Intelligent Learning Environments

Research in Computing Science

Research in Computing Science, Año 19, Volumen 149, No. 1, enero de 2020, es una publicación mensual, editada por el Instituto Politécnico Nacional, a través del Centro de Investigación en Computación. Av. Juan de Dios Bátiz S/N, Esq. Av. Miguel Othon de Mendizábal, Col. Nueva Industrial Vallejo, C.P. 07738, Ciudad de México, Tel. 57 29 60 00, ext. 56571. https://www.rcs.cic.ipn.mx. Editor responsable: Dr. Grigori Sidorov. Reserva de Derechos al Uso Exclusivo del Título No. 04-2019-082310242100-203. ISSN: en trámite, ambos otorgados por el Instituto Politécnico Nacional de Derecho de Autor. Responsable de la última actualización de este número: el Centro de Investigación en Computación, Dr. Grigori Sidorov, Av. Juan de Dios Bátiz S/N, Esq. Av. Miguel Othon de Mendizábal, Col. Nueva Industrial Vallejo, C.P. 07738. Fecha de última modificación 30 de agosto de 2019.

Las opiniones expresadas por los autores no necesariamente reflejan la postura del editor de la publicación.

Research in Computing Science, year 19, Volume 149, No. 1, January 2020, is published monthly by the Center for Computing Research of IPN.

The opinions expressed by the authors does not necessarily reflect the editor's posture.

Intelligent Learning Environments

María Lucía Barrón Estrada
Ramón Zatarain Cabada
María Yasmín Hernández Pérez
Carlos Alberto Reyes García (eds.)

Instituto Politécnico Nacional, Centro de Investigación en Computación
México 2020

ISSN: 1870-4069

Instituto Politécnico Nacional (IPN)
Centro de Investigación en Computación (CIC)
Av. Juan de Dios Bátiz s/n esq. M. Othón de Mendizábal
Unidad Profesional "Adolfo López Mateos", Zacatenco
07738, México D.F., México

http://www.rcs.cic.ipn.mx
http://www.ipn.mx
http://www.cic.ipn.mx

Indexed in LATINDEX, DBLP and Periodica

Electronic edition

ISSN 1870-4069

Editorial

AI has enabled new ways of learning and teaching. This may change society in ways that pose new challenges for educators and educational institutions.

Intelligent Learning Environments (ILE) will provide exciting new opportunities for adapting learning content based on students' cognitive and affective individual needs.

In this volume, we present seven research works in some of the most interesting fields of intelligent learning systems. These papers show clearly the main directions of research in intelligent learning environments in México.

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

We appreciate the funding provided by RedICA (Conacyt Thematic Network in Applied Computational Intelligence) and we 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). Last, but not least, we thank Centro de Investigación en Computación-Instituto Politécnico Nacional (CIC-IPN) for their support in preparation of this volume.

María Lucía Barrón Estrada
Ramón Zatarain Cabada
María Yasmín Hernández Pérez
Carlos Alberto Reyes García

Guest Editors

October 2019

ISSN 1870-4069

Table of Contents

ISSN 1870-4069

An Approach for Knowledge Graph Construction from Spanish Texts

Andrea G. Garcia Perez[1], Ana B. Rios Alvarado[1],
Tania Y. Guerrero Melendez[1], Edgar Tello Leal[1], Jose L. Martinez Rodriguez[2]

[1] Autonomous University of Tamaulipas,
Mexico

[2] CINVESTAV Unidad Tamaulipas,
Mexico

agidaltig@gmail.com, {arios, tyguerre, etello}@docentes.uat.edu.mx,
lmartinez@tamps.cinvestav.mx

Abstract. Knowledge Graphs (KGs) represent valuable data sources for the Educational and Learning field, allowing computers and people to process and interpret information in an easier way. In addition KGs are useful to get information by software systems on any data resource (person, place, organization, among others). KGs are represented through triples composed of entities and semantic relations commonly obtained from textual resources. However, exploiting triples from text is complicated due to linguistic variations, where Spanish has been slightly approached. This paper presents a method for constructing KGs from textual resources in Spanish. The method is composed of four stages: 1) obtaining of documents, 2) identification of entities and their relations, 3) association of entities to linked data resources, and 4) the construction of a schema for the KGs. The experiments were performed over a set of documents in a general and computer science domain. Our method showed encouraging results for the precision in the identification of entities and semantic relationships for the KGs constructed from unstructured texts.

Keywords: knowledge graph, construction of graph from texts.

1 Introduction

In recent years the Web has become a global repository that represents a source of knowledge in a wide range of domains and languages, where the information is shared and stored in different formats. The whole range of data is attractive for different commercial, industrial, and academic institutions. However, extracting and processing information coming from sources such as the Web is not a straightforward task even if it is manually done by a human. There is a growing desire for direct and automatic access to data. For example, in the educational domain, where the data need to be modeled by a representation that facilitates the comprehension, sharing, and reusing of information by users (and systems).

One way to represent a data model is through the Linked Data repositories, which collect resources about different topics that can be interconnected and satisfy diverse standards of publication and exchange of data.

The use of these standards promotes to share and query information, allowing the identification and extraction of new knowledge through the entities (objects of the real world) and the relationships between them [4], which produces *Knowledge Graphs* (KG).

KGs have been adopted as data representation models in applications such as DBpedia, YAGO, Wikidata, among others. A KG can be constructed to store data in a triple store that can be analyzed to acquire or infer new knowledge about entities (e.g., people, places, organizations) and concepts, as well as interconnected entities.

The representation of text as KGs is very important in education or learning environments because KGs allow people to achieve better understanding, interoperability, and accessibility of data [2, 3]. Thus, for exploiting large amounts of knowledge, some approaches obtain a graph model to represent entities and semantic relations [8, 9, 5, 2, 1]. Most of them use NLP techniques for extracting relations in English language, and in some cases belong to an specific domain such as Education [2, 1], Medicine [9, 8], and Security [7]. However, extracting triples (and KGs) from text is a complicated task, where the text may require patterns and rules to obtain entities and semantic relations. Additionally, even though there are over 583 million Spanish speakers[1] in the world and the production of text (e.g.,by collaborative networks, blogs, social networks, emails, and other applications) is increasing daily, this language has been scarcely explored for the extraction and representation of KGs.

In this paper, we propose a method to automatically build KGs from unstructured texts in Spanish. Our method is composed of four stages: 1) obtaining and processing the documents, 2) identification of entities and their relations by lexical patterns using NLP tools, 3) association of entities to linked data resources, and 4) the construction of a schema for the KGs. The entities and relationships are extracted from text in a process which can be performed by lexical patterns and transformed to an RDF representation.

This paper is organized as follows. Section 2 describes the proposed method, starting with the obtaining and processing of text documents in Spanish and then with the identification of entities and semantic relationships (incorporating a method to associate them with DBpedia resources). Next, in section 3 the experiments and results are shown. Finally, Section 4 presents the conclusions and further work.

2 Computational Methodology

Our proposed method aims to generate a document model representation in the form of a KG from a set of general domain unstructured documents written

[1] https://www.ethnologue.com/language/spa

in Spanish. The method is composed of four main steps described in the next subsections.

2.1 Step 1: Obtaining and Processing the Documents

In the first step, each document contained in a collection is prepared for the extraction of entities and semantic relations. For this, the following tasks are needed:

– *Cleaning the document.* The document is processed as UTF-8 format, dealing with errors of accents and special characters.
– *Splitting the text in sentences.* The text is divided into sentences since it is the grammatical structure that allows extracting more relationships with higher precision than other textual units.
– *Grammatical tagging.* Using a grammatical parser, a label (e.g., noun, verb, article) for each word in the sentence is obtained. The labels provided by this process allow the generation of lexical patterns that will identify the semantic relationships between nouns, verbs, determinants, and other grammatical components.
– *Named-entity identification.* We use a Named Entity Recognition parser to identify named entities such as places, people, and organizations.

2.2 Step 2: Identification of Entities and Semantic Relationships

The second step requires the tags obtained by the grammatical tagging and named-entity recognition for extracting entities and semantic relationships (taxonomic, non-taxonomic and structural relations). Thus, it is possible to extract the elements described below:

– *Entities.* The words that represent simple nouns, compound nouns, named entities, and specialized terms are considered as entities, which may contain adjectives, determinants and/or prepositions. We considered a set of lexical patterns to recognize entities with more than one word. For example, the sequence *Magdalena Carmen Frida Kahlo Calderon* is identified.
– *Taxonomic relations.* It classifies a specific concept as part of a more general concept or indicate if an entity has a type. For example, <*FridaKahlo, rdf:type, Artista/Artist*>, where *Frida Kahlo* is a type of *Artist* class.
– *Equivalence relations.* These relationships establish the equality or equivalence between two expressions that are apparently different. For example, *infancia/childhood*[2] is synonym of *niñez/childhood* (in English language both concepts are related with *childhood*).
– *Structural relations.* These relationships describe how a concept (or set of concepts) can be broken down into parts of subsystems. For example,<*puerta de embarque/gate, isPartOf, Aeropuerto/Airport*>, where *Airport* is composed of *gates* and other elements.

[2] Word in Spanish/Word in English

– *Non-taxonomic relationships.* It is a kind of semantic relationship in which two or more entities are linked in a non-hierarchical structure. It can represent an action, event in time or location in space. For example, <*FridaKahlo, nacidaEn/wasBornIn, Coyoacan*> is used to indicate that a person named *Frida Kahlo* was born in a place called *Coyoacan*.

Additionally, a set of lexical patterns and regular expressions are required for identifying entities like *tópicos de creciente interés/topics of growing interest* or structural relations as *el cuerpo humano esta compuesto de células/the human body is composed by cells.*

2.3 Step 3: Association of Entities to a Linked Data Repository

The representation of KGs relies on the Resource Description Framework (RDF[3]). In this data model both the resources being described and the values describing them are nodes in a directed labeled graph. The arcs connecting pairs of nodes correspond to the names of the property types. Thus, a semantic triple is a set of three elements that codifies a statement about semantic data in the form of subject–predicate–object expressions.

We obtain RDF triples using the entities obtained in step 2 and querying property data from a linked data repository, in our case DBpedia. We consider some relevant DBpedia properties: *rdf:type*, *dcterms:subject*, *rdf:seeAlso*, and *owl:sameAs*. These properties are retrieved for all the identified entities because they represent taxonomy, categorization (or type), and equivalence relations. Restricting the association or linked entities with the mentioned properties is a controlled form of enriching the graph without irrelevant or ambiguous information.

We constructed SPARQL[4] queries for consulting the properties in DBpedia. In Listing 1.1 is represented a query associated to the relation *dcterms:subject* for retrieving the resources (*?uri*) related with a specific entity (*?val*):

– SELECT
– ?uri
– ?val
– WHERE ?uri dcterms:subject ?val .

2.4 Step 4: Knowledge Graph Construction

The construction of the KG is divided into two tasks:

– *Scheme specification.* When semantic relations are obtained from linked data repositories as DBpedia, vocabularies with already defined properties are used. In the case of triples extracted from the text, the identified properties or predicates must be specified. For this reason, we define a scheme for such properties. However, only the label of the property is defined because it is not known the range of objects or resources that will use this property.

[3] https://www.w3.org/RDF/
[4] https://www.w3.org/TR/sparql11-overview/

– *Triples construction.* Once the scheme of is specified, it is possible to build the KG using an RDF format, in which the resources and the identified relationships are described (either textual relations or retrieved using DBpedia).

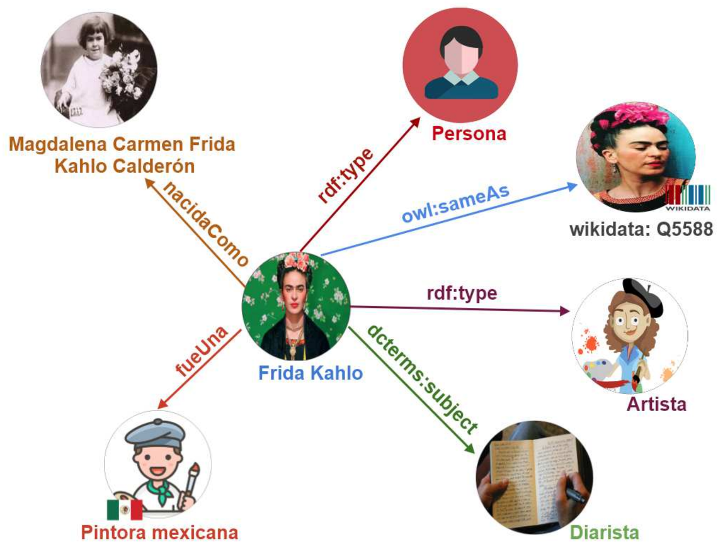


Fig. 1. Example of KG for the entity "Frida Kahlo".

The generated RDF document corresponds to the representation of the processed document, so the KG represents the context and knowledge of the topics described in a set of documents. For each document, an RDF document is constructed.

An example of KG is shown in Figure 1, where the *FridaKhalo* entity is related by using the properties *rdf:type*, *owl:sameAs*, *dcterms:subject* associated with DBpedia, and *wasA*, *named* (in Spanish, *fueUna*, *nacidaComo*, respectively) are data properties extracted from text:

1. <FridaKahlo, *rdf:type*, Persona>
2. <FridaKahlo, *owl:sameAs*, wikidata:Q5588>
3. <FridaKahlo, *rdf:type*, Artista>
4. <FridaKahlo, *dcterms:subject*, Diarista>
5. <FridaKahlo, *fueUna/wasA*, Pintora Mexicana>
6. <FridaKahlo, *nacidaComo/named*, Magdalena Carmen Frida Kahlo Calderon>

3 Experiments and Results

One way to evaluate the KG is to determine the quality of the extracted semantic relationships and entities used to build the graph. However, validating the results of the extraction of such elements can be a complex task due to the limitation of published datasets for the construction of KG in Spanish.

The extraction of the elements can be seen as an information retrieval task, so it can be evaluated with the measures Precision, Recall, and F-measure [6]. Precision evaluates the capability of the method to exclude those elements that do not represent true entities or semantic relationships and Recall assesses the capability to recover all those entities or semantic relationships among which we know that exists. For its part, F-measure is a harmonic average between Precision and Recall and it reflects the performance of the method.

The experiments were conducted to evaluate two stages: 1) identification of entities and semantic relations from text (according to lexical patterns), and 2) identification of each one of the triple elements (subject, predicate, and object); in the case of subject and object their association with a resource in DBpedia for KG construction.

3.1 Dataset

We constructed the dataset used in the experiments, it contains nineteen documents, nine about a general domain and ten about computer science domain, with a total of 250 sentences and 127 semantic relations, in the Spanish language. Each document has an identifier corresponding to a number from 1 to 19. Three computer science domain experts manually identified a set of entities and triples (subject, property, and object) from sentences. We considered entities of class place, people and those resources that are in DBpedia[5] in Spanish according to a human expert.

3.2 Identification of Entities and Semantic Relationships

For the entities identification process individually or into the semantic relationships the following features were considered: extracting all the entities that represent a specialized term, a named entity, simple singular nouns, or compound nouns and matching the sentences with lexical patterns for extracting taxonomic, equivalent, structural, and non-taxonomic relationships. Experiment 1 involves taking account that each sentence match with the lexical patterns. Experiment 2 involves to identify each component of the triple (subject, predicate, and object) given a sentence.

To evaluate the entity extraction process, the domain experts annotated 137 entities for a document. The results of Precision, Recall and F-measure are shown in Table 1. Using the lexical patterns it is possible to obtain entities like *la población del norte de pingüinos Rockhopper/the northern population of Rockhopper penguins*, and *especies de pingüinos/species of penguins.* Such detected entities do not have an associated resource to DBpedia but they represent important concepts into text and they have some semantic relation. On the other hand, the entities *biodiversidad* and *hemisferio sur*, also detected by lexical patterns,

[5] http://es.dbpedia.org/

were associated with the resources *http://es.dbpedia.org/page/Biodiversidad* and *http://es.dbpedia.org/page/Hemisferio_sur*, respectively. As shown in Table 1, when fewer patterns are considered, the number of incorrect identified decreased. However, less than 25% of real relationships is obtained. When more patterns are considered, the number of incorrect increases but precision and recall values are balanced.

Table 1. Entity extraction results.

	Experiment 1	Experiment 2
Entities	137	137
Precision	1.00	0.91
Recall	0.25	0.62
F-measure	0.40	0.74

The results of the relationship extraction process are described in Table 2, where a comparison between the results of both experiments is presented. Given the number and kind of patterns considered for Experiment 1, there are no results for all the documents in that test, which means that in documents 2,3,4,5,6, and 7, entities were not obtained.

In contrast, in documents 1,8, and 9 the entities identified are all correct, getting a Precision of 1.0 but a low Recall and also a low F-measure. Nevertheless, in Experiment 2, all documents obtained results for extracting entities and relations tasks, but only one document had a precision of 1, this was because the number of matches was bigger than other documents.

Table 2. Summary of results for the relationships extraction process.

