Analysis and Evaluation of Distance Learning Students' Performance using MATLAB Fuzzy Logic Tool in Ethiopia

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Abstract

Nowadays, students are learning and developing their skills through internet by using educational videos and e-books which are very relevant in enhancing their learning skills, especially those who are working professionals and they have no time to join regular classes. In developing countries like Ethiopia, the trend of distance learning is very much increasing with the help of the internet. Students enroll in institutes of distance education mode, and expect things like knowledge sharing, teaching learning process, and more awareness in their favor from the institute. There are seven factors: Homework, Quiz, Middle Examination, Final Examination, Video lessons, Read E- books, and Virtual Class Attendance that very much affect distance learning. In this paper we will analyze and evaluate the distance learning students' performance in Ethiopia. The paper presents the analysis and simulation with Fuzzy rules using Fuzzy Inference System (FIS) MATLAB tool to measure students educational performance accurately. We gathered the data of students and used seven parameters which enhance accuracy, flexibility and credibility as compared to using only one limited parameter. At last, results are validated by using Fuzzy Inference System with MATLAB Fuzzy tool.

1. Introduction

Due to the importance of careers or willingness to gain new skills and to keep one's knowledge up-to-date, there is need for people to always learn. Today's Internet provides a huge amount of online educational resources and tools anywhere and anytime of the day. There are solid relations between students and institutions. Students expect the things like knowledge sharing, smooth teaching learning process in their favor or support from the institution. Reputable institutions focus on the performance of their students and try to do it better, so that they could stand in rank position as compared to the other institutions (Neetesh Saxena and Kajal Kaushal Saxena, 2010). Many studies related to this research work have been conducted to evaluate student performance using fuzzy logic based on a conventional form of education. Researchers used a maximum of four parameters to ascertain the performance of students. However, this research seeks to explore several parameters to evaluate and critically assess the performance of distance learning, and not that of conventional educational. Student in Ethiopia are currently pursuing their education in distance mode from India, UK and China. There are six factors, on which the performance of distance learning students mostly depends: Homework, Quiz, Final Examination, Watched Video Lessons, Read E-Book, and Virtual Class Attendance. Each parameter has its own weight proportion which can be set flexibly. Flexibility of fuzzy login helps to measure students' educational performance accurately. In the current application, percentages that are used as values of weight proportion have been recommended by Ethiopian University Distance Learning Department in Addis Ababa.

2. Literature Review

There have been several researches on ways and means of evaluating and predicting students' performance in education. Yıldız et al. (2013) offered an early prediction of student performance during the course. To predict student's early performance, they used data collected within 8 weeks as variables and developed a prediction model based on fuzzy logic. Yadav and Singh (2012) developed a new decision making expert system with fuzzy logic techniques using student's progress and his/her ability in contrast with the existing classical methods. A research team from Malaysia suggested a new approach scaling student performance with three parameters: Academic Examination Point (i.e. CGPA), Industrial Training, and Extra Co-Curricular Activities using fuzzy logic (Nureize Arbaiy, 2006). In another study Gokmen et al. (2010) proposed to evaluate student performance based on two parameters: exam1 and exam 2. Pierrakeas et al (2004) monitored academic performance of students within the academic year measuring homework assignments, and implemented short rules that explain success and predict success or failure in the final exam. Ibrahim and Rusli (2007) used neural network, decision tree, and linear regression to estimate students' academic performance. Most part of previous research works intended to measure student's performance based on normal (formal) education not distance learning education and a limited number of factors such as exam 1, exam 2 and attendance.

2.1 Fuzzy set theory

Fuzzy set theory is built on partial memberships (e.g. an individual is a 0.65 member of a set, an action is 75% true) while the traditional set theory is based on if a value absolutely belongs to a set or not, such as "0 or 1","false or true", and "good or bad". In classic rating system if a student gets 50, he/she can pass a course, and if a student gets 49, she/he fails, because 50 belongs to successful score sets hundred percentile, 49 belongs to failed score set 100%. But in fuzzy logic success or failure limit rate belongs to a set partially, not absolutely. The fuzzy set and logic approach was first introduced by the 100% member of the University of California, Dr. Lotfi Zadeh in the 1960s.

