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Facial expression recognition for intelligent tutoring systems in remote laboratories platform

Jihen KHALFALLAH[a,*], Jaleleddine BEN HADJ SLAMA[b]

[a]*PhD student in Research Unit Advanced Systems in Electrical Engineering (SAGE), National School of Engineers of Sousse (ENISo), Erriadh 4023, Tunisia*
[b]*Professor of Electrical Engineering in National School of Engineers of Sousse (ENISo), Erriadh 4023, Tunisia*

Abstract

In this paper, we present a Web-based intelligent tutoring system, called Remote Laboratory (RL). It is a computer-based learning environment that allows students from anywhere to access and perform experiments on real laboratory equipment from a distance via the Internet. As such, RLs are excellent platforms for students to network and collaborate with students from other. The project creates a platform in higher education sector, to be used to support student collaborative activities in RLs in a structured way that will enable students to develop in technical skills. We discuss how to employ facial expression recognition (FER) to develop an intelligent system to guide the students and also help them to improve the teaching and learning process.

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Keywords: Engineering education; Remote Laboratory; Facial Expression Recognition; Intelligent e-Learning; Intelligent Tutoring Systems

* Corresponding author. Tel.: +216-52-788-611.
E-mail address: jihen.khalfallah@gmail.com

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1. Introduction

For several decades, many research works have focused on issues related to the Remote Laboratory Platform. Getting rid of geographic proximity restrictions has far reaching consequences for education. Students and teachers working from distant locations, 24 hours a day, can share networked remote lab facilities[1]. Positive over negative feedbacks are introduced through years for remote laboratories, nonetheless more improvement appears in teaching material and afterwards, the objective of these laboratories has changed.

This paper describes the emergency of some of these changes and explores in some depth a few of the major factors influencing laboratories today. In particular, it considers the lack of monitoring or supervising a running experiment from geographically dispersed places and how this lack has limited the effectiveness of laboratories and hampered meaningful research in the area. A list of fundamental objectives is presented along with suggestions for possible future research.

The development of such platform requires integration between software engineering, Tutor-Student interaction, learning assistance, and finally the intelligent learning assistance for coherent learning objectives for laboratories. The overall aim of the remote lab was to introduce fundamental concepts and to apply these to a limited range of engineering processes. An attractive way is needed to deep the students' understanding of basic scientific principles and concepts of electronics. While the major reason of poor practicing of students is due to the lack of student assistance during his practical work. To overcome this problem, new forms is introduced for teaching the laboratory part of the electronics courses supported by e-Learning opportunities. We endorse an intelligent e-Learning approach consisting of remote labs with an intelligent tutoring system based on a cognitive model recognizes four basic emotions in student expressions which are anger, sadness, surprise and happiness to achieve the desired educational targets.

This paper is structured as follows: in the next section, it discusses the related work of tutoring systems in e-Learning. Afterwards, it describes the overall and specific objectives of remote lab platform. Next, it introduces a brief overview of facial expression recognition. Afterwards, it includes a general view along with the instruments that is used in order to support the remote lab platform. Then, it presents a strategy of facial expression recognition for intelligent tutoring in this research work. Finally, it concludes with conclusion and some perspectives.

2. Intelligent Tutoring systems in e-Learning

The goal of this section is to outline a detailed overview on the main progresses made in the field of intelligent tutoring systems in e-Learning. Different types of ITS can be classified thanks to various characteristics. An alternative way to diversify them is to consider the various methodologies that are the basis of the tutoring support. The concept of intelligent tutoring systems appears at the end of 1960s. Over the past three decades, the world has seen the emergence of ITS, has greatly changed the content and teaching and learning in our today's educational environments[2].

Currently, intelligent tutoring is considered as one of the most recent advancement in educational technology. In fact, considerable efforts have been deployed to develop ITS for education, like SQL-Tutor, an Intelligent Tutoring Systems for SQL programming founded on Constraint-Based Modeling approach. FERMAT ITS AFFECTIF[3], the first affective ITS in a learning social network recognizes basic emotions in student for Mathematics Learning. JITS[4] is a prototype for an ITS for students learning to program in java. BITS[5], an ITS for learning computer programming, its decision making process is guided by a Bayesian network approach to support students.

