Intelligent Learning Environments

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Intelligent Learning Environments

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Editorial

Computers have been used in the Education field since several decades ago, where many studies have demonstrated computers using Artificial Intelligence techniques can be very helpful in supporting human learning, transforming information into knowledge, using it for tailoring many aspects of the educational process to the particular needs of each actor, and timely providing useful suggestions and recommendations.

The growing usage of computers in education offers an excellent opportunity for exploring new ways of applying AI techniques to education. It also delivers huge amounts of information in need of intelligent management, and poses big challenges to the field on topics such as affective and intelligent tutoring systems, intelligent learning management systems, authoring tools, Student modeling, Applications of cognitive science, etc.

In this volume we present six research works in some of the most interesting fields of intelligent learning systems.

The papers were carefully chosen by the editorial board on the basis of three reviews by the members of the reviewing committee. The reviewers took into account the originality, scientific contribution to the field, soundness and technical quality of the papers.

We appreciate the work done by members of Mexican Society for Artificial Intelligence (Sociedad Mexicana de Inteligencia Artificial), Instituto Tecnológico de Tuxtla Gutierrez (Chiapas, Mexico), and Universidad Autónoma de Chiapas for their support during preparation of this volume.

María Lucía Barrón Estrada
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November 2014

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Representation of an Academic and Institutional Context Using Ontologies

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Abstract. In this paper we describe an ontology model that was designed and implemented to represent academic and institutional contexts related with a research center in Mexico City. The ontology model aims at supporting logic-based query answering and reasoning regarding contexts such as geographical areas, time, persons, libraries, cultural and academic events, teaching and tutoring schedules. The type of questions that the ontology model is capable of answering range from academic issues such as tutoring and thesis supervision; those concerning the location of people, libraries, buildings, roads; those regarding time such as class schedules, event schedules; and even those about the food menu offered at the cafeteria of the institution. In order to evaluate the ontology model, a set of competency questions were translated into SQWRL rule-based query language. Results of queries show the feasibility of using ontological models as the supporting technology to implement ubiquitous and pervasive systems for academic environments.

Keywords: Ontology models, academic contexts, recommendation system.

1 Introduction

Currently academic institutions and research centers manage large amounts of data concerning their academic and research activities, cultural events and services, and personnel. Such information must be available for students, professors, administration staff and visitors. The management of large amounts of data represents an opportunity for the adoption of Semantic Web Technologies. The literature shows a clear trend in the use of ontologies for knowledge management and information sharing systems that manage the context, such as: recommendation systems based on context, context- aware systems, context-adaptive systems [1, 2, 3], to name a few. Furthermore, several studies have reported on the use of ontologies for handling and representing contexts [4, 5, 6, 7]. In this paper we describe the design and implementation of an ontological model for an academic and institutional context. The system offers a logic-based content provider for the answering of academic issues such as tutoring and thesis supervision; those concerning the location of people, libraries, buildings, roads; those regarding time such as class schedules and event schedules. Furthermore, the ontology's services are made available for mobile devices in order to take into account the users' mobility.

The rest of the paper is organized as follows: Section 2 presents our motivation; Section 3 describes the particular contextual models that support the institutional ontology model, and its integration as a web service; Section 4 presents an evaluation of the ontology model based on the defined competency questions, and the user interfaces built to accomplish this task; and finally in section 5 conclusions are presented.

2 Motivation

Over the last decades we have witnessed different research venues for semantic web technologies. Of particular attention is the growing community promoting and adopting the use of ontologies as the instrument for modeling contextual information. For example, an ontology model was developed for home health monitoring [8] especially for patients that need to stay at home, and under the continuous supervision of a care network (e.g. family members, doctors, nurses and the care center). The system provides access to the ambient and biomedical sensing data, the contextual representation of the patient health status, and possible health-care plans. Another interesting application for ontologies is proposed in MAIS [9], implemented for the context of tourist services which enable users to design their tour plans, schedule itineraries and be aware of transportation routes all over the same platform. An ontology model that takes into account location is mIO [10], designed to explore interoperability in a net- worked environment where, for example, content, services, connectivity and accessibility can vary among users' profile and their location.

Ontology models thus can help characterize and specify all of the entities needed to describe the context as a whole [11]. A context can be composed for contextual items such as location, physical data, activity, and instrumental and social context [12]. By means of ontologies it is possible to model an explicit specification of what users' needs and offer back the level of information and services that would support individuals' everyday activities [13],[14]. The set of ontology models described in this paper were designed to represent contexts such as geographical areas, time, persons, libraries, cultural and academic events, teaching and tutoring schedules.

3 An Ontology Model for Academic and Institutional Context

In this section we describe the set of contextual models that together integrate the top level ontology which in turn support the web service available for professors, students, administration staff and visitors. The main objective of this ontological model was to provide a prototype implementation to show the advantages and conveniences of ontology-based solutions for ubiquitous computing and pervasive systems. In particular, we aim in providing a knowledge-based system to support student lifestyle inside the campus. It is important to note that the ontology model was implemented in

Spanish language. On its own each ontology model represents a sub-domain of the contextual environment, i.e. institutional resources, facilities and services. The main ontology, integrating low level models, can be queried for information regarding zones/spaces, individuals, academic and no academic events and buildings.

Geographic Area Ontology. This ontology model seeks to provide contextual information about the physical resources and facilities students would like to use or know about. For example, as they arrive to the institution premises they can query the system for the different zones used for parking lots (*estacionamiento*).

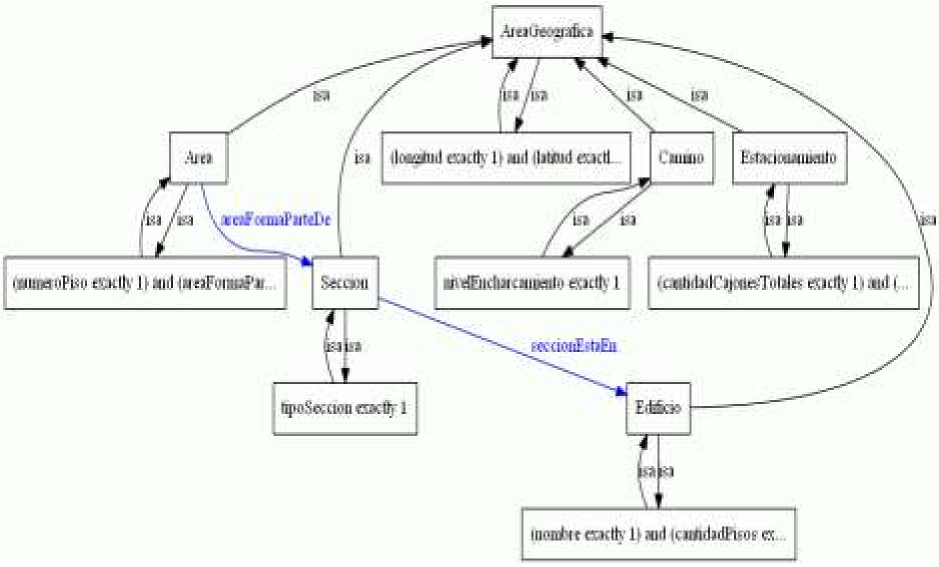

Fig. 1. Geographic area ontology model.

There is an ontology model for main buildings (*edificio*) and another one (*areas*) for the different sub-divisions exists inside buildings, e.g. professors' offices, tutoring cubicles, student counseling, among others. Other buildings' spaces that are occasionally used by students, e.g. toilets, conference rooms and administration offices are modeled into a section's ontology (*sección*). In order to facilitate the location of physical facilities there is available an ontology model for paths (*camino*). As can be observed from Figure 1, any physical facility has a longitude and latitude (GPS landmark) property.

Person Ontology. The Person ontology (Figure 2) aims at representing individuals that are part of the institution, or that are visitors. The class Person is axiomatically described as follows: every person must have exactly one name, every person must have exactly one gender, every person must have exactly one date of birth, every person must have exactly one age, and every person must have at least one nationality. The student class (*alumno*) is used to represent individuals that may be of two classes: MSc degree students and PhD students. With an employee class (*empleado*) we defined academic, teachers and researchers, and administration staff. There is also a class to take into account visitors, no matter for how long these individuals would stay at the institution.

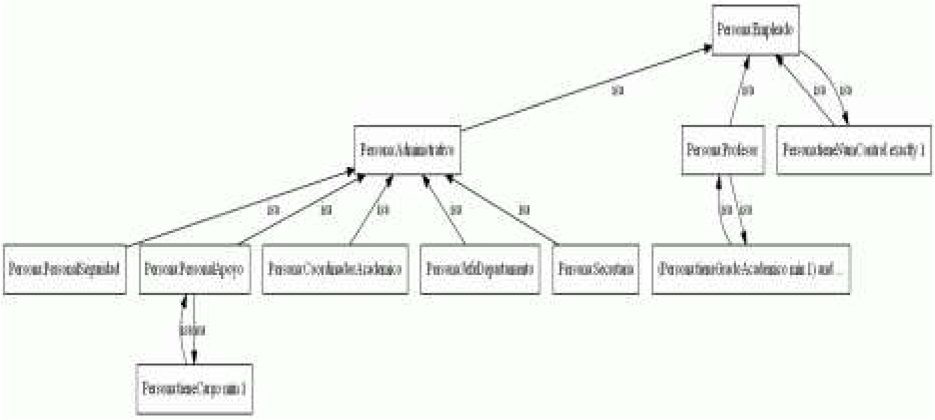

Fig. 2. Person ontology model.

Academic Ontology. This model is used to provide information about the courses or subjects being offered by the institution. Classes contextualizing this ontology include the subject (*materia*), its timetabling, and the professor teaching that particular course. For the sake of space in Figure 3 is offered an extract of the relationships existing between the academic, person and geographic ontologies, highlighting their object properties.

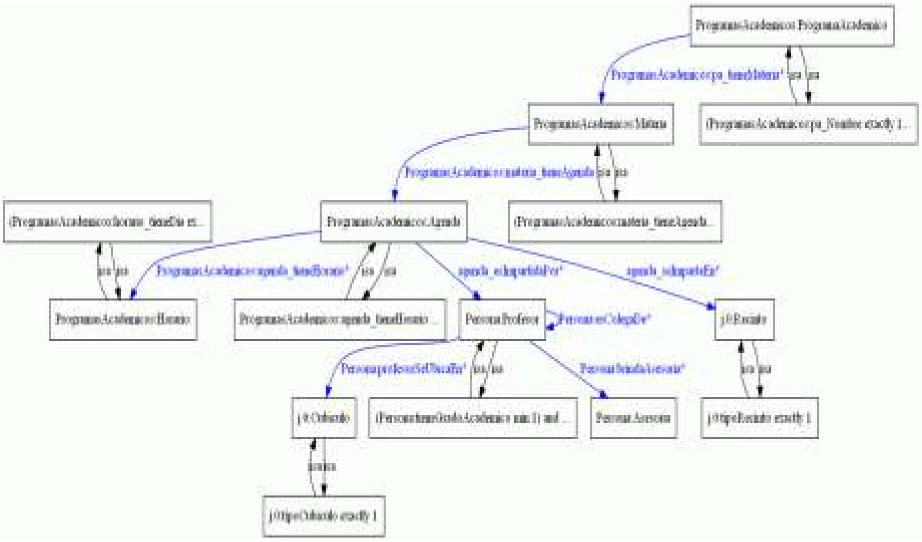

Fig. 3. Semantic relationships between the ontologies Academic, Person and Geographic Area.

As indicated in Figure 3, object properties are important in order to link concepts between ontologies and to support query answering. In particular, the following object properties are of special interest:

- *agenda_tieneHorario*. This object property has as domain the ***ProgramasAcademicos:Agenda*** class and as a range the ***ProgramasAcademicos:Horario*** class. This object property is used to create academic program schedules, associating the time with the subject name of the course.
- *agenda_seImparteEn*. This object property has as domain the ***ProgramasAcademicos:Agenda*** class and as a range the ***Recinto*** class. This object property is used to specify the specific classroom where the course is to be taught.
- *agenda_esImpartidaPor*. This object property has as domain the ***ProgramasAcademicos:Agenda*** class and as a range the ***Persona:Profesor*** class. This object property is used to specify the professor responsible of teaching the course.