	Experiment 1	Experiment 2
Total correct	5	49
Total incorrect	0	23
Total identified	5	75
Total real	84	84
Average precision	1.00	0.65
Average recall	0.06	0.58
Average F-measure	0.31	0.82
Median precision	1.00	0.67
Median recall	0.18	0.60
Median F-measure	0.31	0.60

For the extraction of semantic relations as triples, it was evaluated the Precision, Recall and F-measure in the identification of subject, predicate, and object. A subject or an object can be associated with a resource in DBpedia.

Three human experts manually identified the correct subjects and objects related to the context of the documents.

In general, the results for the method are related to the patterns considered in the identification of entities and the style of writing in the texts. There could be texts in which the author describes some concepts and the method will be benefited. However, the method was designed for general purpose or general domain so it cannot be benefited for any particular writing style.

4 Conclusions and Further Work

In this paper, a method for the construction of knowledge graphs was presented. This method consists of four phases, the last of them focused on the construction of the model.

One of the most important phases is the stage of extraction of entities and semantic relationships and the alternatives to perform it out, the lexical patterns and the results by applying each one of the alternatives. For the entity extraction, it is considered the occurrence of nouns accompanied by other elements that end in simple entities, multiple entities or with a sequence of nouns and concepts, also considering entities that represent specialized terms, among others.

With respect to the semantic relationships, the proposed method is capable of identifying and extracting non-taxonomic, taxonomic, equivalence and structural relations, which represent triples in the knowledge graph. Our method showed encouraging results for the precision in the identification of entities and semantic relationships.

As future work, we plan to extend the experiments to consider the tasks of entity and semantic relation extraction from text and the further step of linking such elements with resources from a knowledge base. Moreover, we also plan to apply the extracted KGs in tasks such as information retrieval and data visualization to measure the degree to which linked data and KGs can support the Educational and Learning field.

Acknowledgements. This work was partially supported by the National Council of Science and Technology (CONACYT) and Basic Science Research Project SEP-CONACYT of Mexico under Grant 256922.

References

1. Buscaldi, D., Dessı, D., Motta, E., Osborne, F., Recupero, D.R.: Mining scholarly data for fine-grained knowledge graph construction. In: Proceedings of the Workshop on Deep Learning for Knowledge Graphs (DL4KG2019) at ESWC2019 (2019)
2. Chen, P., Lu, Y., Zheng, V.W., Chen, X., Yang, B.: Knowedu: A system to construct knowledge graph for education. IEEE Access 6, 31553–31563 (2018), https://doi.org/10.1109/ACCESS.2018.2839607
3. Cui, J., Yu, S.: Fostering deeper learning in a flipped classroom: Effects of knowledge graphs versus concept maps. BJET 50(5), 2308–2328 (2019), https://doi.org/10.1111/bjet.12841

4. Hernández-Pérez, T.: En la era de la web de los datos: primero datos abiertos, después datos masivos. El profesional de la información (EPI) 25(4), 517–525 (2016)
5. Hu, S., Zou, L., Yu, J.X., Wang, H., Zhao, D.: Answering natural language questions by subgraph matching over knowledge graphs. IEEE Transactions on Knowledge and Data Engineering 30(5), 824–837 (2018)
6. Serra, I., Girardi, R.: A process for extracting non-taxonomic relationships of ontologies from text. vol. 3, p. 119. Scientific Research Publishing (2011)
7. Szekely, P., Knoblock, C.A., Slepicka, J., Philpot, A., Singh, A., Yin, C., Kapoor, D., Natarajan, P., Marcu, D., Knight, K., et al.: Building and using a knowledge graph to combat human trafficking. In: International Semantic Web Conference. pp. 205–221. Springer (2015)
8. Yu, T., Li, J., Yu, Q., Tian, Y., Shun, X., Xu, L., Zhu, L., Gao, H.: Knowledge graph for tcm health preservation: Design, construction, and applications. Artificial intelligence in medicine 77, 48–52 (2017)
9. Zaki, N., Tennakoon, C., Al Ashwal, H.: Knowledge graph construction and search for biological databases. In: 2017 International Conference on Research and Innovation in Information Systems (ICRIIS). pp. 1–6. IEEE (2017)

ISSN 1870-4069

Towards Negotiating Agents with Realistic Emotional Relationships in Intelligent Learning Environments

José Ángel Villarreal Hernández[1], María Lucila Morales Rodríguez[1], Laura Cruz Reyes[1], Claudia Gómez Santillán[1], Nelson Rangel Valdez[2], Héctor Fraire Huacuja[1]

[1] Tecnológico Nacional de Mexico, Mexico

[2] CONACyT Research Fellow, Mexico

trekolet@gmail.com,{lucila.morales,lauracruzreyes, claudia.nelson.rangel}@itcm.edu.mx, automatas2002@yahoo.com.mx

Abstract. Social agents within Intelligent Learning Environments can enhance their own abilities by interacting to reach agreements and carrying them out. The typical reasoning process that directs agents to rejection or acceptance of these agreements is negotiation. In broad terms, an agreement is a series of conditions and commitments accepted by the parties involved that may refer to a future action plan, an exchange of articles, or assignment of tasks and roles. This article is aimed at proposing a negotiating agent that manifests realistic reactions resulting from forming emotional relationships that reflect in their interactions the characteristics of their personality and their emotional state. To this end, the use of negotiations in the development of social activities, some approaches for the implementation of negotiations between agents and software for the implementation of these agents are addressed. To conclude, the proposal of an agent that includes personality and emotions in the negotiation process to contribute to the realistic behavior of interactions in social agents is presented.

Keywords: intelligent learning environments, social agents, negotiating agents, decision making, personality and emotions.

1 Introduction

Negotiation is a central activity in human society, although it is common to think that the negotiation process is only carried out to achieve purchase agreements, labor agreements or agreements in politics, we also use it in daily situations without paying much attention. These situations can be as frequent and ordinary as an outing with friends. Continuing with this example, the group must first agree on the date for the meeting; they can also decide whether to take a walk in the park or go to the cinema.

If you pay attention, we find a second negotiation situation in the location, where surely to make a decision the films available on the billboard and their schedule will be reviewed. Towards the end of the afternoon they may be hungry generating a new negotiating situation. Will they go to a restaurant or to the house of one of their friends to order food at home? Will they order pizza, chicken, Chinese food ...?

As you can see in the example, negotiation allows a group of individuals with different interests to find realistic and satisfactory solutions.

Negotiation is a process that seeks to reach an agreement and this may be the solution to situations in which it is necessary to reach business dealings, resolve conflicts or to form alliances [1].

In the real world, the relationship between emotions and personality causes changes in human interactions and therefore in negotiations. A contribution to realistic behavior can focus on modeling behavior using personality to create patterns of behavior and emotions to adapt behavior to particular situations. In this work we use these ideas to create an adaptable negotiating agent.

Within the Intelligent Learning Environments, negotiating agents can participate in simulations as actors or tutors. To provide them with the negotiating capacity we must go to the field of automatic negotiation, this field is dedicated to the investigation and study of the mechanics and strategies of negotiation, resulting in computable procedures used to obtain agreements.

2 Collective of Negotiating Agents

The agreements reached through negotiation allow resolutions for situations of assignment of tasks, allocation of resources and resolution of conflicts between agents. Social agents generally have mechanisms that allow beneficial interactions for the individual purposes of each agent [2, 3], such as:

a. *Communication* that considers communication protocols and levels of communication, can deal from simple isolated data to an integral representation of the communicating agent;
b. *Negotiation*, which is the process of reaching agreements in matters of common interest, consists of negotiation domain, protocol, strategy and rule of agreement;
c. *Cooperation acts* understood as the temporary joint operation that allows beneficial treatment for the agent's purposes;
d. Attitudes of *competition* that are appropriate in limited media environments, negotiation and cooperation come into play.

2.1 Overview of Negotiation between Agents

For the implementation of the processes involved in the negotiations we must first understand what the interactions are like. An interaction is a reciprocal action or influence between two or more entities, we can consider that the interaction requires a capacity and an opportunity to occur since a situation of opportunity that does not have the capacity to perform actions does not produce interaction, in the same way that a capacity without the opportunity to exercise does not produce an interaction either.

In the interactions, the entities involved maintain communication, but how are they to communicate? What is going to communicate?. The ***how*** is resolved by the negotiation protocol and the ***what*** by the agent's decision-making model.

What does a negotiation protocol do? A negotiation protocol determines the general order of the actions that occur during a negotiation session, it is understood as the set of rules that govern the way in which the negotiation is carried out [1]. The protocols describe whether the negotiation has ended, what is the agreement, what actions can be done in the next round. In each particular negotiating state, the number of participants and the valid actions of the participants are taken into account, for example: what messages can be sent by whom, to whom they can send them and at what stage. They can also provide some timeline to agents and notify that a limit of rounds has been reached. In the literature [4] some protocols can be found such as 1) Stacked Alternating Offers, 2) Alternating Multiple Offers, 3) Alternating Majority Consensus, 4) Simple Mediator Based and 5) Mediator Feedback Based.

What should a decision making model consider? During the negotiation, the agent exchanges proposals with the other participants to reach an acceptable agreement, which is a contract that all negotiating parties accept [1]. The set of all possible negotiation results is called negotiation domain. Preferences on the negotiation domain that each agent has define a particular negotiation scenario. So making decisions is navigating the negotiation domain proposing, accepting or rejecting possible solutions.

In the development of a negotiation session it is common for agents to make a proposal and at some point one will be accepted for which the agent must be able to perform the following two tasks: 1) *Formulate offers*, which implies some knowledge of the negotiation issues and their possible values. 2) *Choose appropriate actions*, which implies a design capable of operating with the actions defined in the negotiation protocol, it is generally sought to use them in the most convenient way to their objectives.

2.2 Approaches to Negotiation Techniques between Agents

Observing the techniques of automatic negotiation in the paradigm of agents, Huhns and Stephens in [2] have identified two aspects described below:

Environment-centered techniques: they seek to solve the question: How can the rules of the environment be designed so that the agents in it, regardless of their origin, capabilities or intentions, interact in a productive and equitable way? For this, the negotiation mechanism produced should have the following five characteristics: 1) Efficiency: the environment must not allow agents to waste resources to reach an agreement; 2) Simplicity: the negotiation mechanism should impose low computing demands and bandwidth on agents; 3) Stability: no agent should have an incentive to deviate from the agreed strategies; 4) Distribution: the negotiation mechanism should not require a central decision maker; and 5) Symmetry: the mechanism should not be biased against any agent for arbitrary or inappropriate reasons.

Agent-centered techniques: focus on finding the best strategy for the agent to follow a given environment. Most of these negotiation strategies have been developed for specific problems, so few general negotiation principles have emerged. However, there are two approaches, each based on an assumption about the particular type of agents involved: In the first approach it seeks to formalize the negotiation protocols and their components, through speech acts together with a possible common semantics. This clarifies the conditions of satisfaction for different types of messages. The second approach is based on small sets of agents, which must have a common language and abstraction of the problem to reach a group solution. In the development of the negotiation the agents discuss a set of all the offers that have a positive utility for each agent. These agents follow a pre-established protocol to create a deal, that is, a joint plan between the agents that would satisfy all their objectives.

3 Automated Negotiating Agents

Research on negotiating agents have different methodological and software tools to support planning, documentation, implementation and experimentation. For example, on the side of the methodological tools are AUML [5], ANML [6] and on the software side we find GENIUS [7] and IAGO [8]. These last two tools provide facilities in the development and testing of negotiating agents. Both have been used in the Automated Negotiating Agents Competition (ANAC) tournaments [9, 10, 11].

GENIUS [7] was created as a tool for research in the area of bilateral negotiation of multiple topics that facilitates the creation of negotiating agents and information gathering. Its name comes from the acronym of Generic Environment for Negotiation with Intelligent multi-purpose Usage Simulation. GENIUS allows you to simulate individual negotiation sessions, as well as tournaments between negotiation agents in various negotiation scenarios. It can also be used in experiments with human negotiators who negotiate against automatic agents or other human beings.

On the other hand, the Interactive Arbitration Guide Online (IAGO) platform [8] was specifically developed as a test bench for negotiation between agents and humans. It is a web-based servlet hosting system that provides services for data collection and recording, providing an HTML5 GUI for use by humans and an API to design agents with corporeality and dialogues. Built with web technologies, IAGO supports a variety of functions for realistic communication between human agents such as partial offers, preference statements, natural language argumentation phrases (customizable) and expressive humanoid virtual agent.

4 Towards Individually Adaptable Agents

During the negotiations an agent may face the situation in which a second agent generates interactions of little or no value. This assessment made by the first agent about the second can be produced by an interpretation of the agent's actions, regarding the objectives of the first agent. The evaluated agent would now have associated a status that the first agent (evaluator) should consider in his reasoning.

The evaluating agent must resolve how to meet its objectives considering that there are agents that may not contribute to them or even be contrary to them.

In the following sections we discuss two proposals of the literature in negotiating agents focused on the aspects of pursuit of objectives and management of cooperative behavior. The first proposal uses a reasoning system based on beliefs, desires and intentions (BDI - beliefs, desires and intentions) in a multi-agent negotiation system; the second uses the concept of personality to model cooperative behavior in dependency relationships. To conclude, the conceptual proposal of a negotiating agent adaptable to individual treatment with other agents is presented. The behavior of this agent is the result of the influence of his personality profile and an emotional state on the BDI scheme.

4.1 Agents with Beliefs, Desires and Intentions

The BDI reasoning scheme represents a decision-making mechanism applicable to automatic negotiation. This reasoning allows the individual objectives (desires) to be met in an environment that produces new data to be interpreted by forming beliefs. Decision making (intentions) is affected by these interpretations of the environment. A representative example is the work of Kiam Tian Seow and Khee Yin How in [12] where they present a multi-agent collaboration algorithm that uses the concepts of the BDI scheme. In this work the negotiation is collaborative since it involves the reasoning and interaction of the agents in an attempt to achieve their own objectives. In general terms, each collaborating agent has local knowledge only and the individual intentions of exchanging resources are arbitrated by an agent dedicated to this role. This arbitrating agent coordinates the negotiations and the collaborating agent communicates his intentions awaiting a response. The authors consider that collaborative negotiations allow us to propose a parallel treatment to the problem, which is why they extend centralized algorithms to a parallel-distributed approach.

4.2 Negotiating Agents with Personality

To establish cooperative relationships, agents must be willing to participate in useful behavior and maintain their commitments to other agents. Talman and collaborators in [13] use a model in which an agent chooses actions based on the degree of utility of other agents, given a dependency relationship between them. Agents perform their assigned task by design and choose a collaborator whose behavior is observed, which is interpreted as their personality. The collaborators attend the requests with certain frequency and give results of different reliability, these variations in their behavior are valued by the other agents. In this model, the utility of the agents is characterized in terms of cooperation and reliability. Their experimentation was carried out in a negotiation game in which participants need to exchange resources to achieve their objectives, without information about the resources of others. Talman and collaborators report demonstrating that agents that vary cooperation and trustworthiness regarding who they interact with can outperform agents that do not perform adaptation. They estimate that identifying individuals and adapting behavior to them allows them to punish non-useful behaviors against those that are, which improves the performance of all agents in the system, including non-useful agents.

4.3 Towards a Negotiating Agent with Personality and Emotions

This section presents the currently working on the project of creating an agent with a behavioral model that includes personality and emotions to make it individually adaptive in the development of negotiations. By implementing the behavioral model, the agent would be affected by his reasoning and gain the ability to individually evaluate another agent, form a judgment about it and integrate this judgment into the landscape of a global problem. In this way, it will be able to form emotional relationships with other agents and present reactions to the particular situation since the other agents have different objectives and behaviors. The implementation of this agent was called *Affective Negotiating Agent* (ANA) and the behavior model was given the name of *Architecture for the Integration of Personality and Emotions in Negotiation* (AIPEN). The works described in sections 4.1 and 4.2 use objective-based systems, generate trends in their decision-making and create valuations of other agents. Unlike these works where the main focus is optimization, the ANA design focuses on the behavioral differences that are exhibited in different situations. The differences in negotiation behavior occur in how different types of personalities experience an emotional state in the context of an affective relationship between agents. This will generate changes in the way of dealing with each agent and will cause the evolution of their relationships varying their degree of cooperation.

To exemplify the proposal, first imagine a group of agents that must negotiate using the Alternating Multiple Offers Protocol [4], where each has its own personality profile. The personality profile has the function of directing the action plan that the agent will use giving him a behavioral tendency, ranging from an aggressive negotiation plan to a collaborative one; this action plan consists of a negotiation strategy and a type of dialogue. The emotions of the agent are caused by the experiences that are had with another agent that is the source of those emotions (that is, a causal agent), the role of emotions is to adjust the action plan. The agent must follow that plan by making offers and voting for or against offers shared by the rest of the agents. The supply and voting actions would be accompanied by a dialogue that varies according to the personality profile and the emotional state of the agent, this would serve as a means of expression that allows sharing useful information such as the agent's beliefs and preferences. Given the above, we can initiate a negotiation protocol that would request an initial offer to be shared with the other agents in the negotiation, which in turn also share an opening offer.

Once the agent receives the offers and dialogues from the other negotiators, a three-stage process begins: *interpretation*, *strategy* and *action*. It begins with the stage of *interpretation* where the agent will begin an analysis of each of the responses captured, this process would be based on emotional and personality models so that each agent can determine if the actions and dialogues received are pleasant or not, if the causal agent likes it or not and if he considers the negotiations to progress or not. With the results obtained from this analysis, the agent's emotional state, its negotiation strategy and types of dialogue are updated.

