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AN ALGORITHM BASED ON SENTIMENT ANALYSIS AND FUZZY LOGIC FOR OPINIONS MINING

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ABSTRACT

The collection and analysis of comments is an important topic, as traditional methods are based on analyzing and collecting students' feedback through a questionnaire. This paper aims to extract knowledge to support students' learning processes by understanding students' sentiments regarding the use of gamification quizzes in learning. The paper attempts to apply formative assessment in an innovative way, enrich the activities accompanying the educational process in higher education, and apply fuzzy logic to obtain a more accurate analysis and reflect the true perceived sentiment in the text's content. In addition, this paper proposes an algorithm for a gamification framework based on sentiment analysis and fuzzy logic (AGFSAFL). AGFSAFL consists of four main phases: specifying the proposed gamification algorithm, preprocessing students' opinions about gamification, applying sentiment analysis, and fuzzy logic classifier for student satisfaction level. Furthermore, it presents a visualization of the work of AGFSAFL. In the future, this paper intends to enhance our proposed algorithm to aid people with special needs (i.e., the blind) by converting it into a dynamic interactive application to ease their understanding of the materials.

Keywords: *Gamification, Sentiment Analysis, Student Feedback Analysis, Fuzzy Logic, Algorithm*

1. INTRODUCTION

Education systems consist of four fundamental elements: teachers, students, a university, and a curriculum. Teachers and instructors often struggle to encourage students' motivation and concentration in the learning process. It is a fact that students, especially in our time, often do many things in the classroom besides learning. Student motivation is the backbone of the learning process because it impacts student performance. One of the vital methods of supporting and increasing motivation and interest among students during the learning process in academic institutions is gamification. Furthermore, gamification quizzes help create competition, which supports enjoyment of the educational climate. Gamification is the use of game design components in non-game contexts [1]. Using gamification in higher education assignments enhances academic advancement while reducing stress, providing learning milestones, and developing personal satisfaction [2].

Sentiment analysis (SA) is the domain that analyzes human opinion, sentiment, and assessment of an entity, whether it is an organization, individual, issue, event, or other being [3]. Sentiment analysis attempts to recognize or identify opinions in a text. One goal of sentiment classification is to specify whether a text is objective or subjective or describes a positive or negative attitude. It also classifies the expressions of emotions, such as happiness, sadness, and anger [4]. This study aims to extract knowledge to support students' learning processes by understanding student sentiments regarding the use of gamification quizzes in learning.

Fuzzy-based SA, in which scores are assigned to users' opinions using different dictionaries, is one solution for analyzing those opinions and thus ensuring user satisfaction [3]. In the next phase, fuzzy logic (FL) can be used to calculate user satisfaction at levels used by fuzzy rules [5]. Research suggests that FL is not popular in the field of SA, even though FL reflects the real sentiments perceived in users' opinions [6].

Based on the above, there is a need to conduct the current research, which is based on using a gamification algorithm to analyze students' opinions based on sentiment and fuzzy logic (AGFSAFL) to evaluate students' satisfaction in learning using gamification quizzes. This research recommends applying formative assessment in an innovative way, enriching the activities accompanying the educational process in higher education, and applying fuzzy logic to obtain a more accurate analysis.

2. RELATED WORK

Before getting involved with the proposed algorithm, it is imperative to examine related work based on gamification, sentiment analysis, and fuzzy logic.

Carnero [7] proved that gamification is a creative educational method in the evaluation process that has the greatest impact when used appropriately. They designed two models, one of which was used in the hierarchical fuzzy analysis process, while the other integrated hierarchical fuzzy analysis with the gravity of measurement through the classification-based evaluation method (MACBETH) to determine the best application of gamification within the master's program in industrial engineering. The results concluded that the proposed application is the best gamification app for this course, and Quizizz will be the best choice for teaching the course.

Boytchev and Boytcheva [8] presented a new method for assessing gamification in a STEAM course through a special training course, and the results of the quantitative analysis were discussed. Moreover, they presented a textual analysis of student feedback on the proposed assessment method.

Asghar et al. [9] suggested developing a fuzzy-based SA system for analyzing student opinions and satisfaction by assigning appropriate sentiment scores to opinion words and polarity shifters in input reviews. The SA system calculated the sentiment score for students' opinions and then applied fuzzy logic to measure student satisfaction. The experimental results showed that the proposed work outperformed previous studies.