Other Contextual Ontologies. There are two additional academic ontologies aiming at supporting academic, sports or cultural events. For instance, the events calendar ontology helps users to be aware of what events either academics, sports or cultural, are programmed in the institution calendar, so they cannot miss a single one. In addition, the library ontology model is used to rep- resent the library and the services it offers such as book titles and the number of items that are available for lending. There is also the "Ontology Area" which helps for location of the different sub-divisions exists inside buildings, e.g. professors' offices, tutoring cubicles and student counseling, among others. An "Ontology Cafeteria" offers information about its daily menu.

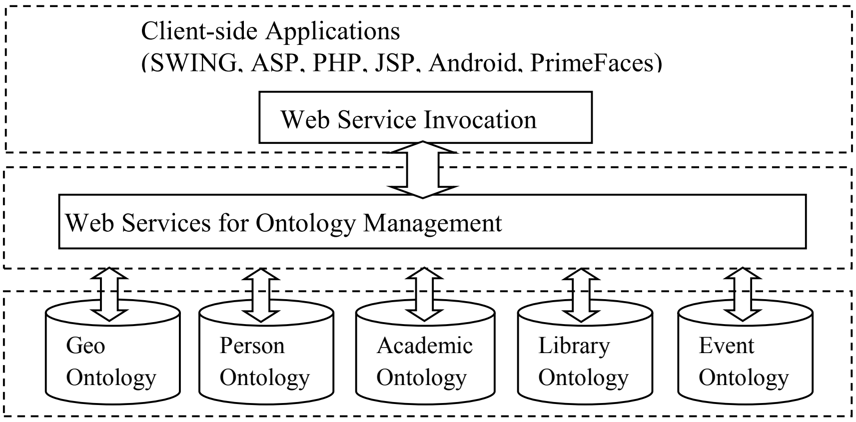

Fig. 4. Architecture for Academic and Institutional Context.

Finally, in Figure 4 we present the three tier architecture which incorporates the ontology layer, the services layer and the client-side applications. As describe above the ontology layer consists of seven ontology models that together provide the semantic concepts and relations for the set of Web services that are invoked from user's client applications, introduced in the evaluation section.

4 Evaluation

The main contribution of this research relies on the system ontology design for the representation of an institutional context in order to support users with information about individuals, buildings, events, and other academic related resources. In order to enable the ontology model answer the contextual questions made by users a set of SWRL rules supporting the reasoning level of the ontology were implemented. Table 1 presents some of the SQWRL rules that met some of the competency questions defined for the institutional model.

Table 1. Competency questions and their respective SQWRL query rule.

Competency Question	Context of interest	SWRL Query
How many articles has Dr. X published?	Looking up for a strong research area.	Persona:Profesor(?p) ^ Persona:tieneNombre(?p, ?y) ^ swrlb:stringEqualIgnoreCase(?y, "Amilcar Meneses Viveros") ^ Persona:tieneArticulosPublicados(?p, ?cantidad) -> sqwrl:select(?cantidad)
How many students graduated in area X?	I would like to go for a successful career.	Persona:Alumno(?x) ^ Area:Area(?area) ^ Area:tieneNombre(?area, ?nombre) ^ swrlb:stringEqualIgnoreCase(?nombre, "PruebaConSistemasDistribuidosYParalelos") ^ Persona:estudiaEn(?x,?area) -> sqwrl:select(?x)
Where is the office of Professor X?	I would like to talk to a professor who may agree to be my thesis's supervisor.	Persona:Persona(?p) ∧ Persona:tieneNombre(?p, "Amilcar Meneses Viveros") ∧ seEncuentraEn(?p,?areaGeografica) ∧ GeographicArea:areaFormaParteDe(?areaGeografica,?seccion) ∧ GeographicArea:tipoSeccion(?seccion,?tipoSeccion) ∧ GeographicArea:seccionEstaEn(?seccion,?edificio) ∧ GeographicArea:nombre(?edificio,?nombreEdificio) -> sqwrl:select(?tipoSeccion,?nombreEdificio)
Is the book X in the library Y?	I need to find literature resources to complete assignments.	Biblioteca:Biblioteca(?y) ^ Biblioteca:Libro(?x) ^ Biblioteca:tieneLibro(?y,?x) ^ Biblioteca:Nombre(?x,"Sustainability in the Chemical Industry") ^ Biblioteca:NombreBiblioteca(?y,"Biblioteca de Química") -> sqwrl:select(?x)
Where is the cubicle of person X located?	I would like to talk to students working on	Persona:Persona(?p) ∧ Persona:tieneNombre(?p, "Marco Antonio Castro Hernandez") ∧ GeographicArea:Cubiculo(?c) ∧ ocupadaPor(?c, ?p) ∧ GeographicArea:tipoCubiculo(?c,?tipoCubiculo)∧

Competency Question	Context of interest	SWRL Query
	research areas that are of my interest.	GeographicArea:areaFormaParteDe(?c,?seccion) ∧ GeographicArea:Seccion(?seccion) ∧ GeographicArea:seccionEstaEn(?seccion,?edificio) ∧ GeographicArea:Edificio(?edificio) ∧ GeographicArea:nombre(?edificio,?nombreEdificio) -> sqwrl:select(?tipoCubiculo,?nombreEdificio)
How many places are available for a particular parking lot?	Hope I can luckily find a slot in the car parking.	GeographicArea:Estacionamiento(?e) ∧ descripcionEstacionamiento(?e,"Estacionamiento Computacion")∧ GeographicArea:cantidadCajonesTotales(?e, ?cTotales) ∧ GeographicArea:cantidadCajonesOcupados(?e, ?cOcupados) ∧ swrlb:subtract(?cDisponibles, ?cTotales, ?cOcupados) ∧ descripcionEstacionamiento(?e,?desc) -> sqwrl:select(?desc, ?cDisponibles)

The ontology model was evaluated using both computer and mobile interfaces. Users can interact with these interfaces to ask questions without having to hassle with edition and execution of SWRL rules. Figure 5 shows some of the questions posted to the ontology model and their correspondent response.

An Android based interface was built to take into account user mobility. Figure 6 presents how the user queries the ontology model to ask for the location of an individual. In Figure 6a, a student issued the query to ask for a teacher's office. S/he first selects the object person (persona) of type teacher (professor) and by leaving the teacher's office instructs the ontology to return this information. Figure 6b, shows that the ontology model by means of the web service returns the full name of the teacher, its office and the building this is in.

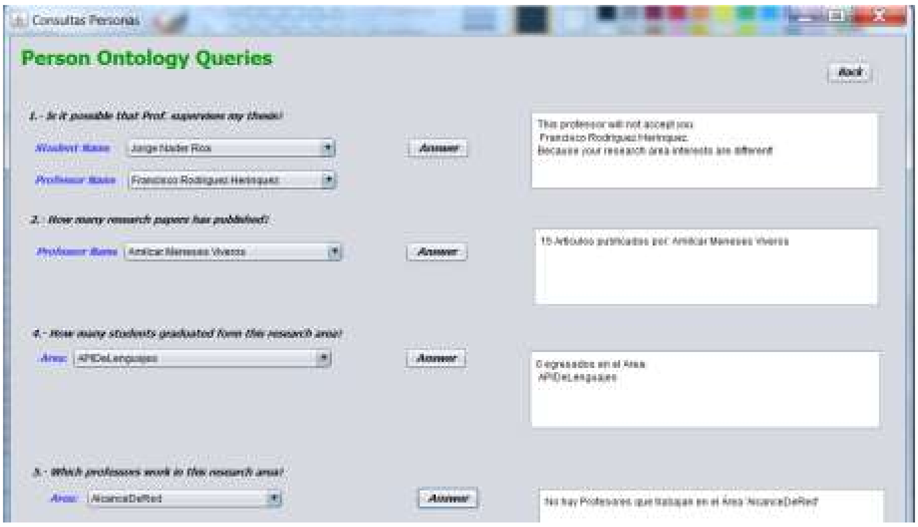

Fig. 5. Java based client to evaluate the ontology model performance.

Fig. 6. The user asks the institutional ontology for the office of a teacher.

5 Conclusions

In this paper we have presented an ontology model that was designed and implemented to represent academic and institutional contexts. In terms of student support the ontology model is capable of answering location and resources/facilities issues. For example, students can get information about the office and classroom the professors is in. They can also identify where buildings, libraries, administration offices are, and what are the routes leading to these institution's spaces. Moreover, users can be aware of the academic (e.g. seminars) and not academic (e.g. sports) events. Ontologies represent a key enabler for context-aware systems, as they enable concept and knowledge sharing while providing a model for context reasoning and query answering. We have evaluated the usefulness of the ontological model through the definition of competency questions and the implementation of an Android application to facilitate the user interaction with the ontology model.

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SCORM Cloud for an Advanced Sequencing of Learning Objects on LMS Moodle Platform

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Abstract: In this research work, the results obtained from the SCORM Cloud module verification in a learning platform (Learning Management System) Moodle 1.9.19, are presented. For this module verification, learning objects based on standard SCORM 2004 Fourth Edition were used, with sequencing according to ADL proposed template 10 and whose sequencing process was developed in a previous, published, research work. Due to scarce information, coupling a Learning Management System (Moodle 1.9.19 in this case) with SCORM Cloud becomes complicated, this paper presents a full description of how to couple SCORM Cloud into a Learning Management System.

Keywords: SCORM Cloud, Moodle, ADL template 10, sequencing, learning object, on-line course automation, intelligent tutoring, learning objectives.

1 Introduction

Learning Management System (LMS) has provided a new opportunity of academic advancement for people who want to continue learning and do not have enough time to follow a course in an academic institution with a fixed schedule**.**

Through these learning platforms the users can enter to conduct their academic activities without time restrictions (unless otherwise decided) and only need a computer with internet access. Within the platform, users with role of "Teacher" or "Administrator" have the ability to add a wide range of resources and activities that contribute to a student's academic background.

Located within the activities, highlighted activities called "SCORM activities" are learning objects developed using an authoring tool in order to be submitted and evaluated by the LMS. The way these activities are made is very important, since it should be visually appealing and interactive for capturing user attention, however it is of equal or greater importance the way in which the material is presented to the student. These activities have sub activities, but there is currently no method to set the sequencing of them to be presented to the student appropriately (based on their interactions in a previous activity). Sub-activities sequencing is done using a software called Reload Editor. With the Reload Editor, rules precondition, post-condition and output conditions, in order to present these sub-activities in an organized manner are configured. There are two ways to perform the sequencing of several Shareable Content Object(SCO), the first is done using identifiers learning objectives (LO) of resources are integrated into the authoring tool to Mapping Local Objectives and the second is by establishing objectives with the Reload Editor (ADL Objectives).

Currently, learning objects that are displayed in an LMS must meet the requirements of the Shareable Content Object Reference Model (SCORM) standard, the most current version of the 2004 Fourth Edition, if an advanced sequencing for the material is required.

SCORM Cloud [2] provides the possibility to reap the benefits of an advanced sequencing based on (local and ADL) objectives of the 2004 fourth edition of SCORM, in platforms that are not able to support that version. Due to scarce information, coupling an LMS (Moodle 1.9.19 in this case) with SCORM Cloud becomes complicated and that is why this is the goal of this research work. The objective is to use the Moodle LMS platform to verify the LO based on the 2004 fourth edition of SCORM, correctly reporting information from the interaction of a student in that activity.

The flexibility provided by the 2004 fourth edition of the SCORM standard for sequencing the LO to be presented to students is unfortunately wasted because most platforms (including Moodle [3]), support only version 1.2 of the standard. Version 1.2 allows only a simple sequencing, that is, within a LO with more than one activity (Multi SCORM package or activity), the student may advance to the next sub-activity or SCO (Shared Content Object) only when the current one is completed. All previous SCO are freely available for consultation, even when the post-exam is reached.

