IAAN: Intelligent Animated Agent with Natural Behaviour for Online Tutoring Platforms

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Abstract: The goal of the work presented in this paper is to develop an Intelligent Animated Agent with Natural Behaviour (IAAN). This agent is integrated into e-learning platforms in order to perform the role of an online tutor. The system stores into a database personalized information of each student regarding their level of education, their learning progress and their interaction with the platform. This information is then used by the 3D modeled virtual agent to give personalized feedback to each student; the purpose of the agent is to guide the students throughout the lectures taking into account their personal needs and interacting with them by means of verbal and non-verbal communication. To achieve this work a thorough study of natural behaviour has been held and a complex state machine is being developed in order to provide IAAN with the sufficient artificial intelligence as to enhance the students motivation and engagement with the learning process.

1 INTRODUCTION

Online tutoring has become very popular in the past years and according to several studies such as the latest survey by Ambient Insight Research (Adkins, 2013); the aggregate growth rate for self-paced e-learning products and services expected for the next five year period (2011-2016) is 7.6%. Distance learning offers a series of benefits that traditional learning cannot compete with, for example in terms of mobility, affordability or flexibility e-learning happens to be much more suitable for nowadays lifestyle. However, online learning also has its drawbacks, the lack of supervision from a tutor in the courses may lead to demotivation, boredom and the final drop of the courses. This is why the integration of virtual agents represented as human characters into these platforms can be an effective solution to make the students feel supported and accompanied throughout the course as a real teacher would.

Michael Graham Moore (Moore, 1989) classified the possible interactions in distance education into three types:

- learner-content
- learner-instructor
- learner-learner

He acknowledged the "learner-instructor" interaction as the most important. Moreover, studies like (Bloom, 1984) demonstrated the effectiveness of a one-on-one human tutoring system against other methods of teaching, and (Lepper et al., 1993), defended the idea that education could be globally improved if every student was provided with a personal tutor. This is something almost impossible to achieve in traditional education but it is not so in online learning.

This work introduces IAAN, a virtual agent represented as a 3D modeled character endowed with intelligence and natural behaviour, designed to perform the role of a real tutor in e-learning platforms. IAAN reacts in real time to the students' interaction with the platform by means of verbal and non-verbal communication. Furthermore, in order to make IAAN as realistic as possible an Intelligent Animated Agent Editor is included into the system allowing real tutors to define the appearance and behaviour of IAAN in response to different situations. This editor is based on the Behaviour Markup Language standard (BML [1]).

Additionally, this work is entirely web based so it solves the interoperability issues presented by most commonly used e-learning systems with other platforms such as Learning Management Systems, web-based virtual world platforms, Virtual Reality learning systems or simulators.

IAAN has been partially integrated into Moodle

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[1]http://www.mindmakers.org/projects/bml-1-0/wiki

(Moodle, 2013) Learning Management System.

This paper is organized as follows; Section 2 analyzes the related work carried out in the last years concerning agents and artificial intelligence, Section 3 describes the architecture followed to accomplish the goals of this work, Section 4 shows integration results from the work. The final section is about conclusions and future work.

2 RELATED WORK

The purpose of this work is to integrate an intelligent 3D virtual agent into e-learning platforms. Concerning this process, Buraga (Buraga, 2003) proposes an agent-oriented extensible framework based on XML family for building a hypermedia e-learning system available on the world-wide-web. This intelligent tutoring system is composed of four major components, the information processed by each component can be stored by XML documents. Some of the components are implemented as intelligent agents.

Angehrn et al. (Angehrn et al., 2001) suggests the use of K-InCA to provide a personalized e-learning system to help people learn and adopt new behaviours. The agent continuously analyses the actions of the user in order to build and maintain a "behavioural profile" reflecting the level of adoption of the "desired" behaviours. Using this profile, the agent provides customized guidance, mentoring, motivation and stimuli, supporting the gradual transformation of the users behaviours.