Mostafa [10] presented a classifier for sentiment analysis in which a dataset was selected from about 1,000 classifiers that were divided into 700 "agree" sentiments and 300 "do not agree" sentiments. The sentiment analysis classifier went through a set of sentiments using text processing, feature selection, and machine learning classification, and three classifiers—NB, SVM, and a decision tree—were used. The results showed that the best results were achieved using the NB classifier. Moreover, the group that used gamification in education achieved better results, which confirms that gamification will improve students' performance in learning.

Sindhu et al. [11] proposed a supervised aspect system of opinion mining based on a two-layer LSTM model. The first layer predicts aspects related to opinions and later determines the orientation (positive, negative, or neutral). The model was tested on the dataset generated from student feedback over the last five years at Sukkur University IBA as well as on the SemEval-2014 data set. The system achieved good accuracy in the aspect extraction task (91%) and the sentiment polarity detection task (93%).

Öhman and Kajava [12] introduced the Sentimentator. This is an annotation platform based on fine-grained sentiment annotation at the sentence level. The ten-dimensional model was used to allow the annotation of 51 unique sentiments and emotions. The system was built using a scoring system designed to reward users for high-quality annotations, as the platform is available to anyone interested in analyzing and detecting sentiment or annotating other datasets.

Albadan et al. [13] contributed to the process of assigning only selected individuals to make unprogrammed decisions by implementing gamification. The purpose was

to implement inference rules based on fuzzy logic in employee selection processes.

Jefferson et al. [14] suggested a fuzzy system based on SA rules that uses fuzzy membership scores to achieve better results in terms of accuracy. They compared the performance of their approach with other classifiers (e.g., decision trees, naive Bayes), and the results indicated that their method performs better than other algorithms. Moreover, it allows users to have different degrees of sentiment without using a larger number of classes.

Howells and Ertugan [15] presented a sentiment analysis model for social media data that integrates social robotics with data mining and fuzzy logic. A highly efficient tool was designed to obtain more information and will be very useful in CRM, as it is used to get more feedback on a specific subject.

Finally, Sivakumar and Reddy [16] proposed a new approach to analyzing students' opinions collected from Twitter API through semantic correlation between the aspect word and the student's opinion sentence. This study helped improve trainers' teaching skills, as classification and clustering techniques were used to classify opinions.

We find that most of the previous related work discussed in this item used the gamification method as an innovative method in formative assessment, some used sentiment analysis and others used the fuzzy logic method in order to determine their level of satisfaction. In this paper, we are combing between sentiment analysis and fuzzy logic to analyze students' opinions about gamification style.

3. SENTIMENT ANALYSIS (SA)

SA is the domain that analyzes human opinion, sentiment, and assessment toward an entity, whether it is an organization, individual, issue, event, or something else [9]. SA is the process of determining whether an opinion of something is positive, negative, or neutral. The SA system combines NLP and ML techniques to assign sentiment scores to each individual opinion [17]. SA is the process of exploring the parts of the text of interest that indicate the direction of opinion [18].

4. FUZZY LOGIC (FL)

FL is an approach that allows for the manipulation of multiple values within a matching variable, as FL tries to solve problems to obtain more accurate conclusions and make better decisions using all available information [19]. FL is a method similar to human thinking that is used to make the most appropriate decisions. It considers all the possibilities that are between numeric values between YES and NO [20]; i.e., FL contains all real values between 0 and 1. When we encounter in our daily lives a situation in which it is not possible to determine whether a statement is true or false, FL offers greater flexibility in thinking to make the appropriate decision and obtain accurate results [21].

5. THE PROPOSED ALGORITHM

The proposed algorithm is divided into four main phases. The first phase specifies that the proposed gamification algorithm is divided into three subprocesses: choosing the platforms, choosing the subject, preparing questions, and preparing a survey (form). The second phase involves preprocessing students' opinions about gamification to remove noise data, which involves the following steps: word tokenization, stop-word removal, case conversion, uppercase words changing into lower case, and spelling correction. The third phase is applying sentiment analysis, which is divided into two sub-phases: subjectivity detection and sentiment classification. The fourth phase is a fuzzy logic classifier for student satisfaction level that consists of the following steps: fuzzy sets, fuzzification, constructing the membership functions, fuzzy if/then rules, and defuzzification. Figure 1 presents the flowchart of the proposed algorithm's stages for analyzing students' opinions based on sentiment and fuzzy logic (GASAFL).