The purpose of these ITSs focuses on problem solving technologies with suitable error feedback. The aim of our platform Remote Laboratory is to help and assist the student in navigating the unknown concepts during his practical work session after capturing Students' affective states. As referred in section 6, some experiments are conducted to demonstrate the effectiveness of using facial expression recognition in remote laboratories.

3. Remote lab platforms

The overall aim of e-Learning is to improve the quality of learning and not to replace traditional teaching methods. The means to achieve this are multiple, complementary and independent and retain their autonomy access to various resources, offers tutoring services to remote communication tools, solving exercises, exchanges and remote collaboration.

In this context, the main goal of this project is to provide a web application Java EE based on service-oriented architecture and web service aimed for remote models of work practice that is must contain a facial recognition module. Our platform must provide first flexibility: one important merit of a Remote Laboratory is the flexibility that it provides to the trainees in getting laboratory experience at anytime and from anywhere. Second, interactivity: Remote Laboratory requires means of interaction between the tutor and the learner. And third, resource sharing: Each learning regardless of his institution may share and use of various resources through the platform among different institutions.

However, the platform for the remote experiments must meet the following main functional requirements: to perform remote lab, to allow more students to use the platform, to manage the access conflict, to allow monitoring of learners, to pass the practical or theoretical evaluations, to manage practical work, to manage Quiz/Questions and finally to manage the reservation of each remote lab[6].

4. Facial expression recognition

According to the scientific study, the facial expression is considered as the most efficient way to analyze the different emotions and intentions communication[7]. Indeed, affect has a strong and bright future of research in ITS[8] and also of psychological studies over the past several decades. Cognitive psychology and cognitive task was widely used application of image analysis to create computer-based intelligent tutoring systems[9,10,11,12,13]. Nevertheless, the need of ITS to really be smart and interact with student is guaranteed by the ability to recognize emotions and to react to them. Last few years, we have noticed that the number of affective intelligent tutoring systems developed for different learning fields is rising[14,15]. Facial expression recognition systems observe and analyze the face and other human features to detect frustration, interest, or boredom[16,17,18,19,20]. Despite these efforts, recognizing facial expression with a high accuracy remains to be difficult and still represents an active research topic.

Though, the majority of the research to detect emotions in a learner of an Intelligent Tutoring Systems has been performed with special hardware sensors such as posture chairs or skin conductance bracelets[14]. We discover that is very important to incorporate all this technology into learning platforms used on the Web especially in remote lab. In this view, the principal benefit of our project is to include this approach in order to distinguish the best learning style and emotional state of a learner during a practical work session due to the input sensing device that is webcam; it detects the human face and fixes his expression. Nevertheless, the eventual shortcoming of the above approaches is that it is difficult to measure accurately whether a student really understands each concept of practical work and the necessity of special downloading software and installation.

5. Experience

In this section, we introduce Remote Laboratory e-Learning platform which is the result of experiences with e-Learning implementation in research unit SAGE at National Engineering School of Sousse.

The lab consists of a classroom prepared with a network permitting large number of students to interact with each other combining or mixing web-based technology and permits to the students to experience online and offline with necessary lecture notes, worked tutorial questions, quizzes and assignments.

The learner request access to the Remote Laboratory Platform through his own PC via the web service, after confirming the reservation of practical work, he wants access to it. The server redirects to the desired practical work through the IP address of the PC which is connected to the UniTrain-I system is in the lab of SAGE unit. The learner starts by handling the equipment remotely.

This experiment consists to concentrate to the experimental study of various diodes in different circuits.

