies above 4 Hz, a specific signal response can be detected in the visual cortex, located at the occipital lobe. A user-tailored brief training session before using the interface ensures the individualisation of the process, thus leading to higher system accuracies. In order to wirelessly control the mobile robot car, the user focuses his/her gaze on one of four checkerboard targets, on a computer screen. The targets alternate their pattern at a constant frequency, which is different for each of them. A mobile wireless EEG device is continuously recording the visual cortex activity through four channels. A specialised algorithm analyses the brain signals in real-time and recognises which target the user is focusing on, using sophisticated machine learning techniques. The next step includes translating the user’s intention into a corresponding motion command (front, back, right, left) and transmitting it to the robot car via wireless communication. The robot car moves to the desired direction, whereas a smartphone camera, mounted onto the robot car, captures the environment around the user and projects it onto the user’s screen. Thus, the user can redefine his/her intentions according to the live feedback from the camera (Figure 1).

The use of a low-cost EEG device in combination with our custom-made brain interpretation algorithms implemented by C. Farmaki (computer engineer), the custom manufacture of the robot car using the Arduino Due onboard microcontroller assembled by G. Christodoulakis (robotics engineer),

The user focuses his/her gaze on one of four checkerboard targets, on a computer screen (right), in order to remotely control the robot car (left). The robot car moves to the desired direction, whereas a smartphone camera, mounted onto the robot car, captures the environment around the user and projects it onto the user’s screen.

and the addition of a conventional smartphone camera ensures the affordability and wide accessibility of the overall solution. The implemented system has been published [3] and successfully presented in public [L1, L2], thus proving its efficiency and robustness in various conditions (daylight or artificial light in enclosed spaces, as well as noisy and crowded environments). The WiFi communication protocol has been used for the transmission of the motion commands to the robot car, however other solutions have been explored and tested, such as the Zigbee protocol.

The major advantage of our interface is that it needs minimal training, works in realistic conditions and can be adapted to user's needs and alternative application scenarios including electric wheelchair navigation. Our team has secured a three-year Operational Programme on Competitiveness, Entrepreneurship and Innovation [L3] to build on top of this prototype and realise an industrial design along with a pilot study proving and extending the possibilities of the current implementation.

The implemented system enables patients suffering from severe neuromuscular paralysis to gain back a certain level of autonomy and communication with the world around them. The proposed technology paves a way where natural obstacles can be eliminated and locked-in patients can live with their families and even access "virtually" or "physically" (under certain conditions) schools, universities, museums, etc.

Links:
[L1] https://kwz.me/htY
[L2] https://kwz.me/htB
[L3] https://kwz.me/htt

References:
[1] L. F. Nicolas-Alonso, J. Gomez-Gil: "Brain computer interfaces, a review," Sensors (Basel), vol. 12, no. 2, 2012, 1211-79.
[2] U. Chaudhary, et al.: "Brain-computer interfaces for communication and rehabilitation", Nature Reviews Neurology, vol. 12, 2016, 513-525.
[3] C. Farmaki et al.: "Applicability of SSVEP-based BCIs for robot navigation in real environments", IEEE EMBC, 2016, 2768-2771.

Please contact:
Vangelis Sakkalis,
ICS-FORTH, Greece
+30 (281) 0391448
sakkalis@ics.forth.gr

LODsyndesis: The Biggest Knowledge Graph of the Linked Open Data Cloud that Includes all Inferred Equivalence Relationships

by Michalis Mountantonakis and Yannis Tzitzikas (ICS-FORTH)

LODsyndesis is the biggest knowledge graph that includes all inferred equivalence relationships, which occur between entities and schemas of hundreds of Linked Open Data cloud datasets. LODsyndesis webpage offers several services for exploiting the aforementioned knowledge graph, e.g., a service for collecting fast all the available information (and their provenance) for 400 million of entities, an advanced Dataset Discovery service for finding the most connected datasets to a given dataset, and others.

The internet's enormous volume of digital open data can be a valuable asset for scientists and other users, but this is only possible if it is easily findable, reusable and exploitable. One challenge is to link and integrate these data so that users can find all data about an entity, and to help estimate the veracity and correctness of the data. One way to achieve this is to publish the data in a structured way using Linked Data techniques.

