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Intelligent Learning Environments

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Editorial

The year 2020 gave us the opportunity to discover new ways to set up learning environments for students in distance education. The pandemic provoked by the SARS-CoV-2 virus forced all teachers, from K-12 to bachelor and graduate level in college and universities, to improvise virtual classrooms in order to continue education.

The development of learning environments and educational technology based on computers is not a new area and, fortunately, many researchers had already dedicated countless hours to create new environments and tools to support learning.

Computer science and specifically artificial intelligence provide methods and techniques that can be applied in the educational field to change and adapt the learning process, providing a personalized learning environment for each student.

Students have many possibilities to access educational resources to learn new topics, to collaborate with peers, to solve problems using fun tools, as well as many other activities. Artificial intelligence techniques applied in the development of software systems have shown it is possible to provide software systems that students can use to gain knowledge and learn at their own pace in different virtual or digital environments.

In this issue, our goal is to offer researchers an opportunity to show how they are exploring new ways of applying AI techniques into educational systems.

In this volume, we present eight research works in some of the most interesting fields of intelligent learning environments. The papers were carefully selected by the editorial board on the basis of three reviews by the members of the Technical Committee. The reviewers considered the originality, scientific contribution to the field, soundness and technical quality of the papers.

We are very grateful to many organizations and people who contributed to WILE 2020. We truly appreciate the support provided by REDICA (Conacyt Thematic Network in Applied Computational Intelligence), and we would like to thank its members that were part of the Technical Committee, as well as members of Mexican Society for Artificial Intelligence (SMIA Sociedad Mexicana de Inteligencia Artificial). We are grateful to Universidad Panamericana (UP) for their support during the virtual event. Last, but not least, we thank Centro de Investigación en Computación-Instituto Politécnico Nacional (CIC-IPN) for their support in preparation of this volume.

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Immersive Virtual Reality with Touch Response: Proposal for Complete Experience

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Abstract. This work proposes the development of an immersive virtual reality environment that includes a haptic device, in order to create a better user experience by adding the sense of touch, with the intention of being applied in both recreational and training projects, such as virtual labs or exploration environments. As a case study, the gymnasium of a higher education institution is reproduced with the original idea of promote the facilities and motivate their use as well as the participation of students in different disciplines, an Oculus Rift device is used together with a Touch 3D stylus haptic device.

Keywords: Haptic devices, virtual reality, tactil retroalimentation, immersive environments.

1 Introduction

In recent years, immersive virtual reality environments are increasingly being used in different areas and are becoming more relevant in training and educational aspects. However, most of this type of environment uses only the sense of sight and hearing, leaving aside the other senses, being that the sense of touch in many occasions can be more important since it allows perceiving sensations that other senses do not. A clear example is the interaction with objects, most of cases the only way to know their texture or rigidity is through contact with them.

In addition, virtual reality environments that incorporate tactile sensations allow greater interaction with the user.

As mentioned in [4], the sense of touch is the only one with immediate outer perception: because of this, touch is the most important sense and the one that teaches the most. Without this sense we would not be able to understand our physical form. According to [8] in order to create sensation of touching a virtual object, a haptic interface device needs to calculate the position of the device by means of sensors and transmit it to the computer, which in turn calculates in real time the force that should be sent to the actuators in the haptic interface, in order to obtain appropriate feedback and the user can have a tactile perception of the virtual objects.

Likewise, in the last years, the use of computers has become indispensable for the daily life of the human being, however, the human-machine interaction has been mainly focused to be visual and auditory.

According to [7] Virtual Reality is a simulation of a three-dimensional environment generated by computers, in which the user is capable of seeing and manipulating the contents of that environment.

This work arises from the earthquake that occurred in Mexico on September 19, 2017, in a higher education school in the south of Mexico City. The buildings destined for classrooms were affected, making it impossible to carry out normal activities, this caused the furniture to be removed from the buildings and located in the gym, preventing the access of students to it and therefore the performance of sports activities.

This situation has caused that students, mainly newcomers, do not know the facilities that this school has. In addition, not being able to use the gym facilities has caused students who participate in sports teams such as basketball, volleyball, etc., to lose interest and motivation, and has also prevented new students participate in these activities.

Currently, most virtual environments offer only visual and auditory feedback, leaving aside the rest of them, like the sense of touch.

According to [3], two types of interaction variants with virtual environments are recognized: immersive and non-immersive modes. In the immersive mode the user "immerses himself" completely in the simulation through the use of specialized hardware devices, on the contrary, the non-immersive user is constantly distracted by events unrelated to the simulation of the computer, therefore, his brain unconsciously perceives that the virtual environment visited is not part of his reality.

This work proposes the creation of an immersive virtual environment that allows knowing the sports facilities that the school has, in order to promote and motivate the participation of students in various sports activities, since an immersive virtual environment can allow users to immerse themselves in a simulation and thereby motivate them to carry out sports activities.

2 Related Work

There are several works that have to do with virtual explorers or haptic devices, such is the case developed by [6] which allows a complete tour with a virtual reality viewer in order for people to know English Pantheon of Real del Monte town through a cell phone with Android operating system. In another developed project, a virtual environment is proposed that allows the rehabilitation of the upper limb, in which a haptic device is included in a non-immersive way, but with a tactile response [9].

There is also the development of a Virtual Reality application that allows moving around a virtual environment on the Vera campus of the Polytechnic

University of Valencia with the Oculus Rift device [10]. Similarly, the system created by [2] allows users to simulate activities that are carried out in the natural movement of their limbs, these activities are typically with the help of a haptic device to have feedback.

Finally, the work of [11] shows the incorporation of a haptic device that allows a keyboard to be perceived within an immersive virtual environment.

3 Method

This work was developed in Unity®, the various components and devices used in this work and the way they interact are shown below.

3.1 Haptic Device and Virtual Reality Device

In this work, the 3D System Touch Stylus haptic device manufactured by 3D Systems, Inc. was used. [1] This device is in charge of making the user perceive tactile sensations, it has six degrees of freedom with three of them feedback which allows feel the weight, texture and shape of objects.

The virtual reality device Oculus Rift developed by Oculus®[5] was used, which allows exploring the virtual environment through its left controller. This device has two controllers and three sensors (Gyroscope, Accelerometer and Magnetometer).

For the incorporation of these devices, libraries are necessary, available in the Unity Store®, which must be integrated in the virtual environment and work together.

3.2 Construction of the Sports Promotion Instalations and Creation of 3D Objects

This project has a scale representation of the sport instalations, Revit program was used, detailing the spaces of doors and windows to facilitate the construction of a complete virtual environment, with the walls completed, these were exported to a compatible format with Unity to be integrated, the figure 1 shows the bench for men's locker room designed for this project.

The creation of the 3D objects was carried out in Solidworks program. In which furniture and objects contained within the sports development facilities of the school were created, such as lockers, tables, books and others.

Objects were created in two ways:

- Piece, in this way objects were made that can be created without using various objects such as lockers, tables and books.
- Assembly, this way was carried out by joining two or more pieces such as the bathroom benches and sinks.

At the end of object creation in SolidWorks, a format accepted by Blender was elected to be later included in Unity, once each of the objects are included in the virtual environment, the necessary scale, position and rotation are given.

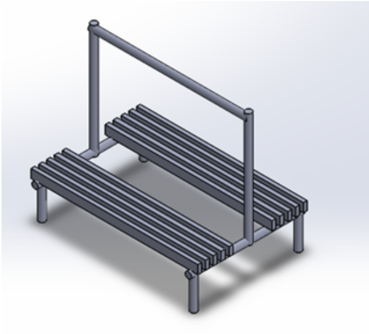

Fig. 1. Benches of men's locker room.

3.3 Virtual Environment

Once the structure of the building and the objects had been designed, the haptic device was integrated, calibrated and configured, likewise, its pointer was inserted as shown in figure 2. It is important to mention that the device must be previously installed on the computer.

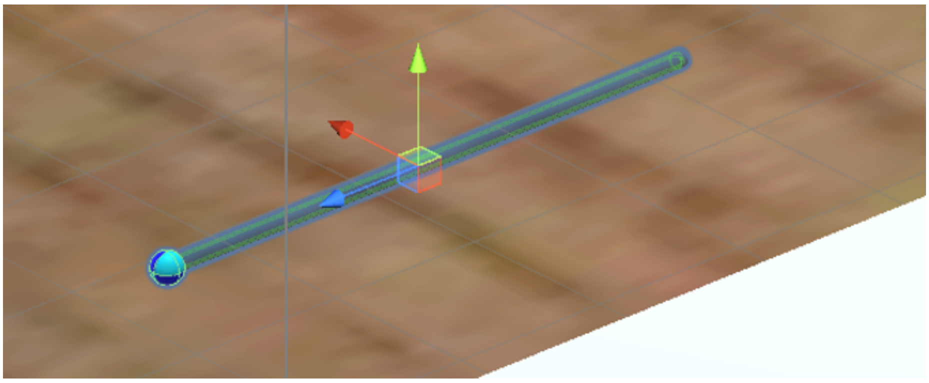

Fig. 2. Haptic device pointer.

This is followed by the integration of the virtual reality viewer, in this case, the Oculus Rift device, which has its own software to configure it on the computer.

In this project, only one Oculus touch controller was used, in this case the left one. So the movement will be completely assigned to this control, the right controller was deactivated and part of the movement code of the left controller was modified to change the functions of buttons and scrolling.

The functions assigned to the Oculus Touch left controller are as follows:

- Command lever: Move the Player through the virtual environment (forward, backward, left and right).
- X button: Player rotation 45 degrees to the right.
- Y button: Player rotation 45 degrees to the left.
- Trigger: Open and close doors.

The prefab object of the haptic device created by 3D Systems was assigned to the main camera of the Oculus rift viewer, with this the haptic device inherits the position and rotation of the viewer, in this way the user can move over the entire virtual environment and can touch everything that is around him.

Finally, the physical properties of the objects that would have in reality, including weight and hardness, were added to the virtual environment in Unity, likewise movements were added when opening doors, bouncing a ball or touching the volleyball net to give more realism to the environment.

In order to users can move through the virtual environment in a more fluid way, 5 scenes were created between they can move, this is done through contact with a transparent object in which the code was developed to indicate which scene must move when having contact, the scenes in which the environment was divided are gym, hallway, office, men's locker room and women's locker room, each of these allows users navigate, see, touch and interact with different objects (see Fig. 3).

Fig. 3. Virtual environment scenes.

3.4 Hardware

For the development and testing of this project, a computer with a 9th generation Core i7 processor with 16 GB of RAM, a GeForce RTX 2060 video card, 4 USB 2.0 ports and an HDMI port was used.

4 Unit Tests

Our users had the following characteristics. Tests were carried out with five people of different ages, genders and different approaches to video games and virtual environments, as illustrated in Table 1.

Table 1. Test users characteristics.

User	Age	Gender	Approach to virtual reality
Subject 1:	22	Female	Yes
Subject 2:	23	Male	No
Subject 3:	23	Male	Yes
Subject 4:	24	Male	No
Subject 5:	37	Male	Yes

Before the tests each of the users were given a brief introduction on how to make use of the movement control, after having a first contact with the simulation only with the Oculus Rift, the haptic device was incorporated so that they could make a full scan.

The tests consisted of taking a free tour of the facilities, the subjects could move, touch and interact with any object in the scenes. At the end they were asked about their experience and how they felt after removing the 3D viewer (see Fig. 4).

Fig. 4. Subject performing the test.

The tests were carried out separately for each user. In each test the ability to move around the environment was evaluated, how immersed they were in the simulation and secondary effects at the end of the simulation. The results are shown in Table 2.

Table 2. Tests observations.

User	Observations
Subject 1:	At the end of the simulation she was abruptly disoriented.
Subject 2:	He experienced nausea and loss of balance.
Subject 3:	When the simulation ended, it took him a while to get used to the real world.
Subject 4:	Are comfortable navigating the virtual environment.
Subject 5:	He showed good control in handling the 3D viewer and the haptic device.

The test subjects commented that they felt really immersed in the virtual world, they did not notice big differences between the real world and the virtual world. With the exception of subject 5, at the time of being immersed in the virtual world, the subjects moved the haptic device from their original position.

5 Conclusions and Future Work

It can be considered that one of the contributions of the project is to allow a total exploration within the three-dimensional virtual environment including a tactile feedback, which makes it possible to perceive textures, apply force to objects, in addition to very fine sensations that cannot be captured by the other senses.

Some of the problems that arose during the development of the project occurred when placing all the rendered objects in the virtual environment, this caused saturation of GPU, causing the visualization in the 3D viewer to be slow.

This incident was resolved by separating the scene that contained all the rendered objects into 5 scenes: gym, hallway, office, women's locker room, and men's locker room, which only contain the objects for the scene, in order for the user can move freely, it was necessary to create a script that loaded the scene that needed to be accessed.

During the tests carried out, the participants showed great amazement when they felt part of the virtual environment, the integration of the haptic device helped users to feel more immersed in virtualization, improving their experience.

Considering the discomforts presented by two of the test subjects, caution is advised to use this project.

It is worth mentioning that the current project is a case study that allows applying this proposal in other areas, such as risky or inaccessible areas, educational and/or training environments, it is possible to improve the project by connecting a non-pedestal haptic device to allow user greater movement.

As a future work, it proposes the reproduction of the entire campus as well as using this proposal to create virtual laboratories or other learning environments.

References

1. 3D Systems, Inc.: Touch^{TM} user guide (2014)
2. Corneliu, A., Mihaela, D., Mircea-Dorin, P., Crenguta, B., Mircea, G.: Teeth reduction dental preparation using virtual and augmented reality by Constanta dental medicine students through the VirDenT system. In: International Conference Development, Energy, Environment, Economics. pp. 21–24 (2011)
3. Escartín, E.: La realidad virtual, una tecnología educativa a nuestro alcance. Pixel-Bit: Revista de medios y educación 15 (2015)
4. Kern, T.A.: Engineering haptic devices: A beginner's guide for engineers (2009)
5. Oculus: Oculus rift (2019)
6. Olvera Mejía, Y.F., Gea Pérez, M.A.: Desarrollo de realidad virtual para publicitar el Panteón Inglés ubicado en Real del Monte Hidalgo [Development of Virtual reality for advertising of the English Pantheon located in Real del Monte Hidalgo]. Programación Matemática y Software 9(3), 44–52
7. Roehl, B.: Special edition using VRML. McMillan Computer Publishers (1996)
8. Srinivasan, M.A.: What is Haptics? Laboratory for Human and Machine Haptics: The Touch Lab (1995)
9. Steinberg, A.D., Zefran, M., Kolesnikov, M., Ashrafi, S.: Periosim: Haptic-based 3D virtual reality teaching and training simulator (2009)
10. Tse, B., Harwin, W., Barrow, A., Quinn, B., San Diego, J., Cox, M.: Design and development of a haptic dental training system - HapTEL. Lecture Notes in Computer Science 6192, 101–108 (2010)
11. Wu, C.M., Hsu, C.W., Lee, T.K., Smith, S.: A virtual reality keyboard with realistic haptic feedback in a fully immersive virtual environment. Virtual Reality 21(1), 19–29 (2017)

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CARLA: Conversational Agent in Virtual Reality with Analytics

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Abstract. Intrusive interfaces used in online learning environments impose extra cognitive load on learners. Fortunately, current technology trends offer new interactive ways with applications that might ease interactions with learning environments. In this paper, we present a framework to develop a spoken Conversational Agent based in viRtual reaLity with Analytics, namely CARLA. This chatbot is meant to provide interaction and support to any user within an e-Learning platform through a spoken dialogue. For the time being, we only present CARLA components and experimentation related to the Natural Language Understanding, the Dialogue Manager, and the Natural Language Generator using open source and low-cost commercial software. The current development state is presented using the case of Power Systems Education based on virtual reality technology.

Keywords: Conversational agent, virtual reality, natural language processing.

1 Introduction

In accordance to Google Trends, due to the COVID-19 pandemic, e-learning technologies have reached their major peak of interest in the last 14 years[4]. From traditional to corporate training, these technologies are a good mean to control the outspread of the virus by keeping social distance in the classroom. E-Learning ranges from isolated platforms such as Virtual Reality (VR) environments, to a high level of intertwined Learning Ecosystems (LEs) [7].

Virtual Reality (VR) allows the deployment of contextualized learning environments with many benefits: it facilitates learning through exploration and

[4] http://bit.ly/eLearningTrend

repetitive practice, integrates many degrees of freedom, it improves students' motivation and engagement to learn, it ranges from low (and conventional) to highly sophisticated (and costly) equipment, and so on [8]. Unfortunately, most of the existing VR systems use conventional computer inputs and hardware such as keyboard and mouse clicks, whereas highly sophisticated interfaces add an extra cognitive load to the process learning. Fortunately, with the growing maturity of conversational technologies, the possibilities for integrating conversation and discourse in e-learning are receiving greater attention in both research and commercial settings. Conversational agents have been produced to meet a wide range of applications, including tutoring, question-answering, conversation practice for language learners, pedagogical agents and learning companions, and dialogues to promote reflection and metacognitive skills [3].