2.2 Fuzzy logic

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Its ultimate goal is to provide foundations for approximate reasoning using imprecise propositions based on fuzzy set theory, in a way similar to the classical reasoning using precise propositions based on the classical set theory (Guanrong Chen and Trung Tat Pham, 2001). Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

2.3 Fuzzy Operators and Reasoning

In order to easily manipulate fuzzy sets, we are redefining the operators of the classical set theory to fit the specific membership functions of fuzzy logic for values strictly between 0 and 1.Unlike the definitions of the properties of fuzzy sets that are always the same, the

definition of operators on fuzzy sets are chosen like membership functions. Here are the two sets of operators commonly used: for the complement (NOT), the intersection (AND), and union (OR) most (Franck Dernoncourt, 2013).

In fuzzy logic, fuzzy reasoning, also known as approximate reasoning, is based on fuzzy rules that are expressed in natural language using linguistic variables which we have given the definition above. A fuzzy rule has the form: If x ϵ A and y ϵ B then z ϵ C, with A, B and C fuzzy sets.

For example: “If (the quality of the food is delicious), then (tip is high)”.

The variable 'tip' belongs to the fuzzy set 'high' to a degree that depends on the degree of validity of the premise, i.e. the membership degree of the variable “food quality” to the fuzzy set “delicious “. The underlying idea is that the more propositions in premise are checked, the more the suggested output actions must be applied. To determine the degree of truth of the proposition fuzzy 'tip will be high', we must define the fuzzy implication (Franck Dernoncourt, 2013).

2.4 Linguistic Variables

Variables in math based computing generally get numerical values, but in fuzzy logic, variables take linguistic variables. A fuzzy system is a static nonlinear mapping between its inputs and outputs (i.e., it is not a dynamic system). Assume, there are inputs xiϵ{x1,…,xn} and outputs yiϵ{y1,…,yn}. Xi inputs and Yi outputs are not fuzzy linguistic variables, but they are “crisps” which are converted to fuzzy inputs and outputs so that they can be handled with fuzzification and defuzzification tools. It can be seen in Figure 1.

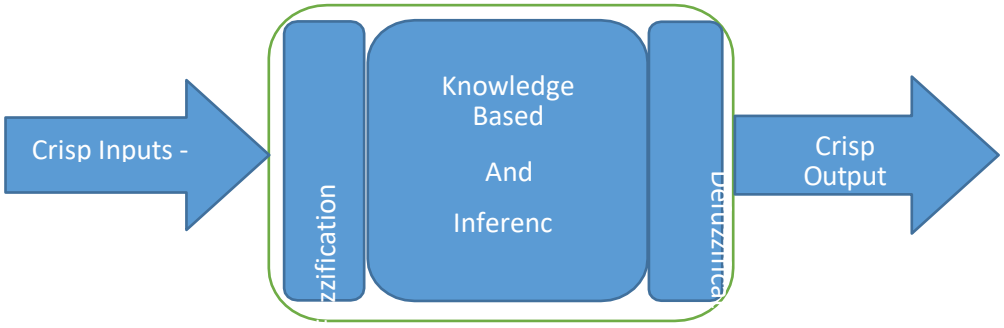

Fig.1: Fuzzy Measurement System.

We have seven crucial factors as input crisps or fuzzy linguistic variables: “Homework”, “Quiz”, “Final Examination”, “Watched Video Lessons”, “Read E-book”, “Virtual Class Attendance” and an outcome “Student Performance”. They are well described in table 1 and table 2.

Table 1: Input Linguistic Variables for the Student Performance Table1:Measurement System

Homework	Quiz	Final	Watched Video Lessons	Read E-Books	Virtual Class Attendance
Very Less	Very Less	Very Less	Very Less	Very Less	Very Less
Less	Less	Less	Less	Less	Less
Medium	Medium	Medium	Medium	Medium	Medium
High	High	High	High	High	High
Very High	Very High	Very High	Very High	Very High	Very High

Table 2: Output Linguistic Variables for the Student Performance Measurement System.