However, the semantic integration of data at a large scale is not a straightforward task, since publishers tend to use different URIs, names, schemas and techniques for creating their data. For instance, to represent a fact, say "Stagira is the birth place of Aristotle", different datasets can use different URIs to represent the entities "Aristotle" and "Stagira", and the schema element "birth place". Figure 1 depicts an example of four datasets that contain information about ``Aristotle". With Linked Data one can partially overcome this difficulty by creating cross-dataset relationships between entities and schemas, i.e., by exploiting some predefined properties, such as owl:sameAs, owl:equivalentProperty and owl:equivalentClass (the equivalence relationships of our example are shown in the upper right side of Figure 1). However, all these relations are transitive and symmetric, which implies that in order to collect all the available information for an entity and to not miss facts that are common to two or more datasets, it is necessary to compute the transitive closure of these relations, a task that presupposes knowledge from all the datasets.

The Information Systems Laboratory of the Institute of Computer Science of FORTH designs and develops innovative indexes, algorithms and tools to assist the process of semantic integration of data at a large scale. The suite of services and tools that have been developed are referred to as "LODsyndesis" [L1]. Comparing to [1], the current version allows the full contents of datasets to be indexed in a parallel way [2,3]. To enable fast access to all the available information about an entity, we have created global scale entity-centric indexes, where we store together all the available information for any entity, by taking into consideration the equivalence relationships among datasets. An example about the entity ``Aristotle” is shown in Figure 1. By collecting all facts about an entity, we can easily spot those that are common in two or more datasets (e.g. we can see that all datasets agree that Stagira is the birth place of Aristotle), the conflicting ones (birthYear), and the complementary ones (Philosopher).

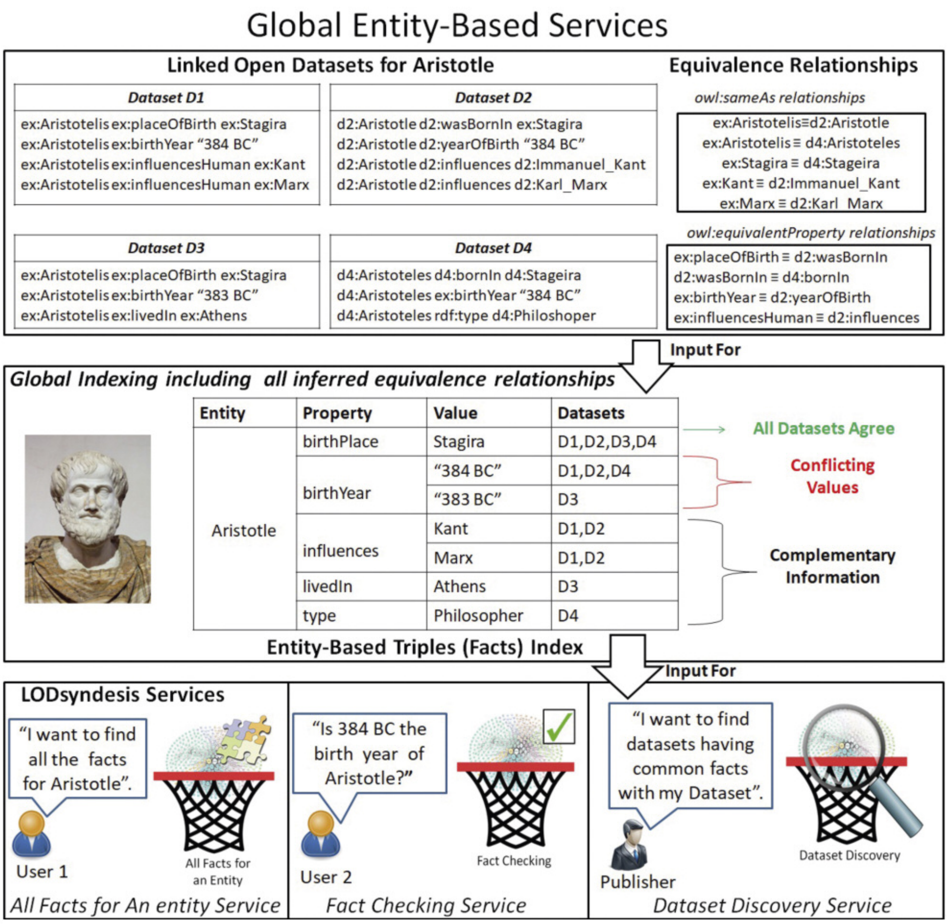


Figure 1: The process of global indexing and the offered LODsyndesis Services.