The behavior in forward bias and reverse bias of the diode can be clearly illustrated by a characteristic which describes the relationship between the current and voltage of the diode. The following figure is designed to compare three different diodes with the model UniTrain-I which corresponds to the circuit connected according to the statement of practical work:

a b

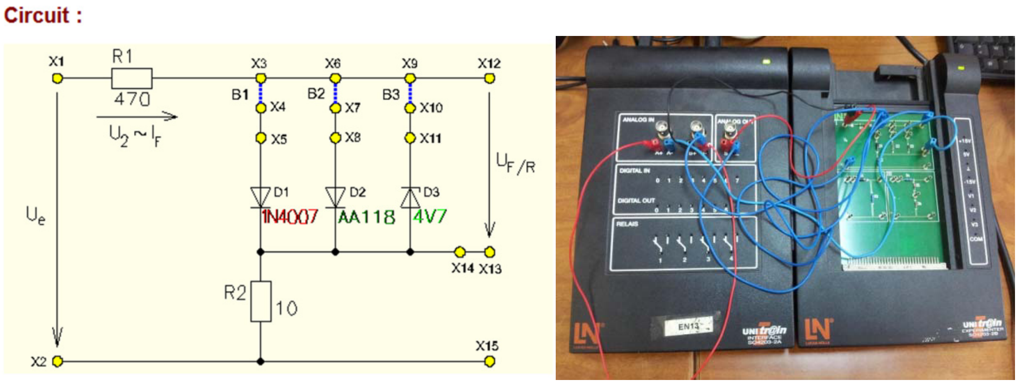

Fig. 1. (a) Interface of the circuit; (b) Interface UniTrain-I model corresponding to the circuit

UniTrain-I[1] is a multimedia e-Learning system with integrated, mobile electronics lab for general education and advanced training in electrical engineering and electronics. It is a powerful experiment and training platform for computer-based vocational and advanced professional training in the fields of electrical engineering and electronics. It combines theory and practice resulting in a highly efficient and effective learning environment with multimedia diversity.

The following test is to experimentally determine the direct characteristic of a silicon diode. To do this, a DC voltage is applied to the diode D1 via a series resistor R1. Increases the voltage step by step, we measure the voltage and valve current values which are the notes from a table and then transfer them to a chart Fig. 2. This approach is very explicit but takes a long time, this being the reason why the comparison of three diodes is carried only in the following assay Fig. 3.

Fig. 2. Interface of the measurement of the diode voltage UF and the diode current IF by switching the virtual instrument on the DC power on the 10 V range

[1] http://www.lucas-nuelle.fr/2420/apg/1425/Produits/UniTrain-I.htm

In the next test, the forward bias characteristics is experimentally determined for a silicon diode and a germanium diode and the characteristics in forward bias and reverse of a Zener diode by using a dynamic record of characteristics.

Sinuoïdale a voltage is applied, ramp-shaped or triangular in the diode via a series resistor. Used an oscilloscope to measure the valve voltage and the valve current then represents the form of characteristic in XY mode.

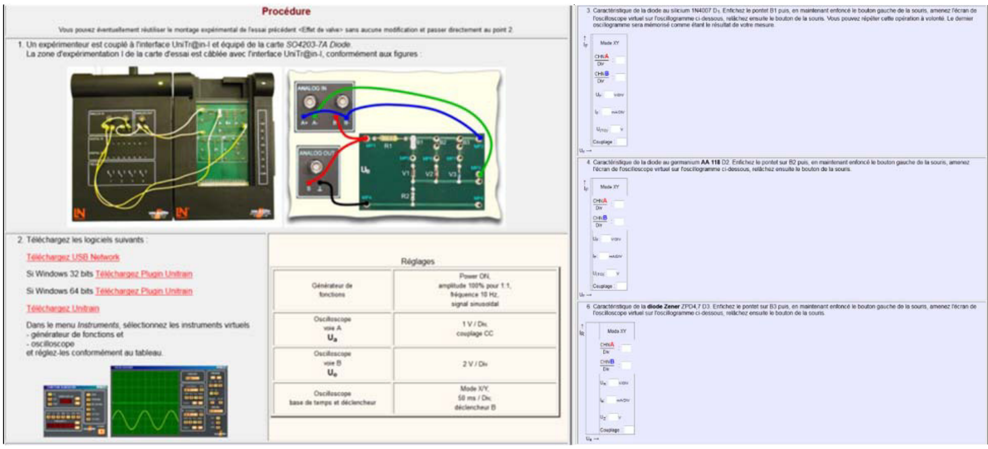

Fig. 3. Practical work interface: Recording characteristics (dynamic)

The figure below shows the implementation of the next page displaying the curve characteristic of the silicon diode D1 1N4007 using the virtual oscilloscope:

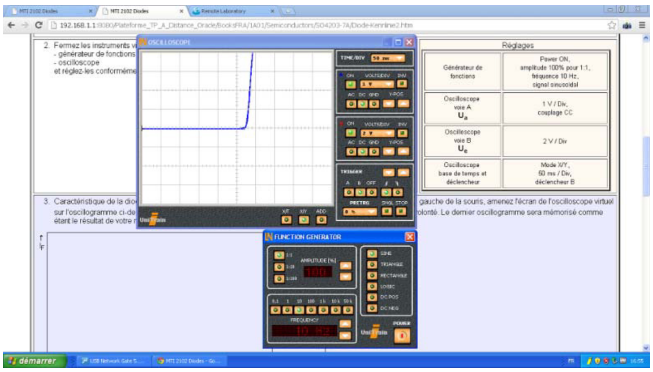

Fig. 4. Interface realization of the silicon diodes practical work

6. Facial expression recognition for intelligent tutoring

The Remote Laboratory provides on-demand network access after confirming the reservation of practical work by the student. The key to aid the student to navigate through the concepts is two-fold. On the one hand, when the student finishes reading the statement of the practical work, the platform provides adaptive feedback[4] due to facial expression recognition. On the other hand, we need to keep track of student knowledge regarding each concept. Facial expression recognition can help us to meet both of these objectives.

The emotion detection of the student based on a machine learning algorithm is able to monitor, to detect a face from a webcam and to extract interesting details based on a given model, an example is presented in Fig. 5. Face recognition system is created with powerful JavaScript library named "Clmtrackr" for fitting facial models for face model detection by means of Constrained Local Models. This library needs files with the extension .js for initial face detection and also for matrix calculation and is based essentially on the algorithms detailed in[21] by Jason Saragih & Simon Lucey in "Face Alignment through Subspace Constrained Mean-Shifts". Clmtrackr tracks a student face and outputs the coordinate positions of the face model as an array, following the numbering of the model which contains 70 points as shown in Fig. 6.

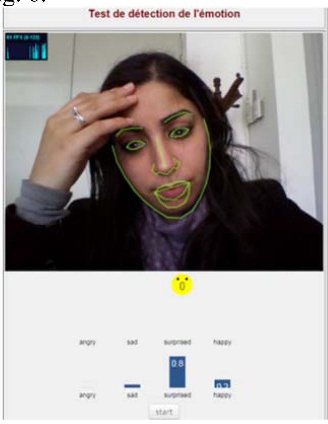

Fig. 5. Interface of Emotion Detection of learner expression

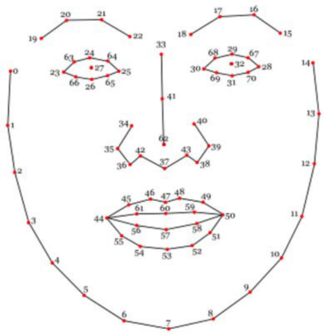

Fig. 6. Face model detection JavaScript

Algorithm fits the facial model by using 70 small classifiers, one classifier for each point in the model. From an initial approximate position, the classifiers search a small region around each point in order to find a better fit, and the model is displaced incrementally in the way giving the best fit, progressively converging on the optimal fit.

When we start a webcam, Clmtrackr will try to detect a face on the given element. Once the face of the student is found, the library will begin to adjust the facial model, and the positions can be returned via the function getCurrentPosition(), in this direction the detection is performed.

The facial expression recognition systems detect and measure the rate of anger, sadness, surprise and happiness of student emotion. Subsequently, the tutor has the ability to identify situations frustration or serenity by observing one of the following five choices:

a) The rate of anger > 0.5 : The student not sure if he understand the concept;
b) The rate of happiness > 0.5 : The student understand the concept;
c) The rate of surprise> 0.5 : The student don't understand;
d) The rate of sadness > 0.5 : The student don't understand the concept;

Also, he can understand expressions via body language and detect some emotional and/or mental states in order to offer assistance in a) or d) and help students in case c) in each question in the remote lab experiment which allows the interactivity between them[19] which allows also human tutors to identify their difficulties in practical work[22]. This latter option takes advantage of a new developed component to be used in the remote experimentation context for pedagogical purposes for improving their understanding of concepts in Remote Laboratory Platform[23].