In this article, we present CARLA, a spoken Conversational Agent in viRtual reaLity with Analytics. This chatbot aims to serve as a tutoring system in a given specific domain situated in a virtual reality environment. It provides knowledge and support to any given user through an interchange of spoken utterances for manipulating objects and navigating the virtual world. As a case of use, the power system education was the topic of choice. Thus, this chatbot is meant to provide knowledge and support for electrical equipment, electrical concepts, energy sources, and other basic principles while allowing the manipulation of the 3D environment.

The rest of this paper is organized as follows: in section 2 materials and tools required by the proposed framework are presented; section 3 details CARLA architecture and explains its functionality; section 4 presents CARLA platform as a whole and an interaction example, also, the DM functionality is analyzed by providing 15 utterances for valid chatbot intentions; finally, section 5 briefly presents conclusions of the project, and discusses future improvements and changes to the platform.

2 Technologies

There are many ways to build a conversational agent, from social media addons to real life embodied service robots such as Pepper, an industrially produced humanoid robot created for business and consumer needs [6]. We propose CARLA as a framework for developing a VR spoken chatbot using low-cost or free technologies. We now discuss the learning environment software, the NLP components are emphasized.

2.1 VR Learning Environment

The learning environment is based on non-immersive VR developed using Unity 3D[5]. Unity 3D is a game engine used for developing serious and non-serious games.

[5] https://unity.com/

It is free and a highly compatible VR engine with multiple operating systems. Similarly, it is beginner-friendly reducing the learning curve for future team members.

For the study case which is the power systems education area, 3D scenarios were designed. These are different power systems facilities such as an electrical substation or a microgrid. Each scenario consists of two scenes, a navigable full-fledged and fully sized power system facility and a catalogue where the facilities components can be studied in detail.

2.2 Chatbot Components

A chatbot is a computer system that works as an interface between human users and software via text or spoken utterances. It is comprised of 3 main elements: the Natural Language Understanding (NLU), a Dialog Manager, and Natural Language Generation (NLG) [2].

The purpose of the NLU is to extract the *intention* of an utterance in the form of a semantic representation. Loosely speaking, an *intent* refers to the data, information, or manipulation over the learning environment the user wants to accomplish. Thus, the NLU parses utterances, first by mapping from speech to text and then producing a linguistic structure which can be handled by a dialogue manager.

In the case of CARLA, the NLU is comprised by the Google Speech API[6], and Stanford CoreNLP toolkit [5]. The first, is a web-based Speech-to-Text tool offered by Google. This service receives an audio file and returns a text file with the recognized words. Google speech cost is 0.006 USD for 15 seconds of recording. This platform was chosen due to it having plenty of documentation and an active community. The second, namely CoreNLP for short, is a NLP toolkit for the Java programming language developed by Stanford CoreNLP Group [5]. This library enables users to construct NLP pipelines through building blocks for higher level text understanding applications: tokenization and sentence splitting, the identification of Parts Of Speech (POS), named entities, and numeric and time values, coreferences, sentiment analysis, and so on.

It supports 6 languages, and depending on the language of choice, some may have less functionalities than others, the English being the most complete one. Nevertheless, due to the VR environment we were forced to use Sergey Tihon's Stanford CoreNLP for .NET[7] version of the toolkit, which also requires IKVM[8] as a way to connect both platforms together. IKVM -wordplay on "JVM", which stands for Java Virtual Machine, in which the creator "just took the two letters adjacent to the J"- is an implementation for Java for the Mono and Microsoft's .NET frameworks.

The Dialog Manager is a module that checks the utterance to a database to manage what response or responses the system should produce in return [2].

[6] https://cloud.google.com/speech-to-text
[7] https://sergey-tihon.github.io/Stanford.NLP.NET/StanfordCoreNLP.html
[8] http://www.ikvm.net

Due to the limited amount of utterances CARLA needs to recognize, all of them (for now) are hard-coded into its system.

The NLG is used to synthesize speech to answer back to the user. Depending on the system type, they can be collected via previous user interactions, have a database, or hard-coded. CARLA utilizes Microsoft Azure's Text-to-Speech SDK[9], a set of web-based services, to synthesize speech in an audio file from text.

3 CARLA Architecture

CARLA is a chatbot embedded into a virtual reality environment. It has three main components: (1) Natural Language Understanding (NLU); (2) Dialog Manager (DM); (3) Natural Language Generator (NLG) (see Fig.1). In the following, we describe the dialogue flow of user utterances.

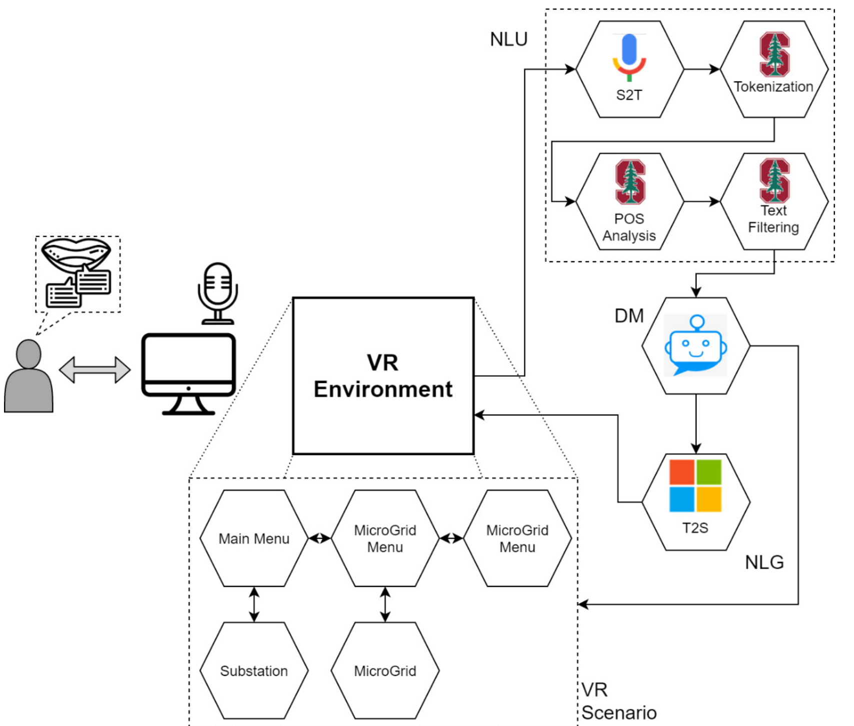

Fig. 1. CARLA framework.

The dialogue step is the NLU step. In CARLA's case, the NLU is a combination of Google Speech-to-Text API and CoreNLP tools. Thus, we turn the user's

[9] https://azure.microsoft.com/en-us/services/cognitive-services/text-to-speech/

voice into a text sentence using Google Speech, implemented in a *push-to-talk* fashion. Once the text of the utterance is obtained, it is necessary to understand the meaning of the sentence.

To this end, three functionalities are provided:

- Tokenization: it is the process of dividing the raw text into individual words.
- Parts Of Speech (POS): it is a categorization of words or lexical items that have similar grammatical properties. Some examples are nouns, verbs, adjectives, and so on. POS *tags* are assigned to tokens to identify the components of the sentence.
- Text filtering: instead of having CARLA analyze the raw text generated by Google Speech, we applied text filtering to analyze only relevant words. Hence, we used the information from the POS analysis and filtered out every single category that we did not need such as stop words like adjectives and punctuation marks.

Once the meaning of the utterance has been extracted by the NLU, an Intent Analysis is performed by comparing the filtered words against the different valid intents. If the intent is valid it modifies one or more objects in the VR environment, as well as provides spoken information. If the intention is not recognized, CARLA will let the user know of this situation. For the time being, this validation is hard-wired but it is expected to be automatized using machine learning algorithms [9].

For the study case, 15 valid intentions were designed namely: *show/what is a solar panel, explain how a solar panel works, show/what is a transformer, explain how a transformer works, show/what is a battery pack, explain how a battery pack works, show/what is a wind turbine, thanks, help, rotate (left and right), stop rotation, zoom in, zoom out, normal zoom, and exit.* The last stage in the human-CARLA interaction is CARLA's spoken answer. For this, we obtain the hard-coded (but can be augmented using generative text content) synthesized into audio feedback answer via the Text-to-Speech SDK in Azure. This tool has more than 140 different voices in more than 45 languages and variants, thus, it provides very expressive voices that sound like human. In particular, this API provides a neural Text to Speech support to display and personalize various styles of speech such as chat, or customer service, and even emotions such as joy and empathy.

A final word regarding the Analytics part of CARLA is deserved. Although for the time being, all analytics is focused at NLP, integration with with a formal knowledge domain model (such as a concept map, classification of dialogue utterances, usage trace data mining, and so on) is expected in the near future.

4 Experimentation

In the following we describe the current development of the VR learning environment shown in Fig. 2, then experimental results regarding CARLA intention recognition performance are presented.

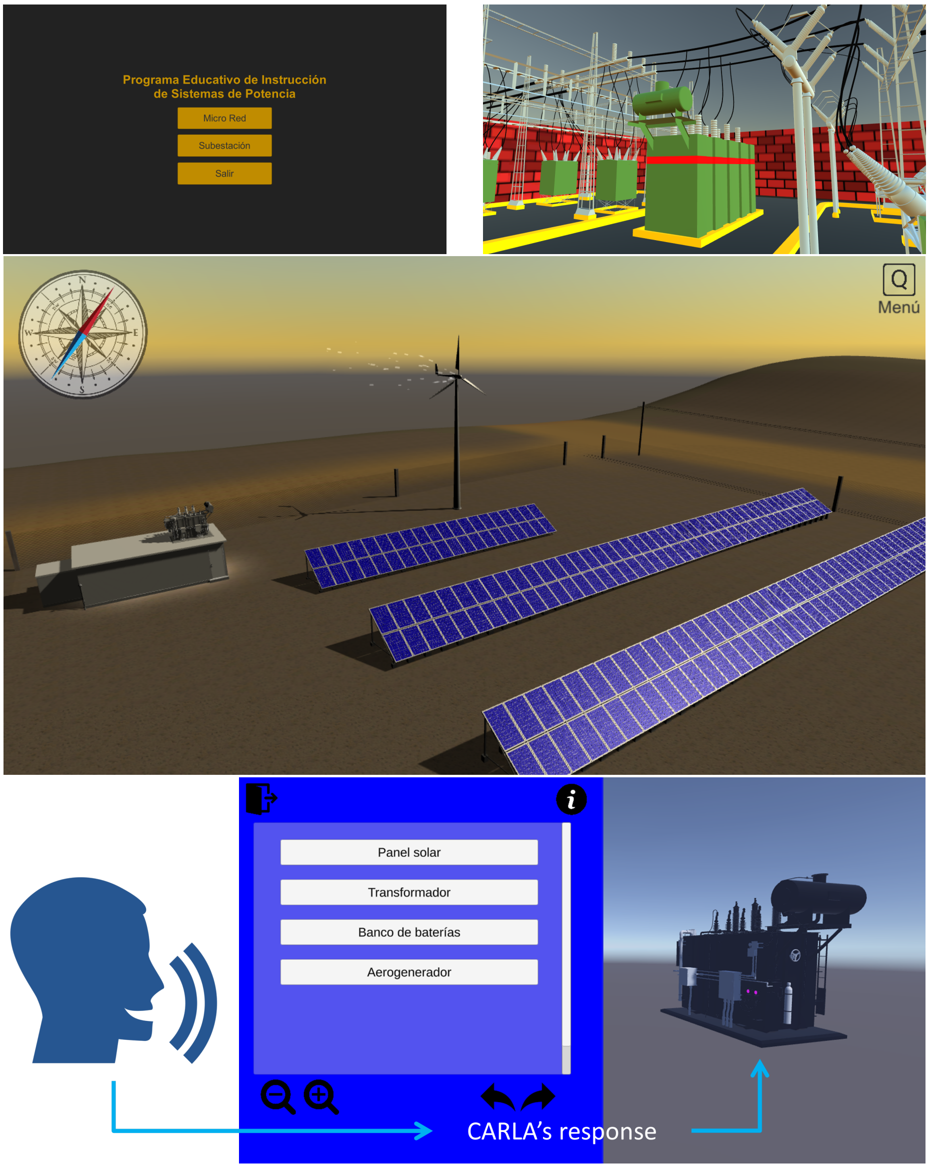

Fig. 2. CARLA VR Learning Environment. On (a) the Main Menu, where the user is greeted by CARLA; on (b) an electrical substation facility; on (c) a real world microgrid with simulation; on (d) the equipment understanding scene.

4.1 CARLA for Power Systems Education

The VR learning environment consists of three main scenes: (1) welcoming scenes, (2) facility navigation scenes, and (3) equipment understanding scenes.

The welcoming scenes are designed to provide learners with information about the available learning facilities and how to navigate through the environment (see Fig. 2).

The navigation scenes are designed to present several power systems facilities, which can be manipulated and explored to understand multiple power systems concepts.

For instance, in Fig. 4, a stylized version of the a electric substation is shown, whereas in Fig. 4 a real world microgrid is presented, where wind and a solar power generation can be manipulated by the learner.

The equipment understanding scenes, present power components in a catalog fashion where users can speak to the system to get information about electrical systems, as well as a general explanations of the physical phenomena under which they operate, depending on the given command.

4.2 CARLA Intentions Recognition Performance

We tested CARLA capabilities in terms of recognition of valid and invalid intentions. A valid intention (a true positive -TP-) is identified and attended given that a specific set of words are contained within a user utterance, whereas an invalid intention (a true negative -TN-) is a request that cannot be attended. In the case of the former, a valid intention would be “CARLA, what is a solar panel?”; in the case of the latter an invalid intention would be “CARLA, why does the sun shine?”; in both cases, CARLA must act accordingly otherwise it will incur in an error (a false negative -FN- if an intention is not recognized using the proper set of words, or a false positive -FP- if an intention is identified when it should not to).

Tests involved a sample of 5 people, 3 males and 2 females with an average age of 37.4 years. Each test subject spoke 40 phrases, of these 10 correspond to invalid intents that had similar pronunciations or letter combinations with valid intents. The results are shown in Table 1.

Table 1. CARLA’s confusion matrix.

	True	**False**	**Total**
Positive	140	12	152
Negative	4	44	48
Total	144	56	200

As can be seen the accuracy (i.e., $\frac{TP+TN}{All}$) of the model is very high with 92%, with a True Positive Rate of 97% and a True Negative Rate of 78%. This means that a naive approach such as using just a set of words, has a high rate of detection for valid intentions but is less robust to invalid ones.

5 Conclusion and Discussion

In this work, we propose CARLA as a whole educational platform which grants access to: an interactive spoken conversational agent in virtual reality with NLP capabilities, a stylized recreation of a real electrical substation, a full-fledged and fully sized micro-grid which can be explored, and their corresponding equipment navigation scenes.

It is important to note that CARLA functionalities are only available with an active internet connection, which can create discontinuities in service availability and affect the users perception of the agent [4].

Experimentations regarding the chatbot main capabilities are promising. For the time being, we only analyzed the recognition of valid and invalid intentions using a naive approach. In terms of the overall accuracy, this approach achieved a 92%. Yet, valid intentions can be triggered using invalid utterances with similar pronunciations or letter combinations. Thus, next improvements to CARLA will be focused on the application of machine learning models to boost the recognition of intentions. Similarly, to detect emotional states relevant for learning, future work will be delve to include facial emotional recognition using Deep Learning techniques which excel in this task. These actions will improve CARLA interactions and will allow personalizing them to meet specific users' needs. In this sense, CARLA is meant to become, at some point in the near future, into an Intelligent Virtual Assistant (IVA) [1], a tutor or learning companion.

References

1. Chung, H., Lee, S.: Intelligent virtual assistant knows your life. CoRR abs/1803.00466 (2018)
2. Galitsky, B.: Developing Enterprise Chatbots. Springer International Publishing (2019)
3. Kerry, A., Ellis, R., Bull, S.: Conversational agents in e-learning. In: International Conference on Innovative Techniques and Applications of Artificial Intelligence. pp. 169–182. Springer (2008)
4. Klopfenstein, L.C., Delpriori, S., Malatini, S., Bogliolo, A.: The rise of bots: A survey of conversational interfaces, patterns, and paradigms. In: Proceedings of the 2017 Conference on Designing Interactive Systems. pp. 555—-565. DIS '17, Association for Computing Machinery, New York, NY, USA (2017)
5. Manning, C.D., Surdeanu, M., Bauer, J., Finkel, J., Bethard, S.J., McClosky, D.: The Stanford CoreNLP natural language processing toolkit. In: Association for Computational Linguistics (ACL) System Demonstrations. pp. 55–60 (2014)
6. Pandey, A.K., Gelin, R.: A mass-produced sociable humanoid robot: Pepper: The first machine of its kind. IEEE Robotics & Automation Magazine 25(3), 40–48 (2018)
7. Santamaría-Bonfil, G.: Towards an interactive learning ecosystem:education in power systems. Research in Computing Science 149(1), 6–7 (2019)
8. Santamaría-Bonfil, G., Ibáñez, M.B., Pérez-Ramírez, M., Arroyo-Figueroa, G., Martínez-Álvarez, F.: Learning analytics for student modeling in virtual reality training systems: Lineworkers case. Computers & Education p. 103871 (2020)

9. Schuurmans, J., Frasincar, F.: Intent classification for dialogue utterances. IEEE Intelligent Systems 35(1), 82–88 (2019)

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Towards the Design of a Socio-Emotional Negotiator Agent as a Serious Games Character that Supports Learning Environments

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Abstract. Serious games are a type of video game used mainly for learning in various topics, in addition to entertaining. The design of characters for serious games requires great attention to detail, from the expression of the character to the intelligence built into its programming. This article presents a theoretical model of a negotiating socio-emotional agent architecture, which proposes a general design of behavior that a character in a serious game can execute. The behavior that is sought to generate tries to simulate the cognitive process in decision making and the process of communicating their responses through expressions and dialogues. The development of a character with these characteristics seeks to generate greater immersion on the part of the user due to the fact that it generates an interaction more attached to the reality, facilitating learning through the simulation environment of a serious game.