This paper is organized as follow: Section 2 provides related works about SCO sequencing and an application of pedagogical tools to an on-line course for e-learning. Section 3 presents the details of the configuration used to couple SCORM Cloud module within the LMS Moodle. Section 4 covers the verification of SCORM Cloud. Section 5 presents the results of this verification. Finally Section 6 and 7 cover the future work and conclusion for this research.

2 Related Work

In [4] authors explain in detail the way to achieve SCORM activities configuration, involving sub-activities or several SCO (as named in SCORM standard, being learning objects containing teaching materials), following the guidelines proposed by ADL with Template 10 and Educative Model 3, and using Reload Editor software. Two forms of achieving sub-activities sequencing of an SCORM activity, are described, applying learning objectives mapping for each activity (from Author Tool) and setting ADL objectives with Reload in order to evaluate them, using shared global objectives and sub-activities cumulative (roll out). In [5] authors explain an application of pedagogical tools to an on-line course for e-learning, including an example of a course specification showing an activity, an example of an script for an activity, and a course development model.

3 Configuring the SCORM Cloud module in Moodle

The SCORM Cloud module used for the configuration tests accommodates LMS Moodle platforms versions 1.9.x. The new module is installed on the server in the directory *../htdocs/Moodle/mod*. Figure 1 shows the location of the SCORM Cloud module Moodle files.

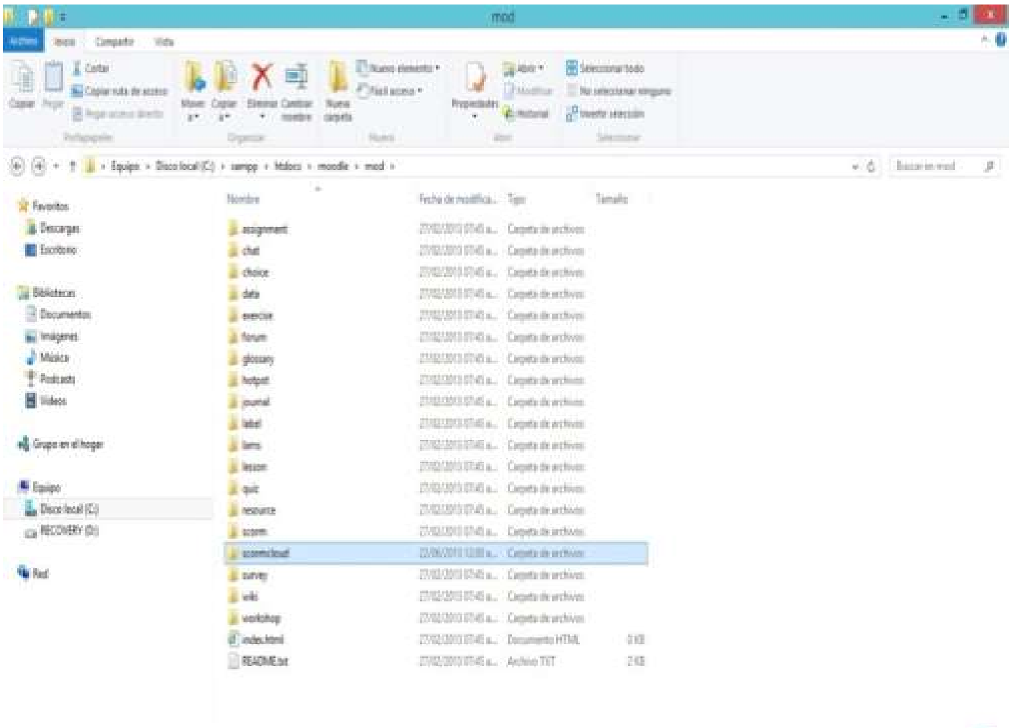

Fig.1. SCORM Cloud module location within Moodle files.

After configuring the new module, it is available in the LMS "Add activity..." menu of the option "Notifications" in the LMS administration menu. Figure 2 identifies the "SCORM Cloud" module in the menu mentioned above. Then, LO preloaded from the LMS "Administration" menu "Files" option was selected in the configuration form of SCORM Cloud activity.

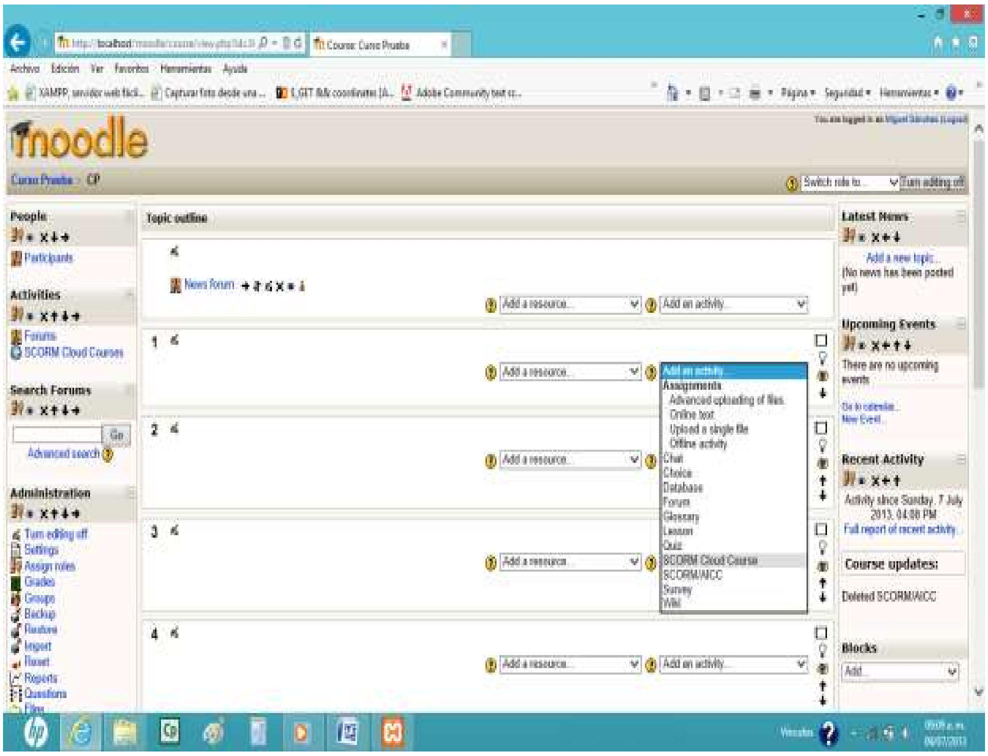

Fig.2. SCORM Cloud module within the "Add an activity..." menu in Moodle.

4 Verification of SCORM Cloud

Verification process of this new module required a LO sequenced with the capabilities of SCORM 2004 Fourth Edition, using the Reload Editor [1]. The example LO was sequenced according to the guidelines of the ADL template 10 (sequencing configuration of the LO was detailed in [4]). Figure 3 shows the behavior with which an LO was sequenced according to this template.

The depiction of Figure 3 is detailed including learning objectives in [4], and is shown in Figure 4.

5 Results

LO sequenced behavior was verified in a LMS Moodle platform version 1.9.19 installed locally. Visualization of the LO is performed in an additional window that is enabled to

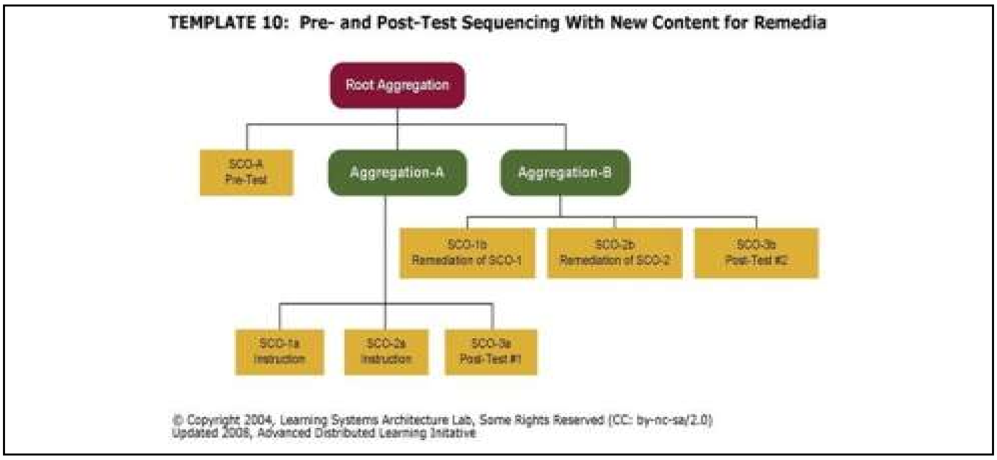

Fig.3. ADL Template 10 [1].

Fig.4. Template 10 based on learning objectives.

display this activity. Figure 5 shows the message launched when an LO is started in SCORM Cloud.

The SCORM Cloud module has a configuration given by RUSTICI [2] (the developers of the SCORM Cloud module). In Figure 6 the configuration mentioned above is shown and also the proper functioning of the LO is depicted, as in first instance it only shows the ordinary material, while remediation material remains hidden.

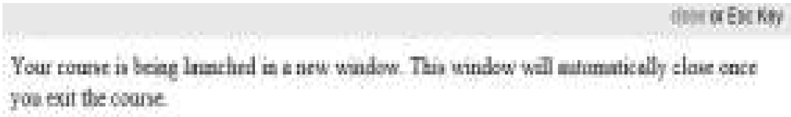

Fig.5. Launching a new window for the SCORM Cloud module.

Fig.6. Ordinary material presented in the SCORM Cloud module.

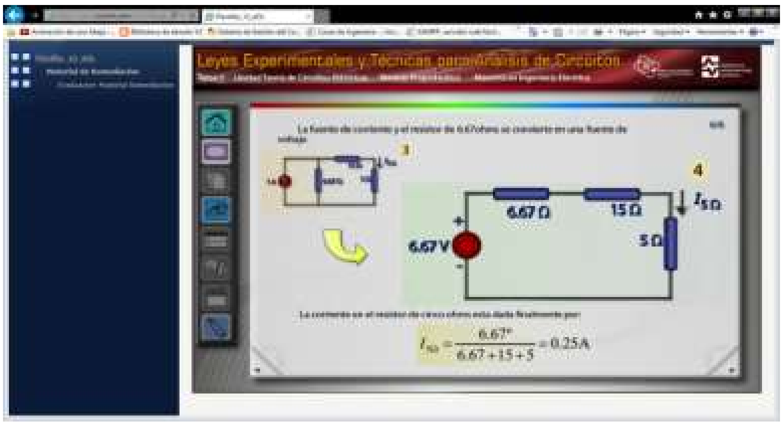

Fig.7. Review of remediation material.

Once the interaction in the Post Exam is completed and depending on the grade obtained in this activity, the student can exit the course or have the option to take the remediation material. This behavior is specified in ADL template 10. Figure 7 shows the interaction of the student in the remediation material. Once the material has been passed (either ordinary material or remediation), student results are exported to the LMS gradebook.

Figure 8 shows the results of the interaction in LMS corresponding to testing a student in the SCORM Cloud module. An important detail to note is that the results are not exported to the LMS gradebook, but remain in the analysis module, that is why the student's grade has to be written manually in the LMS gradebook.