Defining natural behaviour is not an easy task either. The literature and theory of affective computing imply several conditions for synthesized motion to appear natural (Abrilian et al., 2005). Speed of interaction and emotion/speech-correlated believable body motion are among the most important functionalities (Mlakar and Rojc, 2011). Rieger (Rieger et al., 2003) developed a series of rules in order to increase the acceptance of virtual agents in Human-Computer Communication and established a correlation table between the message to rely and the emotion to show.

Steve (Johnson and Rickel, 1997) was one of the first pedagogical agents capable of expressing emotions; it was designed as a stereoscopic 3D character that cohabited with learners, it has been applied to naval training tasks. However, Steve was originally designed to operate in immersive virtual environments and not over the Web.

Project GRETA (Poggi et al., 2005) presents a multimodal Embodied Conversational Agent (ECA)

capable of interpreting APML [2] mark-up language to generate synchronized speech, face, gaze and gesture animations.

More recently, (Benin et al., 2012) presented a three-dimensional animated talking head which repeats any input text in six different emotional ways.

3 INTELLIGENT ANIMATED AGENT ROLES

The final goal of the work presented is to integrate a 3D animated agent into e-learning platforms in order to asses and guide students as a real teacher would.

Many studies have been held to identify the qualities of a good teacher (Azer, 2005) (Korthagen, 2004). Besides, students and teachers do not always agree in the importance of these qualities. From the perspective of students, Brown and McIntyre (Brown and McIntyre, 1993) and Batten (Batten et al., 1993) found the two qualities with highest frequency of mention were the teachers ability to "explain clearly", and "help us with our work". On the other hand, two qualities seen by teachers as crucial, but not mentioned by students, were "planning, structuring and organising the classroom, and fostering student involvement and participation".

Considering previous research, IAAN has been designed to perform several roles throughout the course depending on the needs of the lesson, these roles have been divided into three states:

- **Explanation State.** IAAN will be able to explain new concepts to the user. Humans tend to gesticulate when introducing an idea to others; performing arm movements or pointing out objects, IAAN will act alike.

- **Evaluation State.** One of the most important roles that IAAN must perform is the one of a real tutor. IAAN will guide the students through the lectures and will interact with them giving them personal feedback, responding in real-time to their interaction with the platform.

- **Waiting State.** When IAAN is not in any of the previous states, for example, when self-explanatory audiovisual content is being displayed to the student, IAAN will enter a waiting state mode. IAAN will not interact directly with the student but he will be animated. Humans do not stand hieratical when waiting for something to happen; we balance our body, gaze, cross our arms, etc. As IAAN is endowed with natural be-

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[2]http://apml.areyoupayingattention.com

haviour, he will also perform these kind of movements in this state.

The following section introduces the Intelligent Animated Agent Editor, this tool is being developed to ease the job of defining the virtual agent's appearance and behaviour. With the help of this tool the course editor will be able to define the Explanation and Waiting state. This tool is the core of the Behaviour Module. The Evaluation state will be discussed in more detail in Section 5.

3.1 Intelligent Animated Agent Editor

This tool is being implemented to allow real tutors to design IAAN's appearance and behaviour as they deem most appropriate in each case. To ensure quality education it is important to leverage the knowledge and expertise provided by real teachers.

Regarding IAAN's appearance, McCloud (McCloud, 1994) stated that individuals see themselves as iconic images but see others in a more detailed form, that is, as realistic images. Gulz and Haake (Gulz and Haake, 2006) extended this idea to the role of animated pedagogical agents and stated that if the agent is acting as a teacher, the student will see it as "the other person" and therefore it is better to represent it in a human form. However, the risk of falling into the "uncanny valley" (Mori, 1970) also exists and furthermore depending on the target of the course the editor may consider to represent IAAN in a more cartoonish shape, for example, if the course is targeted for kids. So the decision of IAAN's appearance is entirely left in the hands and teaching experience of the real tutor. The agent's appearance is selected from a list of predefined 3D models and imported into the IAA Editor.

With respect to facial expression, the IAA editor is based on Ekman's six universal emotions (Ekman and Friesen, 1981), so IAAN will be able to show the following facial expressions: happiness, surprise, anger, sadness, disgust and fear. An example of IAAN performing these facial expressions can be found in Figure 1.