Keywords: Virtual agents' architectures, learning environments, serious games.

1 Introduction

The serious games are more than entertainment, they are a useful tool for training in virtual environments through simulations based on real world situations. Besides, serves to support to help people with psychological problems, for example, the game At Risk of Kognito [1], which aims to support university counsellors to treat psychological problems that affect the learning of young people who completed their military social service in the Iraq war, and return to study a university career.

One aspect to put attention in serious game development whatever the topic or implementation purpose is the credibility because it facilitates the process of transfer the knowledge learned in the virtual world to the real world To say that a serious game is credible, levels or scenarios presented are usually designed as real as possible, for example, the game Branches of power [2], which is an educational game that teaches legal processes in the government system of USA.

Likewise, characters should be credible too, therefore is important to endow characters with capabilities to emulate reasoning and expressions kinds like a human [3]. This contributes to increase interaction in users and therefore their learning; a way to reach this interaction is that the character shows personality and emotional aspects generated by its internal cognitive process programming, even implement negotiation skills on its programming, either with other characters or users.

2 Related Work

Nowadays exists serious games implemented in many topics with socio-emotional characters. An example of this games that use this kind of characters is TARDIS [4], this game shows a virtual training and advisory simulation scenario in the context of job interviews for people in job searching. This game stands out the design and modeling of characters which shows non-verbal expressions and behavior, this due to the affective module integrated on its architecture structured with the emotional approach OCC [5] and the decision module based on the approach of BDI agents (agents based on Beliefs, Desires, Intentions) [6].

Other simulation game is presented in Van-Mihn et al [7] work, that shows a virtual simulation of serious game in the context of forest fire, this work distinguish the internal modelling of decision process of the character, which also is based in BDI approach, but including Plans as element of the decision process, which give options to the character to solve activities in the game.

In addition to making decisions, characters in serious games may be able to display emotions. For example, Visschedijk et al [8], demonstrate in their work how the use of emotions in characters impacts users when playing; studies were carried out on different groups of people using humanoid animations with different expressions to measure the effect on users, all this process aiming to serve as a basis for the development of serious games in the context of the use of tactics.

Besides making decisions and showing emotions, serious game characters may have the ability to carry out negotiation processes. An interesting proposal to develop negotiation in a character is that of Villareal Hernandez [9], which, centered in the negotiation on the protocol of alternate multiple offers, demonstrates how emotions and personality alter the agent's decisions. However, this project has not yet been directed towards serious games.

In brief summary, from the aforementioned works, the use of intelligent agents as characters in serious games and the programming of their structure stand out. However, it is necessary to say that the game development of these projects does not follow a methodology or structure that delimits or formalizes in a more complete way the development of both the game and the characters that act in it.

To develop serious games there are different architectures and methodologies, such as the Crawford [10], Fullerton [11] and MTDA + N [12] (Mechanics, Technology, Dynamics, Aesthetics + Narratives). These works focus their design on the description of the mechanics and dynamics of the game, without giving details of the composition of the characters.

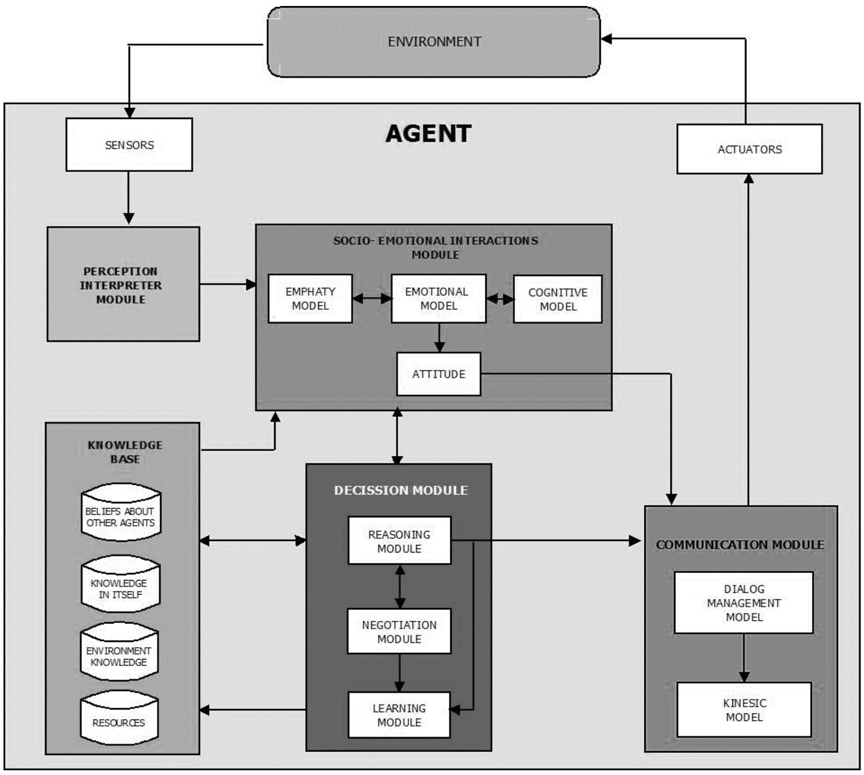

Fig. 1. Socio-emotional negotiator agent architecture.

An evolution of MTDA + N is the GAMENT framework [13], which does incorporate characters from serious games into its structure, unlike other works. GAMENT presents an architecture and methodology where the characters are associated with the components of the architecture. In general, GAMENT associates the elements of MTDA + N in its modules: Mechanics are the algorithms and bases of the game, Technology is the software to be used to develop the game, Dynamics are the interactions of the runtime mechanics, Aesthetics are the visual and auditory elements of the game and particularly interactive Storytelling (Narratives) as the main element of interaction with the user; however, it does not delve into their internal and external structure, as well as the role they must play in the game.

3 Proposal for Character Design in Serious Games

In games, two types of characters can usually be identified, either characters manipulated by the game's algorithms (NPC Non-Playable Character) or characters controlled by the user (Avatars). NPCs can be considered as intelligent virtual agents.

In order to extend the GAMENT architecture [13], a design of an intelligent socio-emotional negotiating agent is proposed considering characteristics and capabilities for interaction with the user (see Fig. 1). Likewise, the proposal of the extension of the methodology of the same framework is made, describing internal and external aspects of the character.

The architecture is composed of four main modules: 1) the Communication module to express the character's responses, 2) Social and Emotional Interactions that structures the agent's behavior, 3) Knowledge Base for reviewing previous interactions and 4) Decision that carries out the agent's reasoning. The components of the proposed architecture are described below.

– *Sensors:* these components receive information from elements of the environment.
– *Actuators:* components of the agent used to execute the response obtained by its reasoning process in the environment.
– *Perception interpreter:* it has a function of classify the information from sensors, comparing it with the knowledge bases and distributing it to the modules of social and emotional interactions and the decision module.
– *Knowledge Base:* they are prior knowledge that the agent has stored. This knowledge deals with previous negotiations, emotional and personality aspects, agent preferences, agent resources, knowledge and behaviors about other agents according to previous interactions and actions of the alternate multiple offers protocol by which the agent is governed to negotiate.
– *Social and emotional interactions:* Through this module the agent determines what response behavior to carry out in the interaction with the other agents. Its process is based on the result of the combination of three models: emotional, empathy and cognitive (according to Morales Rodríguez [14]). The result obtained is called attitude; This result is sent to the *Decision* and *Communication* modules for their influence and expression.
– *Decision module:* determines the solution and/or response of the cognitive process. In addition, could implement a negotiation strategy in case the result of the attitude sent by the *Social and Emotional Interactions* module allows the formulation of an offer. The *Decision module* is made up of three internal parts: the *reasoning module*, the *negotiation module* and the *learning process.*

Through of the *reasoning module* the solution (action) is determined. The agent receives parameters of interpreter of perception and the module of *social and emotional interactions*, which are sent to the *negotiation module* to determine the best possible options to negotiate. With the offers obtained, the reasoning module is in charge of selecting the optimal one and sends it to the *communication module.*

The *negotiation module*, is based on the Villarreal Hernández [9] model, that has a function of develop the offers that the agent can accept to obtain benefits. It is made up of two sub-modules, interpreter and actions. Through the interpreter module, the agent evaluates the stimulus presented by his counterpart and with the actions module he develops the offers to present.

The *learning process* is responsible for updating the agent's knowledge bases; even though if the agent had not come to formulate an offer.

Communication module: It expresses the answers obtained from the *Decision module* and the *Social and Emotional Interactions Module*.

This module is based on the behavioral model of Morales Rodríguez [14], is made up of two parts, the dialogue management model and the kinesic model, which are combined to express the agent's behavior.

These elements are integrated into the methodology described. For example, the *Social and Emotional Interactions Module* is part of the *Mechanics* because the character generates their different behaviors through the internal structure of this module, which does not change when playing. The *Aesthetics* are shown through the *Communication* module, which is responsible for presenting the different expressions of the characters, in addition to their dialogues. So successively each module of the architecture is associated with the GAMENT framework.

The second part of the proposal is the extension of the GAMENT methodology, which center its attention on step 3 that aims to create ideas and diverse concepts of the game applied to the design of environments and characters. In particular, Step 3.5 describes the interactions of the architecture components, emphasizing the role that agents will have in *Interactive Storytelling* and in the learning process, as well as the definition of their *Mechanics*, *Dynamics* and *Aesthetics*.

The following describes the GAMENT methodology by integrating the detail of the elements of the character's architecture:

Step 1. Establish the content to be learned (goal) and the environment of the game (topic).

Step 2. Find and prepare the content to learn and the topic.

Step 3. Create diverse ideas or concepts for the game to be used, improved or discarded as appropriate.

Step 3.1. Propose game environments and visual and auditory elements that make it up.

Step 3.2. Establish the theoretical content, evaluation and feedback.

Step 3.3. Propose the idea of the Narrative that will be developed in the game.

Step 3.4. Get ideas of levels to present in the game and their respective elements: Mechanics, Dynamics, Aesthetics, Narratives and Content to learn.

Step 3.5. Design the virtual agents.

Step 3.5.1. Define the role they will have in Interactive Storytelling

It is necessary to identify the characters that will participate in the game and group them into the category they belong, be it narrator, actor or extra, which are described next.

- Narrator: describe the embedded narratives in which the character participates, through:

- Present their role or activities in the story.
- Describe the instructions to play according to the level where the player is.

- Present the different levels or scenarios, in case the game contains different chapters of the game's history.

- Actor: being a participant in the game by presenting emerging narratives that appear during the game. Some functions that it can perform are:

- Provide clues to solve the different levels of the game.
- Support the user in the activities to be carried out in the game.
- Be the competition of the user in the game.
- Give feedback to the user.

Both can intervene in the game scenario or just be part of the game's interface.

- Extras: it is a character that, as such, does not provide help to the user, it is only a complement to the environment.

Step 3.5.2. Define the role they will have in learning

The agents present in the game, either narrator or actor, must be designed to carry out the following activities:

- Storyteller. The characters to be designed with the role of narrator must present the embedded narratives of the game.

- Actor: the character gives support to the user by presenting content from the topic of the game to solve the challenges of the level or scenario. Some activities that can be performed according to its role are:

- Present the story or theme of the game.
- Describes the elements and challenges of the current level to the user.

- Evaluator: at the end of the game, the character must evaluate the user's performance. This character can be designed to:

- Present the results obtained to the user.
- Give feedback to the user regarding the strategy implemented in the game challenge.

- Extras: they are part of the stage, they complement the design.

Step 3.5.3. Establish the mechanics according to the role of the character

The follows two types of Mechanics that can be applicable to all roles of character.

- **Character movements:** these are the movements that the character will be able to carry out. For example: walking, moving arms or fingers, head movements, etc.
- **Knowledge bases:** these are the different algorithms implicit in its programming to carry out the functions for which it will be designed.

Step 3.5.4. Structure the dynamics according to the role of the character

- Character functions: activities that the character performs in the game. Example: presentation of stage content, answering dialogues, feedback to the user, etc.

- Processes of the character in the game: implicit rational activities of the character, internal processes of its programming. Example: knowledge-based queries, definition of behavior according to behavioral models, etc.

- Presentation of character dialogues: narratives that the character mentions in the game, defined as a basis for the different messages that the user can make.

Step 3.5.5. Aesthetics according to the role of the character.

- **Internal structure of the character.** Design the internal parts of the character. Example: in case of being a humanoid character, structure the skeleton and movements of the skeleton.

- Character design. Design the visible parts of the character. For example, clothing, skin type, hairstyle, among others.

- Design of the character's expressions. Model the different expressions that denote the character's attitude, whether he is happy, sad, serious, asleep, etc.

Step 3.6. Create events to present game content during levels. Propose the desired dynamics and aesthetics.

Step 3.7. Propose objects which will have interaction with the player and their elements: Mechanics, Dynamics, Aesthetics.

Step 3.8. Create elements for evaluation and feedback to the player.

Step 4. Carry out the design phase: structure inputs / outputs, the game, the program and evaluate the design.

Step 5. Create physical prototypes to verify that the mechanics do their job.

Step 6. Create digital prototypes to verify that the core operation of the game systems is as desired.

Step 7. Perform the Playtesting.

Step 8. Test that the game is functional, internally complete and balanced.

Step 9. Verify that the game continues to provide the desired experience and usability.

4 Conclusions and Future Works

This document presents the architecture and methodology of the internal design of a socio-emotional agent capable of carrying out negotiation processes integrating into the GAMENT framework for the development of a serious game. It describes the different modules that the character contains and how they communicate with each other to develop the cognitive process of the character in the game. In addition, these modules are associated with Mechanics, Dynamics, Aesthetics and Narratives to form the extended GAMENT methodology. Through this proposal, serious game developers, both experienced and novice, have a very complete guide to design the relevant characters of their applications, allowing to identify in a more graphic and direct way the functions of the characters and delve into their internal and external design according to the role to play in the game.

As future work, a module can be developed that details the character's negotiation skills, modifying the current protocol, to become independent of a specific negotiation strategy.

References

1. At-Risk for Students: kognito.com/products/at-risk-for-college- students (2020)
2. Branches of Power: icivics.org/games/branches-power (2020)
3. Hamdy, S., King, D.: Affect and believability in game characters. A review of the use of affective computing in games (2017)
4. Anderson, K., André, E., Baur, T., Bernardini, S., Chollet, M., Chryssafidou, E., Damian, I., Ennis, C., Egges, A., Gebhard, P., Jones, H., Ochs, M., Pelachaud, C., Porayska-Pomsta, K., Rizzo, P., Sabouret, N.: The TARDIS Framework: Intelligent virtual agents for social coaching in job interviews. In: Reidsma, D., Katayose, H., and Nijholt, A. (eds.) Advances in computer entertainment. pp. 476–491, Springer International Publishing, Cham (2013)
5. Ortony, A.: On making believable emotional agents believable. Emotions in Humans and Artifacts, 6, pp. 189–211, MIT Press (2003)
6. Georgeff, M., Pell, B., Pollack, M., Tambe, M., Wooldridge, M.J.: The belief-desire-intention model of agency. In: Intelligent Agents V: Agent Theories, Architectures, and Languages, Proceedings of the 5th International Workshop, pp. 1–10, Springer (1999)
7. Le, V.-M., Gaudou, B., Taillandier, P.: A new BDI architecture to formalize cognitive agent behaviors into simulations. Springer-Verl. Berl, Heidelb, 10 (2011)
8. Visschedijk, G.C., Lazonder, A.W., van der Hulst, A., Vink, N., Leemkuil, H.: Modelling human emotions for tactical decision-making games: Emotions for tactical decision games. Br. J. Educ. Technol., 44, pp. 197–207 (2013)
9. Villarreal-Hernández, J.Á.: Desarrollo de estrategias de negociación para Agentes de Software Inteligentes influenciados por su emoción y personalidad (2019)
10. Crawford, C.: The art of computer game design. Osborne, McGrawHill (1984)
11. Fullerton, T., Swain, C., Hoffman, S.S.: Game design workshop-a playcentric approach to creating innovative games. Morgan Kaufmann Publishers (2008)
12. Ralph, P., Monu, K.: A working theory of game design (2014)
13. Ponce-Guzmán, A.Y.: Arquitectura para la concepción de los serious games aplicados a la toma de decisiones basados en el storytelling interactivo (2019)
14. Morales-Rodríguez, M.L.: Modèle d'interaction sociale pour des agents conversationnels animés: Application à la rééducation de patients cérébro-lésés (2007)

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Characterization of the Student's Personality to Develop an Agent that Selects Intelligent Learning Environments Study Materials

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Abstract. This article presents a proposal on the characterization of the student's model considering the attributes that describe their personality. This work seeks similarities to establish a relationship between the personality types and learning styles present in students and in this way identify a correspondence between the learning style and the personality profile that influences how the student learns. The models in which the analysis is focused are the learning style based on the four sensory modes: visual, auditory, reading-writing, and kinesthetic and the type indicator instrument, Myers-Briggs Type Indicators, for the classification of personality. With the analysis of the characteristics of the personality and the attributes of the learning style, a series of relationships were identified that describe the way in which the attributes have similarities, thus identifying the frequency in which the descriptive aspects appear. Through percentages the level of acceptance for each learning style is identified according to the personality profile, this will represent with what type of material the student prefers to acquire knowledge. The result of this work is the characterization of the student's personality profile model to influence the generation of an automated process for selecting materials in an intelligent learning environment through an agent capable of establishing a relationship with their learning style.