After evaluating the actions of the other agents and having a new emotional state, the *strategy* stage is entered. At this stage a variation of the action plan indicated by the personality profile is generated, in which the emotional state of the agent and the quality of the relationship with each agent are taken into account.

To find the new action plan would be considered a mapping (personality, emotion) that is associated with one of several plans, for example *Yield* in the next offer, *Keep* it or *Demand* more; so that each type of personality experiences and reacts differently to each emotion. Now, to integrate the quality of the relationship with each agent in the negotiation reasoning, we take advantage of the previous evaluation. Since the agent can form an individual image of each member of the group, he can also choose which of these to take into account and to what extent to consider them to formulate the following offer, for example, will give benefits to the agents with whom he has better relations and in the case of electing votes, varying the ease with which one votes in favor of an offer. In addition, it will be possible to select the type of dialogue that will be used with a specific agent, which could be *Friendly*, *Rough*, *Neutral* or *Inexpressive* as a result of a mapping (personality, quality of relationship). Thus, for example, in the case of interacting with an agent with whom you have bad relations, the dialogue can become empty (analogy of withdrawing the word to someone who is not to our liking).

As the next step in the protocol, the votes chosen by each agent with respect to each offer are requested, placing the agent in the stage of *action* in which he performs the necessary calculations to accept or reject an offer. The protocol proceeds by sharing the votes between the agents and the group of agents once again enters the stage of *interpretation* in which they analyze the vote and dialogue. The data generated will serve the agent to continue to form an image of the other agents and have elements to decide the following votes and offers. With regard to the protocol, it will follow its normal order alternating rounds of bidding and voting.

The relationships between the agents would evolve producing some social situations. A situation is expected to have a direct effect on the collaboration: an agent could be friends with another agent and as a consequence grant him benefits in the negotiation; or, on the other hand, antagonize and be progressively more demanding, one end of this behavior can be a total cut of communication. Another possible situation is the adaptation of the individual to the group, consider an agent whose offers are very aggressive for a group of agents that do not tolerate that behavior, with the passage of the interactions the aggressive agent could begin to be rejected by the members of that group which would worsen the aggressive agent's chances of reaching an agreement (considering that as bad as it may be, an agreement is more valuable than not achieving any). Consequently, the aggressive agent would be forced to change his behavior with these agents to some extent.

5 Conclusion and Future Works

Whatever the case, social agents with these behavioral adaptation capabilities would be valuable in different fields where negotiations are applied. Agents endowed with these characteristics can enhance their abilities by forming relationships based on the profit or utility that they perceive from others, responding to these relationships with cooperation if they are positive and evasion if they are negative. The above reinforces realistic behavior since it is typical human behavior to associate with individuals with similar goals and problems.

For example, a simulation to perform sales training exercises against different types of personalities such as training in the role of seller or buyer. Another example may be a serious game in which a game mechanic based on negotiation is used to exchange goods or plan agreements between different virtual agents and the player; then during the development of the game different sides could be generated based on the evolution of relationships.

Acknowledgments. This work has been partially supported by: (a) CONACyT/ Programa Nacional de Posgrados de Calidad; (b) Project 3058 from the program Catedras CONACyT, and (c) Tecnológico Nacional de México – Instituto Tecnológico de Ciudad Madero.

References

1. Baarslag, T.: What to bid and when to stop. Dissertation, Delft University of Technology (2014). DOI: 10.4233/uuid:3df6e234-a7c1-4dbe-9eb9-baadabc 04bca.
2. Weiss G.: Multiagent Systems: a Modern Approach to Distributed Artificial Intelligence. MIT Press, Cambridge, Mass. (1999).
3. Ferber J.: Les Systèmes Multi Agents: vers une intelligence collective. InterEditions (1997).
4. Baarslag, T., Pasman, W., Hindriks, K., Tykhonov, D.: Using the Genius Framework for Running Autonomous Negotiating Parties. (2019).
5. Abushark, Y., Thangarajah, J.: AUML Protocols: Specification to Detailed Design. (2013).
6. Paurobally, S.: Rational Agents and the Processes and States of Negotiation (2002).
7. Lin, R., Kraus, S., Baarslag, T., Tykhonov, D., Hindriks, K., Jonker, C.M.: Genius: an Integrated Environment for Supporting the Design of Generic Automated Negotiators. Computational Intelligence. 30, pp. 48–70 (2014). DOI: 10.1111/j.1467-8640.2012.00463.x.
8. Mell, J., Gratch, J.: IAGO: Interactive Arbitration Guide Online (Demonstration). 3 (2016).
9. Jonker, C.M., Hindriks, K.V., Wiggers, P., Broekens, J.: Negotiating Agents. AI Magazine. 33(79) (2012). DOI: 10.1609/aimag.v33i3.2421.
10. Automated Negotiating Agents Competition (ANAC)–Negotiation: http://ii.tudelft.nl/negotiation/index.php/Automated_Negotiating_Agents_Competition (ANAC) (2018).
11. Mell, J., Gratch, J., Baarslag, T., Aydoğran, R., Jonker, C.M.: Results of the First Annual Human-Agent League of the Automated Negotiating Agents Competition. Proceedings of the 18th International Conference on Intelligent Virtual Agents- IVA'18. ACM Press, pp. 23–28 (2018). DOI: 10.1145/3267851.3267907.
12. Seow, K.T., How, K.Y.: Collaborative Assignment : A Multiagent Negotiation Approach Using BDI Concepts, International Joint Conference on Autonomous Agents & Multiagent Systems, AAMAS (2002). DOI: 10.1145/544741.544803.
13. Talman, S., Hadad, M., Gal, Y., Kraus, S.: Adapting to agents' personalities in negotiation. (2005). DOI: 10.1145/1082473.1082532.

ISSN 1870-4069

Determining the Relationship of Admission Features and Finishing University Studies using Educational Data Mining and Information Visualization

Josué Figueroa González, Beatríz A. González Beltrán,
Silvia B. González Brambila, Lourdes Sánchez Guerrero

Universidad Autónoma Metropolitana, Azcapotzalco,
Mexico

{jfgo, bgonzalez, sgb, lsg}@azc.uam.mx

Abstract. The analysis of academic data looking for patterns of interest has increased in the last years. However, this is not a simple process, especially considering the amount of data that is generated in an educative environment. With thousands of data, it is complicated searching for patterns that can simplify or improve an analysis. However, humans have an innate capacity for understanding images better than data, using this ability simplifies the process of finding patterns for its later analysis. This work shows the analysis of admission features for determining their impact in finishing or not of university studies using Educational Data Mining and Information Visualization. Results show that first approaches obtained from visualizing the data and finding patterns simplify the process of determining the effect of these features. It is also shown that a student with an older admission age is prone for not finishing their studies.

Keywords: admission features, educational data mining, information visualization, student performance, visual analytics.

1 Introduction

Educational data mining (EDM) refers to the use of Data mining techniques for analyzing academic or educational information [6]. Applications of EDM cover from predicting the marks in a single exam, to the creation of models for determining if a student would finish or not its studies. A traditional process of EDM involves the same steps of Data Mining (DM): obtaining data, a process for cleaning it, applying DM algorithms according to a desired goal and exploiting results for making decisions.

In DM process, the most important part are the data, they are the source of all the process, so knowing the data, their characteristics or patterns becomes a fundamental step at the moment of the analysis. As data grow, they become more complex for analyzing, so having a previous comprehension of them before the analysis is desirable.

One of the challenges is how to analyze a set of data composed of thousands of registers with several characteristics for finding patterns that later can be studied or verified using EDM techniques. Information Visualization offers an answer to this; humans have a cognitive perception that makes easier finding information in a visual way rather than in a textual one. Information Visualization can be defined as the techniques used to represent textual information in a graphical way for facilitating its analysis [7].

Combining DM and Information Visualization creates a new area called Visual Analytics (VA) which is defined as the science related to analyzing information using visual interfaces [2]. In VA, users view graphic representations of the data and adjust parameters of models according to the interpretation of the graphics. Models are updated, and users can interact again with them. Information Visualization and DM combination applied to an educational environment is the focus of Visual Learning Analytics (VLA) [9].

Many public universities in Mexico face the problem that their rate of graduated students is not as high as expected, in some universities is less than 10%. Reasons for not finishing undergraduate level studies are several, can be personal, academic or labor ones. In the academic, can be identified: performance over different courses, but also, could be related to the admission characteristics of students.

This work presents a combination of Information Visualization and Educational Data Mining for determining the influence of the admission characteristics of entrance age, high school average and mark in the admission exam over students' completion of their professional studies. Goal of the work is showing the benefits of combining Visualization Information with EDM for simplifying the process of analyzing data and identifying those factors that affect students in finishing or not their studies.

2 Related Work

Analysis of whether a student will or not finishing its studies use mainly predictive algorithms and consider performance over different scholar periods in students' trajectory, personal characteristics of the students and admission features.

In [4] was performed a study of 8 different data mining algorithms to predict the performance of students who completed a module in a computing degree course. The sample was composed by the information of 22 students, which was obtained from the Student Information System (SIS) and the time spent by students on the Moodle platform. As a result of this analysis, it was determined that the Random Forest algorithm was the most suitable algorithm to predict the performance of students using the lower mean absolute error and the relative absolute error as evaluating metrics.

In [8], was proposed a Triadic Model for Teaching Analytics composed by a Teaching Expert, a Visual Analytics´ Expert and a Design-Based Research Expert that analyzed, interpreted and acted in real-time and in-situ, generating student´s learning activities to improve the learning environment. They promoted that to deal with the demands of the "New Demands on Teachers in the 21th Century Classrooms" project, teachers need to react in real-time and in situ for capturing information about student's learning, interpreting it, following the curricular goals and making reasoned decisions about next learning steps.

In [1], was studied the relationship between the cognitive admission entry requirements and the academic performance of students in their first year. The data set analyzed was composed of 1,445 student records from 2005 to 2009. Examined features were: students' entry age, the Joint Admissions and Matriculation Board score, the university score and the aggregate West African Examination Council score to predict the class of the student's first year grade. Were used six data mining algorithms. Logistic Regression had the highest prediction accuracy with 50.23% and Decision Tree had the least accuracy with 39.631%. The data mining models and regression shown that although there is a relationship between the admission requirements and the academic performance of students in their first year student, this is not very strong.

In [3], was performed a comparative analysis of data mining tools used for predicting student performance, highlighting the advantages of classification algorithms for this prediction.

Student's GPA is the main attribute that determine the performance of the student.

3 Data and Analysis Process

Analysis process involved discovering patterns through visualization techniques and then verify this patters using predictive algorithms. Were considered the general steps for applying data mining and visualizing information: data processing, visualizing, establishing a statement and finally, verifying the statement.

3.1 Data Set and Data Cleaning

Data set considered for this work was obtained through the General File of Students (AGA, for its Spanish acronym) which contains a lot of information about all the students that have or are studying at university. Were considered engineering students that entered university from the years 2010 to 2014, this period was considered for having a balanced set of students that had and had not finished their studies. The amount of students processed was 8,638. The considered admission characteristics were:

– Entrance age (AGE). Age of the student at the moment of entering university, with a range of years old from 16 to 58 with an average of 26.8.
– High school level average (AVG). The average of high school level obtained from the student, values run from 7 to 10 with an average of 8.2.

– Mark in the admission exam (EXA). The total of points obtained by a student in the admission exam, values run from 400 to 1000 for a maximum of 1000, the average of this feature was 677.

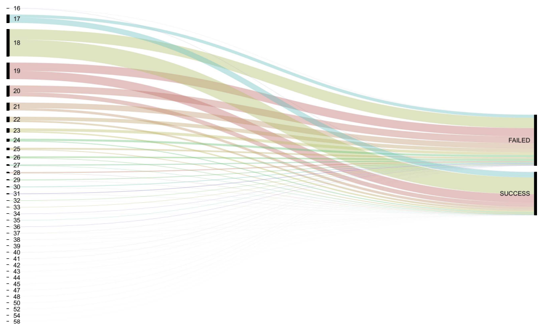


Fig. 1. Relationship of entrance age (AGE) and finishing or not university studies.

Output had two categories, if the student finished (Success) or not (Failed) their studies. Success was considered if the student had obtained its degree or had completed the total of credits of its college career. Failed status was given to those students that did not finish their studies and were dismissed because of reaching the limit time for finishing their studies (12 years) or due to failing the same course more than 5 times.

As part of the cleaning process, some criteria were transformed; for avoiding a lot of variations in the values, was used only the integer part of the average of medium high school level (AVG). Something similar happened with the mark in the admission exam (EXA), where students were grouped in hundreds, from 4 to 5 hundreds, 5 to 6, and so on until the limit of 1,000.

3.2 Visualizing and Analyzing Data

For presenting the relationship between each criterion and the result of Success and Failed, was used the Alluvial diagram using RawGraphics web platform [5]. In this graphic, there are weighted flows over a series of steps composed of nodes, and the size of flows is given by the amount of registers with the same characteristics.

All figures present in the left side the possible values of the displayed features, and in the right side is the result of finishing (Success) or not (Failed) university studies.

The relationship between entrance age and finishing or not university is shown in Fig. 1. Ages run from 16 to 58 years old. There is a clear relationship between the entrance age and the success or failure in the studies. Graphic shows that older students tend to fail in finishing them.

Fig. 2 shows the relationship between the average in the high school and finishing university. Integer average run from 7 (the minimum requested in the university) to 10, values of 0 and 6 appears due to some special cases. Students with an average in the range of 7, tend to fail in their studies. 8 can be considered as a break point with a similar distribution for each case. Students with an average of 9 and 10 tend to finish their studies.

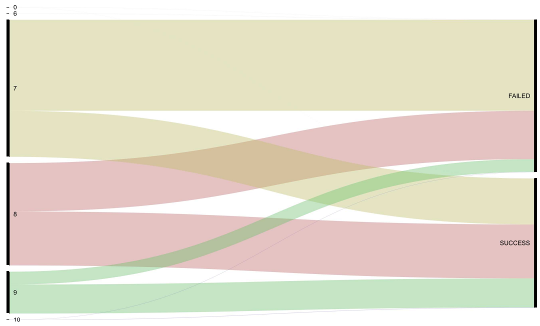


Fig. 2. Relationship of medium high school level average (AVG) and finishing or not university studies.

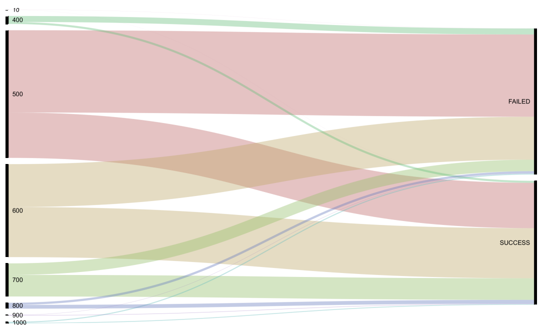


Fig. 3. Relationship of mark in admission test (EXA) and finishing or not university studies.

Fig. 3 presents the relationship of the mark in the admission exam and finishing or not the studies. Admission exam values run from 400 to 1,000; however university ask for a minimum of 500, but in some scholar periods, according to students requests, they can be accepted with a lower mark. Here can be noticed that students in the range from 400 to 500 points tend to fail in their studies. Again, there is a breaking point, 600 points, where there is a similar distribution for finishing or not. Students from 700 to 800 tend to finish their studies in a bigger proportion than those who do not. Students with the best marks, 900 and 1,000 are balanced in the amount of those that finish or not.

3.3 Establishing an Statement

Visual information presented in Fig. 1 to Fig. 3, shows that all criteria has a relationship with their value and finishing or not the studies. However, the one that has the most significant influence in finishing or not studies is entrance age. For this reason, were analyzed students grouped by ages.

- 16 to 18 years old students, where the proportion of students that finished their studies are greater than those who did not.
- 19 years old students appears to be the “breaking point”, a proportion of 50% in each case it seems to be present.
- Students older than 20 years tend to have a bigger proportion of those that did not finish their studies. Although the number of students decrease, the trend of failing in their studies raises.
- This group was divided in other age ranges, considering those who have a similar performance, so were created: students from 20 to 23 years old, from 24 to 27 years old, and finally, students older than 28 years old.

From the data observed in the graphics, it was proposed the following statement: “entrance age has the greatest impact for a student for finishing or not their studies”. This statement was verified using DM techniques. In this work, it was employed a predictive model considering that as bigger the accuracy, more true has to be the statement.

3.4 Verifying the Proposed Statement

For verifying the previous statement, it was generated a predictive model using 70% of the data for training. A classification model, considering all ages, was obtained using a decision tree, specifically the Classification and regression tree algorithm (CART). The model was tested then in different groups of ages.

- Considering only the AGE criteria.
- Considering AGE and AVG criteria.
- Considering AGE, AVG and EXA criteria.
- Not considering AGE.

According to the proposed statement and the figures, it was expected that a set with an older range of ages, has a bigger accuracy on the number of students classified as failed in their studies.

4 Results

The generated tree is shown in Fig. 4. As it can be seen, the root, the most important feature in a decision tree, is the entrance age (AGE) and contains the value of 20 years old. According to Fig. 1, the breaking point was 19 years old, meaning that 20 years old students tend to fail in their studies.