IAAN performs several hand gestures, the scientific community has established four type of hand gestures (Cassell et al., 1994):

- Iconic: or illustrators, they are descriptive gestures often used to illustrate speech.

- Metaphoric: or representational gestures, represent an abstract feature concurrently spoken about.
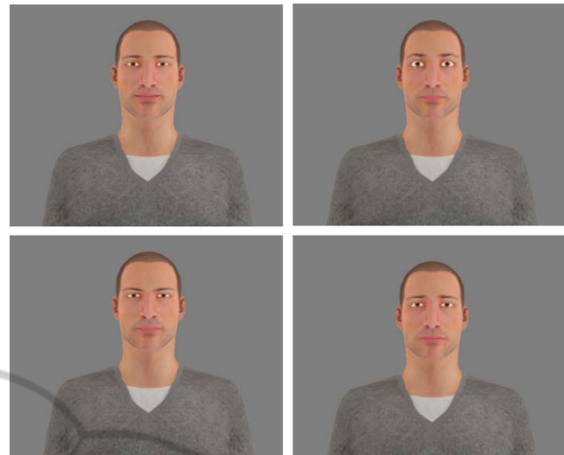
- Deictic: indicate a point in the space.

Figure 1: IAAN represented as a 3D virtual agent expressing facial emotions (happiness, surprise, anger, sadness).

- Beats: small formless waves of the hand that occur to emphasize words.

IAAN communicates in a verbal way with the students, for this purpose the IAA Editor includes a text editor. This text is then transformed into speech by a Text-to-Speech synthesizer.

As shown in Figure 2 the IAA Editor is composed of three main areas; the animations regarding natural behaviour can be found in the *Options Area*, the real tutor selects the desired animation from one of the available menus and drags it onto the *Timeline Area*, this action is repeated as many times as necessary until the desired behaviour is achieved. Then the final result is visualized in the *Viewer Area*.

The composition created in the timeline is translated into a BML file. In the following BML example created with the IAA Editor, a welcoming message has been designed. This BML file is then used as an input to the Animation Engine.

```
<bml xmlns=
   "http://www.bml-initiative.org/bml/bml-1.0"
    character="Iaan"
    id="bml1">
 <gesture id="behavior1" lexeme="hello-waving"
    start="2" end="3"/>
 <faceLexeme  id="behavior2" lexeme="happy"
     amount="0.8" start="2" end="3"/>
 <speech id="speech1" start="4">
    <text>Wellcome to the first lesson!</text>
 </speech>
</bml>
```

4 IMPLEMENTATION

The architecture chosen to accomplish the goals presented in the previous section is shown in Figure 3.
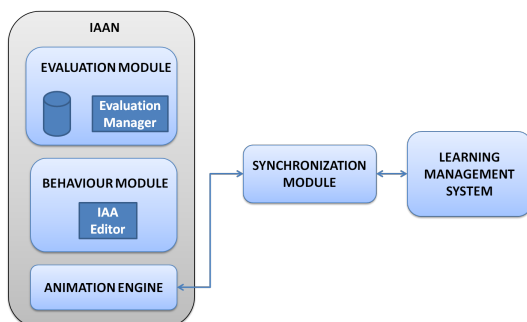
125

Figure 2: Intelligent Animated Agent Editor.

Figure 3: Platform Modules.

The main modules involved in the design of IAAN are the Behaviour Module, the Evaluation Module and the Animated Engine.

The Behaviour Module has been described in Section 3. This module is in charge of defining the behaviour of IAAN in each situation, to make IAAN as realistic as possible a real tutor is in charge of describing IAAN's interaction with the students. To ease this job the IAA Editor has been developed.

Next the Evaluation Module and the Animated Engine will be explained in more detail.

4.1 Evaluation Module

IAAN must accompany the students throughout the course and interact with them whenever is necessary.

To accomplish this IAAN will keep track of each student along the course in order to give personalized feedback to each individual.

This is achieved by storing multiple information into a database and by defining a complex state machine that will inform IAAN when and how to interact with each student.