Keywords: Personality, learning style, intelligent learning environment, selector agent.

1 Introduction

Personality is a unique element that involves our peculiar way of thinking, feeling and acting; consequently, this includes cognitive, affective and motivational psychological processes, a determining factor for the learning process [1].

This article performs an analysis of the personality profile, trying to connect with the teaching-learning style through descriptive attributes. To do this, section 2 analyzes the reading of the different theories about the instruments that involve personality within the teaching-learning styles. Through documentary research it is identified that students have different types of temperaments that involve their personality, however they also have different learning styles that is evidenced in their way of processing information, which is why there are students who have different abilities to analyze, summarize and interpret [1]. In section 3, a recognition of the attributes of both personality and learning style will be made, so that later in section 4, a relationship is established that may involve both and allows the design of a process model for the selection of materials according to that result. Section 5, shows the conclusions and finally section 6 presents future work.

2 Background of the Student's Personality Relationship and his Learning Style

Human beings grasp the world in different ways, therefore, there is no single appropriate way of learning, giving a different version to internal and external stimuli [2].

The concept of learning style basically refers to traits or modes that indicate the characteristics and ways of learning of a student. Identifying, classifying, and relating personality to each student's learning style can mean a different way of acquiring knowledge.

There are different learning styles, to mention a few we have the learning style proposed by Kolb [3] who points out that there are four learning styles: convergent, divergent, assimilating and accommodating. On the other hand, Cepeda [4] mentions that Honey and Mumford proposed four types of learning styles according to the way of organizing and working, these styles classify the student as active, theoretical, reflective and pragmatic.

Flemming and Mills [5] developed an instrument to determine the preference of students when processing information from the sensory point of view. This instrument provides a quantification of student predilections in each of the four sensory modes: visual, aural, reader-writer, kinesthetic (VARK) [6].

In this work we will focus on the VARK style because the sensory characteristics of the student proposed in this model can be associated with the characteristics of educational materials, especially when considering activities and production of multimedia educational material in online educational environments [7].

Regarding personality, there are two main approaches that allow the identification of different classifications. The first approach is based on personality traits such as the Five Factor Model [8] and the second approach based on personality types or styles. Our interest lies in this second approach.

Personality style refers to a series of individual qualities, activities, or behaviors that can be grouped into a category.

Table 1. Attributes that describe personalities influenced by sensory preferences.

Personality	Attribute	Personality	Attribute
ISTP	Convenient Practical objective Adaptable	**ESTP**	Energetic Practical Pragmatic Spontaneous
ISTJ	Obedient Practical Logical Methodical	**ESTJ**	Organized Practical Logical Spontaneous
ISFP	Tolerant Realistic Harmonious Adaptable	**ESFP**	Spontaneous Practical Friendly Harmonious
ISFJ	Obedient Practical Solidary Meticulous	**ESFJ**	Friendly Practical Loyal Organized

Awareness and knowledge of one's own style is one of the most effective ways to enhance human behavior in all those environments in which a sense of personal identity develops [9].

Lozano [10] proposes a learning style by means of the type indicator, this is based on the studies for the classification and identification of the personality type of Myers-Briggs Type Indicator (MBTI) [11], in which preferences are measured on four scales derived from Carl Jung's theory of psychological types [12], which are mentioned below:

1. Influence on the flow of interest: for example if it is Extroverted (E), the interest flows are from the inside out; on the other hand, if it is Introvert (I), the person's interests flow inward.
2. Influence on Attention: if it is Sensorial (S), the person prefers to perceive through the senses and what really exists; if it is Intuitive (N), the person prefers to perceive through their "sixth sense" and take more into account what could be.
3. Influence on judgments and decision making: If it is Thinking (T), it prefers to make judgments or make decisions in an objective rather than impersonal way; however if he is Feeling (F), it prefers to make judgments or make decisions in a subjective and emotional way.
4. Influence in life: if it is Judicious (J), the person prefers to live in a planned and orderly way but if it is of the Perception type (P), the person prefers to live in a flexible and spontaneous way.

To establish the relationship between learning styles and personality, the work of Lozano [10] and Rodríguez [2] was reviewed, which makes a description of personality focused on student learning.

Table 2. Attributes that describe personalities influenced by intuitive preferences.

Personality	Attribute	Personality	Attribute
INFP	Perceptive	**ENFP**	Optimistic
	Innovative		Innovative
	Idealistic		Compassionate
	Adaptable		Versatile
INFJ	Devotee	**ENFJ**	Friendly
	Innovative		Innovative
	Idealistic		Solidary
	Compassionate		Idealistic
INTP	Interrogative	**ENTP**	Take Risks
	Innovative		Innovative
	objective		Outgoing
	Abstract		Adaptable
INTJ	Independent	**ENTJ**	Determined
	Innovative		Innovative
	Analytical		Strategic
	Determined		Outgoing

Table 1 and 2 present the attributes that describe the 16 types of personality that were identified to establish the proposed relationship between personality and the materials used in the learning style.

3 Proposal of the Characterization of the Personality in the Student Associated with the Characteristics of the Learning Style

The personality of students is one of the psychological factors that influence their school performance; personality characteristics can provide us with relevant data to better understand academic performance [13]. Personality can be identified, classified and related to the learning style of each student, this can mean a different way of acquiring knowledge.

To generate the characterization, the analysis of the characteristics of the classification of the study materials was carried out by applying the attributes that were identified according to the VARK style [14]. Students have a dominant value and in some cases they can combine two or more values, each with a different dominant sensory representation system. According to VARK the attributes that describe a visual student are: being creative, observant, imaginative and analytical; an auditory learner is defined as pragmatic, perceptive, analytical, and expressive; a student reader-writer is theoretical, thoughtful, understanding, and thoughtful; the kinesthetic student maintains the attributes of being adaptable, creative, intuitive, and versatile.

Returning to the classification of the 16 types of Lozano's work [10], the attributes that describe the personality are used to relate the characteristics between the learning style and the personality profile, it is proposed to organize these attributes in tables

Table 3. Introvert personality relationship and learning style.

Personality	**Learning style**	Visual				Aural				Reading / Writer				Kinesthetic			
		Creative	Observer	Imaginative	Analytical	Pragmatic	Perceptual	Analytical	Expressive	Theoretical	Reflective	Comprehensive	Thoughtful	Adaptive	Creative	Intuitive	Versatile
ISTP	Convenient		**x**	**x**								**x**		**x**			
	Practical	**x**				**x**									**x**		
	objective		**x**		**x**			**x**		**x**	**x**						
	Adaptable												**x**	**x**			
ISTJ	Obedient											**x**					
	Practical	**x**				**x**									**x**		
	Logical							**x**			**x**		**x**				
	Methodical				**x**			**x**		**x**	**x**		**x**				
ISFP	Tolerant										**x**	**x**		**x**			
	Realistic		**x**				**x**		**x**	**x**	**x**	**x**					
	Harmonious						**x**		**x**								
	Adaptable												**x**	**x**			
ISFJ	Obedient											**x**					
	Practical	**x**				**x**									**x**		
	Solidary													**x**			
	Meticulous				**x**		**x**	**x**			**x**	**x**	**x**				
INFP	Perceptive		**x**		**x**		**x**	**x**									
	Innovative			**x**				**x**							**x**		
	Idealistic			**x**							**x**		**x**			**x**	
	Adaptable													**x**			
INFJ	Devotee				**x**			**x**		**x**	**x**		**x**				
	Innovative			**x**				**x**							**x**		
	Idealistic								**x**				**x**				
	Compassionate																
INTP	Interrogative																
	Innovative			**x**													
	objective		**x**													**x**	
	Abstract		**x**		**x**		**x**				**x**						
INTJ	Independent																**x**
	Innovative			**x**	**x**			**x**							**x**		
	Analytical				**x**			**x**									
	Determined								**x**					**x**			**x**

where the relationship between them is identified, Table 3 shows the attributes of different types of personality that have the flow of introverted interest, however it was also carried out for the personality with the flow of extroverted interest.

The rows represent the attributes of the 16 personality types, the columns contain the characteristics of the VARK sensory modules. The characteristics of the VARK style that are related to the attributes of the personality, indicating with an x the similarity of their abilities to acquire knowledge, in this way it is identified as certain characteristics of the classification of the learning style presents a similarity with the characteristics of the personality.

4 Description of the Student's Personality Model for the Materials Selection Process

For the creation of a selection process for study materials within a learning platform, the information obtained in the analysis of the relationship between personality and VARK learning style will be taken as a basis, which is represented in Table 4.

In this table the relationship of the personality attributes with the learning style can be observed through the percentages of frequencies of similarities found between them, which were obtained by counting the occurrences of the personality attributes and characteristics of the learning style shown in Table 3.

Obtaining this information shows which learning styles the student can feel more empathy with when learning, because they have a higher percentage. However, it is not ruled out that if the learning environment does not have material associate to the learning style, it may be able to offer some other material that can be associated with some of the other learning preferences.

Table 4. Percentage of frequencies of similar attributes between personality and VARK.

Personalidad	V	A	R	K
ISTP	35.71%	14.29%	28.57%	21.43%
ISTJ	16.67%	25.00%	50.00%	8.33%
ISFP	7.69%	30.77%	46.15%	15.38%
ISFJ	18.18%	27.27%	36.36%	18.18%
INFP	33.33%	25.00%	16.67%	25.00%
INFJ	20.00%	30.00%	40.00%	10.00%
INTP	57.14%	14.29%	14.29%	14.29%
INTJ	30.00%	30.00%	0.00%	40.00%
ESTP	23.08%	23.08%	0.00%	53.85%
ESTJ	25.00%	16.67%	33.33%	25.00%
ESFP	23.08%	30.77%	23.08%	23.08%
ESFJ	7.14%	28.57%	42.86%	21.43%
ENFP	18.18%	36.36%	27.27%	18.18%
ENFJ	27.27%	27.27%	27.27%	18.18%
ENTP	20.00%	13.33%	20.00%	46.67%
ENTJ	26.32%	15.79%	21.05%	36.84%

5 Conclusions

In a learning environment it is important to know the preferences of the student, in this work it is proposed to achieve it from their personality. Each student learns differently, not everyone wants to study or do activities with which they do not feel motivated. Knowing the student's personality can describe how they react to learning methods or materials. Another characteristic to consider is the learning style which reflects the preferences on the way of learning, with this it is possible to identify the materials that facilitate the acquisition of knowledge. The study materials have characteristics that could be associated with learning styles, such as an infographic, which stimulates the visual sense.

In this work, the classification of the personality profile and its relationship with the teaching style allows us to observe that a student has a dominant learning style. However, it is possible to work with some material from the other learning styles if their characteristics indicate it. In this way, the preferences that the student has when learning are taken into account, being able to provide the appropriate materials to them.

6 Future Work

With the information obtained, it is possible as future work to create rules that lead to the automation of the process of selecting learning materials under the influence of personality. These rules would contribute to the design of a finite state machine to guide its process. The selection process is one of the main functions of a material selector agent that could be inside an intelligent learning environment.

References

1. Pérez, U., Abraham, E.: Relación del temperamento y estilos de aprendizaje en los estudiantes de derecho de la Universidad Nacional de Tumbes. In: II Congreso Binacional de Investigación, Ciencia y Tecnología de las Universidades del Sur del Ecuador y Norte del Perú (2013)
2. Cea-Rodríguez, J., Sanhueza, H., Filgueira-Muñoz, E.: Tipos psicológicos y estilos de aprendizaje de estudiantes de una facultad de ciencias económicas y administrativas en Chile. RAN - Revista Academia & Negocios, 4, pp. 65–80 (2018)
3. Kolb, D.A.: Experiential learning: experience as the source of learning and development. Prentice Hall, Englewood Cliffs (1984)
4. Rodríguez-Cepeda, R.: Los modelos de aprendizaje de Kolb, Honey y Mumford: implicaciones para la educación en ciencias. Sophia 14, pp. 51–64 (2018)
5. Fleming, N.D., Mills, C.: Not another inventory, rather a catalyst for reflection. To Improve the Academy, pp. 137–149 (1992)
6. Selbach-González, G.A.: Teorías de la personalidad. Red Tercer Milenio (2013)
7. Díaz, G., Urbina, V., Espinal, L., Beltrán, M.: Curso en línea basado en modalidad instruccional ADDIE y Prototipización rápida. Revista de Investigación Educativa de la Escuela de Graduados en Educación 9 (2019)

8. Goldberg, L.R.: An alternative "Description of personality": The Big-Five factor structure. Journal of Personality and Social Psychology, 59, pp. 1216–1229 (1990)
9. De Armas, M., Rodríguez, M.: Estudio de los estilos de aprendizaje de estudiantes y profesores de la Facultad de Ingeniería de la Universidad Central de Venezuela. Revista de la Facultad de Ingeniería Universidad Central de Venezuela, 30, pp. 17–26 (2015)
10. Lozano-Rodríguez, A.: Estilos de Aprendizaje y Enseñanza: Un programa de la estilística educativa. Trillas: ITSM (2001)
11. Myers, I.: Myers-Briggs Type Indicator. Consulting Psychologists' Press (1978)
12. Jung, C.G.: Psychological types. Pantheon Books (1971)
13. Aragón Borja, L.E., Flores Tapia, M. de los Á.: Características de personalidad del estudiante de la carrera de Cirujano Dentista de la FES Iztacala. Revista odontológica mexicana, 18, pp. 19–26 (2014)
14. González, B.: El modelo VARK y el diseño de cursos en línea. Revista Mexicana de Bachillerato a Distancia 4, pp. 96–103 (2012)

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Clicker: Assessment Strategy

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Abstract. Virtual education has become utterly important recently, however, one of the biggest challenges is how students should be evaluated. The focus of this proposal relies in avoiding traditional written exams. Instead, students should active participants in the learning process. Virtual education should benefit from the use of new tools, gamification techniques, etc. In this paper, a novel application called *Clicker* is discussed covering its impact on the learning process, and the evaluation of the students.

Keywords: Web-based intelligent learning system, game-based learning, virtual education, learning evaluation, learning assessment.

1 Introduction

These days, we have a huge challenge in front of us, education radically changed towards a virtual system [5,3,6]. We have migrated our academic activity face-to-face and content in many ways; however, what remains a challenge today is the assessment of the learning process and the evaluation of the students in this new virtual modality [1].

There are many methodologies, techniques and tools for teaching, the Socratic method [2] consists "roughly speaking" in enforcing participation of students by making them to answer questions posted by the teacher . A considerable amount of feedback can be obtained from their answers, which is useful for evaluation, assessment, or deciding wether to remain longer on a specific topic or move on to the next. Some authors consider evaluations to be a complex process with many facets [7].

In [7], the author remarks the importance of assessments instead of simple evaluations. He claimed that a student could study just for the purpose of getting good grades in the evaluations.

This is an important issue with a big impact on education. We present in this paper a novel digital tool which encourages the active participation of students in a quick and dynamic way.

This article is organized as follows. First, some dynamic strategies will be introduced at section 2, and in section 3 Clicker is presented as a novel assessment strategy. Discussion, conclusions and future work is described in section5.

2 State of the Art

There are different tools to measure how much students have learned, some are dynamic and popular, for example: kahoot, and quizizz, just to mention a couple.

2.1 Kahoot

Kahoot is a tool where the teacher creates a game consisting of a set of questions [4]. Each question could have up to 4 answers. When the game starts, each question is shown during a short period of time (customized time) in seconds. At playing the game, all the gamers/students read a question and answer in a general page. Each answer has a related colored figure, a circle, a square, a triangle, and an X. Each gamer, during the customized period of time should touch/click the correct answer, when time is up, Kahoot shows a bar-graphics with the number of gamers who clicked on each answer, also showing which was the right one. In addition to these statistics per question, the score obtained by the best 5 gamers is also shown.

At the end of the game, Kahoot shows a ceremony-like for the best three contestants. It is without doubt a dynamic and interesting tool; however, a student may not be motivated enough and just click on any answer randomly.

2.2 Quizizz

Quizizz is an interesting tool [8], it has many quizzes with general topics, and each user can create new ones, it is also a game, and each one has many questions with a set of answers (usually 4, each one is in a different color). During the game, each participant has to click on one the possible answers, It is an interesting application and there are many games that can be played. The game presents statistics on the performance and score of each player.