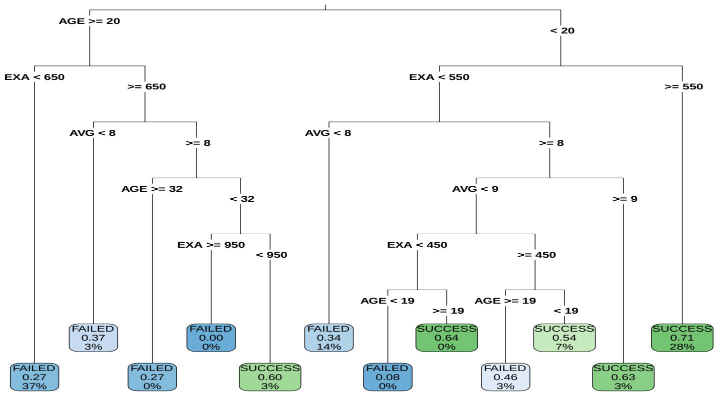


Fig. 4. Decision tree generated after processing data.

Table 1 contains the average accuracy for each group of age and different combinations of criteria.

Table 1. Accuracy of groups of ages and features.

Age group	(AGE)	(AGE+AVG)	(AGE+AVG+EXA)	Not AGE
All ages	60.4	59.7	58.3	58.3
16 to 18	62.51	63.91	67.49	65.84
19	50	60.52	64.60	63.5
20 to 23	66.04	66.04	67.55	65.5
24 to 27	73.02	73.02	74.34	69.7
28 or older	84.87	84.87	84.87	71

Table 1 shows that as the entrance age increases, the accuracy of the models raises, except in the case of 19 years old, the one that was identified as a break point in Fig. 1. This is because students younger than 20 years old did not show a clear distribution for finishing or not their studies, as shown in Fig. 1, meanwhile students older than 20 years old shown a clearer distribution.

5 Conclusions and Future Work

This paper presents the combination of Information Visualization and Educational Data Mining techniques for analyzing the effect of some admission characteristics over the undergraduate student successful rate. According to the state of art, a combination of Information visualization and Educational data mining can simplify the analysis process through finding patterns in a simpler way using images, then testing these patterns through data mining techniques.

Results show that the patterns found in the visualization stage were validated using a decision tree. The proposed statement was that students with an older age tend to not finishing their studies, and graphics show that score in admission test and average in high school have some importance. Visualization allowed determining the set of ages for which the generated model was more effective. Also, a predictive model from which results considering all ages was not efficient (accuracy of 60%) shows a good performance (more than 84%) for a group of older ages. For ages younger than 23 years old, the accuracy is very low. This means that for these students more features should be considered for predicting if they will or not finishing their studies. It was established that the entrance age to be affected was over 20 years old, the model shown this, but results shown that accuracy becomes significant at 24 years old.

This means that probably the group of 20 to 23 years old should be regrouped again. As future works, it is considered a more specific analysis on these groups of ages. Also a similar analysis using visualization should be applied to groups which have a low accuracy adding other characteristics more than admission ones.

References

1. Adekitan, A.I., Noma-Osaghae, E.: Data mining approach to predicting the performance of first year student in a university using the admission requirements. Education and Information Technologies pp. 1–17 (2018)
2. Cook, K.A., Thomas, J.J.: Illuminating the path: The research and development agenda for visual analytics. Tech. rep., Pacific Northwest National Lab.(PNNL), Richland, WA (United States) (2005)
3. Dagim, S., Proo, P., Pro, A.: Predicting performance and potential difficulties of university student using classification: Survey paper. International Journal of Pure and Applied Mathematics 118, 1314–3395 (2018)
4. Hasan, R., Palaniappan, S., Raziff, A.R.A., Mahmood, S., Sarker, K.U.: Student academic performance prediction by using decision tree algorithm. In: 2018 4th International Conference on Computer and Information Sciences (ICCOINS). pp. 1–5. IEEE (2018)
5. Mauri, M., Elli, T., Caviglia, G., Uboldi, G., Azzi, M.: Rawgraphs: a visualisation platform to create open outputs. In: Proceedings of the 12th Biannual Conference on Italian SIGCHI Chapter. p. 28. ACM (2017)
6. Romero, C., Ventura, S.: Educational data mining: a review of the state of the art. IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews) 40(6), 601–618 (2010)

7. Shneiderman, B.: The eyes have it: A task by data type taxonomy for information visualizations. In: The craft of information visualization, pp. 364–371. Elsevier (2003)
8. Vatrapu, R., Teplovs, C., Fujita, N., Bull, S.: Towards visual analytics for teachers' dynamic diagnostic pedagogical decision-making. In: Proceedings of the 1st International Conference on Learning Analytics and Knowledge. pp. 93–98. ACM (2011)
9. Vieira, C., Parsons, P., Byrd, V.: Visual learning analytics of educational data: A systematic literature review and research agenda. Computers & Education 122, 119–135 (2018)

ISSN 1870-4069

Enhancing Online Teaching Laboratories with a Semantic-based Search Mechanism

Gustavo Gutiérrez Carreón, Salvador Antelmo Casanova Valencia, Pedro Chávez Lugo

Universidad Michoacana de San Nicolás de Hidalgo, Mexico

{gagutc, casanova, pchavezl}@umich.mx

Abstract. This paper presents an ontological design to search laboratory instruments and devices on distributed networks. The model was designed to locate learning services semantically, facilitating collaboration and user customization. A semantic-based online laboratory is presented, which provides students and instructors with a search mechanism for laboratory resources, such as instruments and devices. The use of ontologies is the primary mechanism that allows devices and instruments to be defined semantically. This model can be used in any teaching laboratory. A case study of an Optoelectronics online teaching laboratory is presented; in this, undergraduate students can remotely control instruments and devices. The effectiveness of our approach has been measured and evaluated through usability methods.

Keywords: online labs, ontologies, personalized e-learning, semantic search.

1 Introduction

The use of ontologies in general and the semantic description of web services, in particular, is becoming more relevant for interactive learning scenarios because it provides a mechanism to describe the resources and functional capabilities distributed across networks that can be centralized through portals and presented to students in different types of devices. [1] present how the personalization of students' learning process is achieved through leveraging the use of the social semantic web, using resource description framework models, ontologies, social networking, and collaborative tagging. Personalization allows new e-learning environments to act as intelligent systems that best fit the needs of their users and especially students according to their interests, preferences, motivations, objectives, and knowledge.

In this work, we propose a semantic model for online laboratories with the capability to search distributed resources on the Web, which allows semantic browsing of remote instruments and devices, collaboration among participants and customization.

To this end, in the rest of this paper, we first present related work with semantic descriptions for online laboratories; we then introduce the semantic modeling of online laboratory elements and discuss how it can be used to discover resources in a network. Next, we present an optoelectronic online laboratory implementing a common access point for instruments and devices, making them searchable by non-functional properties described in a semantic model. We evaluated our approximation in terms of the System Usability Scale (SUS).

2 Related Work

Recent work in semantic search and ranking is concerned with addressing the challenge of finding entities in the growing Web of Data [2]. In that sense, there is some important research work that deals with semantic search mechanisms based on an ontology for virtual laboratories. Lab2Go of the Carinthia University of Applied Science [3] presents a potential solution in the form of an online portal supported by the Semantic Web. The basic idea of the Web portal is a repository that offers a common framework to collect and describe laboratory data from different laboratory providers located all over the world. They define a general model for online laboratories and a Web repository based on Semantic Web technologies to facilitate the use of new tools to publish and exchange online laboratories and other related resources. As a search tool, the project uses OntoWiki. This tool enables search mechanisms like faced based browsing which allows the user to search for information according to the properties of a particular object. We share all these ideas in the development of our ontological model and search mechanism. Library of Labs (LiLa) [3] has been a European Community funded project to network remote experiments and virtual laboratories. The goal of this project has been the composition and dissemination of a European infrastructure for mutual exchange of experimental setups and simulations, specifically targeted at undergraduate studies in engineering and science.

Go-Lab [4] offers teachers with the capability to create dedicated inquiry learning spaces (ILS) and support this process by proposing scenarios and lesson plans. For apps, Go-Lab follows the OpenSocial metadata specification and the ROLE Ontology. For Smart Device specification, they have opted for Swagger that is strongly focused on automatically generating user interfaces. Swagger is based on JSON Schema to specify the data format of requests and responses. These labs can be searched based on an extensive set of metadata that offer direct links. Students do not need an account to use an ILS shared by the teacher with a secret URL. In its next stage, this project continued with the creation of a complete Cloud Ecosystem for Supporting Inquiry Learning with Online Labs [5]. It relies on two core open access platforms, a sharing one (golabz.eu) offering open educational resources supporting science and technology education, and an authoring one (graasp.eu) enabling the construction and the personalization of such resources directly by teachers for teachers. The laboratory experience generated by the teacher can be privately shared with the students as a standalone Web page using a secret URL displayed when clicking a button.

The FORGE initiative (Forging Online Education) [6] aims at promoting the notion of Self-Regulated Learning (SRL) using a federation of high-performance testbeds and at building unique learning paths based on the integration of a rich linked-data ontology.

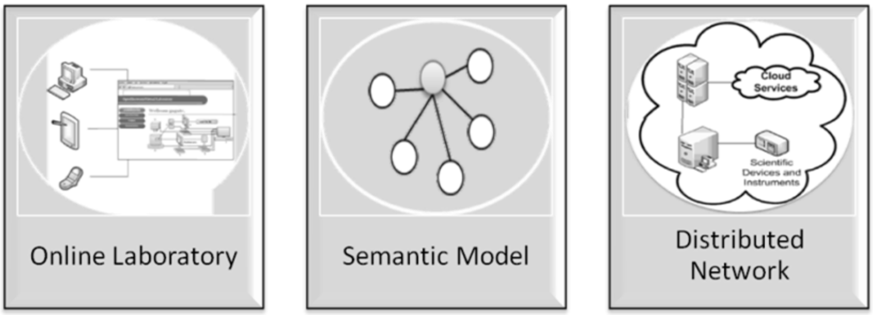


Fig. 1. Online laboratory portal based on a distributed network.

A FORGE vocabulary builds upon existing ontologies such as Metadata for Learning Opportunities (MLO), eXchange of Course-Related Information (XCRI-CAP), or the Teaching Core Vocabulary (TEACH) Through FORGE; traditional online courses are complemented with interactive laboratory courses, supplying an in-depth and hands-on educational experience. To search for learning resources, the student uses a 'goal-setting' widget to record a list of its goals and then uses the Linked Data-enabled Educational Widget Store to discover suitable facilities available as widgets inside interactive learning resources.

Concluding, in the case of Lab2go, they present a complete ontology to describe online laboratories. LiLa presents an ontology that is even more complex than the one used in Lab2go, which is also used to search laboratories. FORGE relies on the use of external ontologies. There are also generic ontologies for the description of instruments, such as the case of SSN (Semantic Sensor Network) [7] or the N8EO project. These works use essential technological solutions, which in all cases describe the components of online labs semantically, in some cases through an ontology and in others through a metadata system, but in all cases, they implement a mechanism of semantic search.

3 Ontology Design of Online Teaching Laboratory Portal

In the online teaching laboratory (Fig. 1), users can connect from various types of devices, such as personal computers, tablets or cell phones, and have access to a centralized portal offering the resources on a distributed network and services. The core functionality of the portal is based on a semantic model, which works as a data container for linking the different services available through the interactive learning environment. As main features of this environment, we can distinguish instruments and device remote control, a role-based access control module, cloud services supporting collaboration and interaction, as well as semantic search of services depending on functional characteristics according to each type of laboratory.

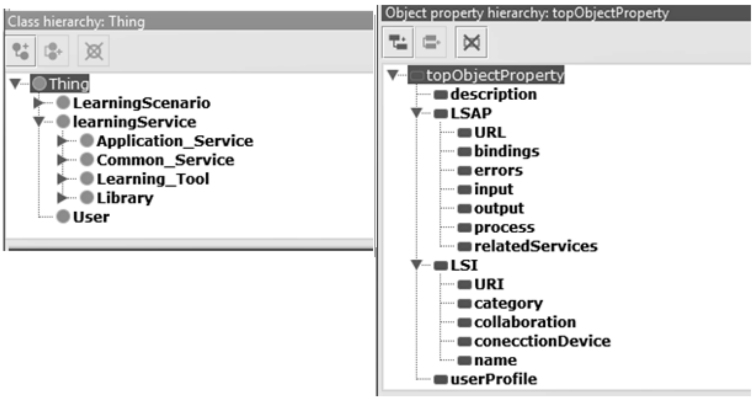


Fig. 2. Online laboratory class.

3.1 Semantic Representation of Services for Online Laboratories

Based on the interaction of the user with the learning environment, the main classes of the ontology and their relationships were identified: User, Learning Scenario, and Learning Service (Fig. 2).

User: This class defines the person, group, or process that uses the learning scenario. Its unique property is userProfile that defines the profile that makes use of a service (learner, teacher, another process, etc).

Learning Scenario: This class defines the stage where the learning process is performed. It allows the interaction between users and the services requested. Its unique property is a Description in which the ontology associated with the learning scenario can be defined.

Learning Services: It is the main class of the model, where, one the one hand, we identify the principal characteristics of Learning Services related to a learning scenario and the activities that support it. On the other hand, we consider Learning Services like a granular functional component with some input information, functional activity, and some output information. In this sense, we form two conceptual groups of properties to achieve a complete description of Learning Services: The Learning Services Identification (LSI) and the Learning Services Access Point (LSAP).

The basic elements used for representing the Semantic Web consist of the use of two core standards: The Resource Description Framework (RDF) [8] and the Web Ontology Language (OWL) [9]. This semantic representation can be extended depending on the specific attributes of the type of laboratory it is intended to put online. RDF Schema defines some classes, which represent the concept of subjects, objects, and predicates. OWL defines ontologies that include classes, properties, and their relationships for a specific application domain. In the case of building an online teaching laboratory aimed at developing experiments using web services, many characteristics of its semantic domain are more significant than merely the learning service name, syntactic description, inputs, and outputs.

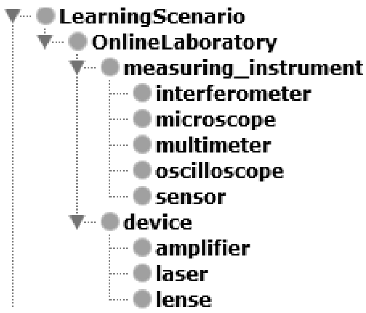


Fig. 3. Optoelectronic class.

4 Case Study: Semantic Search of Devices and Instruments on an Optoelectronic Laboratory

Our semantic model was implemented in an optoelectronic laboratory intended for both teaching and research. On the one hand, this online laboratory was helpful to learn the control of optoelectronic devices through computer equipment. Figure 3 shows the classes related to an optoelectronic laboratory. On the other hand, to access and use equipment managed on servers in various school departments. A computer controls each device or instrument connected to the Internet. Both students and teachers can control all these devices or instruments in real-time, while they manipulate data acquisition as well.

The idea of using a semantic model in an online laboratory is that students when carrying out an experiment involving remote control of instruments and devices can have tools in the same environment that can help them browse and search for these services and publish the URLs to access them. The laboratory aims to provide students with a tool for improving usability and learning experience with less cognitive load and thus more satisfactory. In the case study in which we experimented with an online laboratory, we have focused on defining instruments and devices. However, it can be extended to any object that can be accessed through a URL, such as documents, videos or other types of learning tools defined as a web service.

The process for registering an instrument is that once the service is registered on the Labview server, the administrator or teacher will have to enter the online laboratory to add its access point (URL) and information related to: the name, description, category, type, user profiles for which it will be available, connection device, collaboration, laboratory device and measurement instrument. In our case, these parameters are necessary, and they can be adapted according to the needs of the learning scenario.

This information is stored in an RDF container (called Fuseki in this case). This information can be verified in the instrument catalog, from which we can delete and update elements. When the instrument registration is completed, the functionality is accessed to generate JSON files. Fig. 4 shows the JSON information and the related SPARQL code to generate it.

```
if( !$db ) { print sparql_errno() . ": " . sparql_error(). "\n"; exit; }
    sparql_ns( "labclass","http://www.liberoeducacion.com/laboratories/classes#" );
    sparql_ns( "labdata","http://www.liberoeducacion.com/laboratories/data#" );
$sparql = "
SELECT  ?s ?name ?description ?URI ?category ?type ?userprofile ?collaboration
 ?connectiondevice ?laboratorydevice  ?measuringinstrument WHERE {
    ?s   labclass:name   ?name.
    ?s   labclass:description ?description.
    ?s   labclass:URI ?URI.
    ?s   labclass:description ?description.
    OPTIONAL {?s   labclass:category ?category.}
    OPTIONAL {?s   labclass:type ?type.}
    OPTIONAL {?s   labclass:userprofile ?userprofile.}
    OPTIONAL {?s   labclass:collaboration ?collaboration.}
    OPTIONAL {?s   labclass:connectiondevice ?connectiondevice.}
    OPTIONAL {?s   labclass:laboratorydevice ?laboratorydevice.}
    OPTIONAL {?s   labclass:measuringinstrument ?measuringinstrument.}
        }"  ;
```

Fig. 4. SPARQL code to generate JSON information.

