# A NOVEL TUTOR-GUIDED PLATFORM FOR INTERACTIVE AUGMENTED REALITY LEARNING

Héctor Martínez, David Abadía, Luis Miguel Sanagustín, Isabelle Hupont, Rafael Del-Hoyo
*Instituto Tecnológico de Aragón, P. T. Walqa Ctra. Zaragoza, N-330a, Km 566, Cuarte, Huesca, Spain*

Carlos Sagüés
*Departamento de Informática e Ingeniería de Sistemas, Universidad de Zaragoza, C/Maria de Luna 1, Zaragoza, Spain*

Keywords: Augmented Reality, Virtual Agents, Interactive learning system, Intelligent Tutoring Systems.

Abstract: Modern education is continuously incorporating new technologies in the learning process. Some of these technologies involve Augmented Reality applications and virtual agents. The proposed architecture aims to offer a novel tutor-guided platform for non-programming experienced users to develop intelligent Augmented Reality e-learning applications. The platform has been used to create a bakery tutorial and some children games with learning purposes as examples of its capabilities. A pilot experience has been carried out, and the feedback has shown good results concerning the usefulness and usability of the platform.

## 1 INTRODUCTION

There is a recent interest on including new emerging technologies in e-learning systems in order to enhance the learning process. In particular, Augmented Reality has been proved to be a useful tool (Balog, Pribeanu and Iordache, 2007; Chen, Su, Lee and Wu, 2007; Kaufmann and Dünser, 2007). The concept of Augmented Reality refers to the representation of virtual elements over a real scene captured by a camera. Students find the concept acquisition more attractive and fun when a virtual environment is mixed with the reality. Contrary to other new technologies, Augmented Reality usability has a fast learning process. Even users who have never used any Augmented Reality application before have reported a good feedback in the use of this technology for education purposes (Sumadio and Rambli, 2010). Some examples of Augmented Reality for e-learning can be the MagicBook where a traditional book is augmented to offer virtual content (Billinghurst, Kato and Poupyrev, 2001), a book with finger marker used to enhance the contents (Hwa Lee, Choi and Park, 2009) or an application to learn concepts related with the human body (Juan, Beatrice and Cano, 2008). However, the interaction in those applications is very limited. The purposes of those works are mainly focused to show

virtual 3D contents to the users who can see some objects under different angles and dimensions to better understand how they work. The main gap between Augmented Reality applications and educators is the lack of programming skills of the educators. Thus, the creation process involves computer science experts and pedagogic professionals. Some user-friendly authoring tools have arisen to help those people who don't have programming skills to make some simple but powerful Augmented Reality applications. Some authoring tools examples can be ATOMIC[1] and ZooBurst[2]. However, the created applications are limited to show contents and the logic of the program is fixed by the software creators.

The use of 3D environments enables the use of intelligent virtual agents. In the field of e-learning, the benefits of using virtual humans capable to adapt the transmission of knowledge to each student have been proved (Sklar and Richards, 2006).

It is important to point out that the virtual agent shows intelligent behaviours that respond accordingly to the evolution of the interaction, like, for instance, offering help when needed.

The proposed system is a novel tutor-guided platform for interactive Augmented Reality learning.

---

[1] http://www.sologicolibre.org/projects/atomic/en/index.php

[2] http://alpha.zooburst.com/

The presented system enables to create intelligent Augmented Reality applications for learning purposes. Instead of just showing contents, the final applications are able to offer a rich variety of interactive actions. The system uses an intelligent framework that enables to define application logic using natural language. Therefore, any non-programming expert person is able to create interactive Augmented Reality exercises for e-learning with his/her imagination as the only limitation.

One of the main features of the proposed system is the introduction of a virtual tutor, as an intelligent interactive virtual agent who guides the user through the learning process and evolves his behaviour in function of the user's actions, achieving more interactivity with the student making the exercises.