3 Proposal

Clicker is a novel tool designed in a responsive web page and it is based on the Socratic method [9] to encourage the learning process by asking and answering questions to stimulate critical thinking and to draw out ideas and underlying presuppositions. It is a dynamic application in which questions can be typed in real time and then, sent to the students, in real time also. Alternatively, the questions can be sent from a database previously elaborated.

In this game, the questions can be launched in a specific order, specified by the teacher, who is able to decide which question to send or write a new one during the class session on the flight. Remember that Clicker is a real time play.

This proposal is described in 4 phases:

- **Teacher**. How to generate the questions.
- **Student**. How to log in and be part of the game.
- **Game**. Description of the statistics and feedback delivered by the system.
- **Reinforcement of learning**. How this proposal can contribute in the learning process.

During the next section each section is described in detail.

3.1 Teacher

As a teacher, a user have some task, in this case, in a teacher can:

- Create a new game. Each game has a unique consecutive number (id).
- Create a pool of questions.
- Set the tone of the game.

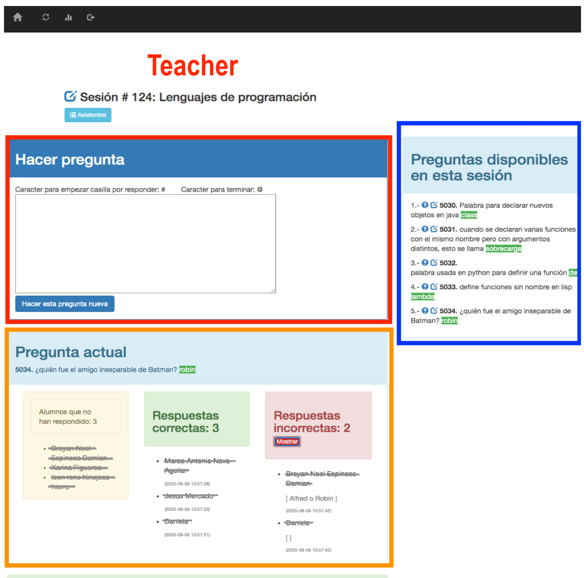

Fig. 1. Teacher interface. The name of the teacher is displayed instead of *Teacher* in the real page.

In Figure 1 the interface of *teacher* is shown. This user has a page with three main regions.

– Area to write a question (red box).
– Questions that have been or can be asked in that game (blue box).
– Statistics on students (orange box):
  a Who remains to answer.
  b Who answered well.
  c Who answered wrong.

Each question is written in natural language. In order to specify the part of the sentence that will be filled by students, the empty part has to be enclosed between symbols @ and #. For example, a complete question can be: `2+2 = @4#`.

The question will be displayed in this way : `2+2 = _____`

Once the question is launched, the section in orange box will be filled, and the new question will appear in the blue box.

3.2 Student

The interface for a *student* is shown in Figure 2. Basically, this page has two regions:

– Answer the current question (red box).
– History of answers for the entire game session (orange box).

Fig. 2. Student interface. The name of the student is displayed instead of *Student* in the real page.

The students must write the answers in the boxes indicated for this. Notice that within the region marked with a red box you can see the quetion and the space for the answer, which is a texbox element. When a student writes his answer, it is automatically evaluated and it is shown at *correct answers* (orange box).

In Figure 2, within the orange box all the answers sent by a student are shown regardless of wether they were right or wrong. Wrong answers are shown in red and right answers are shown in green.

3.3 Statistics

At the third stage of the game a statistics summary page is shown in a page as that of Figure 3. This page is shown to all the students, the purposes the page serve are:

- Feedback to all the students (orange box).
- Motivation through competition among the students (purple box). It shows the best 3 students, like a ranking.
- Showing the current question (red box).

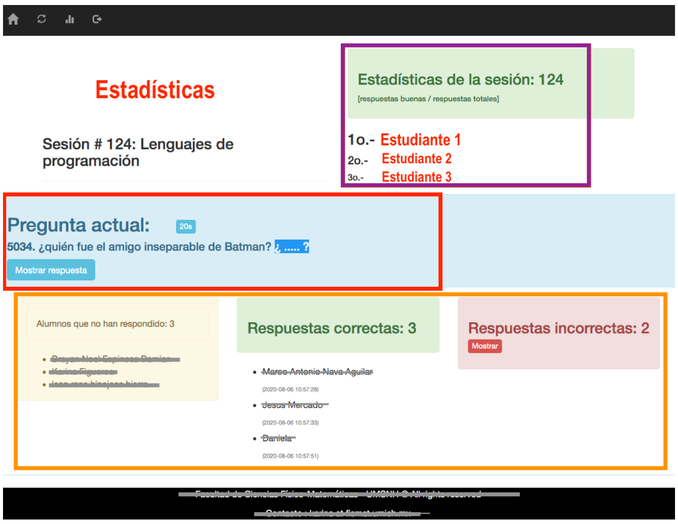

Fig. 3. Statistics interface. All the students can see the information about the game that is shown on this page.

3.4 How it Works

Clicker is an interactive game, the complete process is shown in Figure 4, first a teacher begins a game and a new *id* is provided, then he writes some questions.

The teacher gives the *id* to the students so that they may login to the game, and see the statistics page. When the teacher asks a question (step 1), students type the answer (step 2), when answers are sent, the statistics page is updated shown the numbers of right and wrong answers (step 3).

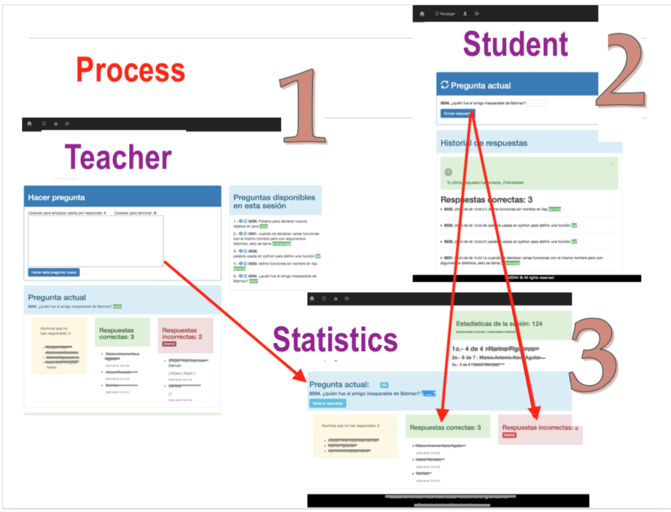

Fig. 4. Complete process. Step 1, Teacher asks a question. Step 2, Students type the answer. Step 3, Statistics for that question/answers are updated.

4 Results

Several teachers have used this tool in their lessons since at least 2 years ago. Students are more interested in the class, since they know that at any time they can be asked to actively participate in the discussion of the subject in turn. They explain and help each other by seeing the problems that their classmates have at answering the questions regarding their lessons. The teacher has a better idea of the degree of achievement of the class in general. He is able to determine when to move to the next topic, and when to reinforce the previous topic. There is also an evaluation tool that accurately reflects the daily work of each student, as well as a diagnostic tool to determine what each student needs to reinforce.

4.1 Interview

In order to collect feedback about Clicker for this paper, a group of students has been interviewed. They were 8 university students, between 19 and 20 years old, *detailed are blinded*. The questions were:

- How many times have you played Clicker?
- Do you think it helped you to retain the issue that was the object of the class?
- Was it stressful or fun to play Clicker?
- Was the interface difficult?
- How much impact does it have to show the names of those who have answered the question correctly?
- How many questions could you get bored with?

Most of the students interviewed have played Clicker around at least 10 lessons. They agree that it is an interesting frame, stressful at times but fun to play. Their favorite part is the ranking. They consider that 12 to 15 questions are enough. Also, they say that the interface is intuitive and easy to use. However, the most interesting part is that they remember easily the questions-answers played.

5 Conclusions and Future Work

Clicker is a novel responsive web application for assessments, which provides both an evaluation and a diagnostic tool. It is a different strategy to motivate our students to participate in class. Each student can view his answers any time, then, this tool can be used to study for a real exam.

As a future work, we are interested in several minor updates, for example, setting a timer for each question; and downloading statistics as a csv file, etc.

Mayor changes are considered, for version 2.0: Design an add-on for "Clicker" that allows mathematical writing as easy as it is to write on the blackboard in order to make mathematical questions clearer and easier; Also, add a module for handling theorems and proofs.

Clicker is available using this url[3].

References

1. Arnab, S., Lim, T., Carvalho, M.B., Bellotti, F., de Freitas, S., Louchart, S., Suttie, N., Berta, R., Gloria, A.D.: Mapping learning and game mechanics for serious games analysis. British Journal of Educational Technology (2014)
2. Delic, H., Bećirović, S.: Socratic method as an approach to teaching. European Researcher 111, 511–517 (11 2016)
3. Kahoot: Kahoot (2020), http://www.kahoot.com
4. Kuzma, A.: Business student attitudes, experience, and satisfaction with online courses. American Journal of Business Education 3, 121–310 (2015)
5. Li, C.: The COVID-19 pandemic has changed education forever. this is how. World Economic Forum (2020)
6. Moneno Olivos, T.: Evaluación del aprendizaje y para el aprendizaje. Reinventar la evaluación en el aula. Universidad Autónoma Metropolitana (2016)
7. Mulenga, E.: Is COVID-19 the gateway for digital learning in mathematics education? Contemporary Educational Technology 12(2) (2020)

[3] http://computo.fismat.umich.mx/clicker

8. Quizizz: Quizizz (2020), http://quizizz.com
9. Sorvatzioti, D.: The Socratic method of teaching in a multidisciplinary educational setting. International Journal of Arts & Sciences pp. 61–71 (2012)

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ReAQ: An Intelligent Tutoring System with Augmented Reality Technology Focused on Chemistry

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Abstract. This paper presents a learning tool called ReAQ, that combines an intelligent tutoring system and augmented reality-oriented to the subject of chemistry. ReAQ facilitates student learning through interaction, three-dimensional visualization, and dynamic adaptation of the content in real-time based on the student's abilities, causing the student to be committed to their learning. Based on an analysis of the educational requirements carried out by 8 teachers of the subject, activities have been designed in a learning tool focused on the topic of "chemical elements, chemical compounds, and chemical reactions". The intelligent tutoring system implements a fuzzy logic module that determines the level of difficulty that the next exercise will have based on the performance of the previous exercise that the student has solved.

Keywords: Augmented reality, intelligent tutor systems, fuzzy logic.

1 Introduction

Chemistry is considered one of the most complicated subjects to learn due to the nature of their abstract contents, which represents a difficult challenge concerning the visualization of chemical elements and compounds [1]. Most students show resistance to identifying chemical elements and forming chemical compounds. Today, with the importance given to Science, Technology, Engineer, and Mathematics (STEM), it is crucial that a student possess the ability to reason and solve problems. Also, the subject of Chemistry in schools tends to play an important role for students to develop the spatial skills that augmented reality offers to them [2].

Augmented Reality (AR) is a technology that allows the user to superimpose digital elements that can be audio, video, image, or three-dimensional element in a real environment [3].

AR might facilitate the visualization of elements that allow the user to understand basic topics. In recent years, many researchers focused their attention on applying AR to different fields like STEM [4,5,6], industry [7], training [8], and customer experiences [9].

On the other hand, Intelligent Tutor Systems (ITSs) provide personalized and real-time help to students. Their capability to adapt feedback according to students' profile allow to deploy instructional methods such as "learning by doing" [10,11,12]. An ITS can be implemented using artificial intelligence techniques like Neuronal Network [13], Data Mining [14], Ruled-based expert systems [15], Fuzzy Logic [6], proving their efficiency in many different fields of knowledge. An effective alternative is incorporating AR into an intelligent tutoring system [16,17].

This work presents an ITS combined with AR technology to learn Chemistry topics aimed at students from the middle-high school. The activities were designed based on the curricular objectives of the chemistry subject of Mexican schools.

2 Related Works

This section presents the works related to AR focused on STEM learning and AR integrated into ITS.

Santamaria [18] used a method to fuse gestures, smart equipment, and digital elements to learn Chemistry experiments. They implement a gesture recognition model trained by a convolutional neural network to recognize gestures in AR and to activate feedback after recognizing a five-finger gesture. According to Chen [19], an AR learning tool remained effectively satisfied with students learning chemistry, Chen focused on the effects of AR learning activities from the perspective of the teacher-centered approach and the student-centered practice approach, to know the conceptual understanding of chemistry topics and the student's interest in the science. Romano [10] presents AR Lab, a learning tool that assists chemistry students during their learning of chemistry glassware, using AR, to help them to assimilate the equipment used in a chemistry lab and their respective functions. Ibañez [20] presents a learning tool where the students can learn the basic principles of geometry to solve area and volume from regular prisms and identify sections of cut made on cylinders and cones. They conducted an interview applying Keller's CIS and IMMS instruments to prove the motivation and usability of the application.

On the other hand, there are several works for developing Intelligent Tutoring Systems focused on the study of STEM. Westerfield [17] presents an ITS combined with AR to teach users how to assemble hardware components on a computer motherboard. The author highlights that the users who interacted with the tutor were faster to do the work compared to the same AR training system without intelligent support. LaViola presents ARWild [21], a tool for the soldier and marine training to master physical tasks in the wild, in places where there is no formal training infrastructure. Almiyad [22] presents Smart AR homework tutoring for medical professionals.

The objective is to teach the user the angle of insertion and the distance traveled by the needle within the patient to perform a successful procedure, through intuitive and adaptive feedback to assist the user. Hsieh [23] presents learning that tool consists of a learning aid, a virtual tutor, and a guiding mechanism for mathematics problem-solving. Students receive feedback immediately after the current exercise. In motivation, the authors affirm that the students show no significant differences between the experimental and control groups. They remarked that guidance and personalization are key to enhance learning with motivation and engagement.

3 Learning Application

ReAQ is an ITS combined with AR focused on the topics of chemical bonds and chemical reactions, of the subject of Sciences at the middle-high school of Mexico. ReAQ provides to the student with tools to identify chemical elements, recognize their symbols and nomenclature, visualize their physical form and their description, as well as formulate chemical compounds, and reactions that are sometimes difficult to visualize. ReAQ is a learning tool developed in Unity 2019 for android devices, implementing Vuforia for AR, SQLite, and Firebase for data persistence.

3.1 Architecture

The architecture of the system follows the traditional architecture of an Intelligent Tutoring System [24, 25] with 4 modules to encapsulate the main processes: KnowledgeModel, PedagogicalModel, StudentModel, and UserAR. Each component within the architecture is briefly described below, and Figure 1 shows ReAQ architecture.

UserAR: In this component, the students interact with the ITS, and is responsible for showing and adapting the required scenes according to the student’s level of knowledge obtained from the result of the interaction. This component contains sub-components that allow you to display elements and chemical reactions and select the best options to control the flow of the tutor's execution. The subcomponent **ARSharedGUI** dynamically adapt the content on the screen of the mobile device. The subcomponent **ARSetScenes** contains the set of scenes designed for each of the elements of the learning tool. The subcomponent **ARControlScene** controls the scene in which the user is interacting with the system and the ITS executes different processes based on user decisions; and the subcomponent **ARAssets** contains and manage all the assets necessary to display the exercises on the screen indicated by the tutor.

The **StudentModel** represents the student's model, which contains the student's profile and personal information (chemistry). The subcomponent *StudentKnowledge* is responsible for creating a representation of the cognitive model of the students. It exchanges information with *TutorController* concerning the observed topics and consults information in the student's database and writes the information on the current session.

The **KnowledgeModel** is responsible for manage the didactic material: basic concepts and the exercises necessary to learn to identify elements, chemical compounds, chemical reactions, the feedback, and the level of difficulty. This component accesses the Exercises and Elements database and interacts with the ARModel component to produce the necessary resources to emulate the AR. The component **ARModel** is responsible for providing UserAR with the digital elements that Vuforia emulates.

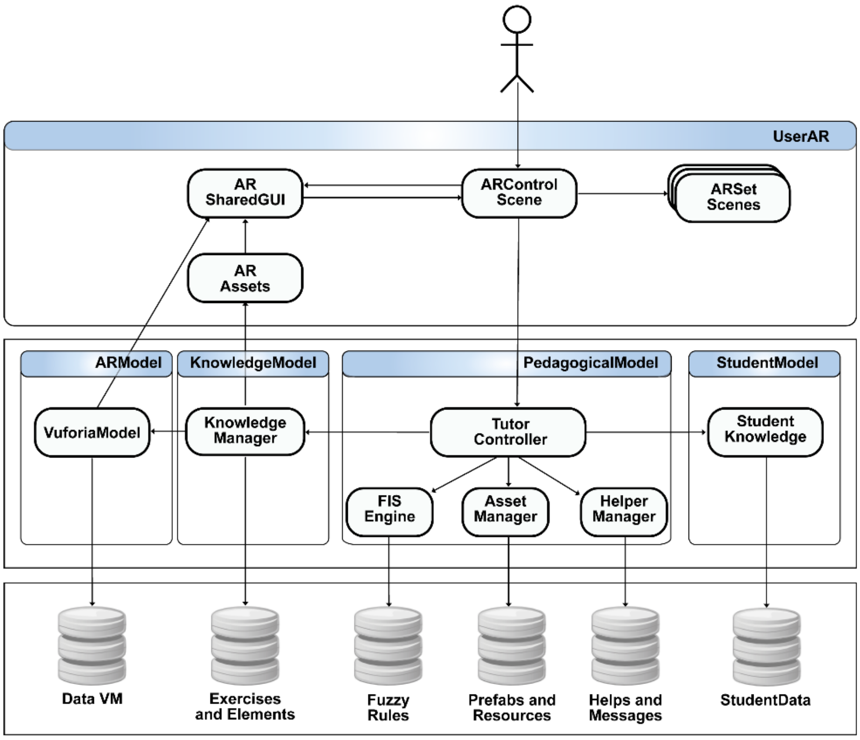

Fig. 1. ReAQ architecture.