The current version of LODsyndesis indexes two billion triples, which contain information for about 400 million of entities from 400 datasets. Apart from the services introduced in [1], it offers two additional state-of-the-art services: (i) a service for finding all the available information (and its provenance) about an entity, and (ii) a fact checking service where one can check which datasets agree that a fact holds for a specific entity (e.g., check whether the birth date of Aristotle is 384 BC) and which are the contradicting values.

In addition, the current version of LODsyndesis contains measurements about the commonalities among all these (or any combination of) datasets, namely: number of common entities, common schema elements, common literals and common facts (all these measurements have been published also to DataHub [L2] for direct exploitation). These measurements are leveraged by the offered Dataset Discovery Service to enable users to find the datasets that are connected to a given dataset.

The measurements provide some interesting insights about the connectivity of the LOD cloud. As reported in [2,3], only 11 % of the possible datasets’ pairs share common entities, and 5.2 % of them share common facts, which means that most datasets contain complementary information, even for the same entities. We have observed that many publishers do not create equivalence relationships with other datasets; consequently their datasets cannot be easily integrated with other datasets. When it comes to efficiency, the creation of all required indexes and the calculation of the aforementioned measurements takes only 81 minutes using 96 machines. Based on these indexes, the provision of services offered by LODsyndesis are very fast, i.e., on average less than five seconds are needed to find the most connected datasets for a given dataset, whereas, on average it takes less than 10 seconds to show (or export) all the available information of an entity, or to check whether a fact holds (for an entity). As future work, we plan to provide more advanced data discovery and veracity estimation services.

This work has received funding from: a) FORTH and b) the General Secretariat for Research and Technology (GSRT) and the Hellenic Foundation for Research and Innovation (HFRI) .

Links:
[L1] http://www.ics.forth.gr/isl/LODsyndesis/
[L2] http://datahub.io/dataset/connectivity-of-lod-datasets

References:
[1] M. Mountantonakis and Y. Tzitzikas: “Services for Large Scale Semantic Integration of Data. ERCIM News, 2017.
[2] M. Mountantonakis and Y. Tzitzikas: “Scalable Methods for Measuring the Connectivity and Quality of Large Numbers of Linked Datasets”, Journal of Data and Information Quality (JDIQ), 9(3), 15, 2018
[3] M. Mountantonakis and Y. Tzitzikas, (2018). High Performance Methods for Linked Open Data Connectivity Analytics. Information, 9(6),134, MDPI, 2018. http://www.mdpi.com/2078-2489/9/6/134

Please contact:
Yannis Tzitzikas, FORTH-ICS and University of Crete
+30 2810 391621, tzitzik@ics.forth.gr

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The workshop are organized by Roberto Saracco (EIT Digital), Francesco Flammini (Linnaeus University), Raj Madhavan (Humanitarian Robotics Technologies)

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ERCIM – the European Research Consortium for Informatics and Mathematics – aims to foster collaborative work within the European research community and to increase cooperation with European industry. Founded in 1989, ERCIM currently includes 15 leading research establishments from 14 European countries. ERCIM is able to undertake consultancy, development and educational projects on any subject related to its field of activity.

ERCIM members are centres of excellence across Europe. ERCIM is internationally recognized as a major representative organization in its field. ERCIM provides access to all major Information Communication Technology research groups in Europe and has established an extensive program in the fields of science, strategy, human capital and outreach. ERCIM publishes ERCIM News, a quarterly high quality magazine and delivers annually the Cor Baayen Award to outstanding young researchers in computer science or applied mathematics. ERCIM also hosts the European branch of the World Wide Web Consortium (W3C).