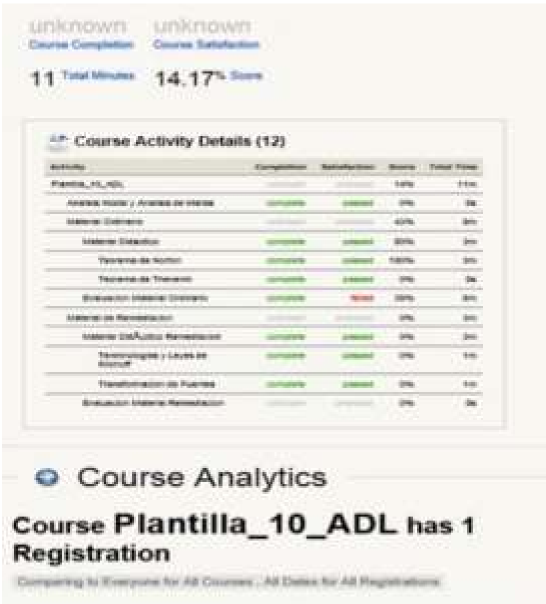

Fig.8. Results from the interaction of a testing student in SCORM Cloud module.

6 Conclusion

In this research work, advanced sequencing of learning objects based on the SCORM 2004 Fourth Edition standard for e-learning, was covered in full, since it is now possible to sequence learning objects in an advanced way and display them in an LMS which is lagged behind this standard. This brings us one step closer to automating online courses delivered through an LMS, where the advanced sequencing is the last step of the intelligent tutoring. Due to scarce information, coupling an LMS (Moodle 1.9.19 in this case) with SCORM Cloud becomes complicated, this paper presents a full description of how to couple SCORM Cloud into an LMS.

As future work, the recording of an LO grade in the LMS gradebook is proposed. Moreover, checking SCORM and LMS Moodle websites constantly is recommended, in case an important new feature or update appears.

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Affective States in Software Programming: Classification of Individuals based on their Keystroke and Mouse Dynamics

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Abstract. In this paper, a method is presented for the classification of an individual into two affective states: boredom and frustration. To gather the necessary data, the individual interacts with an Intelligent Tutoring System focused on the teaching of programming languages. The method involves a classifier based on k-NN, and feature vectors generated by the preprocessing of keystroke dynamics and mouse dynamics data. Accurate results are achieved by determining relevant subsets of the initial feature set, using genetic algorithms. These subsets facilitate the training of the classifiers for each affective state.

Keywords: Affective Computing, Intelligent Learning Environments, Keystroke Dynamics, Mouse Dynamics, k-Nearest Neighbors

1 Introduction

The recognition and simulation of human affects are becoming important fields of study, as many researchers have demonstrated that affect-aware computers can provide better performance in assisting humans [1]. There are works describing different approaches for the recognition and simulation of affective states in human beings. For example El Kaliouby and Robinson [2] proposed a system based on Dynamic Bayesian Networks (DBN) that successfully recognized affective states from a video stream of facial expressions and head gestures in real-time. A work aimed at the simulation of affective states is by Becker-Asano and Wachsmuth [3] who created MAX, a virtual human that simulates emotions in congruence to the mood of the person that interacts with it.

It didn't take long before these techniques were implemented as components of Intelligent Learning Environments (ILE), as the recognized affective states can be used as part of the students' user model. D'Mello, et al. [4] present the development of an affect-sensitive Intelligent Tutoring System (ITS) called AutoTutor, which recognizes the emotions of a learner by monitoring conversational cues, gross body language, and facial features, and attempts to address the presence of negative emotional states with empathetic and motivational statements. Additionally, Drummond and Litman [5] explain a method based on machine learning classification models to asses if a student is zoning out during a spoken learning task.

But as more ILEs embrace these methodologies and techniques pertaining to the field of study known as Affective Computing [1], a problem arises. In order to perform a recognition of the users' affective states, a sensor must be used to gather data. Frequently, these sensors can be considered as intrusive or invasive [6] [7] [8], and can disrupt the learning experience of a student. In this work, a method is proposed for the recognition of affective states based on Keystroke and Mouse Dynamics. Keyboard and mouse input devices should address the problem of the intrusive nature of most sensors, as the vast majority of an ILE's users should be familiarized with the use of this hardware equipment nowadays, and should not regard them as an abnormal factor in the learning environment.

Research works related to Keystroke Dynamics (KD) are carried out either using fixed-texts, or free-texts [9]. KD performed on fixed-texts involves the recognition of typing patterns when typing a pre-established fixed-length text, e.g., a password. In the other case, free-text KD achieves the recognition of typing patterns when typing an arbitrary-length text, e.g., a description of an item. However, as noted by Janakiraman and Sim [10], most of the research regarding KD is done on fixed-text input, the reason being that fixed-text KD usually yields better results than free-text KD. Yet, the authors of this work share the opinion with Janakiraman, R., and Sim, T., that it would be more useful if KD can handle free text as well as fixed text.

As a proof of concept for free-text KD, the method for the recognition of affective states presented in this work is performed in an ITS focused on the teaching of software programming, where students need to input arbitrary-length source code. In this ITS, a student is required to solve a series of programming exercises, and, according to a feature vector extracted from the processed Keystroke and Mouse Dynamics data, a classification of two affective states (boredom and frustration) of the student is accomplished. This classification involves determining if a student was experiencing or not each of the two affective states during the resolution of the programming exercises. With the proposed method, ILEs can predict a learner's affective states, and create better user models in order to provide adaptive, affect-sensitive content.

The structure of this work is organized as follows: Section 2 presents a series of works related to the proposed method in this paper; Section 3 describes the proposed method for the recognition of two affective states in an ITS for the teaching of programming languages; Section 4 explains how an experiment was performed to demonstrate the proposed method, and Section 5 presents the results; finally, a conclusion to this work can be found in Section 6.

2 Related Work

Bosch, D'Mello and Mills [11] analyzed the relationship between affective states and performance of novice programmers when they were learning the basics of computer programming in the Python language. The results of their study indicated that the more common emotions students experienced were engaged, confusion, frustration, and boredom, with 23%, 22%, 14%, and 12% of the students experiencing these emotions, respectively. It was useful to consider these results, as it gives evidence of what affective states to be targeted in order to obtain less biased data. For example, if a less common emotion was chosen, a classifier could opt to classify any feature vector as not experiencing such emotion. Nevertheless, the classifier would obtain accurate results, although the classifier would be inaccurate at determining if a feature vector was actually experiencing the given affective state.

Similar to the previous work, Rodrigo, et al. [12] observed which affective states and behaviors relate to student's achievement within a Computer Science course. The authors found that confusion, boredom and engagement in IDE-related on-task conversation are associated with lower achievement.

Although the use of Keystroke Dynamics (KD) can be found in several research works as a biometric measure, its use as a mechanism for identifying affective states is rare in comparison. Epp, Lippold and Mandryk [13] effectively used KD in conjunction with decision-tree classifiers for the identification of 15 affective states. Although their work was based on fixed-text KD, their decisions on how to extract a feature set from the data generated by the KD process was an inspiration for the proposed method in this work. As for free-text KD, Bixler and D'Mello [14] present a method for the identification of boredom and engagement based on several classification models.

Regarding Mouse Dynamics (MD), some research has been conducted for the identification of affective states, although, as with the case of KD, MD is mainly used as a biometric measure for authentication processes. Salmeron-Majadas, Santos and Boticario [15] use both MD and KD to predict four affective states using five different classification algorithms. Bakhtiyari and Husain [16] discuss a method based on fuzzy models for the recognition of emotions through KD, MD and touch-screen interactions. For a broad review of emotion recognition methods based on KD and MD, the work by Kolakowska [17] is recommended.

3 Proposed Method

A web tutorial was developed to obtain the necessary data (it can be found online at http://app.protoboard.org/). The current state of this platform can't be considered an ITS yet, but its aim is to become one.

The web tutorial's course begins with three introductory videos that explain the fundamentals of programming in Python, and how to solve the programming exercises in the course. What follows after these videos are ten programming exercises that the students need to solve in a consecutive manner.

In Figure 1, the interface of this platform is presented. On the left, a navigation tree is shown, where students can click on the different learning objects that the course contains. On the right, a text processor is embedded, where students can try to solve the programming exercise described below.

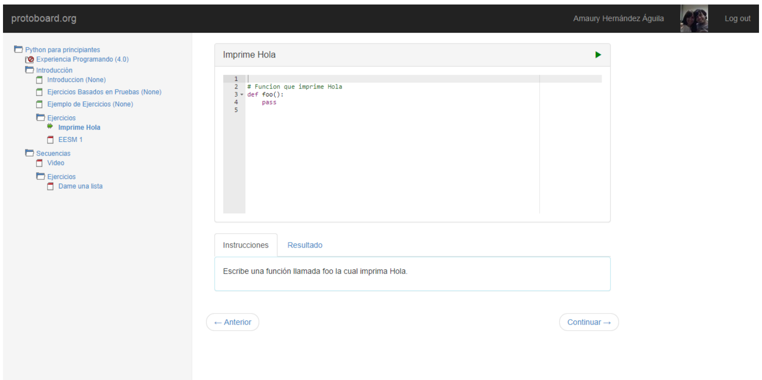

Fig. 1. Interface of the Web Tutorial

Capturing the Keystroke and Mouse Data While a student is trying to solve an exercise, a script coded in JavaScript is running in the background, which captures every keystroke, mouse movement and mouse button press. Each capture of these events records a timestamp in milliseconds (using the method getTime() of JavaScript's built-in object Date) that describes when the event occurred. If the event is a keystroke, the script captures what key was specifically pressed (a JavaScript key code), and what type of event occurred (it can be either a key-down or a key-up event). If it is an event related to a mouse button press, the key code of that button is recorded, as well as the type of event occurred (key-down or key-up). Finally, if the event was a mouse movement, the mouse coordinates inside of the web browser is recorded. The script monitors the mouse position every 100 milliseconds, and if the position has changed, it records the new position.

Capturing the Affective States In order to determine what affective states a student was experiencing, an Experience Sampling Method (ESM) was used [18]. After the students successfully solve a programming exercise, they are presented with an ESM survey that asks what they were feeling during their solving of the exercise. A very brief description is given about what to do in this survey, followed by two statements the students need to answer according to how they were feeling. As an example, the statement "I was feeling frustrated" is presented, and a student needs to answer either "Strongly agree," "Agree," "Neutral," "Disagree," and "Strongly Disagree."

Preprocessing of the Keystroke and Mouse Data The raw data obtained from the JavaScript script needs to be preprocessed in a way that results in a feature vector. Basically, this preprocessing consists in measuring the delays between key-down or key-up events of the keystrokes and mouse button presses a student performed during an exercise. The averages and standard deviations are calculated for each of these delays. To calculate these delays, the keystrokes are grouped in digraphs and trigraphs, as it is a common practice when dealing with Keystroke Dynamics [19].

As most of the mouse button presses performed by a web site user are left button clicks, only these button presses are considered. To calculate the average and standard deviations of these presses, the delays between key-down and a key-up events of the left button clicks are used.

In addition to these averages and standard deviations of the delays between keystrokes and mouse button presses, the average and standard deviations of the number of total events contained in a digraph and a trigraph are calculated. These features are proposed and explained by Epp, Lippold, and Mandryk in [13]. Most of the times, a digraph should contain four events, while a trigraph should contain six events. However, sometimes an individual can start a digraph or a trigraph before ending the previous one. This additional features represent these particular cases, and could be meaningful for the estimation of an individual's affective states.

Regarding the mouse movements, the average and standard deviation of the duration of each mouse movement, and the averages and standard deviations of the movements in the X and Y axes, are calculated.

Lastly, a final feature is added to preprocessing of the data. The web tutorial recorded how many attempts a student required before successfully solving an exercise. This number of attempts is included in the final feature vector.

The final feature vector consists of 39 features.

Preprocessing of the Affective States The answers "Strongly agree," and "Agree" were grouped into a single "Agree" class. The same was performed for the answers "Strongly disagree," and "Disagree." As a result, the feature vectors are now classified as either "Agree," "Neutral," or "Disagree", for each of the two affective states. The reason behind this decision is that the classifiers were performing poorly for such a big set of possible classes.