The **PedagogicalModel** is responsible for making decisions during the teaching-learning process. The system adapts the information to be displayed to the user's needs depending on the information produced by the student's interaction. The subcomponent *TutorController* is responsible for selecting the exercises that students should perform based on the recommendations made by the FISEngine and providing feedback to the student. The subcomponent *FISEngine* handles the fuzzy inference in the system to adapt the pedagogical model to the student's needs. It also controls the flow and rules of the current exercise. *FISEngine* contains the linguistic variables, fuzzy sets, and various labels. The input variables are the number of correct answers, the number of mistakes made by the student, the number of times the student requests help, and the time required to solve the exercise.

Each fuzzy input variable is normalized to a range of values between 0 and 1. The result of the inference is an output variable called the level of difficulty applicable to the following exercise with the fuzzy values of Weak, Very Weak, Normal Difficult, and Very Difficult. For this work, 81 fuzzy rules were defined. Figure 2 shows an example of the definitions of the fuzzy rules. The subcomponent *AssetManager* controls the flow of scenes from the main menu and accesses databases of prefabs, resources, and plugins to configure the current exercise based on user needs. The subcomponent *HelperManager* manages help messages to solve the exercises.

1. If (answer is high) and (mistake is low) and (time is fast) and (help is low) then (level is veryHard)
2. If (answer is high) and (mistake is regular) and (time is fast) and (help is regular) then (level is hard)
3. If (answer is high) and (mistake is high) and (time is normal) and (help is high) then (level is normal)
4. If (answer is low) and (mistake is high) and (time is high) and (help is low) then (level is normal)
5. If (answer is low) and (mistake is low) and (time is slow) and (help is high) then (level is veryWeak)
6. If (answer is low) and (mistake is low) and (time is regular) and (help is regular) then (level is normal)
7. If (answer is low) and (mistake is high) and (time is fast) and (help is low) then (level is weak)

Fig. 2. Fuzzy Rules defined to determinate the next level of difficulty.

3.2 Exercise Content

The first exercise consists of the student identifying five elements out of 25 available. Each element has a marker with its Symbol. Once the five elements are completed, the student, through the information marker, can select between 5 chemical compounds to display relevant information about the compound on the screen using the info marker.

The second, third, and fourth exercises consist of the student forming a covalent bond, an ionic bond, or a metallic bond respectively. The student must collide two elements, through the use of markers required to solve the exercise. If the combination of the two elements is correct, information about the link is displayed and in turn, an animation with a physical appearance is displayed. The goal is to form 5 bonds. In the event of an error, a message is displayed indicating that the combination of elements does not form the compound of the requested link. Figure 3 shows an example of an exercise covalent bond and ionic bond.

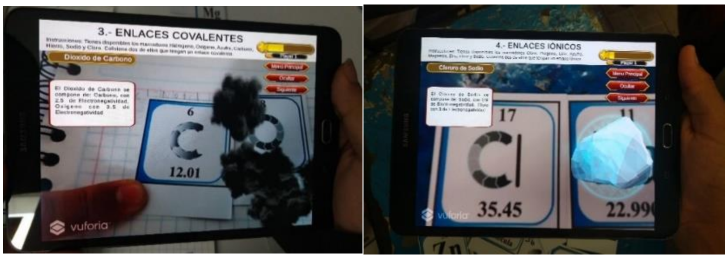

Fig. 3. Covalent bond example (left image) and Ionic bond (right image).

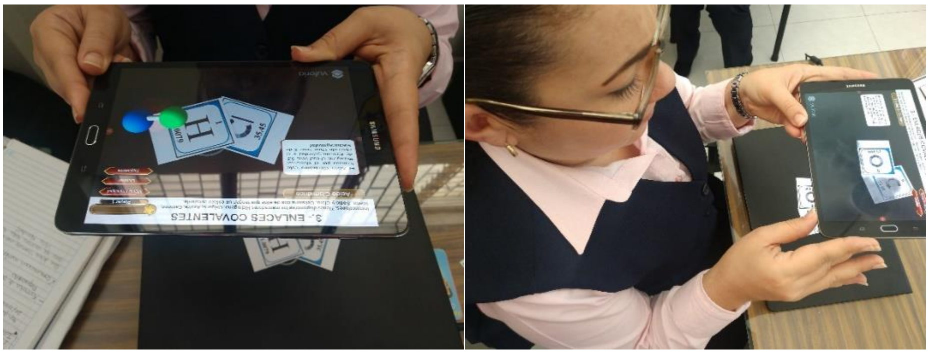

Fig. 4. Teachers interaction with ReAQ.

Table 1. Teachers comments.

Teacher	Type of comment	Comment
Teacher 1	Interesting content	It would be a good element to strengthen student learning.
Teacher 2	Easy to use	Easy to use, looks simple, friendly, eye-catching, and colors match. Even if they do not know how to use it, it is very intuitive and easy to use.
Teacher 3	Easy to use	It is easy to use; the instructions are noticeable clear, and I think they have a lot of skills to master the mobile device.
Teacher 4	GUI friendly	The graphical interface is friendly for the user.
Teacher 5	Improve learning, interesting content	Ideally, the student can receive immediate feedback to improve their skills. I consider that the content is very well structured according to the study program. I believe that students will participate in the classroom using the application.
Teacher 6	Suggestion	It is suggested that the learning tool add an exercise on chemical reactions, where it is observed that reaction occurs when an acid is mixed with little water, an acid with a lot of water, and even mixed with bicarbonate or earth.
Teacher 7	Suggestion	It is suggested that the learning tool must show in the instructions the markers to make the compound required.
Teacher 8	Easy to use, suggestion	It is easy to use. Be careful of the language to be shown in the instructions and to define the objective to fulfill the exercise in use. Remember that the students are younger and maybe irresponsible in the use of the application.

4 Evaluation of the Learning Tool by Experts

This section presents the result of the evaluation and the feedback that the Chemistry teachers gave us. Each teacher was aware of the goal of evaluating the learning tool. Later, the teachers interacted with ReAQ to assess its usability. Teachers believe that ReAQ is innovative, easy to use, and able to hold the student's attention, and agreed that it was feasible to implement it with students in the classroom.

They consider that a learning tool that allows them to visualize or imagine the formation of chemical compounds influences the student to become motivated and lose a little resistance when learning chemistry. Teachers showed interest in implementing it in their teaching practices as a class activity. Also gave us some suggestions to improve the design and use of the application. Figure 4 shows a teacher using ReAQ, and Table 1 shows some of the teacher’s comments on the ReAQ application.

5 Conclusions and Future Work

The learning tool can adapt the contents to the current level of the student due to the fuzzy inference that allows adapting the learning material according to the student's abilities. In the pedagogy, and usability evaluation of ReAQ we got a positive reaction from those who teache the subject and by expert doctors in Chemistry. We got excellent feedback and suggestions to improve the learning tool. It has been concluded that students can feel satisfied, motivated, and confident with the achievements they obtain when interacting with the learning tool and, that they can easily master the learning tool thanks to its friendly interface.

As future work, we will develop the teachers’ suggestion component to give robustness to the learning tool. We also plan to do some experiments with students using ReAQ to analyze the impact it will have on learning gains, and to evaluate the student’s motivation and ReAQ usability.

References

1. Liu, Y., Taber, K.S.: Analysing symbolic expressions in secondary school chemistry: their functions and implications for pedagogy. Chem. Educ. Res. Pract., 17(3), pp. 439–451 (2016)
2. Stieff, M., Uttal, D.: How much can spatial training improve STEM achievement? Educational Psychology Review, 27(4), pp. 607–615 (2015)
3. Azuma, R.: A survey of augmented reality. Presence: Teleoperators and Virtual Environments, 6(4), pp. 355–385 (1997)
4. Laine, T.H.: Mobile educational augmented reality games: A systematic literature review and two case studies. Computers, 7(1), pp. 19 (2018)
5. Majid, N.A.A., Mohammed, H., Sulaiman, R.: Students’ perception of mobile augmented reality applications in learning computer organization. Procedia - Social and Behavioral Sciences, 176, pp. 111–116 (2015)
6. Peña-Rios, A., Hagras, H., Gardner, M., Owusu, G.: A fuzzy logic based system for geolocated augmented reality field service support. In: IEEE International Conference on Fuzzy Systems (2017)
7. Röltgen, D., Dumitrescu, R.: Classification of industrial augmented reality use cases. Procedia CIRP, 91, pp. 93–100 (2020)
8. Sorko, S.R., Brunnhofer, M.: Potentials of augmented reality in training. Procedia Manufacturing, 31, pp. 85–90 (2019)
9. Romano, B., Sands, S., Pallant, J.I.: Augmented reality and the customer journey: An exploratory study. Australasian Marketing Journal (AMJ) (2020)

10. Almasri, A., Ahmed, A., Al-Masri, N., Sultan, Y.A., Mahmoud, A.Y., Zaqout, I., Akkila, A. N., Abu-Naser, S.S.: Intelligent tutoring systems survey for the period 2000-2018. International Journal of Academic Engineering Research, 3(5), pp. 21–37 (2019)
11. Khella, R.A., Abu-Naser, S.S.: An Intelligent Tutoring System for Teaching French (2018)
12. Teresa, I., Torres, M., Sentí, V.E.: Intelligent tutor system for learning object oriented programming. pp. 1–7 (2017)
13. Chen, C.-M., Li, Y.-L.: Personalised context-aware ubiquitous learning system for supporting effective English vocabulary learning. Interactive Learning Environments, 18(4), pp. 341–364 (2010)
14. Taele, P., Hammond, T.: BopoNoto: An intelligent sketch education application for learning zhuyin phonetic script. DMS, pp. 101–107 (2015)
15. Grivokostopoulou, F., Perikos, I., Hatzilygeroudis, I.: An educational system for learning search algorithms and automatically assessing student performance. International Journal of Artificial Intelligence in Education, 27(1), pp. 207–240 (2017)
16. Herbert, B., Ens, B., Weerasinghe, A., Billinghurst, M., Wigley, G.: Design considerations for combining augmented reality with intelligent tutors. Computers & Graphics, 77, pp. 166–182 (2018)
17. Westerfield, G., Mitrovic, A., Billinghurst, M.: Intelligent augmented reality training for motherboard assembly. International Journal of Artificial Intelligence in Education, 25(1), pp. 157–172 (2015)
18. Santamaría-Bonfil, G., Ibáñez, M.B., Pérez-Ramírez, M., Arroyo-Figueroa, G., Martínez-Álvarez, F.: Learning analytics for student modeling in virtual reality training systems: Lineworkers case. Computers & Education, 151, 103871 (2020)
19. Chen, S. Y., Liu, S.Y.: Using augmented reality to experiment with elements in a chemistry course. Computers in Human Behavior, 111, 106418 (2020)
20. Ibáñez, M.B., Uriarte Portillo, A., Zatarain Cabada, R., Barrón, M.L.: Impact of augmented reality technology on academic achievement and motivation of students from public and private Mexican schools. A case study in a middle-school geometry course. Computers and Education, 145 (2020)
21. LaViola, J., Williamson, B., Brooks, C., Veazanchin, S., Sottilare, R., Garrity, P.: Using augmented reality to tutor military tasks in the wild. pp.1–10 (2016)
22. Almiyad, M.A., Oakden, L., Weerasinghe, A., Billinghurst, M.: Intelligent augmented reality tutoring for physical tasks with medical professionals. In: International Conference on Artificial Intelligence in Education, pp. 450–454 (2017)
23. Hsieh, M.-C., Chen, S.-H.: Intelligence augmented reality tutoring system for mathematics teaching and learning. Journal of Internet Technology, 20(5), pp. 1673–1681 (2019)
24. Sottilare, R.A., Holden, H.K.: Motivations for a generalized intelligent framework for tutoring (GIFT) for authoring, instruction and analysis. In: AIED 2013 Workshops Proceedings, 7 (2013)
25. Al-Nakhal, M.A.M., Abu-Naser, S.S.: Adaptive intelligent tutoring system for learning computer theoryadaptive intelligent tutoring system for learning computer theory. B+) European Academic Research, 9(10), pp. 8770–8782 (2017)

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Method for Introducing IoT Project Development Using Free Software Tools

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Abstract. The Internet of Things (IoT) encourages the use of tools that facilitate the development of projects focused on smart cities. These types of projects face significant challenges due to the number of technologies used and the interaction and interrelation between the different systems. There are various methodologies for the development of this type of project, but some are at a very high level to be used by small work teams or people with medium knowledge. This research paper proposes a method for introducing IoT project development focused on small teams or people with medium knowledge. The proposed method works as a guide that covers from the understanding of the business to the implementation of the solution. The method was evaluated through the construction of a prototype that covers the stages of data acquisition, processing and visualization.

Keywords: Application development method, IoT project, internet of things, free software tools.

1 Introduction

The Internet of Things (IoT) has caused transformations that influence aspects such as the economy, the environment, politics and people's daily lives [1]. This encourages the development of intelligent applications capable of interacting with the environment and making decisions based on the information acquired from the different objects [2–4]. However, the development of this type of application involves a high degree of complexity, because it requires increasingly sophisticated techniques of artificial intelligence or automatic learning and generally involves more than one area of knowledge. In this sense, it is important to generate proposals that seek to mitigate the gap that exists between the conceptualization and implementation of the IoT concept.

In this research work, a method is proposed that can be used as a guide for the introduction to the development of internet of things or smart cities applications. The method is detailed through a case of real study in the domain of intelligent transport systems. In the case, a prototype is built that covers the data acquisition, processing and visualization stages. These stages are common in solutions that involve signals from the environment, which are used in the development of data science applications, industry 4.0, smart cities, among others. The use of the method facilitated the construction of the prototype in time and development complexity, thanks to the use of existing free software tools.

The article is organized as follows: Section 2 shows the state of the art; Section 3 describes the proposed method; In section 4 an example of the method is presented to a case study; section 5 shows tests and results. Finally, section 6 presents the conclusions and future work.

2 State of the Art

The development of applications for the internet of things presents a high level of complexity, due to the dependencies and interrelations of the different systems and the technologies involved [5, 6]. The development of this type of applications presents some challenges related to the acquisition, integration, quality or availability of the data applications [7, 8]. Thus, the design of applications for IoT requires understanding and deepening in conceptual, technical and methodological aspects that may differ slightly from traditional development [9, 10]. From the methodological point of view there are some interesting aspects. Por example, there are disciplines focused on the exploitation of data [11, 12], and paradigms focused on exposition of applications and services [13, 14]. However, when reviewing these approaches, several similarities can be observed in terms of their life cycle. i.e., starting with the acquisition of the data and ends with the use of data for a specific purpose [15, 16].

Therefore, the development of applications under the new paradigms is very complex. Some of the traditional tools and methodologies have been adjusted to meet new demands [17, 18]. These adaptations or modifications to the methodologies have reduced the complexity and adaptation of software developers in the construction of the development of new intelligent applications.

3 Method for Introducing IoT Project Development

The proposed method is based on various computational tools and on the benefits offered by internet of things paradigms and smart cities. Figure 1 shows the steps of the proposed method, which are: analysis of the context, requirements analysis, technology analysis, systems design, solution construction and systems implementation. The first stages of our method focus on the conceptualization of the method, while the last two stages focus on the construction of the solution.

The main contribution of our method proposed is focused on the technology analysis stage.

This new proposed stage is where the developer must carry out the analysis of the technology to be used in the development of their application, this directly influences the most appropriate techniques and technologies to use, which allows the reduction of complexity and the time of development of the application. Currently, there are several tools that facilitate the development of Internet of Things applications for developers with different knowledge of these technologies.

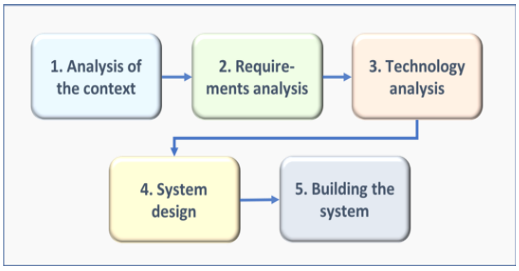

Fig. 1. Overview of the proposed method.