Thanks to the applications created with the proposed system, the traditionally acquired learning concepts can be moved into practical exercises. Due to the attractiveness of some of the technological elements included in the system, such as Augmented Reality exercises and virtual tutors, the learning process becomes more interesting for students.

The rest of the text is organized as follows: section 2 describes an overview of the proposed platform architecture. In section 3, a practical example is explained to show the potential of the platform. Finally, in section 4 some conclusions and future work are discussed.

# 2 PLATFORM ARCHITECTURE OVERVIEW

The proposed platform is a powerful authoring tool for teachers and educators. The system enables the users to create a great variety of Augmented Reality

tutorials, practices or games for learning purposes. The system also offers the possibility of including an intelligent virtual tutor who guides the student through the learning process. Figure 1 shows the proposed architecture. The system has three modules: Perception module, Artificial Intelligence module and 3D Multimedia Scene Manager.

## 2.1 Perception Module

The Perception module allows the student to communicate with the system. The communication can be established by different ways. The main feature of the Perception module is the Augmented Reality system, which is the core of the interaction. The Augmented Reality system detects some markers in the image captured by the camera and calculates their 3D coordinates. Once those coordinates have been calculated, the virtual elements will be mixed with the real video motion and displayed to the student according to the markers position and orientation. The fact of manipulating the virtual elements makes the student to feel like manipulating real objects.

Apart from the Augmented Reality system, the user can communicate with the system through a keyboard, a mouse and a microphone. These system inputs are sent to the Artificial Intelligence module, being the system logic completely transparent to the student.

## 2.2 Artificial Intelligence Module

This module is the engine where the system logic is defined. It is also the inference engine that makes the virtual tutor to react to the student inputs. In this module, the educator can define the instructions for the student to carry out the exercises. The system
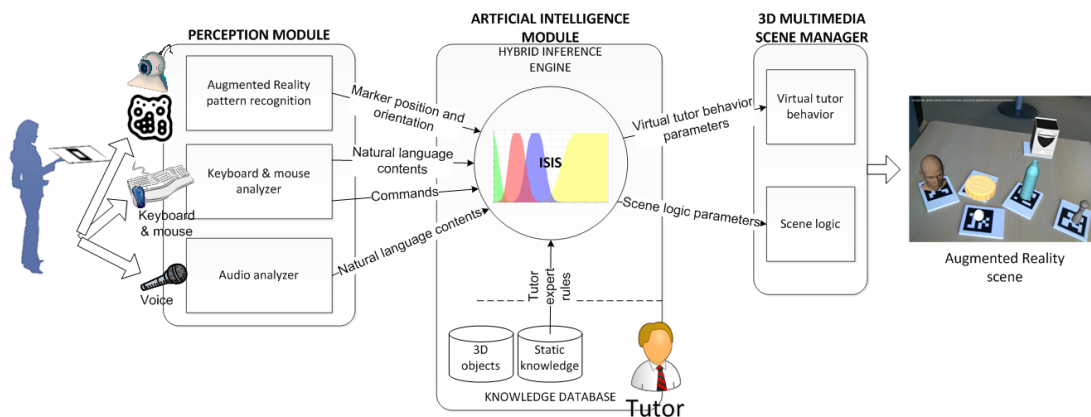


Figure 1: Proposed system's architecture.