Classification The feature vectors need to undergo an optimization process. This process consists on using a Genetic Algorithm to determine a subset of features that facilitates a classifier to obtain good results (this is explained in more detail in Section 4). The resulting feature vector is used as input to a classifier based on the k-Nearest Neighbors (k-NN) algorithm. In the end, two classifiers are trained: one for the frustration affective state, and another one for boredom.

4 Experiment

55 students with basic knowledge in software programming were asked to take the course presented in the web tutorial. The students were either studying Computer Systems Engineering, and were at least in their second year of study, or were students of a Master in Computer Science. Their ages were in the range of 18 to 30 years old. Although no experience in software programming was needed, as the web tutorial's course is of a very basic level, all the participants were required to had completed at least one course in software programming.

The goal for the students was to solve as many exercises in the web tutorial as they could. There was no time limit nor a minimum amount of time required for a participant while trying to solve the courses or complete the tutorial. The participants were able to stop and resume their interaction with the system at any time.

The participants' interaction generated a total of 142 feature vectors, meaning that each student solved an average of 2.58 exercises. The 39 features were associated with the answers of the ESM surveys the students had to answer after each exercise. As a result, the 142 feature vectors were used to train a classifier for each affective state. Each of these classifiers have the task of estimating if a given feature vector corresponds to either an "Agree," "Neutral," or "Disagree" class, for the frustration and boredom affective states.

At a first attempt at training the classifiers, bad results were being obtained. Accuracies of 50% and below were frequent with each of the attempts, as well as Kappa Coefficients below 0.1.

The solution to this problem was to perform a selection of a subset of features in the feature vector. The hypothesis was that the classifiers were performing badly because of the high number of features, and because of the possible irrelevant features, i.e., features that don't help the classifier to improve its results. This preprocessing of the feature vector was done with RapidMiner's Optimize Selection operator based in Genetic Algorithms. Even with a population size of 700, the training and validation process had to be run several times before determining a satisfactory subset of features for both classifiers. In the end, the subset for the frustration classifier consists of 11 features, and the subset for the boredom classifier consists of 13 features.

For the validation of the results, 10-Fold Cross Validation was used.

5 Results

The results obtained with this method are very satisfactory, considering free-text KD was used. The accuracies and Kappa Coefficients obtained are close to what is usually obtained in fixed-text KD methods (for example, the results presented in [13]), and far superior to other research works involving free-text KD to predict affective states (for example, the results presented in [14]).

As can be seen in Figure 2, both accuracies are well above 70% which is considered a very good value in works pertaining to Affective Computing. In the case of the Kappa Coefficients (Figure 2), it is usual to see values below 0.2 in methods involving free-text KD. In this case, both Kappas were close to 0.5. Specifically, the average and the standard deviation of the accuracies for the boredom and frustration classifiers were 83.81%+/-5.51%, and 74.00%+/-6.07%, respectively; and for the average and the standard deviation of the Kappas, they were 0.581+/-0.168 and 0.5+/-0.111, respectively. This means that, although both classifiers performed very well, the proposed method is more suitable for the classification of boredom.

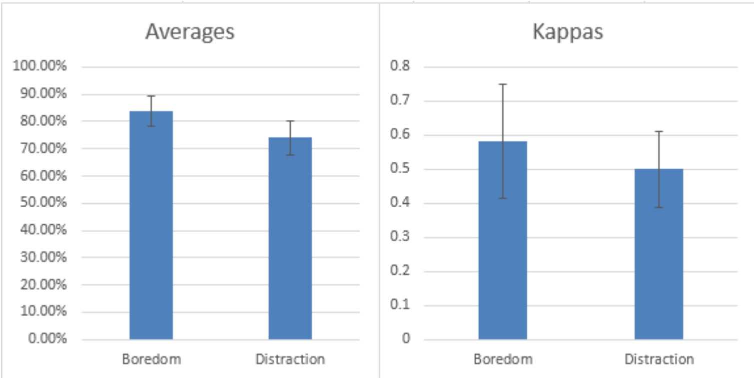

Fig. 2. Accuracies and Kappa Coefficients for the Boredom and Frustration Classifiers

6 Conclusion

The proposed method in this work obtained very satisfactory results. It is usual for a classification method based on free-text KD to obtain accuracies and Kappas below to their counterparts of fixed-text KD, and in this work the results obtained were similar to those works based on fixed-text KD. A possible explanation of this would be the addition of the MD features, and the additional preprocessing performed on the feature vectors.

As mentioned before, in the beginning of the Experiment, the proposed method was obtaining bad results, somewhat comparable to those usually obtained in methods based on free-text KD. However, after the optimization process (determining a subset of features), the results improved.

Acknowledgements

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An Intelligent, Affective and Configurable Tutor for 3rd Grade Natural Numbers Teaching

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Abstract. The current document presents the design and implementation of an Intelligent Tutoring System (ITS) capable of being configured by different experts, in fields that are important for an ITS. Several features have been implemented so that the specialists are the ones who provide the required tools for the teaching of 3rd grade natural numbers. The ITS can be modified by adding fuzzy sets and rules, by changing the Affective module, the diagnostic test and student's learning style. This allows the ITS to change according to the environment and to the needs of the students that uses it.

Keywords: Affective computing, intelligent tutoring systems, neural nets, fuzzy systems.

1 Introduction

The study of human emotion has become increasingly important in different fields, due to the impact they got in our activities performance [1, 2]. In the past couple of years the intelligent tutorial systems (**ITSs**) have incorporated the ability to recognize the affective state of students, which has led to a change on the way they interact taking this in consideration [3-7]. Many of the work so far is being done with the use of special sensors like posture chairs or conductive bracelets [8], but they produce an intrusive and annoying sensation to users. This problem has been solved by some approximations that include the emotion detection inside the ITS [9].

This paper presents a way to achieve an integration of different aspects like affective state, learning style and the level of knowledge of natural numbers the students have. This is accomplished with the use of a Kohonen neural net on a dedicated server out of the ITS environment to recognize the emotions, fuzzy sets and rules to detect de current student level, taking as input the exercises answers and finally an specialized test for the learning style recognition [10].

An ITS is as smart as the knowledge introduced by experts, that's why implementing a platform that is capable of being used by multiple specialists, will gain the necessary experience equal or superior to any other ITS out there. We made a comparison between different ITS [11-13] which are considered the best on their respective fields.

The article is divided as follows: Section 2, Configuring the ITS, explain the capability of configuration by different experts, providing a fundamental feature of customization that makes the ITS capable of being used on different environments. Section 3, ITS Domain, describe the subset of lessons considered from the 3rd grade math book [14]. Section 4, ITS Architecture, shows the structure and relation of the most important components, focusing on those that handle the artificial intelligence. Section 5, Tests and evaluation of the ITS, Considers different aspects selected to make the comparison with multiple ITSs. The last part of the paper is Section 6, Conclusions, which shows the final results of the investigation.

2 Configuration of the ITS

The most distinguish feature of the ITS is the capability of external configuration by an expert in a specific domain. In the exercises case, the teacher is able to introduce the lessons he considers are the best for his students. The same applies for the neuro-fuzzy component, in which a computational expert can access an API to input the rules and sets, in a way such that, when the student makes a mistake or scores an answer, the ITS determines the classification of the student's knowledge. In the same way, the learning style test can be swapped by a psychologist to determine the best learning procedure the student needs and improve the information the ITS have. This leads to a direct improvement in the understanding of the lessons.

The ITS use an affective component to process images collected while the student is answering exercises. This extendable API was conceived with the sole purpose of providing a tool to interexchange the emotion recognition, in a way that the ITS is not directly affected, and the user can't notice. All this capabilities of configuration are implemented in the JSON format, which is defined as a standard of information transfer on the web. The structure it carries can be generated by any online tool, making it easily accessible for experts.

3 ITS Domain

The free text book provided by the Secretary of Public Education (SEP) in México, "Matemáticas 3er Grado", contains 17 subjects. For the design of the ITS, the domain of Natural Numbers was selected. The book has spread the topic across several blocks. Each block contains different lessons that define the objectives the student should meet to perform well in an evaluation.

4 ITS Architecture

The ITS has a relaxed layered architecture which can be visualized in Figure 1. Functions on each layer are explained below.

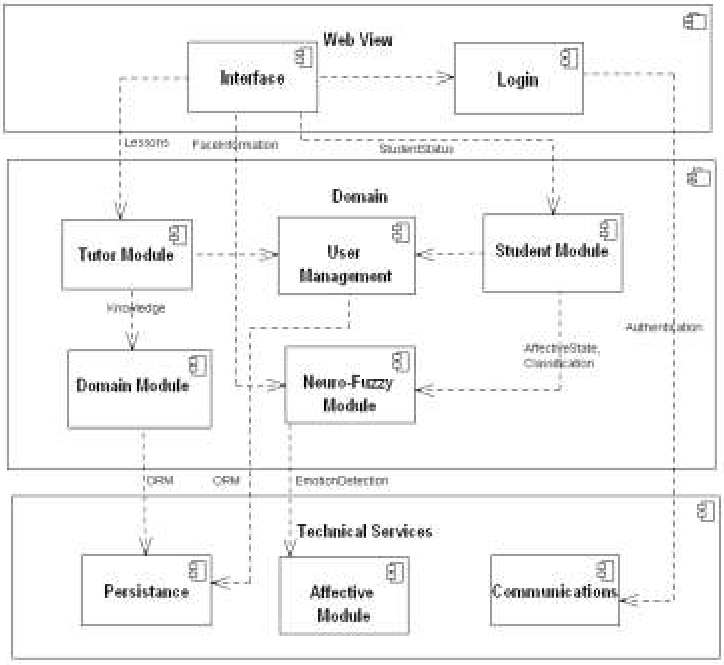

Figure 1. ITS Architecture.

4.1 Web View Layer

It is used for the presentation of the tutor and user interaction. It has two components: **Interface**: It is what the user visualizes and it's implemented with HTML5, CSS3 and JavaScript. **Login**: It provides communication to enter the tutor via Facebook, but plans are in motion to increase it to google+ and twitter via "OAuth authentication".

4.2 Domain Layer

The domain layer implements everything about the tutor logic, artificial intelligence and information transfer to database; all in this layer is implemented in PHP and consists of five components.

4.3 Tutor Module

This module encodes teaching methods that are appropriate for the study area and the student. Based on data of the student´s strengths and weaknesses, level of knowledge, and learning style, the tutor selects the most appropriate educational intervention. For example, if a student has been assessed as a beginner in any given lesson, the module shows some examples of the procedure step by step before inviting the user to answer.

It can also provide feedback, explanations and training as the participant performs the process. As the student gains experience, the module may decide to bring increasingly complex scenarios.

Domain Module. It contains a computational representation of an expert in the field of Natural Numbers. This knowledge allows the ITS to compare the student's actions with that of an expert, to calculate what the student knows and needs to learn. A variety of AI techniques are used to capture how a problem can be solved. For example, rules are used to allow the ITS to generate problems on the fly. It also allows the developer to create templates, which specify an allowable sequence of correct actions. This method avoids the encoding of all possible problems the student can have, and it only requires the specification of how the student need to respond in a scenario.

Student Module. It evaluates the performance of each student to determine their knowledge, skills and reasoning skills. By keeping a module with the details of the strengths and weaknesses of the students, the ITS can offer very specific, relevant instruction.

Learning styles. To determine the learning styles of the students, the Felder-Silverman test [15] is used. This test consists of 44 questions and it is performed at the start. The student's learning style is stored on his academic profile and with this information the ITS selects appropriate material for the lessons, so that the student can learn according to their learning style. In this research only verbal and visual style are considered.

User management. It is the component that accesses the service layer to perform the information saving. It is implemented so that everything is totally encapsulated, in a simple and fast way.

Neuro-fuzzy module. It contains the necessary classes for the fuzzy logic and the connection to the affective component, to provide the information necessary for the ITS to make the right decisions.

Fuzzy logic. The ITS uses the theory of fuzzy sets and rules to calculate the vague and ambiguous values of fuzzy variables *time, emotion* and *exercise difficulty*. The result of this calculation will be taken into account for the next exercise that will be presented to the student.

