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Algorithm for the selection of questions focused on education 4.0 using fuzzy logic

Algoritmo para la selección de reactivos enfocados a la educación 4.0 utilizando lógica difusa

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Abstract

The objective of the present work is to apply fuzzy logic in an algorithm that supports decision-making for the selection of reagents (questions) focused on education 4.0, for which the Delphi method is used to identify the process that must be followed when selecting the questions, that must be presented to students when they use a content reinforcement tool or system that is focused on evaluating student knowledge. The area of Artificial Intelligence IA has several areas of knowledge that could be applied in this algorithm, however, due to the fact that the ways of learning of the students are not known, the fuzzy logic technique is chosen since the sets They can present fuzzy data or with a membership function that varies according to the learning style of the learner.

Education 4.0, Fuzzy logic, Questions

Resumen

El objetivo del presenta trabajo es Aplicar lógica difusa en un algoritmo que apoye en la toma de decisión para la selección de reactivos (preguntas) enfocados a la educación 4.0, para lo cual se emplea el método Delphi para identificar el proceso que se debe seguir al seleccionar las preguntas, que se deben presentar a los estudiantes cuando utilicen alguna herramienta de reforzamiento de contenidos o sistema que este enfocado a evaluar los conocimientos de los estudiantes. El área de Inteligencia Artificial IA tiene varias áreas de conocimiento que se podrían aplicar en este algoritmo, sin embargo, por el hecho de que no se conocen las formas de aprendizaje de los estudiantes se opta por aplicar la técnica de lógica difusa ya que los conjuntos pueden presentar datos difusos o con una función de pertenencia que varié conforme al estilo de aprendizaje que tenga el aprendiz.

Educación 4.0, Lógica difusa, Reactivos

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Introduction

Education 4.0 uses information and communication technologies (ICT) as tools for accessing, organising, designing and disseminating learning content, without neglecting creativity, communication, language skills, teamwork, innovation, emotional intelligence, resilience and social responsibility, among others.

Flores Alanís, A.A., Rodríguez Hernández, J.M., and Chávez González, G., (2019), mention the main characteristics of Education 4.0, according to the Mexican Ministry of Public Education, are:

- Cooperation between student and teacher, seen as the basis of teaching.
- Communication as the main vehicle for learning.
- Real problem solving.
- Incorporation of play and creation of real environments as the main driver of learning.
- Assessment as the instrument for constant improvement and progress.
- Use of ICTs as a tool for accessing, organising, creating and disseminating content.

One of the characteristics of education 4.0 is to consider intelligent algorithms, to simulate decision-making within systems. Ciolacu (2017), performs an analysis, based on different techniques of intelligent algorithms: neural networks, fuzzy logic, support vector machines, decision trees and cluster analysis, to estimate performance in exams, and train the next generation of talent for Industry 4.0.

Therefore, it is proposed to use an artificial intelligence technique in an algorithm to optimise decision making for question selection. Using fuzzy logic in an algorithm that supports decision making for the selection of questions focused on education 4.0.

Theoretical framework

Education 4.0 uses information and communication technologies as tools for accessing, organising, designing and disseminating learning content, without neglecting creativity, communication, teamwork, innovation, emotional intelligence, resilience and social responsibility, among others.

Ranz, (2016), establishes three characteristics of Education 4.0 in learning 4.0.

1. Flexible learning according to the needs and interests of each learner.
2. Learning at the pace and speed of each student regardless of age and/or subject.
3. Digital learning with constant feedback based on the analysis of data derived from the progress of the learning itself (Learning Analytics).

Feedback is a key element of the teaching and learning process in Education 4.0, providing the learner with information on what they have done well or not done well, what they can improve and how to do it.

Another issue of impact to consider in education 4.0 is adaptive learning systems, as these personalise the material to the students to improve interaction, knowledge and knowledge utilisation. Thus, if a student has problems with a particular topic, he or she can be directed to additional materials automatically before moving on to the next topic. This allows the learner to do other activities that strengthen topics where knowledge is not fragile.

Linstone, H., and Turoff, M. (1975), mention that the Delphi method was originally devised in the early 1950s at the US RAND Corporation Research Center by Olaf Helmer and Theodore J. Gordon as a tool for making predictions about a nuclear catastrophe event. Since then, it has been frequently used as a system for obtaining information about the future.