Our method starts with context analysis, which focuses on understanding and modeling the scenario for which you want to develop the IoT application. Once the context is understood, the business requirements and rules that must be considered to obtain the expected functionality are defined and analyzed. The next step is proposed based on experience and its main objective is to allow the identification of data sources and the selection of event detection techniques. In the next step, the design of the prototype architecture is carried out and the final structure of the system to be obtained is modeled. Finally, we proceed with the construction of the system. The next section presents an example of the method's application.

4 Case Study

The validation of our method was carried out in a real case study. This paper presents a smart transport case study which describes a smart application that allows to monitor to handling of a vehicle. When a vehicle is driven in the wrong way, an alert is generated to the users of the application. They may be other drivers or people who are near where the alert was generated. The application detects driving events automatically, which can be: driving at an unauthorized speed, speed changes, driving in the opposite direction, sudden stops of a vehicle, strong turns and road irregularities. However, for reasons of space, only the first two processes will be detailed.

Stage 1. Analysis of the context: in this stage the entities are identified, and the interactions that exist between them. For example, if the following scenario occurs: a car is traveling in an area at an illegal speed. The entities identified in this scenario would be: car, zone and alert. The monitoring of this car in a certain area will allow to identify the attributes of speed limits that the area has, so an alert will be generated when the limits are exceeded. The alert must contain information about the car and the place where this event was generated. In addition, to sending the alert to all users who are close to this event.

Stage 2. Requirements analysis: business requirements and rules are defined at this stage. At this stage, all requirements must be identified considering the frequency of the data, its restrictions, etc. continuing with the scenario of the previous stage: the speed of a car must be analyzed according to the area in which it is located. All areas or roads have a minimum and maximum speed allowed. Any speed value that is outside these limits will be taken as an illegal speed. Monitoring the speed of a car requires the analysis of static and dynamic data, which come from different sources. Dynamic data corresponds to the travel speed and location of the vehicle. The static data correspond to the delimitation of the areas and the speed limits established for each area. Dynamic data can be obtained from different sources (mobile devices, embedded devices, or external devices such as a camera). Static data is taken directly from the traffic regulations.

Stage 3. Analysis of the technology: in this stage, the identification of data sources and the selection of detection techniques are carried out. At this point, it is important to identify the techniques and devices that will be used to monitor the events of the application to be developed. Obtaining information in a smart application can be done in different ways. For example, speed can be determined using a GPS sensor or through a video camera using image processing techniques. Detection of the speed not allowed in a car was carried out through basic mathematical operations. However, building applications for IoT and smart cities generally involves more complex operations that require the use of techniques such as machine learning to obtain more successful results. In our case study application, pattern recognition techniques were used to detect some events identified in the application, such as handling in the opposite direction.

In addition, at this stage the computational tools that will be used for the development of the application must be identified. Free software tools such as: QuantumLeap, and sklearn were used for this case study. QuantumLeap is a generic component of the FIWARE platform, which groups the following modules: Orion Context Broker, MongoDB, CrateDB and Grafana. These components allow managing context information, managing information storage and working with time series to visualize the data in real time respectively. On the other hand, Sklearn is a library developed in Python that contains algorithms focused on pattern recognition. For data transfer, the data models proposed by the FIWARE platform [19] and schema.org [20] were used.

Stage 4. System design: At this stage, the architecture of the prototype to be developed must be defined. The developed smart application allows to monitor the driving of a user through her smartphone. Some aspects that must be considered are those related to the processing and storage capacity of the data acquisition device, for which it must be determined if an external storage of the data is required. As well as the time in the data transfer. However, when using artificial intelligence algorithms and techniques with a high degree of complexity that require large computing capacity, the mobile device may not have enough processing capacity to give immediate responses. In this context, we assume that not all processing can be done in the module that is on the mobile device, or in the cloud. In addition, the design of the modules was carried out with a low level of coupling between them.

This allow us that, in the future the modules can be used independently. Once the abstraction of the stage has been done, we proceed with the design of the architecture.

The proposed architecture for this smart transport application is organized in two subsystems (1) event detection (smartphone) and, (2) monitoring and visualization (cloud). Figure 2 shows the architecture proposed in this case study.

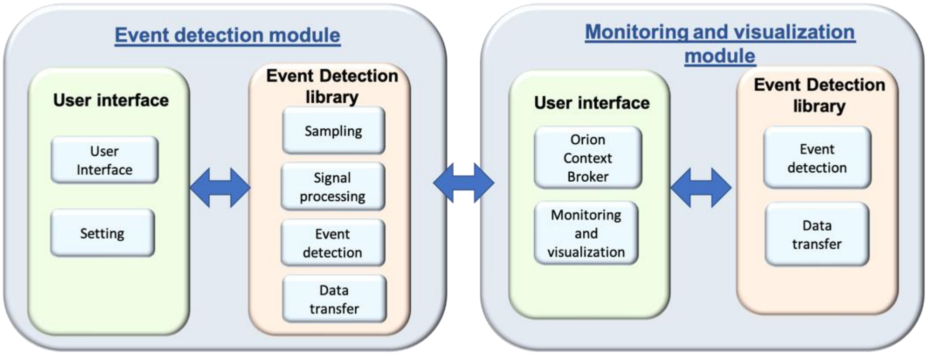

Fig. 2. General Architecture of the smart transport application.

The event detection module gets the data from the smartphone. Therefore, it must be implemented in the smartphone. This module must acquire the data from the sensors, and analyze them to determine if any event has occurred to send information to the monitoring and visualization module. Furthermore, this module must also allow user interaction. With these specifications, an architecture is designed for the event detection module composed of a user interface and a library for event detection. The user interface contains a graphical interface for user interaction and a block that allows the configuration of some parameters such as the connection to the monitoring module. The library is made up of four blocks which cover the process from data acquisition, passes through event detection and ends with data transfer (reprocessed data or alert notifications). The monitoring and visualization module receives the data that comes from the event detection module, stores it, and allows its visualization; and when necessary, processing for event detection is carried out. The design of this module is similar to the event detection module, which is made up of a user interface and an event detection library.

Stage 5. Construction of the system: in this stage, the implementation of the intelligent transport application was carried out. Some of the reference values identified in the application are: the minimum and maximum allowed speed that each of the zones or roads has. This information is taken in real time from the GPS of the smartphone. The first task of acquiring real-time data from the application consists of obtaining every second the GPS position (latitude and longitude), the speed at which the car travels and the time at which the data is obtained. Each data obtained is filtered using the moving averages technique, with the aim of reducing noise. Later all this information is packaged and sent to the distribution block. The second task consist in to obtain and to prepare the data associated with moving the car. In this example, the data of interest is the date, time, longitude, latitude, and speed.

Each data obtained is filtered using the moving averages technique, in order to reduce noise. Then, the data is packaged according to the established parameters and passed to the distribution block. The distribution block takes the received data, adds information if this is necessary (for example, device id) and sends the dataset to the event detection block.

The third task of this stage is the detection of events. In this task, a set of patterns were defined. For example, for the speed change event the following states were defined: At rest, speed increase, speed decrease, constant speed, irregular speed and stop. These patterns allow to identify the type of events that can occur according to the received data set.

For example, if in multiple data sets received, the algorithm detects that the values represent speeding, a "speed not allowed" notification is generated. Notifications can be local or external. Local notifications only inform the user that generated the information, while external notifications send notifications to all users who are close to where the alert was generated.

5 Test and Results

This section presents the results obtained from the tests carried out on the proposed method. The tests carried out were carried out on a group of undergraduate and graduate students from the areas of computing, mechanics and electronics, who should use our method to build intelligent applications with an IoT platform. The applications that the students should build were focused on data collection, automatic event detection or visualization and analysis of historical data. The experimentation process was carried out in the following way: interview to identify the technical skills of the participants, and the development of an intelligent application. Participants should develop an intelligent application starting with the installation of a development environment with an IoT platform; later they should develop the application following with the phases of the proposed method.

The results of the experimentation showed the following data: All participants had basic skills in programming and algorithm design. All the participants knew the concept of IoT, but less than 30% have a clear idea of the concept and the technologies involved. Less than 20% of the participants have been involved in the development of an IoT project. Thus, we can affirm that the identification of free software tools can reduce the implementation time considerably. For example, using FIWARE's Generic QuantumLeap Component it is possible to deploy a data visualization and monitoring environment in less than an hour.

One of the smart applications developed was related to smart transportation. For the tests, three smart phones, a laptop and two virtual machines hosted in the FIWARE Lab Mexico node were used. The module for data acquisition and event detection was installed in the smartphones and the monitoring and visualization module and the database in the virtual machines. The events that we wanted to detect automatically were: speed not allowed and speed changes.

In turn, the following categories were established for speed changes: start of the march, the rest, the stop, the speed increase, the speed decrease and the constant speed. The technique used for the detection of excess speed was a mathematical comparison technique, while for the detection of speed changes three supervised learning algorithms were used: decision trees, Naive Bayes and randomforest. The detection results obtained are the following: speed not allowed 90%, speed changes with decision trees 93.86%, Naive Bayes 71.81% and randomforest 94.12%.

The results obtained show that the reuse of existing software components considerably reduces the complexity and development of IoT applications. However, this does not mean that developing IoT applications is trivial or easy. Instead, current methodological proposals and tools improve understanding and reduce the complexity of new software developments, in addition to considerably reducing software application development times.

6 Conclusions and Future Work

This paper presents a method for introducing IoT application development. The developed method was used to create a prototype that addresses an application in the domain of the internet of things and smart cities. The results obtained in the application tests allow us to infer that the use of the method for the development of this type of solutions is viable. Likewise, the results obtained during the period of application of the method, allowed us to reaffirm the initial idea that advances in the development and implementation of IoT and Artificial Intelligence components decrease the complexity in the development of this type of applications.

Therefore, this makes it easier for people with not so deep knowledge of the internet of things or smart cities to venture into the development of this kind of applications. The main contribution of this research work is the method developed and the case study presented. our example shows two scenarios recurring in the implementing of this type of solution: local processing and external processing. As future work, we are working on refining algorithms for use in other domains.

References

1. Majumdar, C., Lopez-Benitez, M., Merchant, S.N.: Real smart home data-assisted statistical traffic modelling for the internet of things. IEEE Internet Things J., 4662(C), pp. 1–1 (2020)
2. Yi, W., Li, S., Wang, B., Hoseinnezhad, R., Kong, L.: Computationally efficient distributed multi-sensor fusion with multi-bernoulli filter. IEEE Trans. Signal Process., 68, pp. 241–256 (2020)
3. Rafique, W., Zhao, X., Yu, S., Member, S., Yaqoob, I., Member, S.: An application development framework for internet of things service orchestration. 4662(C), pp. 1–14 (2020)

4. Sarbishei, O.: A platform and methodology enabling real-time motion pattern recognition on low-power smart devices. IEEE 5th World Forum Internet Things, WF-IoT 2019 - Conf. Proc., pp. 269–272 (2019)
5. Firmansyah, H.S., Supangkat, S.H., Arman, A.A., Giabbanelli, P.J.: Identifying the components and interrelationships of smart cities in Indonesia: Supporting policymaking via fuzzy cognitive systems. IEEE Access, 7, pp. 46136–46151 (2019)
6. Schoonenberg, W.C.H., Khayal, I.S., Farid, A.M.: A hetero-functional graph theory for modeling interdependent smart city infrastructure (2018)
7. Guzel, M., Kok, I., Akay, D., Ozdemir, S.: ANFIS and Deep Learning based missing sensor data prediction in IoT. Concurr. Comput., pp. 1–15 (2019)
8. Rueda, J.S., Talavera-Portocarrero, J.M.: Similitudes y diferencias entre redes de sensores inalámbricas e internet de las cosas: Hacia una postura clarificadora. Rev. Colomb. Comput., 18(2), pp. 58–74 (2018)
9. Ray, P.P.: A survey on internet of things architectures. J. King Saud Univ. - Comput. Inf. Sci., 30(3), pp. 291–319 (2018)
10. Venticinque, S., Amato, A.: A methodology for deployment of IoT application in fog. J. Ambient Intell. Humaniz. Comput., 10(5), pp. 1955–1976 (2019)
11. Shafiq, S.I., Szczerbicki, E., Sanin, C.: Proposition of the methodology for data acquisition, analysis and visualization in support of industry 4.0. Procedia Comput. Sci., 159, pp. 1976–1985 (2019)
12. Angelov, P.P., Gu, X., Principe, J.C.: A generalized methodology for data analysis. IEEE Trans. Cybern., 48(10), pp. 2981–2993 (2018)
13. Alberti, A.M., Santos, M.A.S., Souza, R., Da Silva, H.D.L.: Platforms for smart environments and future internet design: A Survey. IEEE Access, 7, pp. 165748–165778 (2019)
14. Shah, S.A., Seker, D.Z., Rathore, M.M., Hameed, S., Ben-Yahia, S., Draheim, D.: Towards disaster resilient smart cities: can internet of things and big data analytics be the game changers?. IEEE Access, 7, pp. 91885–91903 (2019)
15. Chen, Q. et al.: A survey on an emerging area: deep learning for smart city data. IEEE Trans. Emerg. Top. Comput. Intell., 3(5), pp. 392–410 (2019)
16. Alsrehin, N.O., Klaib, A.F., Magableh, A.: Intelligent transportation and control systems using data mining and machine learning techniques: A comprehensive study. IEEE Access, 7, pp. 49830–49857 (2019)
17. Liu, C., Nitschke, P., Williams, S.P., Zowghi, D.: Data quality and the internet of things computing. 102(2), pp. 573–599 (2020)
18. Cai, L., Zhu, Y.: The challenges of data quality and data quality assessment in the big data era. Data Sci. J., 14, pp. 1–10 (2015)
19. Home - Fiware-DataModels: https://bit.ly/3ltC5Hu (2020)
20. Place - schema.org Type: https://bit.ly/3lqm6Tf (2020)

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Personalized Summaries Generation: An Approach based on Learning Styles

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Abstract. The increasing information that can be found on the Internet makes very difficult to read and understand all this information in a short period of time. Automatic text summarization aims to address the problem of information overload by extracting the most important information from a document. This allows the reader to make decisions to determine the relevance of the information. This article presents a method for the automatic generation of personalized summaries in Spanish. The personalization is based on the VAK learning styles model. We focus an extractive approach based on heuristics to select the relevant parts of the source content. Our proposed method has been evaluated with junior high school students in a Turing Test experiment with encouraging results.

Keywords: Automatic summarization, learning styles, Turing test, VAK model.

1 Introduction

Today, digital information is growing exponentially, which has caused difficulties in processing and understanding all that information in little time. In this way summaries can help to manage the increasing information. Summarization is the process of converting a text into a shorter version, keeping the essence, meaning and informational elements of the original text. Since the manual summarization represents a time expensive and generally laborious process, the automatic text summarization is a promising research field and is gaining attention from researchers in computer science. Research on automatic text summarization began more than five decades ago with the earlier works of Edmundson [1]. Since then, various theories have been proposed ranging from text linguistics to artificial intelligence.

The main approaches in automatic text summarization are extractive and abstractive. The extractive summaries are generated from the selection of sentences considered outstanding in the source text. Sentences are literally extracted, freely joined, and presented as the summary of the text [2, 3, 4].

The abstractive summaries are created by regenerating new content from the source text; that is, the sentences are reformulated through processes of merging, combining, or deleting terms. In this way, sentences are obtained that, in principle, were not in the source text [5, 6, 7, 8].

Our proposal attempts to provide a solution to the generation of personalized extractive summaries in Spanish, considering the learning style of those who require a summary. Learning styles refers to the fact that each person uses their own method or strategies to learn. The people develop certain preferences or global trends that define a learning style. In this research work, Neurolinguistics Programming Model of Bandler and Grinder [9] was used; this model is also called VAK model for the learning styles it includes: Visual, Auditory and Kinesthetic. The VAK model argues that the people use a series of textual terms in their language and communication system according to their learning style.

Our extractive approach is based on four heuristics to select the relevant sentences to be included in the summary. These heuristics are based on the work of Acero and colleagues [22].

We aim to apply this proposal in educational field. In the academic field, students need to read many research documents in order to conduct their work and in order to have success in their studies. In this context, personalized summaries would be beneficial for students. Therefore, we propose to integrate the proposed summarization model in intelligent learning environment, in this way, the personalization process is based on a student model.

The rest of the paper is organized as follows: Section 2 presents some background concepts on automatic text summarization and learning styles models; Section 3 presents our proposal for personalized text summarization; Section 4 describes the evaluation experiments and results. Finally, Section 5 presents conclusions and outline some future work.

2 Background

2.1 Automatic Text Summarization

Automatic text summarization is the process of shortening digital content documents, to create a summary that represents the most important information within the original content. Research on automatic summarization began with the work of Luhn [11] and Edmundson [1]. To generate summaries without human intervention, they applied the frequency of the words and the position of sentences in the document. Nowadays, several approaches for automatic text summarization can be found in literature; for example, statistical learning [13], machine learning [14, 15], text connectivity [16, 17], conceptual graphs [7, 18], algebraic reduction [19], clustering and probabilistic models [20] and reader-adaptive methods [21].

Automatic summarization can produce a summary of a single document or from multiple documents. The summarization process largely depends on the goals of the user, for example, the summary can be the result of a specific query of the user or it can include a summary of the full information [12].