A fuzzy set can be defined simply as a set with fuzzy boundaries [16].Viewed in another way, in the fuzzy theory, a fuzzy set A of universe X is defined by the function $\mu_A(x)$ called the membership function of the A set. The following equation defines this:

$$\mu_A(x): X \rightarrow [0, 1], \tag{1}$$

where:

$$\mu_A(x) = 1 \text{ If } x \text{ is totally in } A;$$
$$\mu_A(x) = 0 \text{ If } x \text{ is not in } A;$$
$$0 < \mu_A(x) < 1 \text{ if } x \text{ is partially in } A;$$

Some fuzzy rules that are used in our system are:

1. **If** (knowledge is low) **and** (time is slow) **and** (emotion is engaged) **then** (execiseDifficulty is low).
2. **If** (knowledge is regular) **and** (time is fast) **and** (emotion is distracted) **then** (exerciseDifficulty is high).
3. **If** (knowledge is regular) **and** (time is slow) **and** (emotion is neutral) **then** (exerciseDifficulty is low).
4. **If** (knowledge is regular) **and** (time is regular) **and** (emotion is engaged) **then** (exerciseDifficulty is high).
5. **If** (knowledge is good) **and** (time is fast) **and** (emotion is engaged) **then** (exerciseDifficulty is high).

4.4 Services Layer

It contains all the low-level services communication, such as database, connection between systems and interface to the affective module. This layer has three components described below.

Persistence. Handles everything related to database. This component provides the interfaces needed to save and uses ORM technology to be able to persist on different database suppliers.

Affective Module. Responsible for image processing and the return of the emotion that was detected to the upper layer. It provides an API for easy access.

Communications. It is used for interaction with other systems, such as the login to Facebook.

5 Proof and Evaluation of the ITS

The ITS has not yet been tested with students because until this point we are ending the integration of the modules that conforms it. Alternatively, it was decided to benchmark with other intelligent tutoring systems that have a similar purpose. The diverse characteristics of ITS are listed and an assessment is proposed using a Likert scale with values 5-1 representing strongly agree to strongly disagree respectively. This evaluation can be seen on Table 1.

6 Conclusions

During development, it was sought to implement all the features that requires a good ITS, these were: emotional recognition, learning styles, reaction to the cognitive needs of the configuration by experts. The proposed features were evaluated against implemented features and it was concluded that the potential of an ITS to handle the latest on configuration technology has greater influence in the education sector, since it can be adapted to a wider number of environments, such as Mexico.

Table 1. Evaluation of the ITS against others with similar purpose.

ITS Characteristics	Characteristic description	CTAT	Animal Watch	Active Math	Config-urable ITS
Generativity	The ability to generate appropriate problems, hints, and help customized to student learning needs	3	5	4	5
Student modeling	The ability to represent and reason about a student's current knowledge and learning needs and to respond by providing instruction	3	5	4	5
Expert modeling	A representation and way to reason about expert performance in the domain and the implied capability to respond by providing instruction.	5	5	3	5
Mixed initiative	The ability to initiate interactions with a student as well as to interpret and respond usefully to student-initiated interactions.	5	3	4	2
Interactive learning	Learning activities that require authentic student engagement and are appropriately contextualized and domain-relevant.	5	4	4	4
Instructional model	The ability to change teaching mode based on inferences about a student's learning.	4	4	4	4
Self-improving	A system's ability to monitor, evaluates, and improves its own teaching performance based on its experience with previous students.	3	3	3	3

Another valuable contribution to the project was the implementation of access through social networks, which are used every day by a large number of students; this opens a great niche for participation.

Future work seeks to implement a greater number of learning styles to lessons, add other ways to recognize the cognitive state of the student so that not only experts in fuzzy logic can modify it and improvements to the pedagogical agent, so that it'll be able to respond to voice input by the student.

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A B-Learning Model for Training within Electrical Tests Domain

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Abstract. An electrical test performing involves high risk therefore utility companies require high qualified electricians. Traditionally, training on electrical tests has been based on classroom courses; and recently it has been supported by virtual reality systems. These systems have improved training and reduced training time. However the training still depends on courses schedule and instructors, and training systems are not yet adaptive. We propose a model to support adaptive and distance training. The model consists mainly on a representation of the trainees' knowledge and affect. We also proposed an animated pedagogical agent to guide trainees and provide instruction. The agent has facial expressions conveying emotion and empathy to the trainee. This model is intended to be integrated to a virtual reality training system. In this paper, the trainee model and the initial actions of the agent are presented.

Keywords: Electrical tests, virtual reality, student model, blended learning.

1 Introduction

Training new personnel to perform electrical tests faces some problematic situations such as limited opportunity to practice in a substation, knowledge about electrical tests is not easily available, and training might be costly.

We have developed a virtual reality system (VRS) to support traditional training; trainees still attend classroom courses but they complement learning and practice aided by the VRS. The system has improved training, allows self-training and even both costs and training time have been reduced. However the training still depends on training courses plan and the VRS is not adaptive.

Based on this VRS supporting training, we want to compose a blended learning model. Blended learning is a new term and an innovation in education although the concept has already existed for a long time. It can take many forms and there are several definitions which include roughly the same elements. In a formal education context, blended learning is a formal education program in which a student learns at least in part through online delivery of content and instruction with some element of student control over time, place, path or pace and at least in part at a supervised brickand-mortar location away from home [11]. A more general and perhaps more accepted definition states that blended learning is learning that is facilitated by the effective combination of different modes of delivery, models of teaching and styles of learning, and founded on transparent communication amongst all parties involved with a course [4].

We need a more adaptive training model where the individual state of trainees is considered. We are developing a model and a platform for blended training which adapts to trainee' needs in an intelligent way. Figure 1 shows the road map for training. Currently, we are working in phase 3 and our final aim is to have an intelligent system which supports self-training in an adaptive way (phase 4).

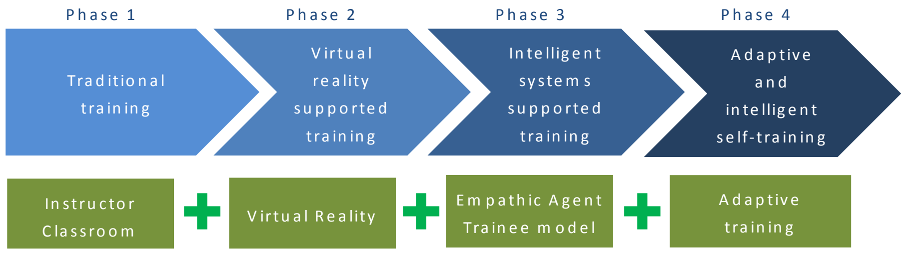

Fig. 1. Training road map for training. The VRS has been implanted successfully, now the empathic agent and trainee model are in development.

This paper presents the work in progress to achieve a system of phase 3. The rest of the paper is organized as following: Section 2 describes the virtual reality system, Section 3 presents the blended training model. Finally, conclusions and future work are presented in Section 4

2 3DMapps System

3DMaPPS is a Virtual Reality Training System created expressly to support electrical tests learning on primary equipment of Distribution Substations [10]. Electrical tests in substations allows foreseeing possible problems, which might end up damaging substation equipment and in turn originating interruptions, which is the ultimate situation expected to be faced by electricity companies. On the other hand, erroneously performed tests might end up in accidents or in equipment damage. Thus, efficient training is mandatory in order to make sure that substation operate in optimum way.

In an overall view of electrical tests, these consist of a sequence of steps where the equipment to be tested has to be bypassed so that is not energized. Then the testing equipment is connected to the primary equipment under test, and outcomes of the tests are recorded. If not other tests is performed, then the testing equipment is disconnected and retired, finally the primary equipment under test in connected again and reestablished. It should be mentioned that in every step safety regulations and measures should be observed [2]. In Figure 2 a transformer being tested is shown.

Fig. 2. Testing a transformer. The VR system shows step by step how to perform an electrical test. The trainee is supported by a control panel with several controls and instructions.

3DMaPPS includes 40 electrical tests to different primary equipment such as transformers, interrupters, capacitors bank, and so on. Among the tests, we can mention isolation resistance, power factor, and operation time.

This kind of systems provides advantages derived from 3D representations. For instance, 3DMaPPs contains different catalogs of 3D models of tools, equipment, materials and safety gear; it also includes a 3D virtual substation. Thus, trainees can visualize 3D tools and navigate virtually a substation. This allows students to get familiar with all items used when tests are performed. It allows self-learning and provides supports for classroom courses, since it is able to keep records of trainees' progress so that instructors can make even personalized training decision. As in real work, electrical tests are presented as sequences of steps. On each step, explanations are provided and activities are illustrated using 3D animations.

These 3D benefits, make 3DMaPPS a useful complementary training tool, which provides support to the learning process. Using the system, trainees can start learning about electrical tests, even though they have not visited yet a real substation. The system also provides two kinds of evaluation which might be useful when trainees are learning by themselves, namely theoretical questionnaires and practical evaluations. The main objective of the system is to complement and enhance traditional method of training. Nevertheless, the risk of electroshock or damage to equipment, still demands that only human experts can certify trainees, when they consider they are ready to realize electrical tests by themselves.

The system is installed in the 16 distribution areas across the country. This benefits some hundreds of new electricians. The system was developed using OGRE, C# and 3DSMax. 3DSMax allowed the creations of all 3D models and animations. OGRE, a game engine was used to render scenes and C# to develop the interface of the system and organization of presentation of the electrical tests.

Thus far, the system has been helpful as a supporting tool to improve training. Nevertheless other technologies can be integrated to our VR systems, so that they can exhibit intelligent and adaptive behaviors which improve them as training tools.

Next section shows the proposal of a model to integrate intelligent and adaptive features to VRS.

3 Blended Training Model

The VRS has improved the training process, supporting the traditional training by means of presenting 3D representations of electrical tests and substations. This allows to learn and to practice electrical tests before visiting a substation and perform the real electrical tests. Although 3DMaPPS has shown to be useful in training, it is not adaptable to individual electricians; namely, the system provides instructional content regardless the particular states of trainees. Now we want to provide intelligent support to trainees and trainers.

Currently, we are developing a model and an intelligent system to support traditional training. This new model recognizes the knowledge state of students in order to have more precise information for instructors to grant a certification o to recommend attending other training courses. Moreover, the model includes recognizing the affective state of trainees. Then the instruction is presented in a proper way by an empathic agent. The training model is presented in Figure 3.

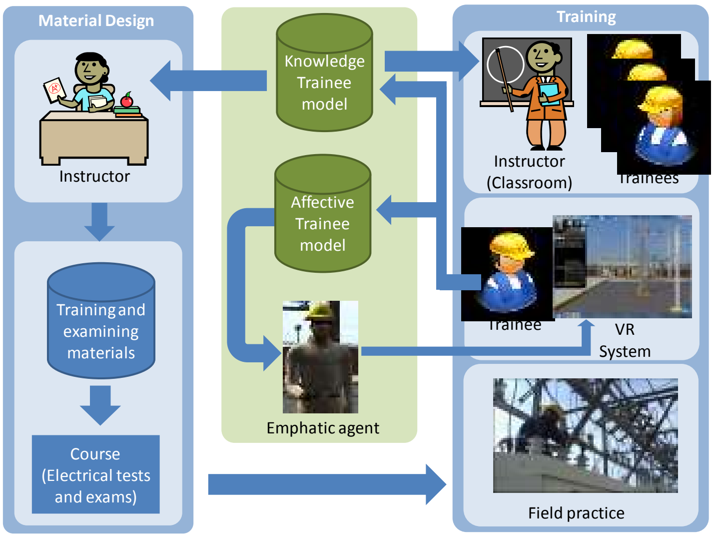

Fig. 3. Blended training model. The model tries to provide instruction in a suitable way by means of an emphatic agent. Also the model provides instructors with knowledge to design material and courses and to adapt the instruction to particular trainees.