Failed	Weak	Weak Normal	Normal	Normal Good	Good	Good Excellent	Excellent

2.5 Membership Functions

The membership function of a fuzzy set is a generalization of the indicator function in classical sets. In fuzzy logic, it represents the degree of truth as an extension of valuation. Degrees of truth are often confused with probabilities, although they are conceptually distinct, because fuzzy truth represents membership in vaguely defined sets, not likelihood of some event or condition (Wikipedia). In other words, membership functions μA(x) are the values or degrees of values of linguistic variables. Membership functions and mathematical proportions of them for the current evaluation system are defined below in Table 3 and Table 4.

Table 3: Input crisps

Homework	Quiz	Final Exam	Watched Video Lessons	Read E-Books	Virtual Class Attendance
Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)	Very less (0-25)
Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)	Less (20-45)
Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)	Medium (40-65)
High (60-85)	High (60-85)	High (60-85)	High (60-85)	High (60-85)	High (60-85)
Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)	Very High (80-100)

Table No. 4. Student Performance as an Outcome Crisp

Failed (0-49)	Weak (50-57)	WeakNormal (58-64)	Normal (65-74)	Normal Good (75-79)	Good (80-84)	Good Excellent (85-89)	Excellent (90-100)

1. If (Homework is Very Low) and (Quiz is Very Low) and (Middle Exam is Very Low) and (Final Exam is Very Low) and (Watched Video Lessons is Very Low) and (Read E-Books is Very Low) and (Virtual Class Attendance is Very Low), then Student Performance is Very Low.

2. If (Homework is Excellent) and (Quiz is Excellent) and (Middle Exam is Excellent) and (Final Exam is Excellent) and (Watched Video Lessons is Excellent) and (Read E-Books is Excellent) and (Virtual Class Attendance is Excellent) then (Student Performance is Excellent).

3. Implementation of the Student Performance Evaluation System & Result

After having developed theoretical and practical basis, we test our system on simulation tools. For this target we choose Fuzzy Logic Toolbox of MATLAB. Firstly, we create a system as new application using mamdani type technique as it is simple and easy (Fig.2.) wherever input is interfacing with output of the system. Since Mamdani systems have more intuitive and easier to understand rule bases, they are well-suited to expert system applications where the rules are created from human expert knowledge.

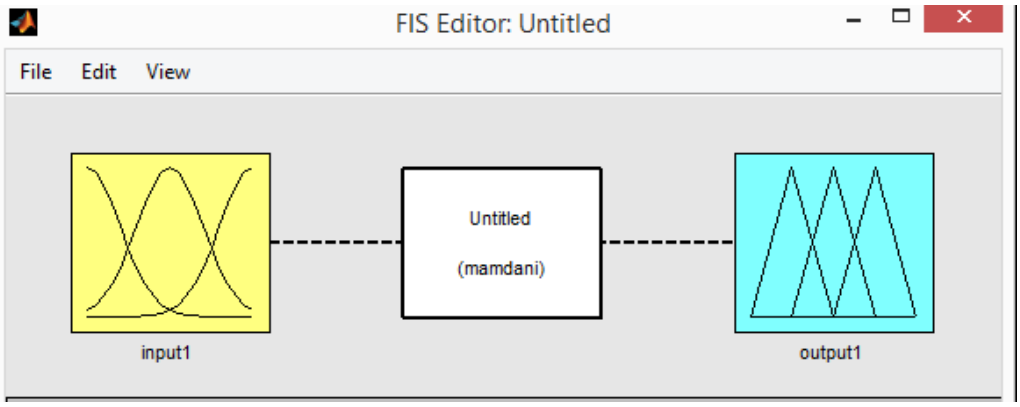

Fig. 2: New Application

Fig. 3 determines linguistic input - output variables using different member ship functions and makes rules edited with various possible conditions . Here input variables are homework ,quiz, final exam, watching videos and reading books . All these input variables are fed into mamdani type expert system and fuzzification of all input variables are Gaussians function which are interrelated to each other and have minimum and maximum values[0 1]. Output system is triangular function which carries all values of low, medium, high, and very high values and represent the students' performance analysis.