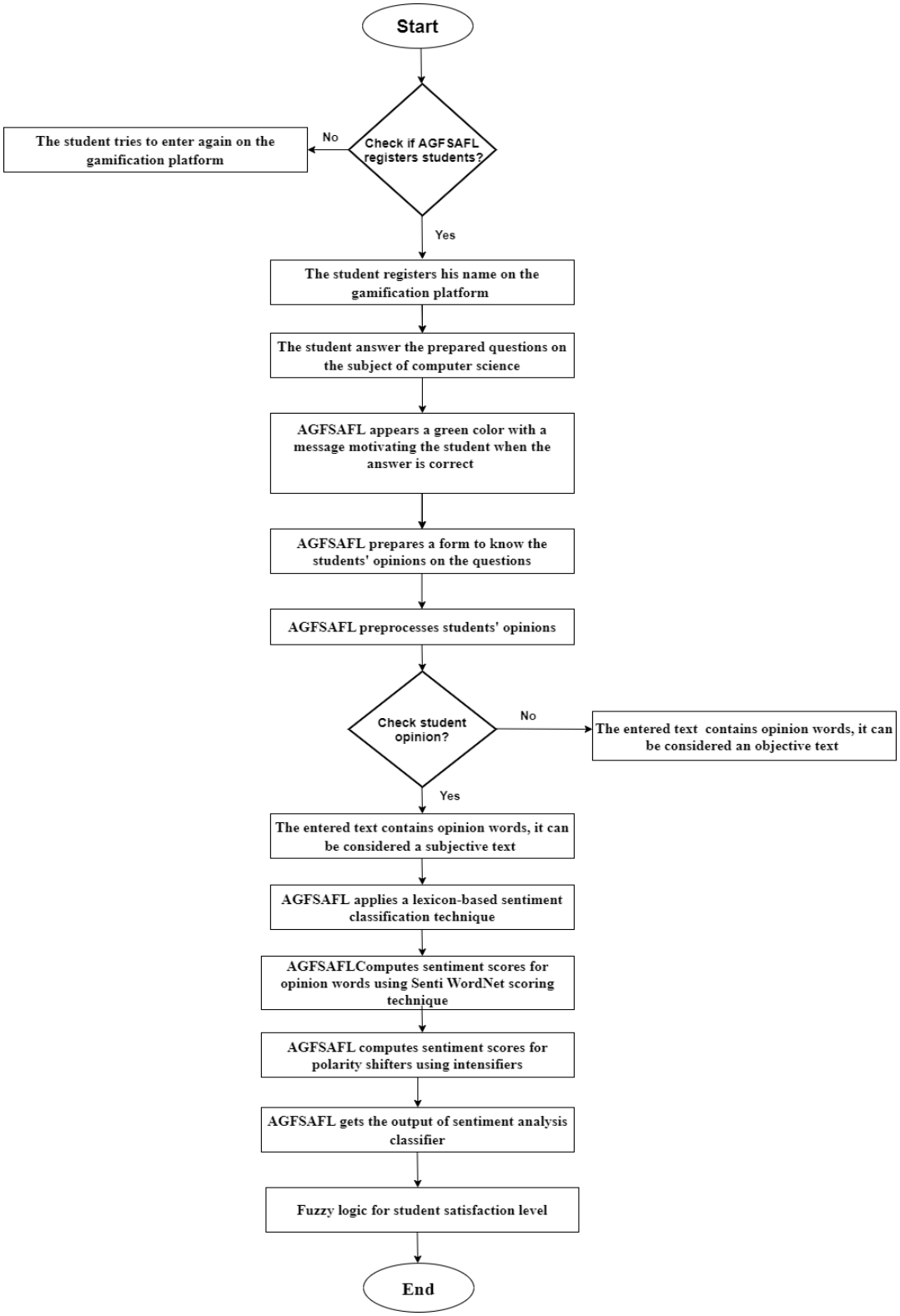

Figure1: Flowchart of an example of AGFSAFL working

5.1 Specifying the proposed gamification algorithm phase

Figure 2 shows Algorithm 1 for how AGFSAFL specifies the proposed gamification algorithm. This phase can be divided into three subprocesses: choosing the platforms, choosing a subject and preparing questions, and preparing a survey form.