"Through a long history of successful research collaborations in projects and working groups and a highly-selective mobility programme, ERCIM has managed to become the premier network of ICT research institutions in Europe. ERCIM has a consistent presence in EU funded research programmes conducting and promoting high-end research with European and global impact. It has a strong position in advising at the research policy level and contributes significantly to the shaping of EC framework programmes. ERCIM provides a unique pool of research resources within Europe fostering both the career development of young researchers and the synergies among established groups. Membership is a privilege."

Dimitris Plexousakis, ICS-FORTH, ERCIM AISBL Board

Benefits of Membership

As members of ERCIM AISBL, institutions benefit from:

- International recognition as a leading centre for ICT R&D, as member of the ERCIM European-wide network of centres of excellence;
- More influence on European and national government R&D strategy in ICT. ERCIM members team up to speak with a common voice and produce strategic reports to shape the European research agenda;
- Privileged access to standardisation bodies, such as the W3C which is hosted by ERCIM, and to other bodies with which ERCIM has also established strategic cooperation. These include ETSI, the European Mathematical Society and Informatics Europe;
- Invitations to join projects of strategic importance;
- Establishing personal contacts with executives of leading European research institutes during the bi-annual ERCIM meetings;
- Invitations to join committees and boards developing ICT strategy nationally and internationally;
- Excellent networking possibilities with more than 10,000 research colleagues across Europe. ERCIM's mobility activities, such as the fellowship programme, leverage scientific cooperation and excellence;
- Professional development of staff including international recognition;
- Publicity through the ERCIM website and ERCIM News, the widely read quarterly magazine.

How to Become a Member

- Prospective members must be outstanding research institutions (including universities) within their country;
- Applicants should address a request to the ERCIM Office. The application should inlcude:
  - Name and address of the institution;
  - Short description of the institution's activities;
  - Staff (full time equivalent) relevant to ERCIM's fields of activity;
  - Number of European projects in which the institution is currently involved;
  - Name of the representative and a deputy.
- Membership applications will be reviewed by an internal board and may include an on-site visit;
- The decision on admission of new members is made by the General Assembly of the Association, in accordance with the procedure defined in the Bylaws (http://kwz.me/U7), and notified in writing by the Secretary to the applicant;
- Admission becomes effective upon payment of the appropriate membership fee in each year of membership;
- Membership is renewable as long as the criteria for excellence in research and an active participation in the ERCIM community, cooperating for excellence, are met.

Please contact the ERCIM Office: contact@ercim.eu

The Hague Summit for Accountability & Internet Democracy

The first Hague Summit for Accountability & Internet Democracy on "Shaping an Internet of Values" took place in the Peace Palace in The Hague, the Netherlands on 31 May 2018. This is an annual global forum for dialogue among stakeholders and thought leaders in the digital environment, encompassing the World Wide Web, social media, big data analytics, AI, robotics and IoT, as well as ethical and legal challenges. The Summit focused on safeguarding the role of the internet as a tool of engagement, increasing access to knowledge and promoting maximum sustainable net benefit for people and societies. Speakers represented governments, international policy makers, NGOs, the ICT industry and other platforms. Summit partners are UNESCO, ITU, the Dutch Ministry of the Interior and Kingdom Relations, the City of The Hague and the organizer, the Institute for Accountability in the Digital Age. Deputy Prime Minister Kajsa Ollongren from the Netherlands welcomed the participants. ERCIM president Jos Baeten and the W3C Benelux Office took part in the round table discussions.

More information: https://aidinstitute.org/summit/

Panel discussion at the summit. Picture: Wim van IJzendoorn/Institute for Accountability in the Digital Age (I4ADA).

Community Group on "Data Privacy Vocabularies and Controls"

The EU SPECIAL project (Scalable Policy-aware Linked Data Architecture For Privacy, Transparency and Compliance) managed by ERCIM, supported and organized a W3C workshop on data privacy controls and vocabularies on 17-18 April 2018. The initial idea was that linked data annotations can help tackle the issue of privacy in modern data environments. This would allow the creation of a new generation of privacy enhancing technologies. The advent of the enactment of the GDPR was also prominent in the discussions.

After the workshop, the participants drew up a list of priorities including vocabularies or taxonomies that should be standardized. The hope is that such vocabularies also enable automatic application and verification of privacy policies, that the SPECIAL project and other interested peoples are working on. Therefore, the project created a Community Group, with the name Data Privacy Vocabularies and Controls (DPVCG), that was opened on 25th of May 2018, the day the GDPR came into force. The idea is that the group also organizes face-to-face meetings, at privacy conferences and similar events.