There are two main ways to generate a summary automatically: the extractive summarization and the abstractive summarization. The extractive approach consists of selecting and extracting the most important sentences or phrases from the original content; then combining all the selected sentences to generate the summary. The abstractive approach consists of generating new sentences based on the original content but keeping the points as they are exposed in the original content.

2.2 Learning Styles Model

Learning theories describe proposals about how the people learn new concepts and abilities; several learning theories have been proposed, all of them state different, and sometimes, contrasting points of view; for example, the dispute between proposals focused on the student and proposals focused on the teachers. The learning styles theory relies on the hypothesis where everyone has a particular way to learn including strategies and preferences, emphasizing that individuals perceive and process information in different ways. Consequently, learning styles theory states learning of individuals has more to do with a process focusing the learning style than with the intelligence of the individuals. Several learning styles models have been proposed, such as the Felder-Silverman Learning Styles Model [31], Kolb Model [32] and the VAK Model [9] among others.

The Felder-Silverman Learning Styles Model proposes four categorizations for learning styles: sensing-intuitive, visual-verbal, active-reflective, and sequential-global. The Kolb Model works on two levels: a four-stage cycle of learning and four separate learning styles: diverging, assimilating, converging, and accommodating. This theory is concerned with internal cognitive processes of learners. The Visual Auditory Kinesthetic, VAK, Model proposed by Bandler and Grinder is based on Neuro-Linguistic Programming.

3 Automatic Generation of Personalized Summaries

The automatic generation of summaries of text is the process of extracting important information from the original text, producing a summary [5]. The summaries according to their purpose can be classified into generic, domain-specific, and query-based. Besides, according to their output the summaries can be abstractive or extractive [10].

We propose a method for generating text summaries using a student model and a learning styles model, which allowed the summaries to be personalized. The model generates domain-specific extractive summaries of documents in Spanish. Fig. 1 shows the architecture of our proposal. This architecture contains several processes and resources to carry out the generation of personalized summaries.

The external resources are composed by a student model, a collection of words VAK, and a collection of proper nouns. The student model contains a representation of the state of the users including their VAK learning style obtained from the Neurolinguistics Programming Test [34]. This information allows us to generate personalized summaries according to the learning style of each user.

The collection of VAK words is composed of words related with each one of the VAK learning styles as proposed by Bandler and Grinder [9].

They argue that people use a learning style which determine their language and their communication system. The proposed set of VAK words is composed by 67 words: 22 visual words, 24 auditory words and 21 kinesthetic words). In order to enriched this set of VAK words, we conducted an analysis of words and their synonyms as result of this study, the collection of VAK words is composed for 1132 new words: 380 visual words, 392 auditory words and 360 kinesthetic words. In Table 1 some examples for the VAK words are presented.

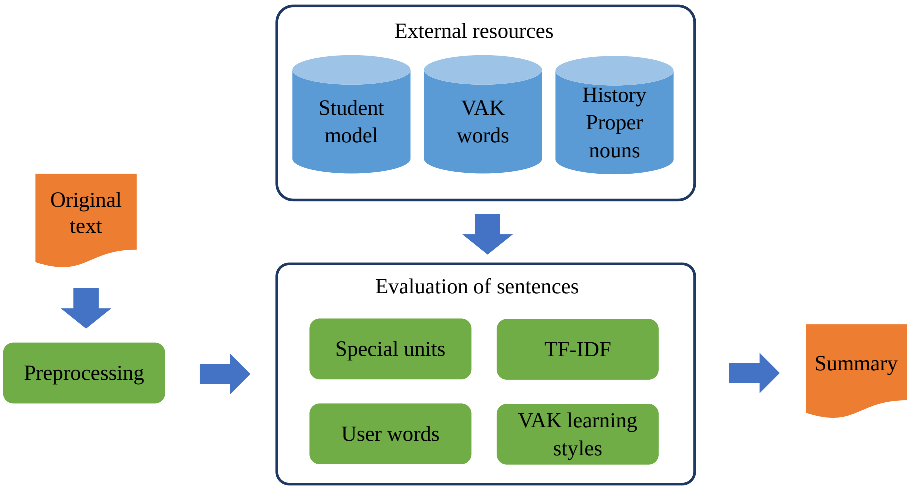

Fig. 1. The architecture of our proposal of generation of automatic summaries of texts.

Table 1. Words related to each learning style according to the Visual Auditory and Kinesthetic Model.

Learning style	Spanish word	English translation
Visual	Obviamente Claro Perspectiva Ilustrar	Obviously Clear Perspective To illustrate
Auditory	Grito Armonía Hablar Sonoro	Scream Harmony To talk Sonorous
Kinesthetic	Pesado Sentir Calor Frialdad	Heavy To feel Hot Coldness

To build the collection of proper nouns, an analysis of official books for History I and History II for junior high school was conducted. The study looked for all the nouns that designated a person, place, company, or things with a singular name.

This study was conducted in a manual way. This set is composed by 244 proper nouns. Table 2 shows some examples of proper nouns.

In preprocessing stage, a plain text document is transformed into an object with minimal linguistic characteristics such as words and sentences. In our proposal, the following basic preprocessing tasks were carried out: segmentation, tokenization, noise elimination, and stop-words elimination.

Table 2. Examples of proper nouns included in the collection of proper nouns.

Word type	Spanish proper nouns	English translation
Thing	Plan de Ayutla	Ayutla Plan
Country	Trinidad y Tobago	Trinidad and Tobago
Historical figure	Benito Juárez	Benito Juarez
Historical figurer	Alejandro Magno	Alexander the Great

Then, the sentences of the text are evaluated according to four heuristics to provide weight for each of the sentences of the text to be summarized and to select the most relevant ones and to be included in the summary. These heuristics are based on the work of Acero and colleagues [22].

The first heuristic, special units, consists of giving a weight to the sentences that contain one or more special units found in that sentence. Special units are acronyms, numbers and proper nouns included in the collection of History proper nouns. The sentence is given to a weight *N* according to the number of special units identified in the sentence.

The second heuristic, TF-IDF, consists of identifying the most relevant words from the text and checking how many of these relevant words are found in each sentence. The relevant words are identified calculating the TF-IDF statistic of words in the sentences. In this way, a high weight is assigned to sentences that contain a greater number of relevant words. The weight is obtained according with the number of relevant words that the sentence contains. Sentences that do not contain any relevant word are assigned a weight of zero.

The third heuristic, user terms, consists of enhancing those sentences that have a greater relevance for the user. The user provides some important words to be included in the summary, which are kept in the student model, to personalize the generated summary. The weight of the sentences in this heuristic is oriented to the similarity with the preferences of the user. Sentences that contain one or more words that the user has considered in their interests are given the weight of 1. If the sentence does not contain any words of interest to the user, they are given the weight of zero.

The fourth heuristic, learning styles, consists of identifying the words that are related to the learning style of the user according to the VAK model. The sentence weight is assigned according to the number of words related to the VAK learning style of the user found in each sentence. Sentences do not contain any term from the VAK words according to the learning style of the user are assigned to zero.

After, the evaluation of the sentences, the four weights for each sentence is used to obtain a single weight for the sentences. The final weight is calculated by means of Eq. 1. Four external parameters, *a*, *b*, *c*, *d,* are included to estipulate the importance of each heuristic. Thus, prioritizing one heuristic over another and being able to perform the tests. The sentences with highest weight are selected.

$$Sentence\ weight = \frac{(a*H1)+(b*H2)+(c*H3)+(d*H4)}{a+b+c+d}. \quad (1)$$

4 Experiments and Results

For many years, to evaluate the quality of automatically produced summaries has been a challenge for research groups within this area. The evaluation of a summary becomes a very subjective task because there is no ideal summary to compare an automatically generated summary and neither to evaluate its customization. To evaluate our proposal, the automatic generation of extractive summaries, we conducted a study based on the Turing Test [35] as proposed by Molina and Torres [36].

In the study 210 second-year junior high school students participated, whose ages range from 11 to 16 years. They are students from a village near to Mexico City. The participants filled in the Neurolinguistics Programming Test [34], thus we can know their VAK learning style. Within this learning style classification, they were randomly selected as judges or summarizer students. A group of 45 participants were designated as judges (15 visual judges, 15 auditory judges and 15 kinesthetic judges) and 6 participants were designated as summarizer students (2 visual students, 2 kinesthetic students, and 2 auditory). As part of the experiments, we built a collection of 45 Spanish text documents from books of History I and History II from junior high school. This collection was provided to students in order to they can elaborate the summaries.

This experiment consisted of evaluating the quality of the summaries based on the Turing test [35] and consists of having a group of human judges, which must identify the origin, human or automatic, of a series of summaries. The results are validated with a statistical hypothesis test.

For the generation of summaries by humans, each of the 6 summarizer students were assigned with two randomly selected documents from the collection of text documents, thus, they must make two summaries. Since we are evaluating extractive documents, they were asked to decide in each given text document, which sentence is relevant to be included in the summary. On the other hand, for the generation of automatic summaries made by a software system, we used our proposal to generate 6 summaries: 2 visual summaries, 2 auditory summaries and 2 kinesthetic summaries. All the summaries are from different text documents.

Once the summaries were generated by the students and by the software system. Each one of the 45 judges was assigned with the 12 summaries. The sole instruction given to the judges was to determine if they believed that the summary was made by a human or generated by a machine, this is by a summarizer software system.

To evaluate the significance of the results, the experiment *Lady Tasting Tea* proposed by Fisher was conducted. In that experiment, Ronald A. Fisher developed an exact statistical test based on counting the number of successes and failures by means of a contingency table [37]. According to the results of the 45 judges, contingency tables were created for each judge.

The validation of the summaries was carried out through the approach of two hypotheses: the null hypothesis, H_0, which states there is no relation between the responses of the judges and the origin of the summary; and the alternative hypothesis,

H_1, which states there is a positive relation in the response of the judges. We use the Fisher Test function from the R programming language to calculate the *p-values*. We used the standard test setup: two tails with a 95% confidence interval. From the 45 judges, only two judges presented a statistically significant result (*p-value*<0.05). While the remaining 43 judges cannot affirm that their result is significant in distinguishing the true origin of the summaries. Therefore, we argue that the 43 judges found the same quality in the summaries made by humans as in the summaries generated by our proposal.

5 Conclusions and Future Work

In this paper, we presented an extractive approach for personalized automatic summarization. The personalization is based on the learning style of the user. We used the Neurolinguistics Programming Model, also called VAK model. This model proposes a set of words related to each learning style. We strengthen including more words for the three learning styles. We argue people would better understand a summary that includes words related with their learning styles.

We evaluated the quality of the summaries base on the Turing Test. The results obtained from the experiment carried out allowed us to demonstrate that the summaries developed with the presented heuristics had the same quality as those summaries carried out by the group of high school level students manually.

Currently, we are working in the evaluation of the personalization of summaries, trying to know whether including the VAK learning style produces learning gains in the understanding of the summaries, and also we want to know whether user selected words and VAK words make a difference in the quality of the summaries and whether there is a correlation between students competences and their judgements.

References

1. Edmundson, H.P.: New Methods in Automatic Extracting (1969)
2. Pembe, F.C., Güngör, T.: Automated query-biased and structure-preserving text summarization on web documents. In: Proceedings of the International Symposium on Innovations in Intelligent Systems and Applications (2007)
3. Chatterjee, N., Sahoo, P.K.: Random indexing and modified random indexing based approach for extractive text summarization. Computer Speech and Language, pp. 33–44 (2015)
4. Ferreira, R., Freitas, F., de Souza, L., Dueire, R., Lima, R., Simske, S.J., Favaro, L.: Context based text summarization system. In: 11th IAPR International Workshop on Document Analysis Systems (2014)
5. Banerjee, S., Mitra, P., Sugiyama, K.: Multi-document abstractive summarization using ilp based multi-sentence compression. In: Proceedings of the Twenty-Fourth International Joint Conference on Artificial Intelligence, pp. 1208–1214 (2015)
6. Gaikwad, D.K., Mahender, C.N.: A review paper on text summarization. International Journal of Advanced Research in Computer and Communication Engineering, pp. 154–160 (2016)

7. Miranda-Jiménez, S., Gelbukh, A., Sidorov, G.: Generación de resúmenes por medio de grafos conceptuales. Revista Signos. Estudios de Lingüística, pp. 463–485 (2014)
8. Rawat, P., Ganpatrao, N.G., Gupta, D.: Text summarization using abstractive methods. Journal of Network Communications and Emerging Technologies (JNCET), pp. 26–29 (2017)
9. Bandler, R., Grinder, J.: De sapos a príncipes: Santiago de Chile. Cuatro Vientos (1982)
10. Kumar, Y.J., et al.: A review on automatic text summarization approaches. J. Comput. Sci., 4, pp. 178–190 (2016)
11. Luhn, H.P.: A statistical approach to mechanized encoding. IBM Journal of research and development, pp. 309–317 (1957)
12. Vilca, G.C.: Generación automática de resúmenes abstractivos mono documento utilizando análisis semántico y de discurso. Universidad Católica de Perú (2017)
13. Jeong, H.: Efficient keyword extraction and text summarization for reading articles on smartphone. Papers of Department of Computer Science and Engineering, 34, pp. 779–794 (2015)
14. Wong, K.F., Wu, M., Li, W.: Extractive summarization using supervised and semi-supervised learning. Association for Computational Linguistics, 1, pp. 985–992 (2008)
15. Fattah, M.A.: A hybrid machine learning model for multi-document summarization. Applied Intelligence, 4, pp. 592–600 (2014)
16. Pal, R., Maiti, P.K., Saha, D.: An approach to automatic text summarization using simplified lesk algorithm and wordnet. International Journal of Control Theory and Computer Modeling, 4, pp. 15–23 (2013)
17. Atkinson J., Munoz. R.: Rhetorics-based multi-document summarization. Expert Systems with Applications, 11, pp. 4346–4352 (2013)
18. Martinez-Romo, J., Araujo, L., Fernandez, A.D.: SemGraph: Extracting keyphrases following a novel semantic graph-based approach. J. Assoc. Inf. Sci. Technol., 67(1), pp. 71–82 (2016)
19. Lee, J.H., Park, S., Ahn, Ch.M., Kim, D.: Automatic generic document summarization based on non-negative matrix factorization. Information Processing and Management, 45(1), pp. 20–34 (2009)
20. Mei, J.P., Chen, L: SumCR: A new subtopic based extractive approach for text summarization. Knowledge and Information Systems, 31(3), p. 527–545 (2012)
21. Kumar, C., Pingali, P., Varma, V.: Generating personalized summaries using publicly available web documents. IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology, pp. 103–106 (2008)
22. Acero, I., Alcojor, M., Díaz, A., Gómez, J.M., Maña, M.J.: Generación automática de resúmenes personalizados. Procesamiento del Lenguaje Natural, 27 (2001)
23. Amigó, E., Gonzalo, J., Peñas, A., Verdejo, F.: Qarla: a framework for the evaluation of text summarization systems. In: 43rd Annual Meeting of the Association for Computational Linguistics (ACL'05), pp. 280–289 (2005)
24. Mani, I., House, D., Klein, G., Hirschman, L., Firmin, T., Sundheim, B.: The tipster summac text summarization evaluation. In: Ninth conference on European chapter of the Association for Computational Linguistics, pp. 77–85 (1999)
25. Saggion, H., Lapalme, G.: Concept identification and presentation in the context of technical text summarization. In: ANLP/NAACL Workshop on Automatic Summarization (2000)
26. Orasan, C., Hasler, L.: Computer-aided summarisation: How much does it really help. In: Proceedings of Recent Advances in Natural Language Processing, pp. 437–444 (2007)
27. Molina, A., Torres-Moreno, J.M., da Cunha, I., SanJuan, E., Sierra, G.: Sentence compression in Spanish driven by discourse segmentation and language models. Cornell University, Computation and Language (cs.CL) Information Retrieval (2012)
28. Lin, Ch.Y.: ROUGE: A package for automatic evaluation of summaries. In: Workshop Text Summarization Branches Out (ACL'04) (2004)

29. Molina, A.: Compresión automática de frases: un estudio hacia la generación de resúmenes en español. Inteligencia Artificial, 16(51), pp. 41–62 (2013)
30. Molina, A., da Cunha, I., Torres-Moreno, J.M., Velazquez-Morales, P.: La compresión de frases: un recurso para la optimización de resumen automático de documentos. Linguamática, 2(39), pp. 13–27 (2010)
31. Constante, M.A., Guevara, P.D.: Los estilos de aprendizaje son características identitarias o rasgos cognitivos, afectivos. Revista Publicando, 4(12), pp. 181–196 (2017)
32. Kolb, D.A.: Experiential learning: experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall (1984)
33. Felder, R., Silverman, L.: Learning and teaching styles in engineering education: Engineering education, pp. 674–681 (1988)
34. De la Parra, E.: Herencia de vida para tus hijos. Crecimiento integral con técnicas PNL, pp. 88–95 (2004)
35. Turing, A.M.: Computing machinery and intelligence. Mind, 59(236), pp. 433–460 (1950)
36. Molina, A., Torres-Moreno, J.M.: The Turing test for automatic text summarization evaluation. Linguamática, 7(2), pp. 45–55 (2015)
37. Agresti, A.: Categorical data analysis. Wiley Interscience, 359 (2002)

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