4.1.1 User Profile Database

It is crucial to know as much as possible about each student in order to assess them according to their personal needs. Table 1 shows the information stored into the database for further analyses, regarding personal information as well as the student's interaction with the e-learning platform.

Table 1: User Profile Information.

Personal Information	Platform Usage
Name	Logins
Age	Session Duration
Address	Interaction Speed
Knowledge Level	Mistake Frequency

Taking this information into account the course editor is able to design specific evaluation rules for each student.

The first thing the course editor must decide is the EVALUATION HARSHNESS, initially this parameter

is set depending on the student's age and knowledge level, but as the course progresses and the student acquires more knowledge this scale can be modified.

The Platform Usage information is designed to establish a BEHAVIOUR_PATTERN for each student, for example; the amount of logins per week, the session duration, the frequency in answering questions, the mistaken answers. Bearing this pattern in mind, IAAN will interact with the student whenever a disorder in the pattern takes place.

4.1.2 Evaluation Manager

The Evaluation Manager is designed as a finite state machine (FSM). As seen in Figure 4 the Evaluation Manager takes as inputs the EVALUATION_HARSHNESS, the BEHAVIOUR_PATTERN and the BML_FILES that define IAAN's natural behaviour which have been previously designed with the IAA editor .

Taking these inputs into account the Evaluation Manager waits for behaviour pattern alerts and if they occur the manager orders IAAN to interact with the student by means of the previously designed BML files. Regarding the User Profile Information the possible alerts have been defined as follows:

- LOGIN_ALERT. The course editor is in charge of establishing an amount of logins per week (or month) for each student in order to fulfil his assignments. If this recommendation is altered in any way the platform is notified with an alert message and IAAN is launched to interact with the student.

- INTERACTION_ALERT: Once the student has logged in he interacts with the platform in a determined frequency. Modifying this frequency may mean several things, for example, if the interaction speed increases it may indicate the student finds the lesson too easy, on the contrary if the speed decreases the lesson might be too difficult or it may simply mean the student is taking a break. IAAN is able to interact with the student to find out what is happening.

- MISTAKE_ALERT. If the student commits more mistakes than usual the course level might not be appropriate or the student might not be paying attention. IAAN might enter the Explanation state in order to clarify concepts or draw the student's attention by introducing a multimedia effect.

- SESSION_ALERT. A recommended minimum and maximum time is set to perform each session, if this time is altered IAAN shows up to check if the student has finished his assignment.

The messages in round boxes from Figure 4 represent examples of IAAN communicating with the student in each alert situation. For example, if the Evaluation Manager detects an INTERACTION_ALERT IAAN launches the BML file describing the behaviour to adopt under this circumstance, for instance, IAAN will ask the student: "Are you taking a break?". Another example would be in the event of a MISTAKE_ALERT, in this case IAAN will express concern by asking: "Is the lesson too difficult?".

With these queries IAAN seeks to encourage the student to continue working, letting him know he is not alone and that he is being supervised.
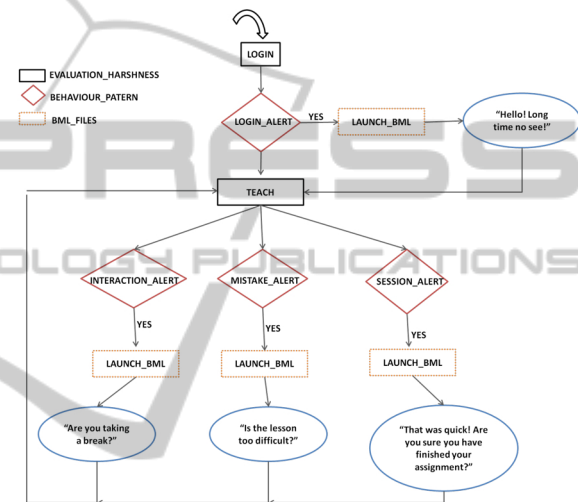
Figure 4: Evaluation FSM Example.