is controlled by an intelligent rules-based framework called ISIS: Intelligent Support Interaction System (Martínez, del-Hoyo, Sanagustín, Hupont, Abadía and Sagüés, 2011). Any non-programmer user can easily implement the system behaviour by defining natural language rules. Two kind of rules can be established: crisp and fuzzy rules (Zadeh, 1965). Figure 2 shows an example of fuzzy rules definition using the ISIS' interface. Furthermore, the language interaction between the virtual tutor and the student is described using the Artificial Intelligence Markup Language (AIML).
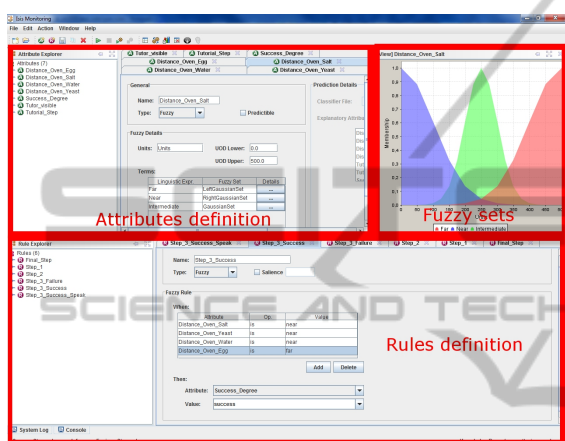


Figure 2: Screen of the ISIS tool for Fuzzy rules definition. The screen is divided in two parts. The first one is used to define the attributes (the definition of fuzzy attributes is accompanied of their fuzzy sets). The second part is used to define the system rules.

## 2.3 3D Multimedia Scene Manager

The 3D Multimedia Scene Manager is the module that creates a virtual environment to be mixed with the real video motion. This module communicates with the Artificial Intelligence module and evolves according to the data received from it. It allows to include any kind of multimedia content (3D models, audio, video, still images or webpages) in the e-learning application.

One important figure in the system is the virtual tutor, which is the entity in charge of guiding the user through the learning process. The virtual tutor can be selected according to the context of the application and the end user. For example, a human look-like virtual tutor can be used for training formative applications while some toons can be used as virtual tutors for children learning applications (using different toons depending on the age of the target students). The fact of personalizing the virtual tutor gives an added value to the system because the student gets more empathy with the virtual tutor and

he/she makes so in a faster way. The student is able to interact with the virtual tutor who responds in an intelligent way to the actions made by the user as wrong answers, help questions and so on. The virtual tutor intelligent behaviour is controlled by ISIS so it is able to interact with the user in an intelligent natural way. The virtual tutor figure has been created with the purpose of making the student to feel accompanied at every moment. The virtual tutor communicates with the student through chat or voice but also with emotions and gestures. It is also in charge of offering help to the student both when the virtual tutor thinks that it is necessary or when the student asks for it. The offered help may be a simple comment but also can be a more complex element such as a video or a web browser. When the conversation student-virtual tutor is established, the latter will search in a question-answer engine and will answer as accurately as possible attending to the student's needs.

## 3 PRACTICAL APPLICATIONS

In order to prove the potential of the system, two different application examples have been created. Firstly, a tutorial for making bread has been developed. This tutorial is oriented to train future bakers, helping them to acquire and reinforce the concepts needed to cook bread. The tutorial consists of some exercises oriented to different difficulty levels. The second developed application consists of a series of educational games for children to learn basic concepts, such as learning vowels or increasing their creativity.

### 3.1 Bakery Tutorial

The bakery tutorial is an example created to show the capabilities of the system oriented to formative training applications. The tutorial is guided by a human look-like virtual 3D tutor. The tutorial instructions are offered in two formats simultaneously (audio and text), in order to achieve a better comprehension of the information from the student. The system also shows some videos when some tasks are successfully completed. Thanks to the combination of different exercises and rules, the educator is able to offer different applications for different students, adapting the level for each case. The tutorial begins with a welcome message and the student is asked to put the virtual tutor in the scene. Once the virtual tutor is visible, it introduces himself and the tutorial begins. The tutorial consists of a

variety of consecutive exercises with different levels of difficulty.

Depending on the exercise, the student is instantiated to select, between the different tools, those needed to cook the bread (Figure 3.a). He/she can also be asked to locate the available ingredients on the scene (Figure 3.b).

Another example of interaction in the exercises is the possibility of modifying the 3D objects properties. Thanks to some useful controls (such as buttons and selectors), the student is able to set the quantity of every ingredient needed to prepare the bread. For example, Figure 3.c shows how the quantity of the water needed to properly cook the bread can be fixed.