Choosing the platforms: This step is used to help students create a spirit of educational and enjoyable competition and consolidate the information. It also encourages students to engage in self-reflection and assessment through the concept of purposeful gamification.

Choosing a subject and preparing questions: In this step, one of the subjects of computer science (data security) was chosen, and a set of questions was prepared through more than one gamification platform to form a formative assessment of the students. The intent was to motivate them through the badges on the gamification platforms to create a spirit of competition among the students.

Preparing a survey form: A form is prepared to obtain the students' opinions on the questions that were developed in the gamification algorithm so that the students' opinions can be analyzed using sentiment analysis.

Algorithm 1: How AGFSAFL specifies the proposed gamification algorithm

Step1: Start

Step2: AGFSAFL chooses the different gamification platforms.

Step3: AGFSAFL chooses one of the subjects of computer science.
Step4: AGFSAFL prepares a set of questions through more than one gamification platform.
Step5: The student registers their name on the gamification platform in which the questions are located.
Step6: If the student's answer to the question is correct **Then**

A green color appears with a message motivating the student to continue answering the questions

Step7: Else A red color appears with an angry emotion

Step8: AGFSAFL prepares a form to learn the students' opinions on the questions.

Step9: End

Figure2: Algorithm 1 for specifying the proposed gamification

5.2 Preprocessing students' opinions phase

Figure 3 shows Algorithm 2 for how AGFSAFL preprocesses students' opinions. This phase consists of the following steps: word tokenization, stop-word removal, case conversion, uppercase words being changed into lowercase, and spelling correction.

Word tokenization: This is used to divide the text into words to take each word later for analysis. We then perform the process of classifying the sentiments, whether they are positive, negative, or neutral.

Removing stop-words: In this step, all the stop-words are removed from the students' opinions. They are not important, as they are noise data in the students' opinion; these date later hinder the process of classifying the feelings in the students' opinions.

Case conversion: Case conversion is used to convert the uppercase words in the opinions of the students into lowercase words. For example, the word "GOOD" is changed to "good."

Spelling correction: This is used for spell checking while typing because of speed or typing with "fat fingers." Microsoft released a REST API that can be used in Python for spell checking.

Algorithm 2: How AGFSAFL preprocesses students' opinions

Step1: Start

Step2: AGFSAFL presents the form to learn the students' opinions on the questions.

Step3: AGFSAFL preprocesses the students' opinions.

Step4: AGFSAFL uses a Python-based NLTK tokenizer, where each word needs to be captured and subjected to analysis.

Step5: AGFSAFL removes all stop-words from the opinions of the students.

Step6: AGFSAFL uses case conversion to convert the uppercase words in the opinions of the students into lowercase words.

Step7: AGFSAFL uses the REST API used in Python to correct spelling errors.

Step8: End

Figure 3: Algorithm 2 for preprocessing students' opinions

5.3 Applying the sentiment analysis phase

Figure 4 shows Algorithm 3 for how AGFSAFL applies sentiment analysis. This phase is divided into two subphases: subjectivity detection and sentiment classification.

Subjectivity detection: In this step, the text entered in the students' opinions about the questions developed using the different gamification platforms in the prepared form is distinguished as subjective or objective using various opinion lexicons, such as WordNet. The objective text does not contain opinion words, while the subjective text includes concepts with opinion words. This step aims to identify and retain subjectivity by checking the presence of these words in several opinion lexicons. Each sentence of the students' opinions is checked for the existence of opinion terms with the help of various opinion lexicons. A sentence containing one or more opinion words is classified as subjective; otherwise, it is objective. For example, in one of the students' opinions, the phrase "The teaching style is excellent" might appear. "Excellent" is an opinion term; therefore, the text in which it appears is considered subjective. In another example, "The teacher performs their tasks in the lecture" is stated. This does not include the term "opinion," and therefore, it is considered to be an objective text.

Sentiment classification: In this step, sentiments are classified based on the lexicon. The sentiment scores are calculated for the students' opinions by assigning scores to the opinion terms. This produces better performance as we use the Senti WordNet technique.