4.2 Animation Engine

The Animation Engine is composed by several modules developed using JavaScript programming language and following all the HTML5 and Web3D standards. These modules have been developed as an abstraction layer over O3D[3] engine which has been selected amongst other engines (GLGE, x3dom, etc.) for its benefits, as it is not a very high level API it allows great flexibility when developing new features.

WebGL (Leung and Salga, 2010) technology has been used to render IAAN via the web. WebGL is based on OpenGL, which is a widely used open source 3D graphics standard. Nowadays, most common browsers support this technology; Google Chrome, Mozilla Firefox, Apple Safari or Opera.

The modules that compose the Animation Engine are in charge, amongst other features, of rendering 3D modeled characters into web browsers, parsing BML files which define the character's behaviour and ani-

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[3]http://code.google.com/p/o3d/

Figure 5: Integration of IAAN into Moodle.

mations and communicating with the e-learning platform.

5 INTEGRATION

The work presented in this paper is entirely web based, this fact makes the platform compatible with most widely-used learning management systems (LMS)[4]; Edmodo (Edmodo, 2013), Moodle (Moodle, 2013), Blackboard (Blackboard, 2013), SumTotal Systems (SumTotal, 2013), etc.

In the work presented IAAN has been partially integrated into Moodle. Moodle is based on a Model-View-Controller coding design pattern. To integrate IAAN into Moodle the modules from this work must be added to the configuration file of the platform.

This platform offers a very interesting feature for our work; the *Configurable Reports*. This block is a Moodle custom reports builder designed in a modular way to allow developers to create new plugins. The types of reports available are:

- Courses reports, with information regarding courses.

- Categories reports, with information regarding categories.

- User reports, with information regarding users and their activity in a course.

- Timeline reports, this is a special type of report that displays a timeline showing data depending on the start and end time of the current row.

- Custom SQL Reports, custom SQL queries.

Taking advantage of this feature a Synchronization Module is being developed as a communication bridge between Moodle and the Animation Engine (Figure 3).

For this work a very simple English Course has been created in Moodle with multiple choice quizzes for the student to answer. Figure 5 shows the integration of IAAN into the created course.

Validation results regarding the entire platform integration have not yet been performed as it is still work in progress. However, some of our final users in different applications have been able to interact with IAAN and they have pointed out its natural behaviour and communication as an engaging and realistic way of interaction.

6 CONCLUSIONS AND FUTURE WORK

An intelligent virtual agent represented as a 3D modeled character has been presented in this paper. Thanks to the IAA editor the agent is gifted with nat-

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[4]http://edudemic.com/wp-content/uploads/2012/10/top-20-lms-software-solutions.png

ural behaviour, allowing real tutors to use their experience to define the agent's reactions in different circumstances.

The Evaluation Module described in this work is still being developed. The main goal of this module is to turn the animated agent into an autonomous agent that needs no exterior intervention to respond to students' interaction in real-time.

The modules of this work have been developed following a Model-View-Controller coding pattern to ease the integration with the selected e-learning platform. IAAN has been successfully integrated into Moodle, though only partially functional as the Evaluation Module is still under development.

The Animation Engine introduced in this work is constantly improved to suit new needs. The final goal is to develop an animation engine capable of reproducing human behaviour as realistic as possible.

A synchronization module is being developed in order to optimize the communication between IAAN and Moodle. Furthermore, we are studying other LMS in order to develop a general synchronization module turning IAAN into a multiplatform assistant.

Finally, we are defining the validation phase to test the work presented in this paper with real students in order to confirm IAAN's positive effect. The results of these evaluations will verify whether IAAN's natural behaviour and real-time emotional response has a beneficial effect on the students learning engagement and final cognitive results.

REFERENCES

Abrilian, S., Devillers, L., Buisine, S., and Martin, J.-C. (2005). Emotv1: Annotation of real-life emotions for the specification of multimodal affective interfaces. In *HCI International*.

Adkins (2013). The worldwide market for self-paced elearning products and services: 2011-2016 forecast and analysis.