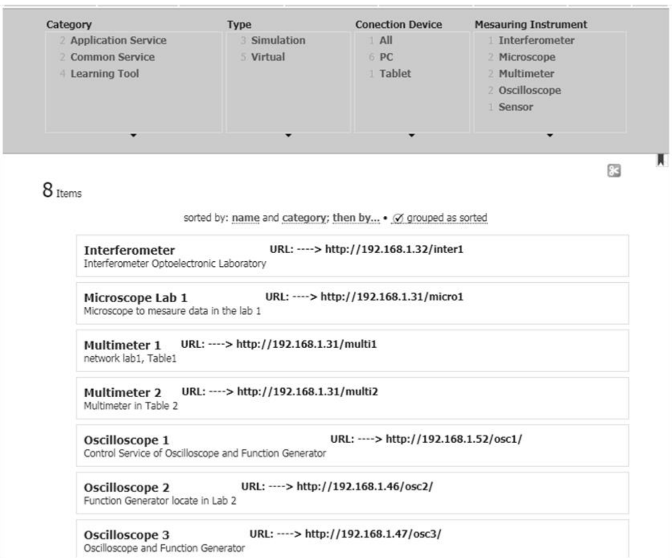


Fig. 5. Exhibit and search screen.

Once JSON files are generated, students, teachers, and administrators can perform search and navigation of services based on their categories and semantic classification using the Exhibit tool (Exhibit). Figure 9 shows the Exhibit functionality and the screen of semantic search. (Figure 5).

4.1 Experimental Procedure

The online optoelectronic laboratory portal was used for practical work in the courses of Electronics, Analogical-Digital Control, Optical Instrumentation and Optoelectronics taken by undergraduate students (N=25). It could be transferred to any engineering curriculum that includes these courses. Students knew laboratory instruments and devices and had basic knowledge of virtual instrumentation with LabView.

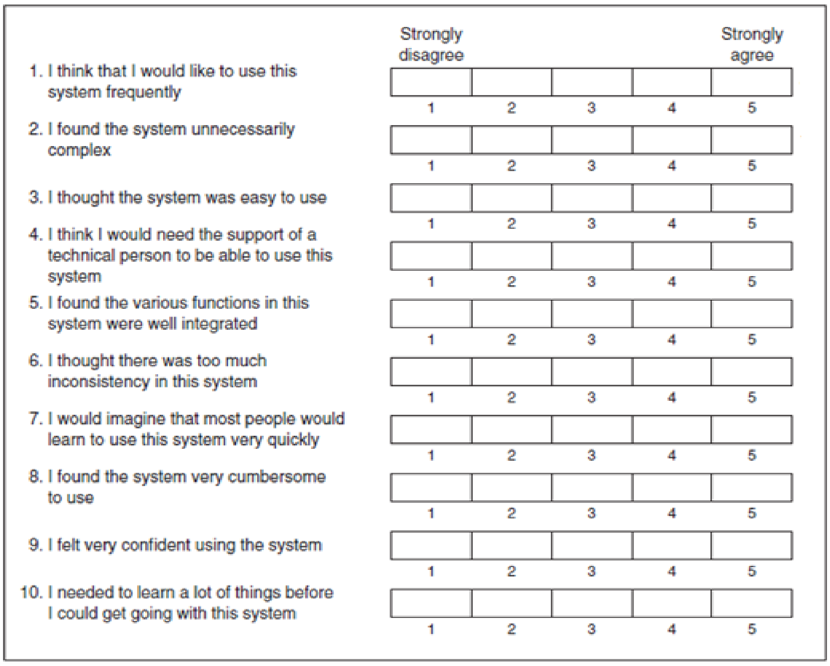


Fig. 6. The System Usability Scale (SUS) questionnaire.

Table 1. SUS score.

n	max	min	M	SD
25	92.5	80	87.7	2.969

n= students, max= maximum value, min = minimum value, M= Mean, SD = standard deviation

After students completed the experiment, they were asked to answer the System Usability Scale (SUS). SUS is a simple, ten-item attitude 5 points Likert scale (ranging from 1-strongly disagree to 5-strongly agree), giving a global view of subjective assessments of usability [10]. In particular, [11] showed the following qualitative interpretation of SUS scores:

- SUS = 51 => Poor/OK,
- SUS = 72 => Acceptable/Good,
- SUS = 85 => Excellent.

Figure 6 presents the ten questions used in the SUS questionnaire. The analysis reflects the max, min and mean of SUS score (M) (Table 1). Comparing the final mean SUS score (87.7) that our laboratory with the results of [11], we can conclude that the laboratory usability can be placed in the third quartile, which is a very good result which can be considered on the grade scale "excellent" (SUS > 80).

5 Conclusions, Limitations and Future Research

This work presents an ontology design approach that automatically discovers semantic concepts from online resources. This ontology design integrated into a web application for an online laboratory, which is based on non-functional attributes of learning services of distributed networks, especially those based on cloud computing. This provides a complete semantic description of Web services, setting aside the traditional technologies of syntactic search methods, allowing a complete semantic description based on functional and non-functional properties of Web services. Being a limitation of the current work, it would be interesting to experiment with a larger ontology and with a greater number of instruments. Future work is now centered on other important issues that include technical aspects related to the incorporation of new functionalities based on cloud-services and the semantic composition of new services from existing ones.

Future work also needs to address methodological aspects that explore new approaches of instructional design to further enhance collaborative and personalized learning, as well as to deal with the problems related to access laboratories such as authentication, scheduling, and interoperability.

References

1. Halimi, K., Seridi-Bouchelaghem, H., Faron-Zucker, C.: An enhanced personal learning environment using social semantic web technologies. Interactive Learning Environments, 22(2), pp. 165–187 (2013). DOI: 10.1080/10494820.2013.788032.
2. Butt, A.S., Haller, A., Xie, L.: Ontology search: An empirical evaluation. In International Semantic Web Conference, Springer, Cham., pp. 130–147 (2014).
3. Richter, T., Boehringer, D., Jeschke, S.: Lila: A european project on networked experiments. In Automation, Communication and Cybernetics in Science and Engineering Springer Berlin Heidelberg, pp. 307–317 (2010).
4. De Jong, T., Sotiriou, S., Gillet, D.: Innovations in STEM education: the Go-Lab federation of online labs. Smart Learning Environments, 1(3) (2014).
5. Gillet, D., Rodríguez-Triana, M.J., De Jong, T., Bollen, L., Dikke, D.: Cloud ecosystem for supporting inquiry learning with online labs: Creation, personalization, and exploitation. In 4th Experiment@International Conference IEEE, pp. 208–213 (2017). DOI: 10.1109/EXPAT.2017.7984406.
6. Marquez-Barja, J.M., Jourjon, G., Mikroyannidis, A., Tranoris, C., Domingue, J., DaSilva, L.A.: FORGE: Enhancing elearning and research in ICT through remote experimentation. In Global Engineering Education Conference (EDUCON´14), pp. 1157–1163 (2014). DOI: 10.1109/EDUCON.2014.7130485.
7. Compton, M., Barnaghi, P., Bermudez, L., García-Castro, R., Corcho, O., Cox, S., Huang, V.: The SSN ontology of the W3C semantic sensor network incubator group. Web semantics: science, services and agents on the World Wide Web, 17, pp. 25–32 (2012). DOI: 10.1016/j.websem.2012.05.003.
8. Cyganiak, R., Wood, D., Lanthaler, M., Klyne, G., Carroll, J.J., McBride, B.: RDF 1.1 concepts and abstract syntax. W3C recommendation, 25(02) (2014).

9. Motik, B., Grau, B.C., Horrocks, I., Wu, Z., Fokoue, A., Lutz, C.: OWL 2 web ontology language profiles. W3C recommendation, 27, 61 (2009).
10. Brooke, J.: SUS-A quick and dirty usability scale. Usability evaluation in industry, 189(194), pp. 4–7 (1996).
11. Bangor, A., Kortum, P.T., Miller, J.T.: An empirical evaluation of the system usability scale. Intl. Journal of Human–Computer Interaction, 24(6), pp. 574–594 (2008). DOI: 10.1080/10447310802205776.

ISSN 1870-4069

A 3D Learning Environment for Teaching Computational Thinking

José Mario Ríos Félix[1], Ramón Zatarain Cabada[1], María Lucia Barrón Estrada[1], Yasmín Hernández Pérez[2]

[1] Tecnológico Nacional de Mexico,
Mexico

[2] Instituto Nacional de Electricidad y Energías Limpias,
Mexico

{mario_rios, rzatarain, lbarron}@itculiacan.edu.mx,
myhp@iie.org.mx

Abstract. Mexico is in the process of integrating Computational Thinking into the public educational curriculum. This paper presents a learning environment that encompasses the four main elements of computational thinking and, in turn, integrates emotional recognition and gamification techniques, with the purpose of optimizing interaction with students. A preliminary test was performed using a technology acceptance model, the result indicates a favorably perceived enjoyment with the application by the students. Nevertheless, experiments focused on analyzing cognitive learning will be carried out.

Keywords: computational thinking, emotional recognition, gamification, learning environment, problem solving, algorithms.

1 Introduction

In our current era, digital skills are necessary for most of the activities that people do every day. Whether you work as a teacher, engineer, doctor, artist, or entrepreneur, you need to interact with various technological means to be able to carry on the day to day. Information and communication technologies (ICTs) have a great impact on most areas of human activity, so companies require a trained workforce in the use of ICTs. It is essential that new generations possess the skills and knowledge that are essential to carry out their daily activities efficiently.

In different countries, initiatives have been created to include Computational Thinking (CT) topics in the basic education curriculum. CT is about formulating solutions to problems with sufficient clarity and, systematically enough, to tell a computer how to solve a specific problem [1, 2]. To integrate the teaching of digital skills into a wide range of educational levels, CT teaching initiatives have been channeled primarily by teaching children to program.

In Mexico, “@prende 2.0” was implemented at the end of 2016, which is a Digital Strategy in Education, prepared by the Ministry of Public Education [3]. This strategy seeks to encourage the use of Information and Communication Technologies to stimulate the development of digital and CT skills, necessary in the social and economic context of the 21st century. Currently this educational platform, covers different subjects (e.g. natural sciences, arts education, physical education, Spanish, civic and ethical training, geography, history, and mathematics) for fifth and sixth grade of primary school. This platform provides audios, thematic diagrams, documents, images, interactive resources and videos. However, these resources do not yet address CT issues. This represents an educational lag compared to other countries.

Currently, Mexico is in the process of implementing public policies for the integration of Computational Thinking in the public educational curriculum [4]. The proposal presented in this document is a learning tool for computational thinking, which relies on affective computing, to recognize emotions focused on learning and applies gamification techniques to motivate its use.

Affective Computing is a branch of Artificial Intelligence whose objective is to allow intelligent systems to recognize, feel, infer and interpret human emotions [5]. The recognition of emotions implies great challenges, due to the difficulties for the definition, and classification of emotional expressions for different people, without contextual or psychological information [6].

This paper is organized as follows. Section 2 deals with related works, emphasizing current initiatives that seek to teach computational thinking. Next, in section 3, the structure and operation of EasyLogic 3D (our learning tool) are explained. Then, in section 4, the experiments and results found are described. Finally, section 5 discusses about the conclusions and future work of our project.

2 Related Work

In many countries, various initiatives have emerged that seek to encourage the incursion of programming and CT in early stages of education. Some of the most important initiatives are mentioned below.

Code.org is a non-profit organization dedicated to expanding participation in computer science by making it available in more schools and increasing the participation of women and students of color with little representation [7]. This organization promotes "The Hour of Code", which is an introduction to one hour sessions of computer science education, designed to show that everyone can learn to program and thus understand the fundamentals of the discipline [8]. One of the great qualities of Code.org is the use of a learning management system, so it has a very well-structured scope and sequence of the puzzles within the platform.

Computational Thinking Initiatives [9], is a program of the Wolfram Foundation, whose motto is "Empowering computer generation." This initiative offers programs and resources to improve CT skills among students around the world. Its mission is to quickly train a broad spectrum of young people today, to become cutting-edge computational thinkers.

European Coding Initiative [10], with its slogan "All you need is to code", promotes coding and CT at all educational levels. It was created in June 2014 sponsored by the European Commission and involves non-profit organizations such as: CoderDojo, Code.org and European Schoolnet.

In general, the teaching of CT is dominated by an approach, in which students learn programming concepts (instruction structure, variables, cycles, data, among others) and the use of abstractions to formally represent the relationships between computing and real-world objects [11].

One of the global most used tools for learning programming concepts in general is Scratch [12]. Scratch is currently described as an authoring tool, since it allows the creation of interactive stories, games, musical compositions, cartoons and simulations. One of its great capabilities is the ability to import and edit images to integrate them into your project.

There are also proposals that focus on construction-based robotics activities [13]–[16], ranging from simulation of robotic environments, to direct robot programming. While the acquisition of robotics equipment can be expensive, they also have many advantages, as they provide users with immediate and concrete information about the effectiveness of their programs, which promotes self-analysis and facilitates debugging.

3 EasyLogic 3D: A Learning Environment

The objective of this research project is to develop an intelligent learning environment, aimed at teaching computational thinking, using cutting-edge techniques such as the recognition of emotions focused on learning and motivational techniques used in education. In general terms, the learning environment is a web platform. To make the tool interesting for students, a 3D graphic engine was integrated, with the purpose of involving the students, so that they had the impression that it is a game, when they are really learning.

The research method used consists of 4 stages: Analysis, Design, Implementation, and Testing. The hypothesis that is sought to clarify is: the students who learn using our tool show greater commitment and motivation in their interaction, compared to students who learn the same concepts through other traditional methods.

3.1 Architecture

The general structure of the system uses a layered architectural pattern known as Model-View-Controller (MVC). This pattern separates the data, the business logic and the way in which the information will be represented to the user within the application. Figure 1 shows the architectural design for the application: in view section, multiple modules are observed, each one for a specific task within the application. In Controller section, each element interacts directly with assistance and *gamification module*. The *assistance module* brings aid to students while using the application depending on user usage and emotion data, likewise, the *gamification module* seeks to keep students

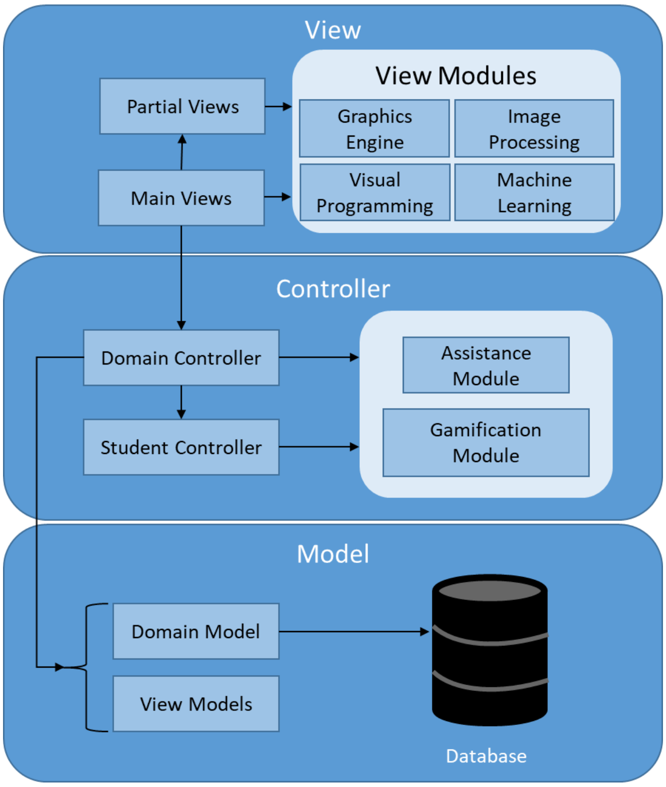


Fig. 1. Architectural design of the application.

motivated to continue using the application, through motivational messages, progress information, among others. Detailed explanation is presented below.

3.2 Assistance Module

The Assistance module is an independent module that analyses user usage data, in this way, determines if they require an intervention during their learning process. The data used by the algorithm consist of three elements: Time spent in the current exercise, number of executions, and student emotion.

Time spent and number of executions, correspond to real-time information, which is obtained while the user solves some exercise in the application. The emotion of the user is historical information of each of the students, previously stored in the database.

The last *n* emotions (configurable value) registered by the user are used to be processed by the classification algorithm. The current version of this module stablishes a minimum time of 30 seconds, and a minimum between 0 to 2 executions (depending the exercise), before being able to display an intervention. Figure 2 shows the algorithm implemented to decide the type of intervention that will be shown.

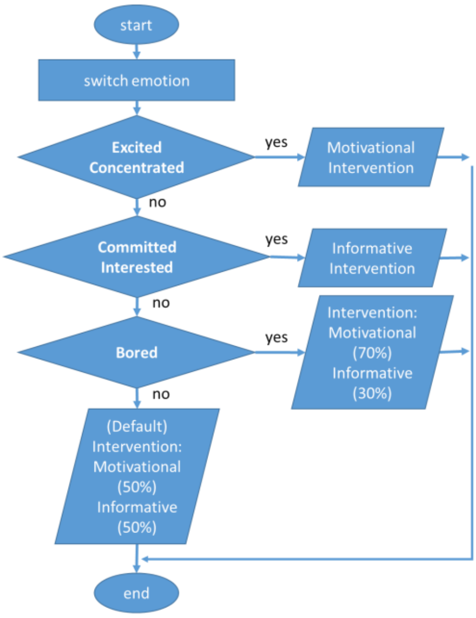


Fig. 2. Logic used to choose the type of intervention to be displayed.