The group is open to everybody with an interest in creating (Linked Data) vocabularies for privacy.

Link for participation: https://www.w3.org/community/dpvcg/

SCHLOSS DAGSTUHL
Leibniz-Zentrum für Informatik

Call for Proposals

Dagstuhl Seminars and Perspectives Workshops

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is accepting proposals for scientific seminars/workshops in all areas of computer science, in particular also in connection with other fields.

If accepted the event will be hosted in the seclusion of Dagstuhl's well known, own, dedicated facilities in Wadern on the western fringe of Germany. Moreover, the Dagstuhl office will assume most of the organisational/ administrative work, and the Dagstuhl scientific staff will support the organizers in preparing, running, and documenting the event. Thanks to subsidies the costs are very low for participants.

Dagstuhl events are typically proposed by a group of three to four outstanding researchers of different affiliations. This organizer team should represent a range of research communities and reflect Dagstuhl's international orientation. More information, in particular, details about event form and setup as well as the proposal form and the proposing process can be found on

http://www.dagstuhl.de/dsproposal

Schloss Dagstuhl – Leibniz-Zentrum für Informatik is funded by the German federal and state government. It pursues a mission of furthering world class research in computer science by facilitating communication and interaction between researchers.

Important Dates

- Proposal submission: October 15 to November 1, 2018
- Notification: February 2019
- Seminar dates: Between August 2019 and July 2020.

ERCIM
European Research Consortium
for Informatics and Mathematics

ERCIM – the European Research Consortium for Informatics and Mathematics is an organisation dedicated to the advancement of European research and development in information technology and applied mathematics. Its member institutions aim to foster collaborative work within the European research community and to increase co-operation with European industry.

ERCIM is the European Host of the World Wide Web Consortium.

Consiglio Nazionale delle Ricerche
Area della Ricerca CNR di Pisa
Via G. Moruzzi 1, 56124 Pisa, Italy
http://www.iit.cnr.it/

Norwegian University of Science and Technology
Faculty of Information Technology, Mathematics and Electrical Engineering, N 7491 Trondheim, Norway
http://www.ntnu.no/

Centrum Wiskunde & Informatica
Science Park 123,
NL-1098 XG Amsterdam, The Netherlands
http://www.cwi.nl/

RISE SICS
Box 1263,
SE-164 29 Kista, Sweden
http://www.sics.se/

Fonds National de la Recherche
6, rue Antoine de Saint-Exupéry, B.P. 1777
L-1017 Luxembourg-Kirchberg
http://www.fnr.lu/

SBA Research gGmbH
Favoritenstraße 16, 1040 Wien
http://www.sba-research.org/

Foundation for Research and Technology – Hellas
Institute of Computer Science
P.O. Box 1385, GR-71110 Heraklion, Crete, Greece
http://www.ics.forth.gr/

Magyar Tudományos Akadémia
Számítástechnikai és Automatizálási Kutató Intézet
P.O. Box 63, H-1518 Budapest, Hungary
http://www.sztaki.hu/

Fraunhofer ICT Group
Anna-Louisa-Karsch-Str. 2
10178 Berlin, Germany
http://www.iuk.fraunhofer.de/

University of Cyprus
P.O. Box 20537
1678 Nicosia, Cyprus
http://www.cs.ucy.ac.cy/

INESC
c/o INESC Porto, Campus da FEUP,
Rua Dr. Roberto Frias, nº 378,
4200-465 Porto, Portugal

Universty of Warsaw
Faculty of Mathematics, Informatics and Mechanics
Banacha 2, 02-097 Warsaw, Poland
http://www.mimuw.edu.pl/

Institut National de Recherche en Informatique
et en Automatique
B.P. 105, F-78153 Le Chesnay, France
http://www.inria.fr/

I.S.I. – Industrial Systems Institute
Patras Science Park building
Platani, Patras, Greece, GR-26504
http://www.isi.gr/

VTT Technical Research Centre of Finland Ltd
PO Box 1000
FIN-02044 VTT, Finland
http://www.vttresearch.com