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Fuzzy set theory was proposed by Lotfi A. Zadeh in the mid-1960s in order to mathematically represent the intrinsic imprecision of certain categories of objects, while the original motivation was to help handle imprecise aspects of the real world. For the proposal of this algorithm, the function to be used will be the trapezoidal function, which allows the necessary membership of the different linguistic variables to be used. Figure 1 illustrates the behaviour of the trapezoidal membership function of the algorithm

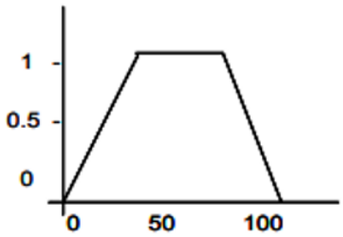

Figure 1 Trapezoidal function
Source: Own elaboration

The steps to be followed in fuzzy logic are as follows:

1. Fusification: degrees of membership are assigned to each of the input variables in relation to the fuzzy sets previously defined using the membership functions associated with the fuzzy sets of the reagents to be used in the system.

2. Knowledge base: linguistic control rules must be defined to make the decisions that will decide how the system should act.

3. Inference: the information of the knowledge base is used to generate rules by using conditions, for example: if case 1 and case 2, then action; or the connective or could be used, for example: if case 1 or case 2, then action.

4. Defuzzification: the simple mathematical method such as the centroid method is used.

Development

5. Based on what has been identified about education 4.0 and the needs to be addressed, the following algorithm is proposed for the selection of questions focused on education 4.0.

Algorithm

1. Select topic

2. Select experts on the topic

3. Identify the content, activities and processes of the materials to be presented according to the topic.

4. Develop a corpus of questions (questionnaires) to be used to reinforce the knowledge covered in the materials.

5. Apply the questions to the learner randomly from a training set to serve as a basis for each topic.

6. Analysis of the results of the questions applied.

6.1 Identification of topics in which the student does not obtain a relevant percentage (70%) in their scores, which allows to identify topics for review and/or feedback, return to step 4.

6.2 Identification of topics in which the student passes with a percentage higher than 80% in their score, allowing to know the topics that dominate or are of interest to the student, and thus be able to perform the feedback.

7. Conduct learning analytics on student data to identify the data and educational management processes that, crucially, can improve student learning.

7.1 If score is above 95% then go to step 8.

7.2 In other identified subjects scoring less than 80% then go back to step 4.

8. Give positive feedback to the learner and present some motivational element.

9. Educational content, activities or processes can be adapted to provide an enhanced or more personalised experience for the learner, based on the information analysed through learning analytics.

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Figure 2 illustrates the steps of the algorithm. Some other aspects to consider in the different steps are the following:

- Selection of expert: In this work, "expert" is considered to be any person who has experience as a professional in the area of programming, knowledge, expertise and/or affinity on one or more of one of the different topics, (Programming teachers, software developers, entrepreneurs in the area of software development).

- Elaborate a corpus of questions: The collection of the information necessary to meet the objectives initially set out in the choice of topic, content and materials. Observation by experts of which topics should be emphasised, given the relevance of the objectives to be achieved.

- Apply questions (training set): Apply questions to the learner randomly from a set of questions (training set) based on the topic and experience of the experts.