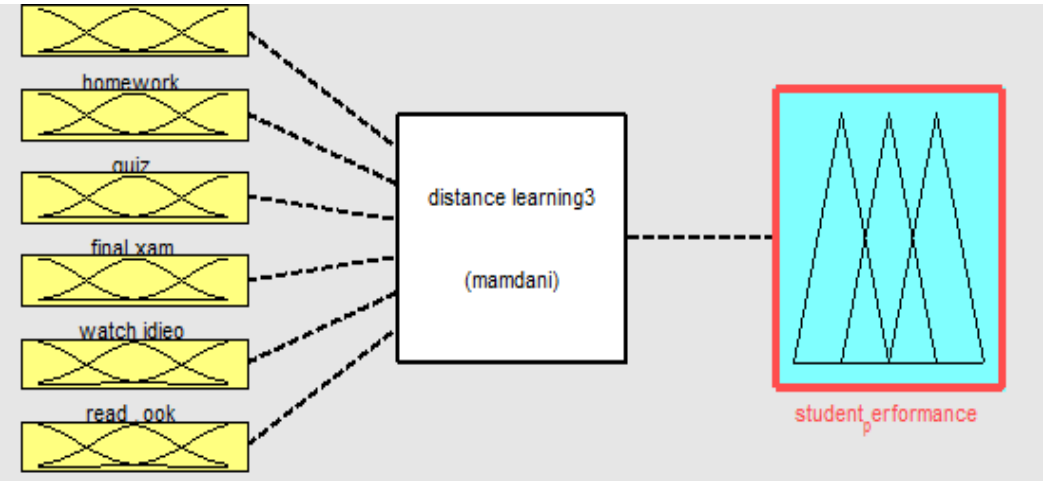

Fig.3. System analysis with input and output crisps

Fig.4. represents the membership function of homework.The function of homework is traingular which is categorized by very low, low, normal, high, and very high as per the range from 0 to 100.

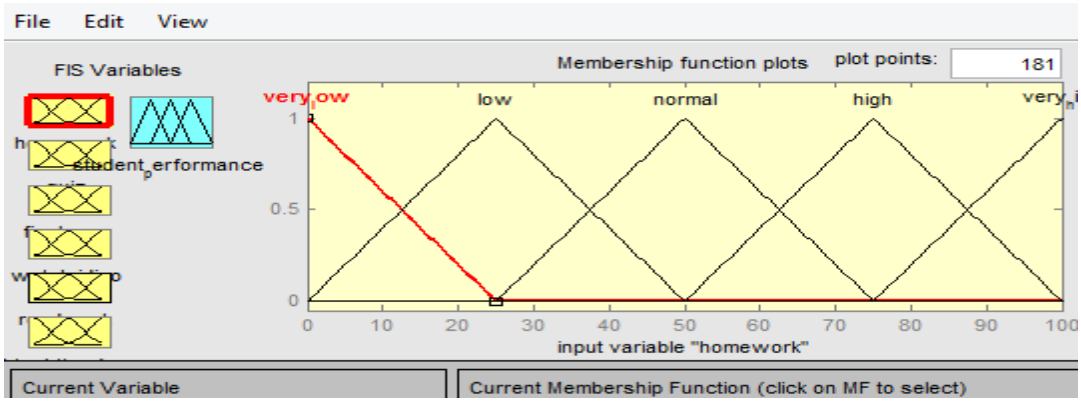

Fig. 4 .Membership function " HomeWork"

Fig.5. represents the membership function of output variable "student performance". The function of "student perpormance" output variable is traingular which is categorized by very low, low, average, good and excellent as per the range from 0 to 100.