Figure 3.d shows an example of a tutorial exercise that has been successfully completed. The goal of the exercise is to select the right ingredients and take them next to the oven (leaving apart those which are wrong). When the right ingredients have been selected, those ingredients and the oven disappear and a piece of bread appears instead. Finally, an explanatory video is displayed to enhance the concepts that have been learned.
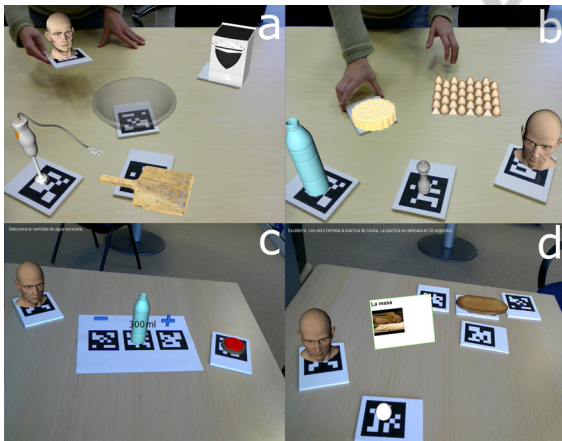


Figure 3: Some examples of exercises. (a) and (b) are choosing exercises (ingredients (a) and tools (b)). (c) is an example of virtual buttons usage. The user can change the quantity of water needed to cook the bread using the virtual controls. (d) Another practical exercise. The tutor reacts to the user's actions and a video is displayed when the exercise has been successfully solved.

The virtual tutor accompanies the student through the different exercises. It explains the concepts, asks the student to perform some tasks and congratulates the student when some task has been achieved. The virtual tutor does not only communicate with the student through his voice but also with nonverbal communication. The tutor can react with some emotions, such as smiling or

showing a sad expression, according to the different actions of the student. As it has been mentioned, the tutor may help the student to accomplish the different tasks. Apart from explaining the different goals, the virtual tutor offers some help when it detects that the student has some problems. A chat help mode is also available, in order to allow the student to ask for help using the keyboard.

As it has been explained, the system logic can be completely defined by the educator through natural language rules. The tutorial has been implemented with those rules. An example of fuzzy rule can be the following:

```
if ((Distance_Oven_Salt is near) and
    (Distance_Oven_Yeast is near) and
    (Distance_oven_water is near) and
    (Distance_oven_Egg is far)) then
Success_Degree is success
```

As it can be seen, the rule defines the condition to successfully complete the exercise showed in Figure 3. Every distance has been defined as a fuzzy variable. The quantity of every ingredient has also been defined as a fuzzy set, so it is easy to define another rule to establish the condition of a right quantity for any ingredient, as, for example:

```
if (Water_Quantity is high) then
Success_Degree is failure
```

## 3.2 Children Learning Games

The second application is made up of some educational games for children. The goal of those games is to learn some basic concepts while playing. The games are hosted by a virtual tutor. The virtual tutor is here a ginger bread toon. Two examples of those games are introduced in the next lines.

The first example is a puzzle game. The child is asked by the virtual tutor to complete a basic puzzle. If the virtual tutor detects that the child is having some problems to achieve the goal, it encourages him/her. A help chat mode is also available if needed. When the puzzle is completed, the virtual tutor congratulates the child and remarks the congratulation with some nonverbal communication such as smiling and dancing. Figure 4.a and 4.b show an example of the game. The game logic has been implemented in ISIS with fuzzy attributes for distances and angles between the different pieces of the puzzle.