Angehrn, A. A., Nabeth, T., Razmerita, L., and Roda, C. (2001). K-inca: Using artificial agents to help people learn and adopt new behaviours. In *ICALT*, pages 225–226.

Azer, S. A. (2005). The qualities of a good teacher: how can they be acquired and sustained? *Journal of the Royal Society of Medicine*, 98(2):67–69.

Batten, M., Marland, P., Khamis, M., and for Educational Research., A. C. (1993). *Knowing how to teach well : teachers reflect on their classroom practice / Margaret Batten, Perc Marland, Mon Khamis*. ACER Hawthorn, Vic.

Benin, A., Leone, G. R., and Cosi, P. (2012). A 3d talking head for mobile devices based on unofficial ios webgl support. In *Proceedings of the 17th International Conference on 3D Web Technology*, pages 117–120. ACM.

Blackboard (2013). Wherever your learning takes place. http://uki.blackboard.com. Accessed November, 2013.

Bloom, B. S. (1984). The 2 sigma problem: The search for methods of group instruction as effective as one-to-one tutoring. *Educational Researcher*, 13(6):4–16.

Brown, S. and McIntyre, D. (1993). *Making Sense of Teaching*. Open University Press.

Buraga, S.-C. (2003). Developing agent-oriented e-learning systems. In *in Proceedings of The 14th International Conference on Control Systems And Computer Science vol. II, I. Dumitrache and C. Buiu, Eds, Politehnica*. Press.

Cassell, J., Pelachaud, C., Badler, N., Steedman, M., Achorn, B., Becket, T., Douville, B., Prevost, S., and Stone, M. (1994). Animated conversation: rule-based generation of facial expression, gesture & spoken intonation for multiple conversational agents. In *Proceedings of the 21st annual conference on Computer graphics and interactive techniques*, pages 413–420. ACM.

Edmodo (2013). Where learning happens. https://www.edmodo.com. Accessed November, 2013.

Ekman, P. and Friesen, W. V. (1981). The repertoire of nonverbal behavior: Categories, origins, usage, and coding. *Nonverbal communication, interaction, and gesture*, pages 57–106.

Gulz, A. and Haake, M. (2006). Design of animated pedagogical agentsa look at their look. *International Journal of Human-Computer Studies*, 64(4):322–339.

Johnson, W. L. and Rickel, J. (1997). Steve: An animated pedagogical agent for procedural training in virtual environments. *ACM SIGART Bulletin*, 8(1-4):16–21.

Korthagen, F. A. (2004). In search of the essence of a good teacher: towards a more holistic approach in teacher education. *Teaching and Teacher Education*, 20(1):77 – 97.

Lepper, M. R., Woolverton, M., Mumme, D. L., and Gurtner, J. L. (1993). Motivational techniques of expert human tutors: Lessons for the design of computer-based tutors. In Lajoie, S. P. and Derry, S. J., editors, *Computers as Cognitive Tools*, pages 75–105. Lawrence Erlbaum Associates.

Leung, C. and Salga, A. (2010). Enabling webgl. In *Proceedings of the 19th international conference on World wide web*, pages 1369–1370. ACM.

McCloud, S. (1994). *Understanding comics*. William Morrow Paperbacks.

Mlakar, I. and Rojc, M. (2011). Towards ecas animation of expressive complex behaviour. *Analysis of Verbal and Nonverbal Communication and Enactment. The Processing Issues*, pages 185–198.

Moodle (2013). Open-source community-based tools for learning. https://moodle.org. Accessed November, 2013.

Moore, M. G. (1989). Three types of interaction. *The American Journal of Distance Education*, 3:1–6.

Mori, M. (1970). Bukimi no tani [the uncanny valley]. *Energy*, 7:33–35.

Poggi, I., Pelachaud, C., de Rosis, F., Carofiglio, V., and de Carolis, B. (2005). GRETA. A Believable Embodied Conversational Agent. pages 27–45.

Rieger, T. et al. (2003). Avatar gestures. *Journal of WSCG 2003*, 11:379–386.

SumTotal, S. (2013). Learning management and talent management solutions. http://www.sumtotalsystems.com. Accessed November, 2013.