3.3 Gamification Module

The gamification module integrates elements that are commonly found in games to the teaching tool, with the purpose of motivating students to continue using the tool. The following elements have been integrated: points, trophies, levels and progress bar:

- Points. For each exercise performed, the points obtained by the student are calculated, using an algorithm that calculates based on the base value of each exercise (depending on its difficulty), number of errors made, and the number of executions required to solve the current exercise.
- Trophies. A series of trophies are included, which are acquired by accumulating points within the tool.
- Levels. Exercises are classified depending on the level of difficulty of these, which implies a variation in the base value of points obtained for each exercise.
- Progress bar. An interface to be able to visualize the progress that the user has obtained.

The gamification module is used to obtain information about the current score of each user. In addition, it is responsible for the generation of motivational interventions, based on information about trophies that a user is about to reach, or through motivational phrases.

Fig. 3. Graphic interface of the educational environment.

3.4 Image Processing Module

For image processing OpenCV.js [17] was used, a link to a subset of OpenCV functions, suitable for the web platform. Face images from students were extracted, through a face recognition classifier, using a pretrained Haar cascade model, which is one of the most effective methods for this task.

3.5 Machine Learning Module

For the recognition of educational related emotions, a machine learning model was used, which is a variant of a previous work [18], with an accuracy of 82%. This model can recognize 5 different classes: Boring, Committed, Excited, Concentrated, and Interested. The model was trained using a corpus of spontaneous facial expressions, which were obtained from the observation of electroencephalographic (EEG) signals [19]. The five emotions that are recognized by this model are focused on learning, which allows us to use this information, to manipulate in real time the interaction of the application with the user.

3.6 Visual Programming Module

Blockly [20] was used as the visual programming block editor, to ease the creation of algorithms within the application. Blockly is an extensible and configurable JavaScript library created by Google.

3.7 Graphical Application Interface

As mentioned earlier, the system uses various components that interact with each other, which together form a CT teaching environment. Fig. 3 presents the graphic interface of the learning environment, at the left side, an interface for selection of the exercises is presented. On the right side of Fig. 3, a 3D world composed of a platform (grid of positions), the main character (Cyborg), barriers to limit movements, and a goal (objective) is presented for solving algorithm learning exercises.

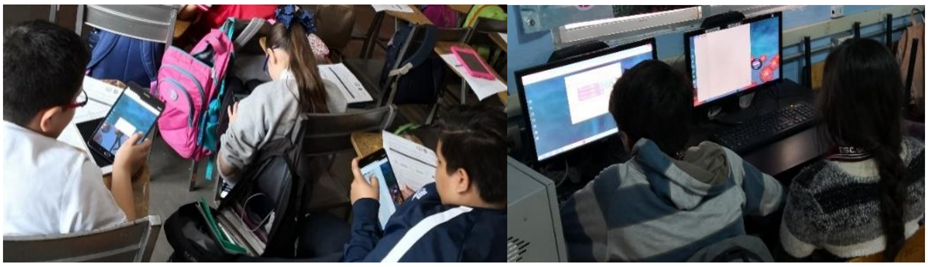


Fig. 4. Testing session with public school students.

The exercises gradually increase their difficulty, where the following programming concepts are covered: sequential structures, variables, conditional structures and finally repetitive structures.

4 Experiments and Results

Preliminary tests were applied to validate the correct operation of the application, as well as other aspects related to its usability.

4.1 Usability Testing with Experts

These tests were applied first to postgraduate students to get feedback and thus improve the application. To carry out these tests, 14 graduate students in the area of computer science were asked to use the tool. The process consisted of performing 10 exercises within the application, and then answering a brief survey, so that it could serve as feedback.

4.2 Usability Testing with Students

Because the tool is aimed to K5 and K9 students, usability tests were performed with representative users of sixth year of elementary school and first year of high school. The objective was to identify usability problems and collect qualitative and quantitative data, and in this way determine areas for performance improvement and user experience. Figure 4 shows at the right side, students from ETI 75 high school in our city (Culiacán, Sinaloa), who used the application from desktop computers. On the left side, students from the Natalio Landeros Ramos elementary school, also located in Culiacán, who used the application from portable tablets.

After using the tool, students were asked to answer a brief survey to understand their perception of the system. Using the Technological Acceptance Model (TAM) [21], survey results were analyzed to measure perceived usability, perceived ease of use, intended use, among others. The results obtained from this survey were favorable in the aspect perceived enjoyment with the application ($\alpha > 0.6$), and not so favorable in the ease of use, intention of use and attitude towards the use of the tool ($\alpha < 0.6$).

5 Conclusions and Future Work

Computational Thinking is a cognitive process, which implies logical reasoning. The various initiatives related to the CT that exist globally seek to train new generations, so that they obtain the ability to formulate solutions to the problems that will be presented to them, and that will have to be solved using future technologies. Mexico has an educational delay compared to other countries, in relation to the incursion of CT, which must be addressed in the coming years.

In this work, a modern learning environment that integrates emotion recognition and gamification has been presented. This work represents an educational proposal aimed to basic education in Mexico, which would seek to update the national curriculum and thus be integrated into the curricula established by the educational institutions of Mexico.

Preliminary tests carried out indicate favorable results with respect to the perceived enjoyment with the application by the students, which indicates that, in general, the integration of all the elements included in the tool was successful. However, these same preliminary tests indicated some areas of opportunity to continue improving the learning tool.

As future work, multiple tests to compare our tool against other learning methods will be performed, and thus obtain information on the effectiveness of our tool to evaluate commitment and motivation presented during the interaction with the learning environment. It is also expected to develop different machine learning models, seeking to obtain greater precision in the emotional recognition of students.

References

1. Csizmadia, A., Dorling, M., Curzon, P., Humphreys, S.: Computational thinking - A guide for teachers. Research Gate (2015).
2. Zapata-Ros, M.: Pensamiento computacional: Una nueva alfabetización digital. Revista de Educación a Distancia, 46 (2015). DOI: 10.6018/red/46/4.
3. Gómez-Navarro, D.A., Alvarado-López, R.A., Martínez-Domínguez, M., Díaz de León-Castañeda, C.: La brecha digital: una revisión conceptual y aportaciones metodológicas para su estudio de México, Entreciencias Diálogos en la Sociedad del Conocimiento, 6(16) (2018).
4. Cárdenas-Peralta, M.C.: Pensamiento Computacional educación básica. Aprende 2.0, pp. 1–56, (2018).
5. Poria, S., Cambria, E., Bajpai, R., Hussain, A.: A review of affective computing: From unimodal analysis to multimodal fusion. Fusion, 37, pp. 98–125 (2017).
6. Fan,Y., Lu, X., Li, D., Liu, Y.: Video-Based Emotion Recognition using CNN-RNN and C3D Hybrid Networks (2016).
7. Code.org: What will you create? [Online] https://code.org/ (2019).
8. Vogel, S.: Power, Discourse, and Knowledge in Computer Science Education Advocacy: An Analysis of Popular Code.org Videos. pp. 32–117, (2016). DOI: 10.31235/osf.io/rz9gw.
9. Wolfram Foundation: Computational Thinking Initiatives. [Online] https://www.computationinitiative.org/ (2019).
10. Balanskat, A., Engelhardt, K.: Computing our future. pp. 87 (2015).
11. Aho, A.V.: Computation and computational thinking. Comput. J., vol. 55, no. 7, pp. 833–835 (2011). DOI: 10.1093/comjnl/bxs074.

12. Brennan, K., Resnick, M.: New frameworks for studying and assessing the development of computational thinking. Annu. Am. Educ. Res. Assoc. Meet. Vancouver, Canada, pp. 1–25 (2012).
13. Sullivan, F.R., Heffernan, J.: Robotic construction kits as computational manipulatives for learning in the STEM disciplines. J. Res. Technol. Educ., 48(2), pp. 105–128 (2016).
14. Falk, G., Mannock, K.L.: First steps in creative computational thinking with natural language programming and Lego M INDSTORMS. pp. 10–16 (2018).
15. Bers, M.U., Flannery, L., Kazakoff, E.R., Sullivan, A.: Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. Comput. Educ., 72, pp. 145–157 (2014).
16. Rode, J.A., von Rekowski, T., Weibert, A., Booker J.: From computational thinking to computational making. Proc. ACM Int. Jt. Conf. Pervasive Ubiquitous Comput., pp. 401–402 (2015).
17. Taheri, S., Veidenbaum, A., Nicolau, A., Hu, N.: OpenCV: Computer Vision Processing for the Web (2018). DOI: 10.1145/3204949.3208126.
18. González-Hernández, F., Zatarain-Cabada, R., Barrón-Estrada, M.L., Rodríguez-Rangel, H.: Recognition of learning-centered emotions using a convolutional neural network. J. Intell. Fuzzy Syst., 34(5), pp. 3325–3336 (2018).
19. Zatarain-Cabada, R., Barron-Estrada, M.L., Leal-Hernandez, D., Rios-Felix, J.M.: Creation of a Facial Expression Corpus from EEG Signals for Learning Centered Emotions. Proc. - IEEE 17th Int. Conf. Adv. Learn. Technol. (ICALT´17), pp. 387–390 (2017).
20. Fraser, N.: Google blockly-a visual programming editor. [Online] https://developers.google.com/blockly/ (2016).
21. Granic, A., Marangunic, N.: Technology acceptance model : a literature review from 1986 to 2013. pp. 81–95 (2015).

ISSN 1870-4069

Towards User Enjoyment: An Algorithm for Enhancement of Flow and Engagement in Virtual Reality Video Games

Andrés Mitre Ortiz, Héctor Cardona Reyes, Jaime Muñoz Arteaga

Center for Research in Mathematics, Human-Centered Computing Lab, Mexico

{andres.mitre, hector.cardona}@cimat.mx, jaime.munoz@edu.uaa.mx

Abstract. Although there is a broad work to enhance flow and engagement of User Experience (UX) in video games, they tend to generalize the technique used for every player, this leads to undesired user experience and negative outcomes. In addition, these works lack immersion and they generalized users preferences when applied to video games. To overcome this issue, we proposed a Q-learning algorithm that adjusts the game to proper challenges and skills of every single user. Hence, we intensify immersion by introducing the algorithm in a Virtual Reality (VR) video game, a practical case is presented to demonstrate the approach.

Keywords: flow, Q-learning, engagement, virtual reality, video games.

1 Introduction

Recent studies in User Experience (UX) has been applied to multiple applications [12, 7, 6], as in video games, researchers use diverse techniques to evaluate user experiences [33, 29] in terms of flow [8], these studies are evaluated with different methods, such as interviews [33], Experience Sampling Method (ESM) [29, 10] and questionnaires [18], being ESM the most used in the literature.

Video games are frequently considered a pleasurable and rewarding activity [15, 21], as well as improving interest in a method that keep users at the limit of their performance. They are considered a deeply engaging activity due to UX, such as presence, immersion, flow, psychological absorption and dissociation [20]. Video games has been considered for multiple applications, in a systematic review of computer games, Boyle et al. [5] stated that games for Science, Technology, Engineering and Maths (STEM) with a learning purpose, had a knowledge acquisition outcome [12], on the other hand, entertainment games addressed affective, cognitive and physiological states, e.g. exercise [23], stimuli [7] and life quality [6]. In contrast, Virtual reality (VR) is an emerging technology that contributes to the presence and telepresence [18] that refers to the sense of being in an environment, this technology is widely applied to different fields, such as entertainment [19], education [22] and health [25].

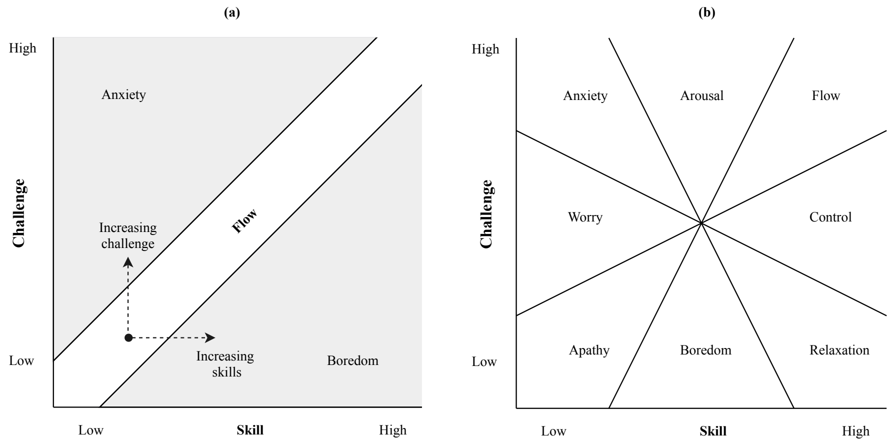


Fig. 1. Flow channels. (a) Flow channel from Csikszentmihalyi, 1990 (b) Adapted from Csikszentmihalyi, 1997, figure represents, four combinations of high/low skills and high/low challenges, representing a state equilibrium or unbalanced.

Ryan et al. [27] demonstrated that virtual worlds had considered human interaction in virtual worlds in an attempt to relate it to player satisfaction. Their survey experiments demonstrate that perceived in-game autonomy and competence are associated with game enjoyment.

Csikszentmihalyi describes flow as a process of optimal experience, where people under certain activity, put their abilities to their limit, by focused concentration and elevated enjoyment [8, 9]. Hamari [13], describes engagement in flow experiences as a reflection of complete absorption in a challenging activity, with the occurrence of elevated concentration, interest and enjoyment without any distraction. Schiefel et al. [28] reports that concentration is related to meaningful learning, interest reflects elemental motivation and stimulates users to continue the activity.

Flow experience relies on skills and challenges induced by an activity, where anxiety is evocated when the challenges are higher than user skills, and boredom is presence present when challenges are below user skills. According to the literature, if challenges of the activity are raised, the goal is to improve the player skills in order to enter a state of flow or optimal experience (see figure 1).

As algorithms enhance flow and engagement in video games approaches target to improve UX, they generalize UX for every user. This paper proposes a technique that does not generalize UX and targets to personal in Virtual Reality video games. In the next section, we introduce related works within flow and engagement in video games, in section 3 the proposal is presented and section 4 describes the conclusion and future work.

Table 1. Literature review of flow control in video games.

Author	Flow	Engagement	Technique	Evaluation	Control	Experiment	Game
Yannakakis Georgios N, et al. [38]	-	-	ANN	Survey	Physical	Children	Bug-smasher
Gustavo Andrade, et al. [2]	-	-	Reinforcement Learning (RL)	Statistical analysis	Fight actions	Simulation	Knock'em [3]
Hunicke Robin, et al. [16]	•	•	DDA	Not mentioned	Fight and defense actions	Simulation	Half-Life
Pieter Spronck, et al. [31]	-	-	ML: Dynamic Scripting	Simulation	Tactic of human gameplay	Simulation	Combat team game
Ibáñez-Martínez, Jesús, et al. [17]	•	•	DDA	None	Game parameters	Novel strategy	Tennis video game
Yannakakis Georgios N, et al. [37]	•	-	Feedforward NN and fuzzy-NN	Statistical analysis	Metric for real-time entertainment	People	Pacman and Bug-smasher
Vicencio-Moreira, Rodrigo, et al. [35]	-	-	Player-balancing techniques	Statistical analysis	Game mechanics	People	Mega Robot Shootout
Bian Dayi, et al. [4]	-	•	ML: Random Forest	Statistical analysis	Difficulty level	People	Virtual driving task
Mirna Paula Silva, et al. [30]	•	-	DDA	Statistical analysis	Difficulty level	Simulation	MOBA (DotA)
Simone Amico [1]	•	•	DDA	Statistical analysis	Difficulty level	People	VR Game

2 Related Works

The review of the state of art in the analysis of flow from video games is extensive, most of the work, focus on the characteristics of the game or the stimuli of the outcome experience, either being in flow, anxiety or boredom.

Multiple studies in video games are focused to increase UX with different techniques such as gamification [14], matchmaking systems, adaptive physics, Dynamic Difficulty Adjustment (DDA) [16, 17, 30], Neural Networks (NN) [38], Machine Learning (ML) [4] and Reinforcement Learning (RL) [2]. Although the literature is broad, a minority of papers focus in flow and engagement. According to our knowledge, only one work in the literature focused to enhance flow in Virtual Reality video games [1].

Simone adjusted the game based on performance DDA (users score), affective DDA using Galvanic Skin Sensor —Galvanic Skin Response (GSR) is a physiological signal that stimuli through emotions—, and a mixed performance-affective DDA. Results showed that performance DDA led to easy game-play for users, affective DDA led to difficult levels, but the mix of both of them led to the best results. The paper stated that it did not find a significant difference between participants who had experience in VR, and participants who did not. Table 1 shows a summary of related works that are applied to video games environments.