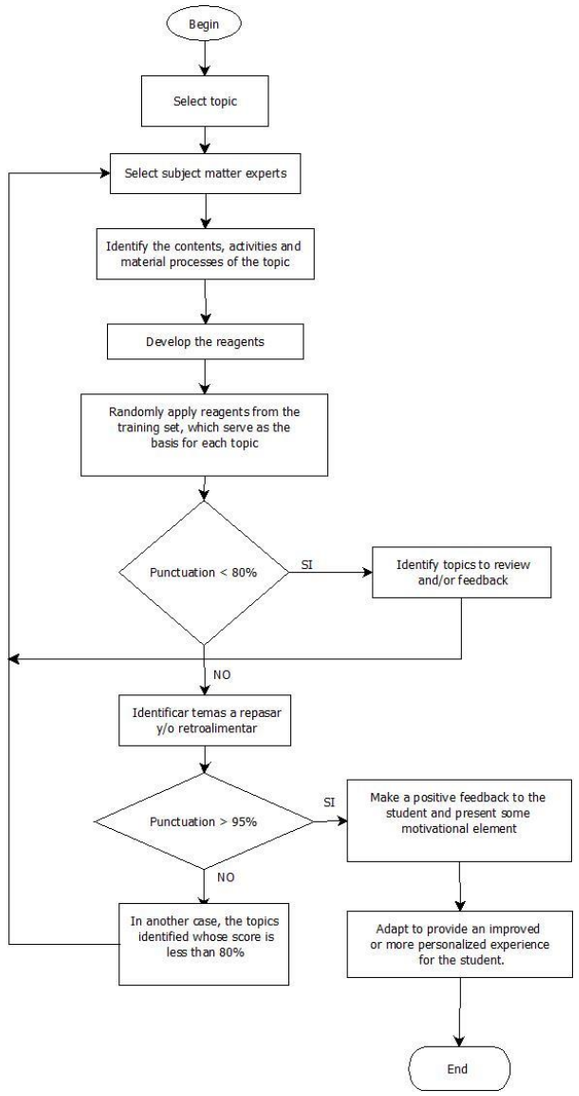

Figure 2 Flowchart
Source: Own elaboration

Results

One of the topics that we have identified as being difficult for students of the Computer Systems Engineering and Information and Communication Technologies Engineering educational programmes of the TecNM campus San Martín Texmelucan to understand and apply 100%, is the topic of data types, considering for example the ranges of values according to each type of primitive data in Java and the amount of memory they need to be stored.

Table 1, shows the primitive data of the java language.

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	Data type	Storage	Range of values	Example of information that can be stored
Numeric Integers	byte	1 byte (8 bits)	-128, 127	Age of a person=101
	short	2 bytes	-32,768, 32,767	Days lived of an adolescent=16*365=5840
	int	4 bytes	-2^{31} a 2^{31}-1.	speedLight = 299792458
	long	8 bytes	-2^{63} a 2^{63}-1.	lightYear = lightSpeed * 365
Floating point numerics	float	4 bytes	$1.4x10^{-45}$ a $3.4028235x10^{38}$	pi= 3.1415926535
	double	8 bytes	$4.9x10^{-324}$ a $1.7976931348623157x10^{308}$.	e= 2.718281828459045235360
Booleans	Boolean	2 byte	0, 1	B=a>b;
Characters	char	2 bytes	Caracteres individuales	'A' ó 'a'

Table 1 Primitive data types in java
Source: Own elaboration

In addition, students are generally looking for playful activities that allow them to acquire knowledge quickly and visually, so an activity that could be used would be to relate two columns, such as the one presented in Figure 3, which is an activity that allows the application of the recommendations of the Education 4.0 approach.

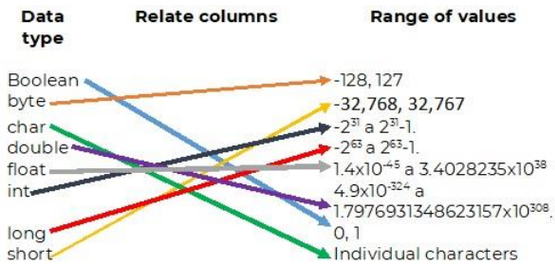

Figure 3 List of data types
Source: Own elaboration

The activity may seem simple but if the ranges of values of the types of numbers or characters that can be represented are not understood, the training questions will not give optimal results, so it will be necessary to identify other questions that will strengthen the students' knowledge. An example is described below.
Detected problem range of values
Data type: Float

Value range 1. $4x10^{-45}$ a $3.4028235x10^{38}$

Example:

- pi=3.1415926535
- Weight person = 68.210 kilos.
- Diameter = 90.21 centimetres.

Therefore, when the student no longer presents difficulties in answering the questions of the problems presented to him/her, the phase in which it is necessary to provide feedback or motivate the student to retain the knowledge acquired can be implemented by using motivational phrases or images, so that he/she continues to use this learning approach.

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Conclusions

In conclusion, an algorithm was presented in which from the point of view of the use of techniques based on fuzzy logic in which it is planned to detect learning styles and areas of opportunity, more representative of a student, since it takes information provided by the student himself, data generated by the practical identification of the learning exercise.

The definition of each of the linguistic variables, and of the respective fuzzy sets, will be adjusted in general terms to the qualitative requirements of the attributes that make up the subject to be addressed.

Identifying learning styles in this work will allow designers and developers of digital educational materials (teachers) to develop personalised educational content oriented to exploit to the maximum those aspects that facilitate the learning process of a diversity of individuals with different learning characteristics.

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