Another example of learning-oriented child game is a vowel-learning game. The five vowels are shown to the child, and the virtual tutor asks him/her to press one of them. If the wrong vowel has been selected, the virtual tutor shows a sad face and asks

the vowel again. On the other hand, if the right vowel has been pressed, the virtual tutor smiles and dances. In order to enhance the learning process, when the right vowel has been selected, the virtual tutor says some sentences relative to some words that begin with that letter. After that, another random vowel is asked to continue with the game. Figure 4.c and 4.d show the proposed game.
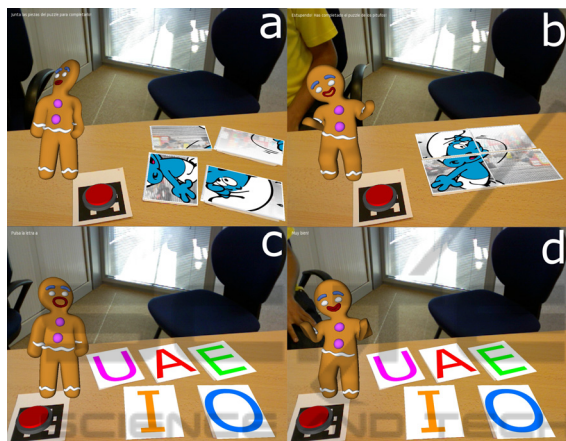


Figure 4: Examples of children learning games. Some puzzle pieces (a) and vowels (c) are offered to the child. When the puzzle is successfully completed (b) or the right vowel has been selected (d), the virtual tutor congratulates the child, smiles and dances.

## 3.3 Evaluation with Users

The bakery tutorial has been used in a pilot experience. Twenty students between 20 and 50 years old have tested the tutorial and have been asked to evaluate the system through a poll. Some basic Augmented Reality examples have been introduced to the students using the system. Once the concept has been introduced to the students, they have tried the different exercises.

Firstly, the students have performed the exercises without the presence of the virtual tutor. After that, the same exercises have been carried out with the help of the virtual tutor.

When the tutorial has finished, the students have been asked to evaluate the system. The main ideas obtained from the polls have been that the interactivity based on Augmented Reality and the virtual tutor are two elements that improve the concept acquisition. Moreover, the system has proved to be very usable even in the cases of students who have never used an Augmented Reality application before. The fact of having the possibility to interact has been also pointed out by the students.

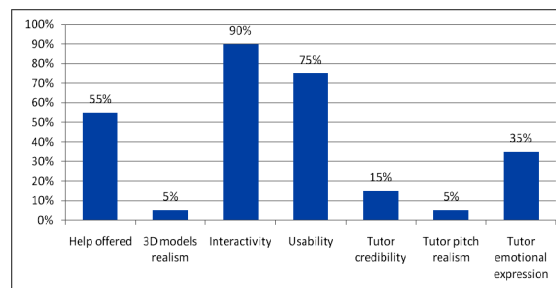Figure 5 shows the results of the acceptance levels of some aspects.



Figure 5: Remarkable aspects of the bakery tutorial. The interactivity, usability and the help offered by the tutor have been the most valuable aspects for the students.

It is also remarkable that 3D models and tutor pitch are a crucial issue for the student's perception and credibility towards such interactive systems.

## 4 CONCLUSIONS AND FUTURE WORK

An intelligent interactive e-learning authoring tool based on Augmented Reality has been presented. The system allows teachers to create interactive learning applications including exercises, tutorials and games. The applications can be adapted to different environments, ranging from training courses to school concepts acquisition for children.

The application of an artificial intelligence rules-based engine with Augmented Reality as user interface supposes a new approach respect to existent work, as it enables the creation of formative applications based on rules, which define the interaction between the virtual elements (3D models, images, sounds and videos) and the student in order to enable the improvement of the interactivity in the learning process.

The proposed Augmented Reality applications consist of a work area (typically a desk) where some markers are shown to a camera connected to a computer. The system detects the markers with pattern recognition and offers the markers position and orientation to an intelligent virtual environment. Then, the virtual environment is shown over the real video in real-time, according to the markers position and orientation.