Although multiple works to enhance UX in video games exist, there are some drawbacks that authors do not consider such as:

- Most of the work focus on Dynamic Difficulty Adjustment (DDA), this limits only to different type of levels.
- Related works based on flow theory generalize the flow channel. They improve the flow according to challenges proportional to users' skills, or an average from a group of participants, assuming that every user or player has the same preferences, instead of personalized flow channels for every single player.

– Do not implement their applications in virtual worlds environment, this leads to an absence of deep engagement.
– Do not implement Machine Learning techniques, they instead adjust video game settings based on DDA and ETM.

Based on these drawbacks, and to solve these problems and ensure a flow experience for every user, this paper proposes a technique to enhance flow in VR video games in a personal way, according to user preferences with a Reinforcement Learning algorithm.

3 Proposal

The work proposes a Reinforcement Learning (RL) algorithm. Sutton et al. [32] stated that RL maps situations to actions to maximize a numerical reward signal, "the learner is not told which actions to take, but instead must discover which actions yield the most reward by trying them". This framework is usually defined in terms of the Markov Decision Processes (MDP), where an agent learns and take decisions inside an environment at each sequence of discrete-time steps, $t = 0, 1, 2, 3, ...$ At each time step t, the agents takes an action from a finite set of $states(s)$ of the environment $S_t \in S$ and on that selects an *action*, $A_t \in A(s)$, reaching a new state (s) and receives a reward, $R(s, a, s')$. MDPs maximize a long-term performance criterion, which represents the expected value of future rewards, the agents try to learn the optimal policy π. The policy maps from perceived states of the environment to actions to be taken in the current state.

3.1 Q-learning Algorithm

Q learning is a model-free incremental learning algorithm which optimizes sequential decision-making problems [36]. Q-learning has been applied to diverse problems in control systems, gaming and robotics [26]. Q-learning consists of iteratively computing values for the action-value function:

$$Q(s, a) \leftarrow Q(s, a) + \alpha[r + \gamma. V(s') - Q(s, a)]. \tag{1}$$

In eq. 1 $Q(s, a)$ is known as the action-value function, defined as the expected return from state s_n within an action (a). An optimal policy can be constructed starting from every state, $V(s') = max_a Q(s', a)$, where α is the learning rate and γ is a discount factor. Q learning differs from other Machine Learning algorithms since it does not require training data, the algorithm is able to find the optimal solution by iterating itself.

3.2 Input Variables

In the proposed approach, the agent controls the actions of the VR video game who is able to take actions at the end of every trial or level, the algorithm finds the parameters preferred by the user and take them into a state of flow. The followings definitions for the algorithm are:

1. *States:* according to Csikszentmihaly in Fig. 1 (b), the following states (s) are defined: anxiety, arousal, flow, worry, control, apathy, boredom and relaxation, creating a set of states:

$$S_t = \{s_0, s_1, s_2, ..., s_7\}. \quad (2)$$

2. *Actions:* to influence into users in an affective manner, we proceed to the literature to see how to affect the states of the user. According to Fassbender et al. [11] a study in a Reality Center found that participants were more engaged listening to instrumental background music while doing an activity, Tian et al. in [34] found that color scheme has a statistically significant effect on user preferences. To trigger immersion in VR, Rautaray et al. in [24] provided an analysis of the gesture recognition used in Human-Computer Interaction (HCI), based on this work, it is reliable to get the most affective gestures and applied them into a VR environment. According to the state of art, these variables have an affective effect on users, hence their experience while doing a certain activity can be changed or optimized. The set of actions is listed as:

   - A_0 : increase time,
   - A_1 : decrease time,
   - A_2 : mute background audio,
   - A_3 : play background audio,
   - A_4 : colorful graphics,
   - A_5 : gray-scale graphics,
   - A_6 : toggle gesture technique:

$$A_t = \{A_0, A_1, A_2, ..., A_6\}, \quad (3)$$

3. *External information:* user preferences are different for every player, an Experience Sampling Method (ESM) is included after an acquisition stage in order to get their preferences. Other information to the system which the states depend on are: user time, user score, audio status, color interface and technique used.

3.3 VR Video Game

Conforming to the input variables of the algorithm, a variety of VR video games can be developed since the input variables are suitable for every game, the variables can be easily modified. Hence the proposal can be applied to a broad genre of games such as arcade, educational, shooter, fighting, racing, Multiplayer Online Battle Arena (MOBA), sports and serious game. Figure 2 illustrates a general representation of the proposed system.

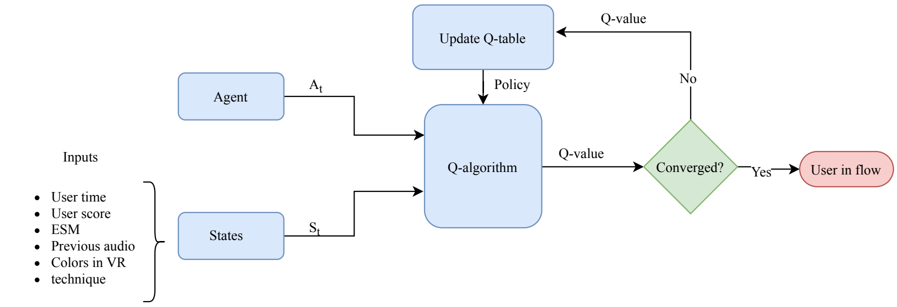


Fig. 2. General diagram of the system with the Q-learning algorithm.

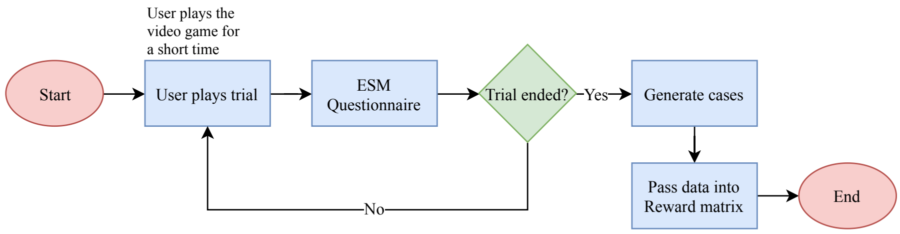


Fig. 3. Acquisition stage to get user preferences.

The Q-algorithm iterates after every trail and update the input parameters of the system, in every trail the algorithm will verify if the state of flow has been reached by the user —when Q-value has converged—, once it reach such as state, the algorithm finds the optimal policy that enhance the user experience.

In an example of a practical case, an user plays the video game for the first time, in order to get their preferences, an acquisition stage (Fig. 3) is required, this consist in generating different cases (preferences) in function of customized parameters of the video game (e.g. time, music background, interactive technique, etc). To get different cases, a trial of the video game is played for a short time, afterwards the cases are created —cases are a combination of parameters of the video game. These cases are considered as the input actions in the reward matrix for the Q-learning algorithm.

According to Fig. 3, flow state will be distant for every user, e.g. an user can prefer high challenges and low skills, in contrast another user can prefer high skills and low challenges. The algorithm will iterate until it converges, in other words when user loops in the state of flow.

4 Conclusion and Future Work

In this paper, a Q-learning algorithm to enhance flow and engagement in users in a personal manner while being in a VR video game is proposed, hence every policy that reaches the flow state will be different in function of the user. The proposal ensures that every user enjoys the game play.

Previous works improves user experience, ignoring the fact that every user has different preferences when playing video games, e.g. there may be users that prefer a higher levels of challenge that leads into difficult matches, in the other hand, there may be users that will enjoy easier matches. Another drawback in the literature is that most of the used techniques are applied to 2D video games, these outcomes into less engagement in contrast to VR video games.

As a future work, we plan to test the proposed algorithm, a group of participants will be tested during a 1 week with several trails. Statistical analysis will be used to evaluate the results as well as an Experience Sampling Method (ESM). Some failures could come from usability: video game is not property designed, experiment: environment circumstances, process and validation can result to undesired outcomes, User Experience: consistency, predictability, visual representations and customizability are factors that need consideration in order to avoid problem. According to our knowledge, the presented paper is the first work to implement Reinforcement Learning algorithm to enhance user flow and engagement in VR video game.

References

1. Amico, S.: ETNA: a Virtual Reality Game with Affective Dynamic Difficulty Adjustment based on Skin Conductance. Ph.D. thesis, University of Illinois (2018)
2. Andrade, G., Ramalho, G., Santana, H., Corruble, V.: Challenge-sensitive action selection: an application to game balancing. In: IEEE/WIC/ACM International Conference on Intelligent Agent Technology. pp. 194–200. IEEE (2005)
3. Andrade, G., Santana, H., Furtado, A., Leitão, A., Ramalho, G.: Online adaptation of computer games agents: A reinforcement learning approach (2004)
4. Bian, D., Wade, J., Warren, Z., Sarkar, N.: Online engagement detection and task adaptation in a virtual reality based driving simulator for autism intervention. In: International Conference on Universal Access in Human-Computer Interaction. vol. 9739, pp. 538–547. Springer Verlag (2016)
5. Boyle, E.A., Hainey, T., Connolly, T.M., Gray, G., Earp, J., Ott, M., Lim, T., Ninaus, M., Ribeiro, C., Pereira, J.: An update to the systematic literature review of empirical evidence of the impacts and outcomes of computer games and serious games. Computers & Education 94, 178–192 (2016)
6. Chen, P.Y., Hsieh, W.L., Wei, S.H., Kao, C.L.: Interactive wiimote gaze stabilization exercise training system for patients with vestibular hypofunction. Journal of NeuroEngineering and Rehabilitation 9(1) (2012)
7. Cook, N.F., McAloon, T., O'Neill, P., Beggs, R.: Impact of a web based interactive simulation game (PULSE) on nursing students' experience and performance in life support training - A pilot study. Nurse Education Today 32(6), 714–720 (aug 2012)
8. Csikszentmihalyi, M.: Flow: The Psychology of Optimal Experience. The Academy of Management Review 16(3), 636 (1990), https://www.researchgate.net/publication/224927532
9. Csikszentmihalyi, M., Hunter, J.: Happiness in everyday life: The uses of experience sampling. Journal of Happiness Studies 4, 185–199 (apr 2003)

10. Delle Fave, A., Bassi, M., Massimini, F.: Quality of experience and risk perception in high-altitude rock climbing. Journal of Applied Sport Psychology 15(1), 82–98 (mar 2003)
11. Fassbender, E., Richards, D., Bilgin, A., Thompson, W.F., Heiden, W.: Virschool: The effect of background music and immersive display systems on memory for facts learned in an educational virtual environment. Computers & Education 58(1), 490–500 (2012)
12. Forsyth, C., Pavlik Jr, P., Graesser, A.C., Cai, Z., Germany, M.l., Millis, K., Dolan, R.P., Butler, H., Halpern, D.: Learning gains for core concepts in a serious game on scientific reasoning. International Educational Data Mining Society (2012)
13. Hamari, J., Shernoff, D.J., Rowe, E., Coller, B., Asbell-Clarke, J., Edwards, T.: Challenging games help students learn: An empirical study on engagement, flow and immersion in game-based learning. Computers in Human Behavior 54, 170–179 (aug 2016)
14. Han, H.C.: Gamified pedagogy: From gaming theory to creating a self-motivated learning environment in studio art. Studies in Art Education 56(3), 257–267 (2015)
15. Hull, D.C., Williams, G.A., Griffiths, M.D.: Video game characteristics, happiness and flow as predictors of addiction among video game players: A pilot study. Journal of Behavioral Addictions 2(3), 145–152 (sep 2013)
16. Hunicke, R.: The case for dynamic difficulty adjustment in games. In: International Conference on Advances in computer entertainment technology. vol. WS-04-04, pp. 91–96 (2004)
17. Ibáñez-Martínez, J., Delgado-Mata, C.: From competitive to social two-player videogames. In: Proceedings of the 2nd Workshop on Child, Computer and Interaction, WOCCI '09 (2009)
18. Jerald, J.: The VR book: Human-centered design for virtual reality. Morgan & Claypool (2016)
19. Kodama, R., Koge, M., Taguchi, S., Kajimoto, H.: COMS-VR: Mobile virtual reality entertainment system using electric car and head-mounted display. In: 2017 IEEE Symposium on 3D User Interfaces, 3DUI 2017 - Proceedings. pp. 130–133. Institute of Electrical and Electronics Engineers Inc. (apr 2017)
20. Laffan, D.A., Greaney, J., Barton, H., Kaye, L.K.: The relationships between the structural video game characteristics, video game engagement and happiness among individuals who play video games. Computers in Human Behavior 65, 544–549 (dec 2016)
21. McGonigal, J.: Reality is broken: Why games make us better and how they can change the world. Penguin Press (2011)
22. Merchant, Z., Goetz, E.T., Cifuentes, L., Keeney-Kennicutt, W., Davis, T.J.: Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers and Education 70, 29–40 (2014)
23. Pichierri, G., Murer, K., De Bruin, E.D.: A cognitive-motor intervention using a dance video game to enhance foot placement accuracy and gait under dual task conditions in older adults: A randomized controlled trial. BMC Geriatrics 12 (2012)
24. Rautaray, S.S., Agrawal, A.: Vision based hand gesture recognition for human computer interaction: a survey. Artificial intelligence review 43(1), 1–54 (2015)
25. Reyes, H.C., Arteaga, J.M.: Multidisciplinary production of interactive environments to support occupational therapies. Journal of biomedical informatics 63, 90–99 (2016)

26. Riedmiller, M., Merke, A., Meir, D., Hoffman, A., Sinner, A., Thate, O., Ehrmann, R.: Karlsruhe brainstormers-a reinforcement learning approach to robotic soccer. In: Robot Soccer World Cup. pp. 367–372 (2001)
27. Ryan, R.M., Rigby, C.S., Przybylski, A.: The motivational pull of video games: A self-determination theory approach. Motivation and Emotion 30(4), 347–363 (dec 2006)
28. Schiefele, U., Krapp, A., Winteler, A.: Interest as a predictor of academic achievement: A meta-analysis of research. The role of interest in learning and development pp. 183–212 (1992)
29. Schüler, J., Brunner, S.: The rewarding effect of flow experience on performance in a marathon race. Psychology of Sport and Exercise 10(1), 168–174 (jan 2009)
30. Silva, M.P., Silva, V.D.N., Chaimowicz, L.: Dynamic difficulty adjustment through an adaptive AI. In: Proceedings of SBGames 2015. pp. 173–182. IEEE Computer Society (dec 2016)
31. Spronck, P., Sprinkhuizen-Kuyper, I., Postma, E.: Difficulty scaling of game AI. In: Proceedings of the 5th International Conference on Intelligent Games and Simulation. pp. 33–37 (2004)
32. Sutton, R.S., Barto, A.G., et al.: Introduction to reinforcement learning, vol. 2. MIT press Cambridge (1998)
33. Swann, C., Keegan, R., Crust, L., Piggott, D.: Psychological states underlying excellent performance in professional golfers: "Letting it happen" vs. "making it happen". Psychology of Sport and Exercise 23, 101–113 (mar 2016)
34. Tian, S., Luo, X., Lu, D., Chen, Y.: Study on the effect of web color scheme on user behavior. In: 2017 International Conference on Virtual Reality and Visualization (ICVRV). pp. 408–410. IEEE (2017)
35. Vicencio-Moreira, R., Mandryk, R.L., Gutwin, C.: Now you can compete with anyone: Balancing players of different skill levels in a first-person shooter game. In: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems. pp. 2255–2264. ACM (2015)
36. Watkins, C.J., Dayan, P.: Q-learning. Machine learning 8(3-4), 279–292 (1992)
37. Yannakakis, G.N., Hallam, J.: Modeling and augmenting game entertainment through challenge and curiosity. International Journal on Artificial Intelligence Tools 16(06), 981–999 (2007)
38. Yannakakis, G.N., Hallam, J.: Real-time game adaptation for optimizing player satisfaction. IEEE Transactions on Computational Intelligence and AI in Games 1(2), 121–133 (jun 2009)

ISSN 1870-4069

Towards an Interactive Learning Ecosystem: Education in Power Systems

Guillermo Santamaría-Bonfil

CONACYT-INEEL,
Cuernavaca, Morelos,
Mexico

guillermo.santamaria@ineel.mx

Abstract. In this paper, it is presented the ongoing work on developing an Interactive Learning Ecosystem for power systems education and training. Opportunities to employ low-cost human computer interfaces for creating an Interactive Learning Ecosystem based on intelligent Human-Computer Interfaces are presented. Then, an Interactive Learning Ecosystem framework is shown. The ongoing work integrating these interfaces within Virtual Reality systems that compose a power systems education ecosystem are presented and discussed.

Keywords: interactive learning ecosystems, human-computer interfaces, big data, data science, power systems education.

1 Introduction

E-learning technologies have taken a major role in education, from traditional academic setups to corporate training, these have become part of most individuals everyday learning. These technologies range from isolated platforms such as Learning Management Systems (LMS) or Virtual Reality (VR) environments, to Learning Ecosystems (LEs) which integrates one or more technologies such that users' information is standardized, shared, and exploited between the LE components [4, 10]. In particular, designing e-learning technologies through the lens of LEs is indispensable in today educational landscape, due to the large amount of systems that need to exchange and maintain educational information in formal and informal settings [4, 5].