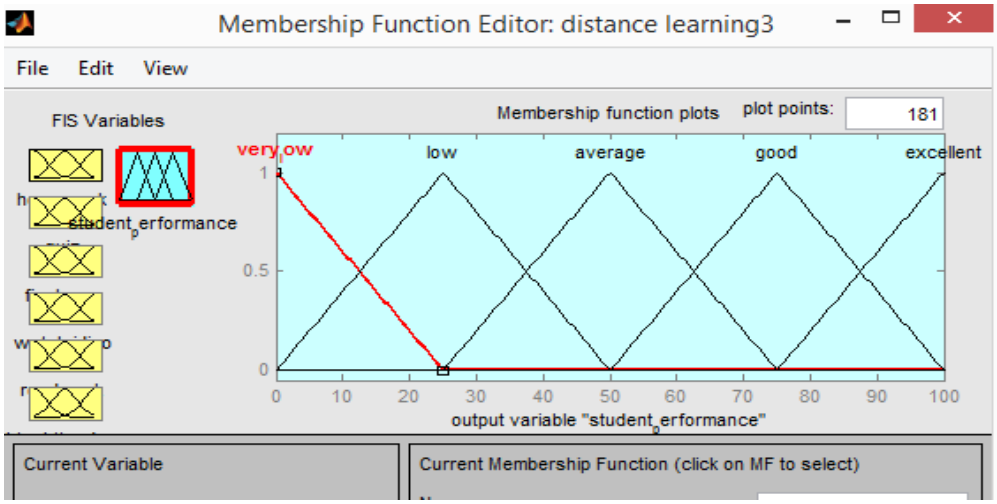

Fig.5 .Membership function "Student Performance"

Fig.6. represents the rule editor which edits the rules that define the behavior of the system Rule viewer to view the fuzzy inference diagram. Use this viewer as a diagnostic to see, for example, which rules are active, or how individual membership function shapes influence the results. Based on the description of the input and output variables defined with Fuzzy Logic designer, the rule editor allows construct the rule statement automatically. For example, in this research work, the following are some rules generated:

Rule1: If "Quiz" is very less, "Homework" is very less, "watching video" is very less, "reading book" is very less and "virtual attendance is very less", then "Student Performance" is very less.

Rule 2: If "Quiz" is very less, "Homework" is less, "watching video" is very less, "reading book" is very less and "virtual attendance is less", then "Student Performance" is very less.

Rule 3: If "Quiz" is very less, "Homework" is less, "watching video" is very less, "reading book" is very less and "virtual attendance is less", then "Student Performance" is less.

Rule 4: If "Quiz" is very less, "Homework" is very less, "watching video" is very less, "reading book" is very less and "virtual attendance is very less", then "Student Performance" is very less.

Rule 5: If "Quiz" is high, "Homework" is high, "watching video" is high, "reading book" is high and

"virtual attendance is high", then "Student Performance" is high or good.

Rule 6: If "Quiz" is very less, "Homework" is less, "watching video" is less, "reading book" is less and "virtual attendance is less", then "Student Performance" is less of average

Rule7: If "Quiz" is very high, "Homework" is very high, "watching video" is very high, "reading book" is very high and "virtual attendance is very high", then "Student Performance" is very high or excellent.