The training and examining material were developed and designed by a team of experts. Currently, a course is planned by an instructor. The instructor teaches trainees in classroom and also trainees learn and practice with the VRS as much as they want.

When trainees have attended the appropriate courses they have to serve as auxiliary electrician in a real substation.

Now we are proposing to model the trainee´s knowledge and affect. This trainee model is useful for instructors, who will be able to design new courses and new examining materials, redesign training material and certify trainees. The affect will be used by the emphatic agent to show facial expressions to motivate trainees.

In this third phase, the trainee's knowledge the trainee will not be used to adapt the instruction; since the electrical test have to be thought in a sequence of steps.

3.1 Pedagogical Trainee Model

The pedagogical trainee model is a representation of the student's knowledge about electrical tests included in the course. The model is updated when the trainee practices the electrical tests and when he solves theoretical exams. The model consists of a Bayesian network. The Bayesian network is built when the instructor design a course. Fig. 4 shows an example of a network for a course with five electrical tests. In turn each test is composed by a sequence of steps and sub-steps, as shown in Figure 5.

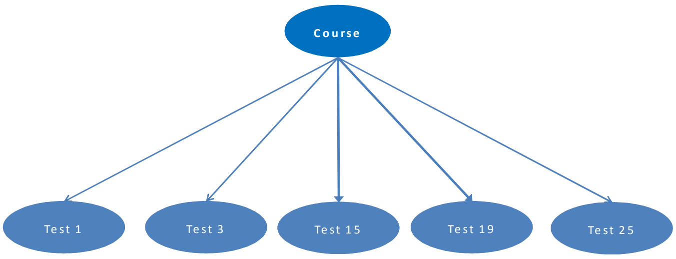

Fig. 4. Bayesian network for a course with five electrical tests. Each test node is another Bayesian network which represents how trainees has performed the electrical tests.

The Bayesian network is composed by a node for each electrical test included in the course and a node for an exam which comprises the items of the theoretical exam also designed by the instructor. In turn, each node of the Bayesian network (see Figure 4) representing a test is a Bayesian network composed by steps and sub-steps. In Figure 5 a test with four steps is shown; but most electrical tests have an average of 40 steps.

Initially, each node representing a sub-step has two possible values: correct and incorrect which correspond to the possible result of performing the sub-step (to execute an instruction). The nodes representing steps have two possible values: learnt and not learnt and their probabilities are conditionally dependent on the probabilities of the sub-step nodes. Step nodes represent the probability that the trainee has learnt the step. Test nodes also have two values: acquired and not acquired and their probabilities are conditionally dependent on the probabilities of the step nodes.

The theoretical exam is also represented by a Bayesian network composed by a number of items. The causal relationships between items and conditional probabilities for each node will be established when the exam is designed by the instructor. For the time being, we have not defined the complete structure and values of this Bayesian network. However we want to model trainee' guesses and slips on the basis of the relationships between the items and the evidence of the answers to questions. Figure 6 shows an exam with 8 items as a preliminary example.

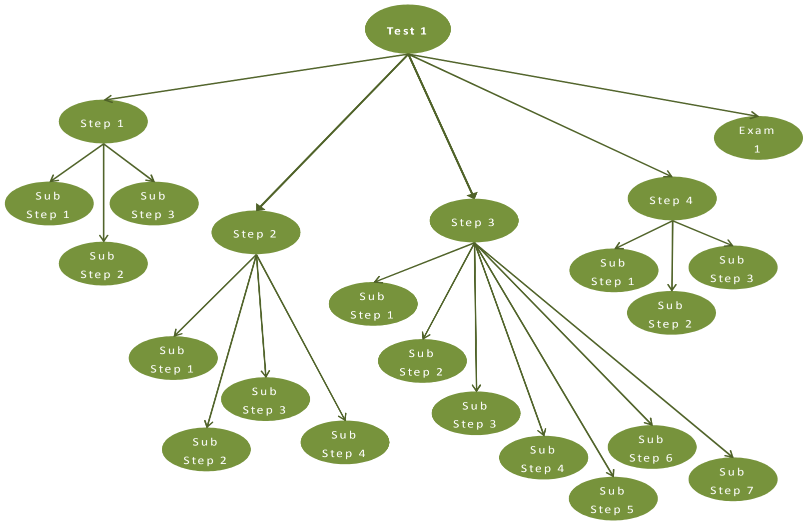

Fig. 5. Bayesian network for an electrical test with four steps. The knowledge about electrical test is impacted by the knowledge of each step and a theoretical exam.

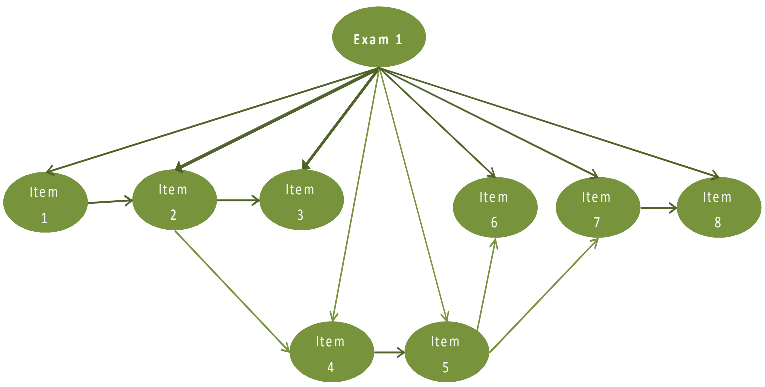

Fig. 6. Bayesian network for an exam including eight items. Initial structure which represents only the relationship between topics of items.

3.2 Affective Trainee Model

The affective trainee model uses the OCC model [9] to provide a causal assessment of emotions based on contextual information. The OCC model defines emotional state as the outcome of the cognitive appraisal of the current situation with respect to one's goals. The trainee model consists of a dynamic Bayesian network (DBN) that probabilistically relates personality, goals and interaction events with affective states, based on the theory defined by the OCC model. Figure 7 shows a high level representation of the model, where each node in the network is actually a set of nodes in the detailed model. The model is based on the proposal by [3] and in our previous work [5].

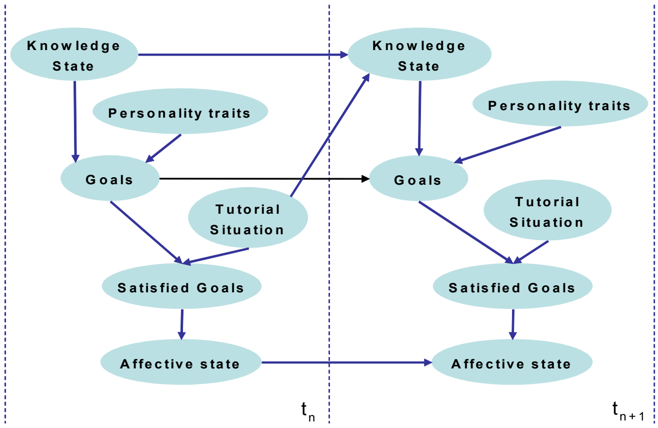

Fig. 7. High level DBN for the affective student model. We include two time slice to represent the dynamic behavior of affect and its impact in the next state.

The DBN models the dynamic nature of emotions. To infer the affective state at t_n, it considers the student's knowledge, personality, and the tutorial situation at that time, as well as the student affective state at t_{n-1}. The tutorial situation is defined based on the results of the trainee actions.

The trainee's appraisal of the current situation given his goal is represented by the relation between the goals and the tutorial situation nodes through the satisfied goals node. The influence of the appraisal process on the trainee's affect is represented by the link between the satisfied goals node and the affective state node. From the complete set of emotions proposed by the OCC model, the affective model only includes six emotions: joy, distress, pride, shame, admiration and reproach.

According to the OCC model, one's goals are fundamental to determine one's affective state, but asking the students to express these goals during training would be too intrusive. Consequently, the goals in our network are inferred from indirect sources of evidence. We use personality traits as a predictor of the student's goals, but we also include the student's knowledge.

3.3 Animated Agent

Training activities are presented to trainees through an animated pedagogical agent. These agents represent a major trend to have a more natural human-computer interaction [1, 7]. Animated pedagogical agents interact face to face with the students through facial expressions, gaze, emotions and deictic gestures; and cohabit with the students learning environments. Animated pedagogical agents have a significant impact on training systems as they give the impression that someone is on the other side [12]; thus the trainee perceives a very different behavior from a traditional system and more alike to human behavior. Among the behaviors of an animated pedagogical agent are those typical of intelligent tutoring systems, but there are some particular of these characters, such as demonstrations of complex tasks, observe and assist the trainee to perform their tasks, in addition to guiding trainees in virtual spaces [13].

We are using the characteristics of the operators for developing the agent, such as wearing the uniform and safety helmet, among other features. We believe that by representing the tutor as an electrician, operators will accept the training environment for operators, which is useful for learning. Fig. 8 shows the animated agent.

Empathy is the ability to perceive, understand and experience others' emotions, in other words, step into the shoes of another. This construct has been incorporated in animated agents with the aim to achieve believability, social interaction and user engagement [6].

In this initial phase, the animated agent will deploy the emotions recognized in the student base in the OCC model as described above.

Fig. 8. Animated agent. The animated character wears the uniform and safety gear (Helmet, glasses, cotton uniform, leather boots, gloves and so on) as electricians, trying to convey empathy, besides to the emotional reactions.

4 Conclusions and Future Work

There might be instructional domains where learners can self-learn using a system whose instructional content is comprehensive and really well done. In such cases presence of instructor might not be determinant for trainees. Nevertheless, for the systems mentioned here (3DMaPPS), this is not the case. Electrical Test procedures involve high risk and also physical activity, which is not provided by a non-immersive VR training system. The point here is that these systems are still limited with respect to the real electrical tests performance, there are physical actions such as claiming up a transformer, removing cables or taking care of safety regulations within specific circumstances, whose expertise cannot be obtained by using the system, but in real work. This is why within this domain involving high risk actions, the systems is not entitled to emit a certificate to enable people to perform electrical tests; this must be responsibility of a human instructor who will have to cover the physical and practical training and verify the skills of the trainees.

Thus, the system is a helpful complementary training tool which can be used to enhance the traditional training but it cannot be used instead of it.

As future work we are planning to show the trainee model to trainee as a self-evaluation tool. Self-assessment is one of the meta-cognitive skills necessary for effective learning. Students need to be able to critically assess their knowledge in order to decide what they need to study [8]. For the time being the open trainee model is used only by instructors.

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Designing an Itinerant Science Museum

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Abstract. In this paper, we present the main activities of the development process of an itinerant science museum. We have developed applications for three target platforms: portable computers, mobile devices and web accessible applications. The selection of these platforms enable the museum to be highly transportable (even in a set of backpacks). The applications are interactivity rich because they can also use hardware sensors, as video cameras and Kinect sensors. The developed applications were already presented to 200 elementary school students with a good appreciation from them as evidenced by the results of an exit survey done in these demonstrations.

1 Introduction

Museums have important roles in society. One of their most important role is to promote education and culture. Recently, a new kind of museum has emerged, the so called interactive museum. These museums use information technologies intensively. Interactive museums are different to traditional museums because they let the visitors to interact with and to manipulate the elements of the demonstrations. Such an interaction is intended to help the visitor to understand the knowledge content embodied in the demonstration. Interactive museums are complementary to the formal instruction of the visitors. That is particularly interesting because the visitor population covers a broad range of ages. Another advantage of the interactive museum is that the visitor is not restricted to spend a limited time in each stand, he can stay for short or long periods of time.

A study made by Mexico's CONACULTA[1] reveals that a half of the visitors to Mexican museums possess a higher education degree. The study also shows that these visitors were taken for the first time to a museum in their childhood. Another interesting fact from this study is that less that

[1] National Council for Culture and Arts (Spanish: Consejo Nacional para la Cultura y las Artes)

10 percent of the visitors lives outside the most important cities in the country [7]. From there, we can hypothesize that people living in rural locations can not experience a museum visit in their lifetime.