A key aspect of LEs is that these are principally shaped by Big Data (BD) and Data Science (DS) technologies. Loosely speaking, BD refers to large heterogeneous data, generated at fast speed, and which is too large to process or store using a single machine [11]. DS on the other side, can be comprehended as a new paradigm that unifies theory, experiments, and software, for developing methods to support new scientific discoveries through the analysis of large data amounts [13]. In fact, these two are becoming major players in the e-learning field. Even now governments are reporting a) how BD&DS contribute in the assimilation, ingestion, storage, information exchange, and exploitation of students trace data from heterogeneous systems, and b) conceptualizing how these technologies shall be incorporated into educational areas hereafter [11]. Likewise, BD&DS powers Machine Learning (ML) algorithms in areas such as Face Recognition, Emotional and Gestural Recognition from facial, body, and textual expressions, Natural Language Processing (NLP) [2, 7, 14, 16], to mention a few.

On the other hand, advances in the aforementioned ML areas and the fast-paced hardware improvements, have allowed to develop reliable devices that provides more natural Human-Computer Interfaces (HCIs), which are already prepared to be integrated into LEs. These range from *Do-It-Yourself* (DIY) low cost sensors networks based on open-source platforms such as Arduino™or Raspberry Pi™, to highly sophisticated plug-and-play robots such as Pepper™which are already equipped with touch sensors, light sensors, 3D cameras, Emotional Recognition, and so on [12].

Hence, in this work it is discussed the ongoing work to develop a framework namely *Interactive Learning Ecosystem* (ILE), which integrates HCIs into a LE to provide more natural and individualized HC interactions. In particular, it is discussed HCIs which allow to a) estimate an student affective state, b) control applications through hand and fingers gesture recognition, and c) control applications and provide personalized support through voice commands. These HCIs are examined at different interaction levels within the ecosystem, from navigation controls in a specific VR application, to higher level individualized assistance. Moreover, it is analyzed how data generated from such interactions shall be streamed, standardized, and stored for its subsequent exploitation. Therefore, this work is organized as follows: in Sect. 2 it is presented the HCI devices and the proposed ILE framework; in Sect. 3 the ongoing work regarding the integration of HCIs into a ILE to be used for power systems education; in Sect. 4 a discussion is elaborated regarding the current ILE state and the future work to be delved.

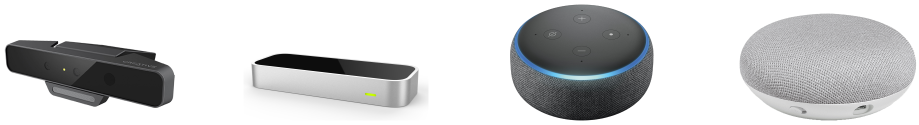
2 Materials & Methods

Nowadays the amount of *intelligent* HCIs is huge. These are *intelligent* in the sense that can carry out one or more human functions by themselves, e.g. inferring the affective state of a person by its facial expressions. Together they form a network of sensors, which in fact, can be considered as devices of the Internet of Things (IoT). As such, these require an standardized protocol to gather interaction data from heterogeneous systems for its future exploitation. The e-learning specification namely, eXperience API (xAPI), offers a solution to this issue [11]. Any interaction coded as a xAPI learning experience is then delivered to a BD infrastructure where interaction messages are streamed, ingested, stored, and analyzed using Learning Analytics (DS applied to educative data).

2.1 HCI Devices

Devices such as Intel RealSense™RS300 camera, the Leap Motion™(LM) hand gesture tracking, Alexa Echo Dot™(AED) and Google Home™(GH) Mini virtual agents, are examples of gadgets improvements brought by BD&DS. For the time being, these four devices are considered and evaluated as part of the ILE due to its low cost and high compatibility; these are shown in Fig. 1. An important aspect of these devices is that, while the RS300 camera and the LM can work offline given that they are already provided with embedded systems, GH and AED require internet access to provide its NLP services.

Tracking devices such as LM or RS300 are 3D cameras which are capable of gesture tracking, face recognition, and estimate affective states by using skeleton, head, facial, hands and fingers landmarks to generate motion data features. While the RS300 device is capable to identify an individual facial expressions, affective state, and track body and hand gestures, the LM device is specific for hand and fingers gesture tracking [6, 15]. These two devices can work independently to capture different data or in a redundant fashion to improve fidelity by integrating multimodal and multiple-sensors data.

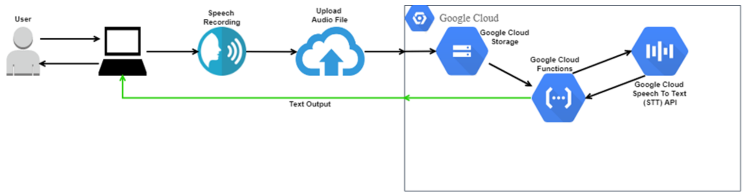


(a). (a) **(b).** (b) **(c).** (c) **(d).** (d)

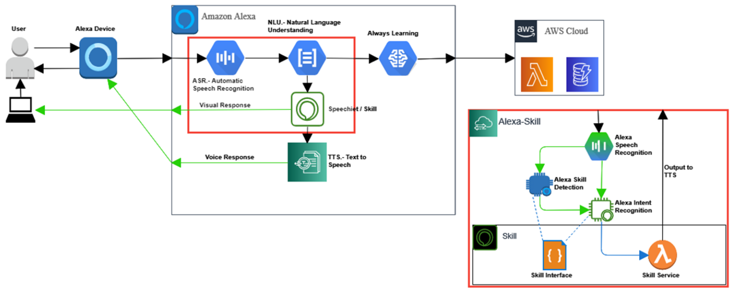
Fig. 1. HCIs considered in the ILE: (a) RS300 camera, (b) Leap Motion, (c) Alexa Echo Dot, and (d) Google Home Mini.

On the other hand, GH and AEO are considered Intelligent Virtual Assistants (IVAs), although these are known by many names [3, 9]. An IVA is any software agent that provides aid and services to an individual commands in an personalized fashion. These commands are in the form of speech (i.e. Spoken Dialogue Systems) or text (i.e. Chatbots). IVAs provide a wide range of spoken dialogue applications, from controlling home appliances with voice commands (i.e. Domotics) to tracking personal activities such as physical excercise, productivity, and so on. Loosely speaking, most spoken dialogue IVAs follow the following process: Speech is converted to Text (S2T), then text is mapped into an action (Natural Language Understanding -NLU-) namely *Skill*, if the skill exists the corresponding action is carried out, result is then synthesized into a natural language expression, and given to the user by converting it from Text to Speech (T2S) [3, 9]. For instance, GH and AEO dialogue system schemes are shown in Figs. 2a and 2b, respectively. Both systems are designed to work for dedicated devices [3], however, Google Speech API as well as Amazon API now can be integrated with a plethora of devices. Likewise, both APIs provide advanced deep learning models to carry out the Automatic Speech Recognition

(ASR) necessary for the S2T process and NLU to recognize *intents*, words that triggers an skill. Nevertheless, while Alexa enables developer to build skills, the GH is constrained to prefabricated built-in skills.



(a). (a)



(b). (b)

Fig. 2. IVAs speech dialogue processing. On (a) Google Cloud Speech API, on (b) the Alexa Voice Services components for NLU.

2.2 Interactive Learning Ecosystem

Using the aforementioned HCIs, we now proceed to describe the proposed ILE framework. Fig. 3 presents the overall data flow, and ILE components. These ecosystem is composed by several systems such as a Virtual Reality Training System (VRTS), a LMS, Social Media, etc; generate data from these is then validated, ingested, processed, stored, and exploited by a big data infrastructure [11]. It is worth mentioning that, HCIs interactions will conform a multimodal data that will be required to be parsed into learning experiences by the message broker.

In this ILE, HCIs interactions can be discussed at two levels: single applications and personalized support. For the first lets consider a VRTS, the RS camera is used to recognize facial expressions and affective states during a training session. During these sessions the VRTS is controlled with the LM and AEO: the former to navigate and interact with the environment, whereas the latter to ask details and information about the virtual environment.

While these multimodal data can be used for improving training in the VR application, a higher level of personalization can be achieved by integrating Alexa third party skills. This means that, during the training session, an individual may request information to web search engines, track productivity, or even perform domotic actions such as turning off the washing machine. These information will be gather by the ILE to obtain a broader scope of an individual such as his/her health, activity schedules, interests, and so on.

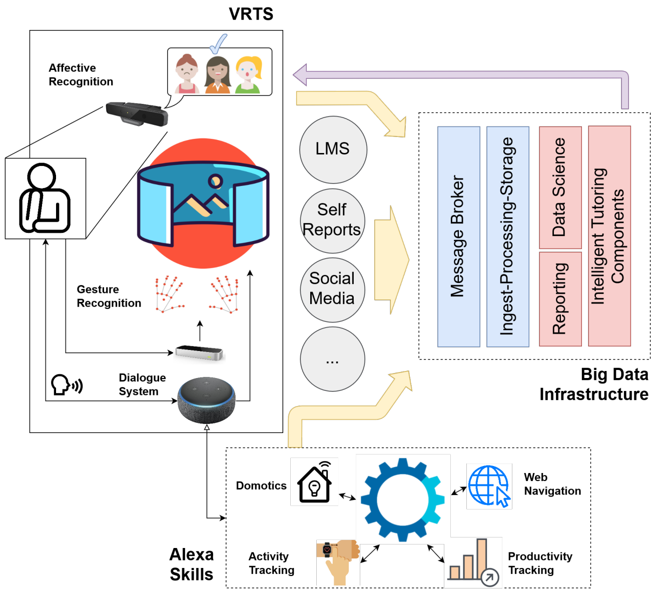


Fig. 3. Proposed Interactive Learning Framework.

3 Ongoing Development in Power Systems Education

Education for electrical power systems range from electricity and physical theoretical concepts to practical maintenance courses. These courses may consist in the usage or management of specialized software for electrical engineering, the proper operation of maintenance tools, equipment, and protective hardware, to mention a few. In the following it is described how two virtual systems belonging to a power systems LE, integrates HCIs such as LM and AED.

3.1 Robotic Operated Vehicles for Underwater Inspection and Maintenance of offshore Facilities

Underwater offshore facilities such as the required by wind power turbines or oil extraction platforms are inspected, maintained, and cleaned by human divers.

Yet, underwater operations are inherently dangerous due to oceanic conditions such as water flow velocity and wave height. Fortunately, underwater Remotely Operated Vehicles (ROVs) are now replacing the physical presence of divers in these undependable conditions. This does not only provides a safer environment for workers, but also lowers inspection and maintenance costs of offshore facilities. Nevertheless, ROVs are expensive vehicles which utilities and oil companies cannot afford to damage or lose.

Therefore, ROV pilots require to be trained properly in the operation of these vehicles previously to be allowed to carry out maintenance in the field. SimRov is a VRTS used to train ROV operators in underwater operations and the operation of the ROV itself [1]. For this, the student operates a virtual ROV equipped with two arms, video cameras, and thrusters to move around. However, the typical HCIs used in this type of VRTS are joysticks and keyboards. In particular, these are unnatural in the operation of robotic arms, and it has been proposed to use LM to replace joysticks to control the robotic arms in a more amenable form [8]. Therefore, LM is integrated to the SimRov VRTS to improve the manipulation of the robotic arms, Fig. 4 shows the ongoing work regarding the development of such interface.

Fig. 4. ROV for offshore underwater maintenance controlled by LM.

3.2 Virtual MicroGrids (μG) for Power Systems Education

Climate change has increased the urge to employ renewable energy sources and the development of resilent networks. Among the technologies to address these issues stand MicroGrids (μGs). These are small scale networks restricted to a specific geographical area, which are powered by traditional plants, renewable energy sources, and stationary energy storage systems. μGs satisfy several roles, from prosumers which sell energy to the power network, to the satisfaction of the electrical demand in rural regions.

The development of such frameworks have lead into the creation of new job opportunities which require prepared professionals to satisfy the labor demand. This, has lead into the development of training systems that must ensure teaching effectiveness that allows students to carry out experimental activities. In this sense, the Virtual μG (VμG) has been developed. This is a VRTS that aims to train professionals in the operation and maintenance of microgrids. For achieving this the user operates an avatar which is situated into a virtual μG, where he/she must carry out maintenance and operation maneuvers.

Navigation and interactions within the virtual environment are performed using a keyboard to fulfill maneuvers steps. Additional information requested by the user regarding the maneuver steps, the maneuver objective, and μG components are provided by a proprietary Alexa Skill through the AEO. Fig. 5 shows the ongoing work regarding the development of this VRTS.

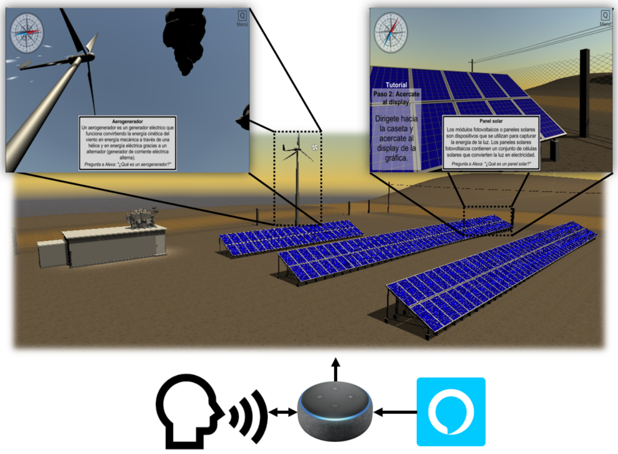


Fig. 5. Virtual μG integration with Alexa Echo Dot. The devices provides information about navigation and items around the VR environment.

4 Discussion

In this work it is presented a proposal for building an ILE for power systems education. This goes towards generating a standardized system for storing HCIs interactions as learning experiences within a BD infrastructure. To date the development have focused upon the tools for building the ILE. Resulting VRTS systems and their integration with the LM and AEO are encouraging, thus, the next steps involve polishing HCIs integration with VRTS, the integration of a multimodal dataset coming from HCIs interactions, and the experimental design for assessing improvements in learning by students.

Acknowledgement. The work is supported by Cátedras CONACYT Program.

References

1. Beltran-Labra, R., Pérez-Ramírez, M., Zezzatti, C.A.O.O., Ontiveros-Hernández, N.J.: Simulador ROV multiplayer para escenarios petroleros submarinos. Research in Computing Science 140, 67–77 (2017)
2. Chatterjee, A., Gupta, U., Chinnakotla, M.K., Srikanth, R., Galley, M., Agrawal, P.: Understanding emotions in text using deep learning and big data. Computers in Human Behavior 93(2018), 309–317 (2019)
3. Chung, H., Iorga, M., Voas, J., Lee, S.: "alexa, can i trust you?". Computer 50(9), 100–104 (2017)
4. Fonseca, D., García-Peñalvo, F.J.: Interactive and collaborative technological ecosystems for improving academic motivation and engagement. Universal Access in the Information Society 18(3), 423–430 (2019)
5. García-Peñalvo, F.: Technological ecosystems. IEEE Revista Iberoamericana de Tecnologias del Aprendizaje 11(1), 31–32 (2016)
6. Guzsvinecz, T., Szucs, V., Sik-Lanyi, C.: Suitability of the kinect sensor and leap motion controller-a literature review. Sensors 19(5), 1072 (2019)
7. Hossain, M.S., Muhammad, G.: Emotion recognition using deep learning approach from audio–visual emotional big data. Information Fusion 49, 69–78 (2019)
8. Jun Wei, L., Wei Sen, L., Md. Sani, Z.: Leap motion underwater robotic arm control. Jurnal Teknologi 74(9), 153–159 (2015)
9. Kepuska, V., Bohouta, G.: Next-generation of virtual personal assistants (microsoft cortana, apple siri, amazon alexa and google home). vol. 2018-January, pp. 99–103 (2018)
10. Santamaría-Bonfil, G.: Towards a learning ecosystem for linemen training. Research in Computing Science 148(5), 125—-132 (2019)
11. Santamaría-Bonfil, G., Escobedo-Briones, G., Perez, M., Arroyo-Figueroa, G.: A learning ecosystem for linemen training based on big data components and learning analytics. Journal of Universal Computer Science 25(5), 541–568 (2019)
12. Santamaría-Bonfil, G., Toledano-López, O.G.: Emoji as a proxy of emotional communication pp. 1–20 (2019)
13. Shcherbakov, M., Shcherbakova, N., Brebels, A., Janovsky, T., Kamaev, V.: Lean data science research life cycle: A concept for data analysis software development 466 CCIS, 708–716 (2014)
14. Taigman, Y., Yang, M., Ranzato, M., Wolf, L.: Deepface: Closing the gap to human-level performance in face verification. In: Proceedings of the IEEE conference on computer vision and pattern recognition. pp. 1701–1708 (2014)
15. Tang, T.Y., Chen, G., Winoto, P.: Emotion recognition via face tracking with realsense™3d camera for children with autism. pp. 533–539 (2017)
16. Xu, R., Chen, J., Han, J., Tan, L., Xu, L.: Towards emotion-sensitive learning cognitive state analysis of big data in education: deep learning-based facial expression analysis using ordinal information. Computing (2019)

Electronic edition
Available online: http://www.rcs.cic.ipn.mx