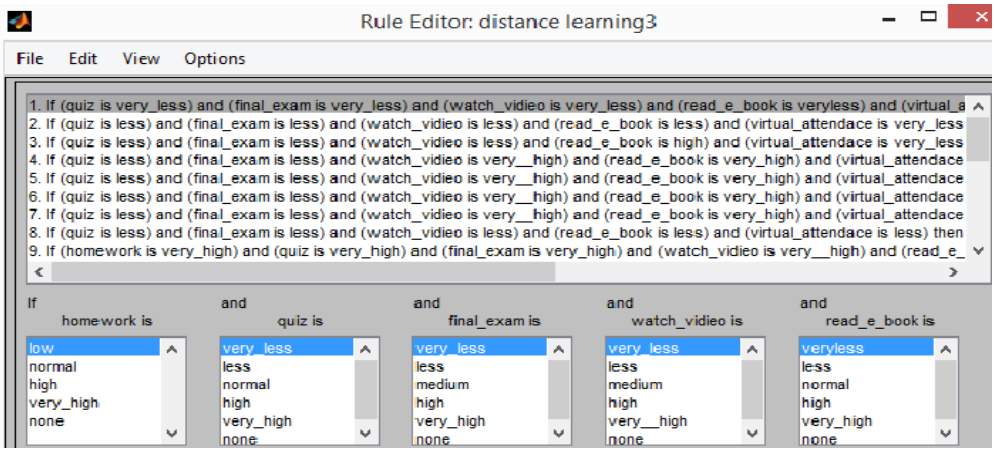

Fig.6.Rules Editor

Here we are going to analyze the result with an example: Homework=85.5, Quiz=89.9, Final Exam=77.8, Watched Video Lessons=83.5, Read E-Books=81.8, Virtual Class Attendance=77.7, and the result of Student Performance=84 is Good (Fig.7). Let's check the rule number 43. (If (Homework is VeryHigh) and (Quiz is VeryHigh) and (MiddleExam is Low) and (FinalExam is High) and (WatchedVidoeLessons is VeryHigh) and (Read_E_Books is Low) and (VirtualClassAttendance is VeryHigh) then (StudentPerformance is Good) (Fig.7). Comparing the outcome of the calculation and the result of the current rule, we can see that results are the same and we could say that implementation was successful. Additionally, it is flexible to change parameters and rules to be able to get other outcomes and analyze them.

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Fig.7 .Performance analysis **Result**

The 3D surface view for the rule that relates the students' performance to both quiz and homework are demonstrated in Fig. 8. The dark blue surface represents high student performance when both homework and quiz are high. The green surface represents a good student performance when one of the two conditions is high. The yellow surface represents a very high performance when both quiz and homework are high.

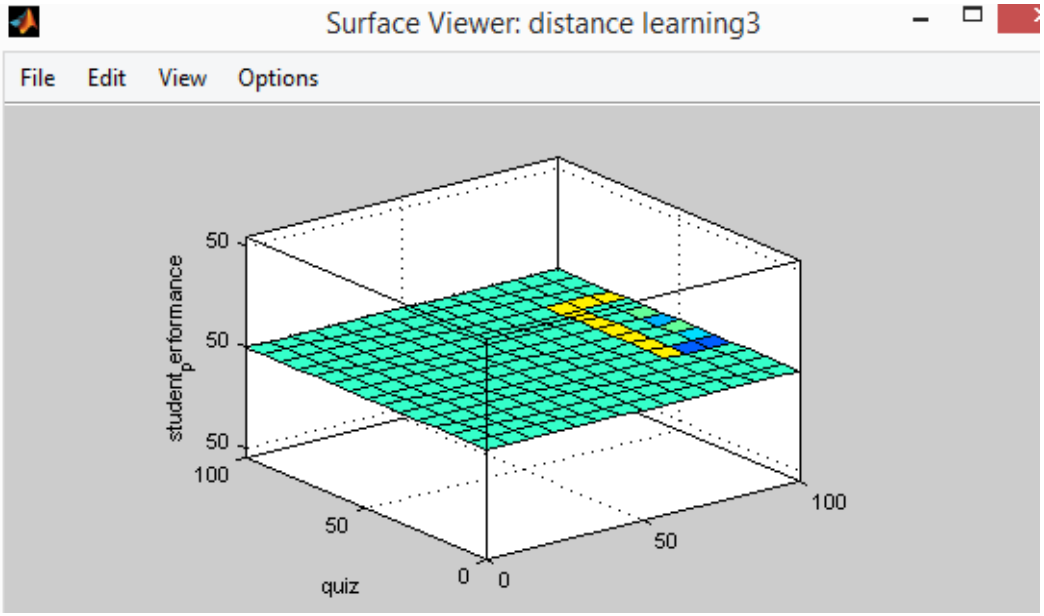

Fig.8. 3-D Surface Viewers

4. Conclusion

To sum up, it appears that many scholars did several researches with regards to the measurement of student's performance, more specifically in the area of conventional education and limited to only a few variables (parameters). This left a void which this research addressed. In measuring student performance, we used seven parameters which enhance accuracy, flexibility and credibility as compared to using only limited parameters. The variables used in evaluating students' performance were sufficient and efficient enough to aid students to get the average score. This provides the students with several options to improve on their performance. Fuzzy logic approach was crucial in scaling these variables or parameters to get the desired result of the research. This student evaluating approach is being used by Addis Ababa University. However, this method does have its own limitation because it only caters for a single subject. We will attempt to create an approach that can accommodate multiple subjects in the future.

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