One important feature offered by the system is the ability of interaction. The user can manipulate the markers, which at the end supposes to interact with the virtual elements (3D models, images,

browsers…). Some of those virtual elements are buttons or selectors what enables the user to change some properties of the other virtual elements. Other features of the virtual elements, such as distances and angles, are also properties that evolve the system, according to how the student manipulates them.

The complete learning process is guided by a virtual tutor. The virtual tutor can be selected from the available ones according to the context and the end user. For example, a human look-like model has been used to develop a training tutorial while some toons have been used to create children learning games. The virtual tutor teaches the student and offers him/her some exercises to carry out. The student can interact with the virtual tutor in a variety of ways (listening to the instructions, chatting, talking to it or receiving nonverbal communication). The virtual tutor acts according to intelligent framework, which is also responsible of the system logic.

The bakery tutorial has been tested in a pilot experience and has reported good results. The students have been able to use the application without any problems even if they had not used an Augmented Reality application before. The help of the virtual tutor has shown to be enough to start using the application. The results of the experience agree with the results of other similar studies (Balog et al., 2007; Chen et al., 2007; Kaufmann and Dünser, 2007).

Besides, the virtual 3D representation of complex objects may be a help for the student to assimilate the concepts because sometimes it is difficult to visually image the objects.

In the future, the system is expected to automatically analyze the learning indicators obtained in order to adapt the contents for each student in real-time, instead of the mediation of the real tutor and so to provide a personalized learning process. Emotional detection for content adaptation is also a desirable feature to obtain in the future.

In order to track the student learning process by the educator, currently the system is being integrated in a standard Learning Management System.

## REFERENCES

Balog, A., Pribeanu, C., Iordache, D., 2007. Augmented reality in schools: Preliminary evaluation results from a summer school. International Journal of Social Sciences, 2(3), pp. 163–166.

Billinghurst, M., Kato, H., Poupyrev, I., 2001. The MagicBook — Moving Seamlessly between Reality and Virtuality. IEEE Computer Graphics and Applications, vol. 21, no. 3, pp. 6-8.

Chen, C. H., Su, C. C., Lee, P. Y., Wu, F. G., 2007. Augmented Interface for Children Chinese Learning. 7th IEEE International Conference on Advanced Learning Technologies, pp. 268–270.

Hwa Lee, S., Choi, J., Park, J., 2009. Interactive e-learning system using pattern recognition and Augmented Reality. IEEE Transactions on Consumer Electronics, vol.55, no.2, pp. 883-890.

Juan, C., Beatrice, F., Cano, J., 2008. An Augmented Reality System for Learning the Interior of the Human Body. 8th IEEE International Conference on Advanced Learning Technologies, ICALT. 186-188.

Kaufmann, H., Dünser, A., 2007. Summary of usability evaluations of an educational augmented reality application. Virtual Reality, pp. 660–669.

Lin, C. T., Lee, C. S., 1996. Neural fuzzy systems: a neuro-fuzzy synergism to intelligent systems, Prentice-Hall, Inc. Upper Saddle.

Martínez, H., del-Hoyo, R., Sanagustín, L. M., Hupont, I., Abadía, D., Sagüés, C., 2011. Augmented Reality Based Intelligent Interactive e-Learning Platform. 3rd International Conference on Agents and Artificial Intelligence (ICAART).

Sklar, E., Richards, D., 2006. The use of agents in human learning systems. Proceedings of the 5th international Joint Conference on Autonomous Agents and Multiagent Systems AAMAS '06. ACM, New York, NY, pp. 767-774.

Sumadio, D. D., Rambli, D. R. A, 2010. Preliminary Evaluation on User Acceptance of the Augmented Reality Use for Education. Second International Conference on Computer Engineering and Applications. ICCEA, vol. 2, pp. 461-465.

Zadeh, L. A., 1965. Fuzzy sets. Information and control, 8(3), pp. 338–353.