Algorithm 3: How AGFSAFL applies sentiment analysis

Step1: Start
Step2: AGFSAFL classifies the text extracted from the students' opinions about the questions as subjective or objective.
Step3: AGFSAFL uses the WordNet lexicon.
Step4: If the entered text contains opinion words **Then**
It can be considered a subjective text
Step5: Else it can be considered an objective text.
Step6: AGFSAFL applies a lexicon-based sentiment classification technique.
Step7: AGFSAFL computes sentiment scores for opinion words using the Senti
WordNet scoring technique.
Step8: AGFSAFL computes sentiment scores for polarity shifters using
intensifiers.
Step9: AGFSAFL gets the output from the sentiment analysis classifier.
Step10: End

Figure 4: Algorithm 3 for applying sentiment analysis

5.4 Fuzzy logic classifier

In this step, we determine the student's level of satisfaction through the student's feedback about the questions placed in the gamification algorithm. The FL classifier is used (Figure 5a). The FL classifier includes sub-phases: fuzzy sets, fuzzification, construct membership functions, fuzzy if/then rules, and defuzzification. Figure 5(b) shows Algorithm 4 for how AGFSAFL applies fuzzy logic to determine the student's level of satisfaction. Figure 5(c) shows a flowchart of an example of a fuzzy logic classifier.

Fuzzy sets: This step defines the input and output variables. In this step, our input variable is student sentiment, and our output variable is student satisfaction.

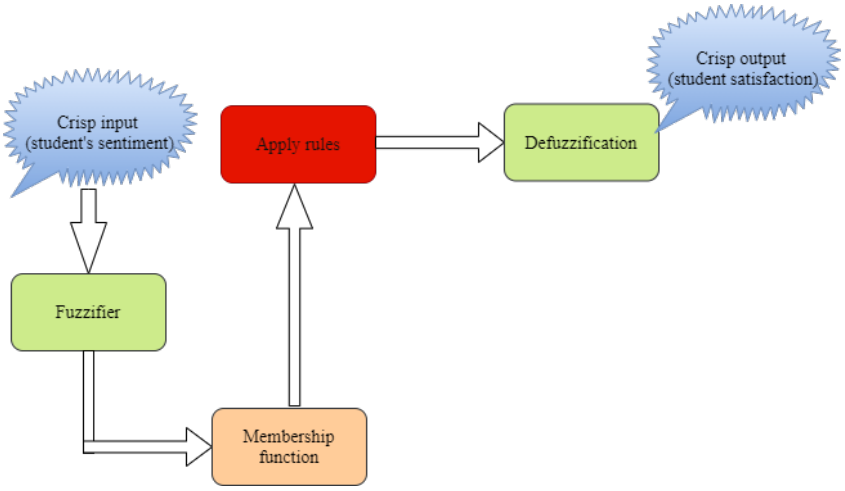

Figure 5. (a): Fuzzy logic classifier

Fuzzification: In this step, the crisp input is turned into fuzzy values using a membership function [22]. In our work, we assign three terms to students' opinions corresponding to input variables (negative, neutral, positive) and output variables (not satisfied, moderate, satisfied).

Membership function: This function is used to plot fuzzy sets when there are various types of membership functions. In the proposed algorithm, we used the triangular membership function.

Fuzzy If/Then rules: Through this step, the fuzzy rules are entered to produce the appropriate result [23]: if (antecedent), then (consequence). For example, on if/then rules: if (student sentiment is positive), then (student satisfaction is satisfied).

Defuzzification: Defuzzification is used to determine student satisfaction. The fuzzy values are converted into crisp values.

Algorithm 4: How AGFSAFL applies fuzzy logic to determine students' level of satisfaction

Step1: Start
Step2: AGFSAFL determines the input (student sentiment) and output (student satisfaction) linguistic variables.
Step3: AGFSAFL converts the crisp input into fuzzy values using fuzzification.
Step4: AGFSAFL assigns three concepts for the input (Negative, Neutral, Positive) and three concepts for the output (Not satisfied, Moderate, Satisfied).
Step5: AGFSAFL takes the triangular membership function.
Step6: AGFSAFL uses fuzzy if/then rules to obtain the result.
Step7: If student sentiment is negative **Then** student satisfaction is Not satisfied.
Step8: If student sentiment is positive **Then** student satisfaction is satisfied.
Step9: If student sentiment is neutral **Then** student satisfaction is moderate.
Step10: AGFSAFL converts the fuzzy values into crisp values using defuzzification.
Step11: End