Modern life demands a set of skills for every individual such as the ability to communicate, the capability of solving problems and to be proficient in the use of computers among others. Mexican educational system has the goals of: providing rich instructional materials, to promote scientific computation, to augment the covered population, and to be fair in the possibility of access for all the citizens [5].

Mexican government has also put in its agenda to close the digital divide [3] by providing access to every Mexican citizen to the information and communication technologies. At this moment, Mexico's Telecommunications reform has been approved by the Mexican Congress and it will help to decrease the disadvantage of the poorest population sector. As an example, this reform makes mandatory to provide Internet access to rural communities via satellite.

The purpose of developing an itinerant science museum (ISM) is to be able to visit rural communities to promote science and technology. This will result in an increasing number of people being interested in science. The mobility of the ISM is a key feature to bring scientific demonstrations everywhere. In the literature, we can find previous works on ISMs. For example, the *Itinerant Museum of Chemistry History* [2], helps people to learn about chemistry by performing experiments. Another example of ISMs is the *Astrobiology Road Show* proposed by Barge *et at.* [1], that includes five thematics rooms.

This work presents the design and implementation of an ISM. The proposed museum consists mainly of a set of interactive computer software applications. These applications are deployed in different platforms: portable computers, mobile devices and the Web. The use of these platforms enable the use of applications practically anywhere. The ISM is complemented with some other computer-controlled demonstrations and mobile robotics exhibitions.

Section 2 introduces our approach to ISM, and a description of its main features is given. The details about the ISM development are described in Section 3. In Section 4, the results are shown. Finally, the conclusions are presented in Section 5.

2 Description of the itinerant science museum

The main goal of the proposed ISM is to attract students to be interested in science, engineering, mathematics and technology [8]. We have not targeted a specific age interval for the audience but our main interest is to reach children and teenagers (6-17 years old).

Another key requirement for the ISM is to be portable enough to be able to visit communities under bad access conditions. Difficulty of access can be due to road networks in bad conditions because the lack of maintenance, or even to the lack of a road to get there. Under such conditions, the adaptation of a bus, trailer or any other vehicle is difficult and expensive. We proposed then the approach of ISM in a backpack.

Our ISM proposal covers several subjects: language, mathematics, computer vision, physics and probability topics. Several interactive applications were developed to address these subjects. Each interactive application addresses a learning objective that is implemented using technological tools (computer tools, sensors devices, mobile robots, etc.) For all of them, interactivity is a key feature to engage the user in the learning activity. Several platforms have been used for the deployment of the interactive application: portable computers, mobile devices and web applications. For example, the Web can be a good way to extend the time that the visitors spend using the interactive applications.

2.1 Itinerant demonstrations

The itinerant science museum can be installed in practically any place in rural communities. A good place to install the ISM is the local elementary school. We set up one exhibition stand for each application to be demonstrated. We use a learning by doing strategy [9]. The children perform some activities in the stand. These activities are intended to provoke learning of some scientific concept and ideas.

Each application stand is composed of several elements (computing platform, applications, sensor, projectors, mobile robots, etc.) All of them are accompanied by a poster with instructions on how to use the application and a paragraph describing the intended learning outcomes.

There is also the help of a person to ease the use of the application and to explain the questions arising from the learning topic. These assistants are trained to deal with such situations. Each application stand has an exclusive area for the users and for the spectators that observe when some other people use the interactive application.

For each demonstration, we choose a layout taking into account the space constraints and the number of visitors to be served. Figure 1 shows two exemplary layouts. In the case of scholars, the attendants are divided into a number of groups and they follow a pre-defined path in the exhibition layout. Nevertheless, if the available space to set up the ISM is large enough, the attendants could visit the exhibitions without following a fixed sequence. With respect to time constraints, in the guided tour approach, we pre-define a time slot to visit each demonstration in order to let all the students to see the entire exhibition. If there is no time constraints, every visitor could stand at each interactive application as long as he wants. We will pass now to describe the main features of the each type of interactive application.

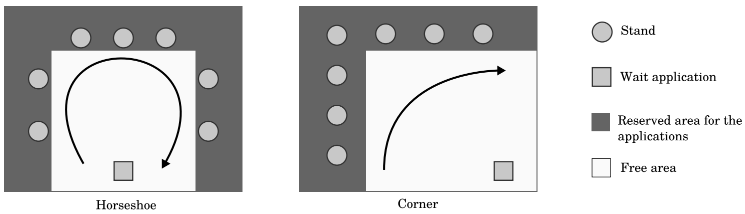


Fig. 1. Examples of the layouts used in the exhibitions.

2.2 Mobile applications

There are a number of stands where the interactive application is executed on a mobile device. The visitors can manipulate the elements of the application by using touch gestures. Tablets are very easy to carry and this is very useful to serve a lot of users in the ISMs. The main restriction in mobile devices is the lack of input ports to connect sophisticated sensors and their reduced computing power to execute demanding applications.

2.3 Computer application

There are also a number of interactive applications that are suited for both portable and desktop computers. For example, Kinect sensors or camera sensors are designed mostly to work with personal computers. The use of the sensors improve the user experience with regard to the interactivity. Most of the applications developed to use sensors can not be ported directly to mobile devices or to web access.

2.4 Web applications

For most of the ISM applications, there is a Web application that can accessed through the Internet. A web site has been designed to host the applications of the ISM. However, in the Web applications, the interactivity degree is reduced because of the limitations in available sensors and bandwidth constraints.

3 Application development process

In this Section, we describe the software development process carried out for this project. Each application type of the ISM requires both a common set of specifications because the nature of its common purpose, and a particular set of requirements imposed by the target platform.

When an application is targeted for several devices, it has to be developed for several operating systems. That implies to select an adequate scope for each platform given the available resources for development (libraries, programming languages, etc.)

Another issue in target specific applications is the sensor availability. As an example, most mobile devices have a camera, but it is located at a fixed position that may be inappropriate for a computer vision application. A portable or desktop computer have input ports that can be used to connect the camera enabling us to use it in a example, most mobile devices have a camera, but it is located at a fixed position that may be inappropriate for a computer vision application. A portable or desktop computer have input ports that can be used to connect the camera enabling us to use it in a different geometric setup. In the software side, a particular framework can be available only for some operating systems. Moreover, computing power is not the same for each type or target platform. All these issues have to been addressed in order to make appropriate decision choices on the scope of the application for each targeted platform.

The common set of requirements for all the application are: i) The intention of being a tool for learning a concept, ii) the need of being as interactive as possible to engage the user in the learning activity and, iii) to have an attractive interface to capture the interest of the visitor for him to start using it. There requirements are very similar to those for computer video games.

We have used the game development engine Unity for the development of the interactive applications. Unity provides also the capability to handle multi-platform developments. The programming language used for our project was C#. C# is an object-oriented programming language that is easy to learn and to adopt for any programmer. The game development engine also supports the integration of C and C++ artifacts. That is useful for image processing and sensor handling capabilities because the related methods perform better in such programming languages. The integration of C and C++ libraries has only been used for personal computer targets.

The interactive application development model is shown in Figure 2. Firstly, we define the concept to be taught. We develop then a use case for the concept[4]that could incorporate interactive actions between the user and the computing device. The software development process is then executed. We test the application to ensure its reliability and robustness [6]. The last step is to deploy the interactive application in the ISM and to get feedback from the user.

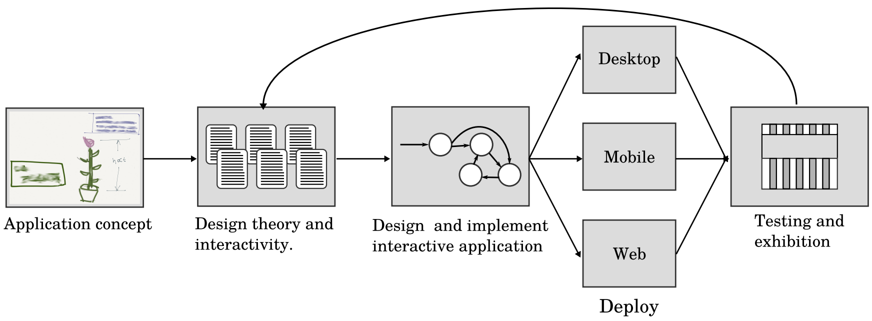


Fig. 2. Interactive application life cycle

4 Results

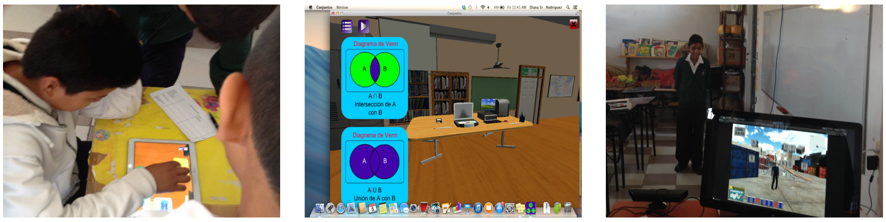
As a result of the development, we have developed eight interactive applications. A summary of these applications is shown in Table 1. We describe there the main features of each application. Some of the applications were developed to use the Kinect sensor (*Word hunter*) and several others to include computer vision methods (*Virtual Areas* and *Magic Window*). The applications using hardware sensors run both in Windows and Mac OS X operating systems. The full set of eight applications was developed in approximately an eight month period.

Two hundred (200) children have been exposed to the interactive applications of the ISM. We have tested both layout arrangements for the stands presented in the Figure 1 during these exhibitions. We have found that the layout is better for open areas and the horseshoe layout works better for indoor places. The opinions about the interactive applications were good in most cases. Those opinions and observations were recorded in paper-based surveys. In Figure 3, there are some pictures from the

Table 1. Application summary

Application	Area	Desktop	Mobile	Web	Description
Bernoulli Gun	Physics	Mac OS X, Windows	Android	Unity Web Player	It teaches the Bernoulli principle by controlling a water flow using a tab.
Sets	Mathematics	Mac OS X, Windows	Android	Unity Web Player	It teaches the set theory using.
Gaussian Bell	Probability	Mac OS X, Windows	Android	Unity Web Player	It teaches about the origin of the Gaussian probability density functions.
Magic Windows	Computer vision	Mac OS X, Windows	not supported	not supported	It teaches how works the computer vision to manipulate images.
Virtual Areas	Computer vision, Mathematics	Mac OS X, Windows	not supported	not supported	It teaches how to calculate areas by using simple shapes and a computer vision interface.
Word Hunter	language	Mac OS X, Windows	not supported	not supported	It teaches new vocabulary, this application uses the Kinect sensor for the interactions.
Gravity	Physics	Mac OS X, Windows	Android	Unity Web Player	It shows how the gravity works in the Moon, Earth and Mars.
Plant	Biology, Botanic	Mac OS X, Windows	Android	Unity Web Player	It teaches facts about the parts of the plant.

exhibitions of the ISM during an itinerant exhibition, and a screen shot of one of the interactive applications.



(a) Itinerant exhibition (b) Interactive application (c) Interactivity using Kinect

Fig. 3. a) Children playing with an interactive application, during and exhibition. b) Desktop interactive application and c) A child playing in the *Word Hunter* stand.

5 Discussion and Future Work

We have presented several aspects of the development of a ISM. The ISM is intended to promote science and technology knowledge and learning in least favored sector of Mexican population. Nevertheless, the applications can be accessed in their website versions from anywhere. In order to amplify the impact of the project in the target audience, we will continue to demonstrate the ISM in some other places. The proposed ISM has shown be a good alternative to catch the interest of new people to the sciences.

The mobility of the ISM and the way of distributing its applications, increases its coverage. The ISM exhibitions have shown a good acceptance by the people. The layouts proposed for the exhibitions have worked well in indoor and outdoor locations. Future work goals will include to increase the interactivity by improving the human machine interface; and the work towards discovering more engaging ways to learn the concepts behind applications.

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