6.1. Implementation

Our platform Remote Laboratory includes distance remote lab in order to conduct experiment for distance students. It follows the Tutor-Student architecture where the Tutor takes the role of the server and the Student behaves like the client[24]. In this work, a Java EE (Enterprise Edition) and Web Services-based approach to be used in the remote lab context for pedagogical purposes is presented. In this way, Web Services technology allows learners to realize his practical work in the form of remote procedure calls via Http channel and access our Web-based laboratory website. To communicate, client and server programs must establish a communication session across the network that connect them. The Tutor-Student interface enable this latter to interact with experiment and performs the selected remote experience. A server receives client requests and forwards these to the device which decrypts these commands for start out the real-time device[25]. Meanwhile, the tutor also has looking a student's webcam enabling monitoring and assistance. Remote Laboratory provides not only the web lab's communication but also administration and authentication tools. The data are stored in Oracle 11g database.

6.2. Testing the Platform

Many attempts are made addressed to the first year in Electrical Engineering students studying basic electronic. They tested the platform while realizing the remote practical work in full. At the end we give them a questionnaire. Concerning learners' attitude towards remote labs we plan to exploit this questionnaire with the objective to evaluate the remote labs by learner about the following characteristics: Comprehensive, Clear, Educational, well organized, Interesting, well documented, Satisfactory and Important[26]. The first results of investigation denote that the Remote Laboratory Platform is generally well accepted from the students. Regarding the technical evaluation of remote labs, the main focus will be given to consider the way how the tutor will make feedback with the student in order to measure usability of our project.

In this paper, we present the methodology of validation of the use of the concept of facial recognition in distance education as referred in Fig. 7. Thereby, we recorded the student volunteers for the realization of the practical work, and then we applied the facial expression recognition algorithm to the recorded video sequences. The results are very promising and are align with the survey questionnaire. The first statistical results of face recognition helped to highlight the need of student's assistance in some steps during their practical work. In consequence, improvements of the content of practical work were carried out in order to overcome the difficulties encountered by students. The tests with the new content of practical work are evaluated in progress with other student volunteers.

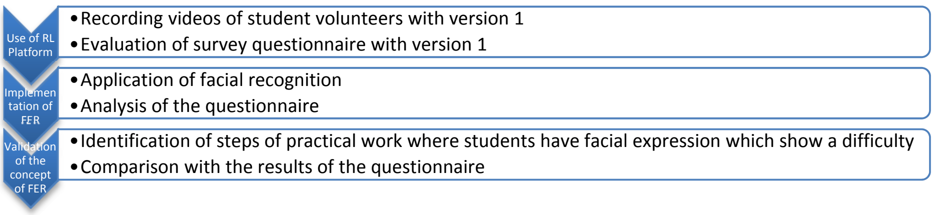

Fig. 7. Validation of the methodology of applying Facial expression recognition to RL

7. Conclusion

This contribution endorse an intelligent e-Learning approach with consisting of remote labs with an intelligent tutoring system based on a cognitive model to achieve the desired educational targets. It provides remote access to several types of materials which includes instruction notes, tests, and examples. Remote Laboratory Platform must manage the simultaneous access of learners in order to provide the access conflict. It explores the practical applications for teaching control engineering concepts to undergraduate students with sharing information and knowledge. The project is original in the engineering education, because it offers a promising solution in order to supervise the work of students and answer their questions in real time while ensuring the interaction with the intelligent tutor.

Future work will involve incorporating more sophisticated concepts of tracking mode to supervise and evaluate the learner into Remote Laboratory. We also hope to extend Remote Laboratory incorporating other safety educational materials. It provides to the student an intelligent navigation support, guidance and recommendation with intelligent tutoring systems. The platform may include means of monitoring and generate automatic learning assistance after study his face and other human features to detect and also measure frustration, interest and boredom to help trainer in their teaching role and of course learner to overcome their difficulties during their practical work. In addition, we describe later how to guide the students' learning process. Moreover, we hope to add problem solving support to the platform and able to maintain security.

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