Figure 5. (b): Algorithm 4 for applying fuzzy logic

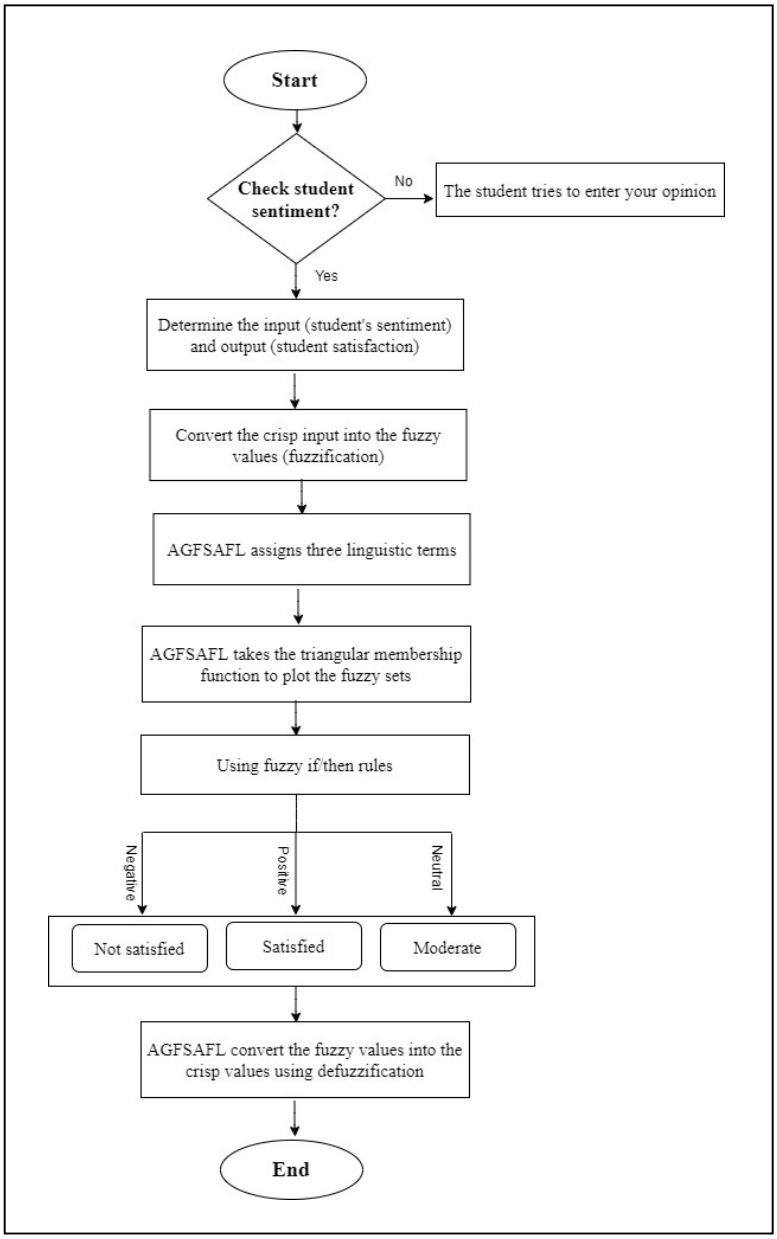

Figure 5. (c): Flowchart of an example of a fuzzy logic classifier

6. CONCLUSION

This paper has presented AGFSAFL to analyze students' opinions. Our algorithm consists of several phases: specifying the proposed gamification algorithm (choose the platforms, choose the subject, prepare questions, and prepare a survey form), preprocessing students' opinions (word tokenization, stop-word removal, case conversion, uppercase words changing into lowercase, and spelling correction), applying sentiment analysis (subjectivity detection and sentiment classification), and using a fuzzy logic classifier for student satisfaction level (fuzzy sets, fuzzification, constructing the membership functions, fuzzy if/then rules, and defuzzification). Using our algorithm, we apply formative assessment in an innovative way, enrich the activities accompanying the educational process in higher education, and apply fuzzy logic to obtain a more accurate analysis.

In future work, we want to develop the theoretical framework by applying it to a data set of students so that we can analyze their sentiments and level of satisfaction in the method used in formative assessment. In addition, we want to record students' opinions in a way that is more accurate using another sentiment dictionary, such as Senti Full. Moreover, we want to improve the proposed algorithm to help people of determination and special abilities by using a dynamic application that they can interact with, as it helps them in their understanding of the materials through the development of the gamification algorithm.

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