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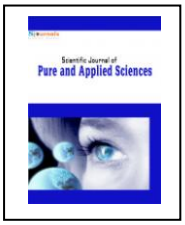

Original article

Efficient smart system fuzzy logic model for determining candidates' performances for university admission in Nigeria

P.O. Adebayo[a,*], W.B. Yahya[b], E.E. Akpan[a], M.K. Garba[b]
[a]*Federal Polytechnic Nasarawa, Nasarawa State, Nigeria.*
[b]*Department of Statistics, University of Ilorin, P.M.B. 1515, Ilorin, Nigeria.*

*Corresponding author; Federal Polytechnic Nasarawa, Nasarawa State, Nigeria.

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ABSTRACT

This paper depicts adaptation of expert systems technology using fuzzy logic to handle qualitative and uncertain facts in the decision making process. Over the years, performance evaluations of students are based on qualitative facts, which are now becoming numerically inestimable as a result of uncertainty factors. Through fuzzy logic the qualitative terms like; low, medium and high; low, moderate and high were numerically weighted during the final decision making on students' performance. The key parameters were given weights according to their priorities through mapping of numeric results from uncertain knowledge. Mathematical formulae were applied to calculate the numeric results at the final stage. In this way, the developed fuzzy expert system was demonstrated to be an effective tool for evaluating the performances of candidates seeking for admission into Nigeria tertiary institutions. This may also be adopted as a useful tool by stakeholders in government and Industry to predict the standard and long term expectations in the nation-building enterprise.

1. Introduction

Education sector has been the driving force of all developmental policies of government in the developed economy of the worlds. However, the quality of education received by people in a country largely depends on

government's commitment to education in the area of funding and provision of necessary infrastructures as well as development and implementation of functional educational policies.

The status of the Nigerian educational system at the moment is unenviable. It is low in quality and standard, limited in its reach and disturbing in its future (Kazeem and Ige, 2010). Prior to 1984, schools in Nigeria were less crowded and there were some measure of academic excellence, as schools witnessed little or no disruptions from strike and riots; entrance into institutions of higher learning were quite competitive; cultism, violence and brazen examination malpractices and indecent behaviour among students and teachers were not a virtue (Kazeem, 2004).

Beginning from 1984 however, a number of policy pronouncements were made that can be said to have impacted either positively or negatively on Nigeria educational system at all levels. For instance, the democratic government of former President Sheu Shagari inaugurated the Open University system in Nigeria in 1982. The project was designed to address the problem of access to University education in Nigeria. However, that policy was abrogated by the military government in 1984 (Kazeem, 2004) and only to be re-introduced during the era of the former President Olusegun Obasanjo in 2001.

By the Structural Adjustment Programme (SAP) policy pronouncement during the former President Ibrahim Badamosi Babangida regime in 1986, higher institutions of learning in Nigeria were mandated to devise alternative sources of funding. As a result, Nigerian higher institutions, especially the Universities had to float all manners of part-time and diploma programs in order to increase the number of their intakes and generate additional income to meet up with their financial needs. Some of such programs later became homes for those who are ill-equipped for higher education (Odukoya, 2009).

In order to actualize the vision 2020 agenda, the then Nigerian president, President Umaru Musa Yar'adua on assumption of office in 2007 drew up a national seven point agenda in order to articulate policy priorities that would strengthen reforms and build the economy for the betterment and benefit of all. One of the policy priorities of Yar'adua government was the development of educational sector. Generally, the seven point agenda which was hinged on policy reforms were meant to address the following issues: Sustainable growth in the real sector; Physical infrastructure - power, energy and transport; Agriculture; Human capital development - education and health; Security, law and order; Combating corruption and; Niger Delta development (Robert, 2010).

Since education is the pathway to any nation-building enterprise, academics and researchers began to come out with policies and techniques that can make the goal of education achievable. From last few decades, West African Examination Council (WAEC) and UTME results were the major prerequisites for admission into any of the tertiary institutions in Nigeria.

Therefore, for any candidate with only secondary school certificate to be admitted into any of the Nigerian Universities, he/she must pass the Unified Tertiary Matriculation Examination (UTME) which is being conducted annually in Nigeria by Joint Admission and Matriculation Board (JAMB). This examination name, UTME was later changed to Unified Tertiary Matriculation Examination (UTME) after the integration of the entry examinations of other non-degree awarding institutions into the examination modules of JAMB as a single package.

In order to sanitize University's admission process and improve the quality of intakes into the Nigeria University system, Post-UME (PUME) or Post-UTME(PUTME) screening exercise using computer based tests (CBT) was introduced by many Universities and other tertiary institutions in Nigeria to screen prospective students seeking admission for their eligibility at the entry level. This is meant to validate the candidates' JAMB results and ensure that only the worthy candidates are offered admission into these higher institutions.

The Post-UTME test was first conducted and administered on candidates seeking admission into higher institutions in Nigeria by the University of Ilorin, Ilorin, Nigeria in 2009. As earlier stated, the Post-UTME test, if properly conducted is aimed to ensure that the candidates admitted are of high quality (Omolewa, 200l). This would consequently redress and reduced the spate of examination malpractices and eliminate cultism and crimes in tertiary institutions in Nigeria.

At the moment, the eligibility of candidates seeking admission into any of the Nigeria's higher institutions of learning is based on the candidates' scores from five relevant 'O' level subjects, UTME and PUTME. It is the combination of these three scores that would determines the final performance and eligibility of the candidate for admission.

However, given the size of applicants into Nigeria higher institutions of learning, especially the university that keeps increasing geometrically annually, determination of the candidates eligibility for admission based on their scores from the three examinations as highlighted above could be very tedious and grossly inefficient if proper scheme that could efficiently handle such is not put in place. It is the appreciation of the need for such a scheme

that motivated this present research work to evolve an efficient machine learning model and scheme that would be suitable to predict the final performance of prospective admission seekers into higher institutions in Nigeria based on their scores in 'O' level subjects, UTME and PUTME.

A number of machine learning techniques that could be employed to accomplish this kind of task are available in the literature (Yahya, 2009; Yahya et al., 2011; Yahya, 2012; Yahya et al., 2014).More specifically, as a pattern recognition problem, among the appealing techniques in this modern age is the Artificial Intelligence (AI) (i.e. expert systems, intelligent systems or smart systems), fuzzy classification, k-sequential selection (k-SS), support vector machines and the like (Amin, 2009; Yahya, 2012; Yahya et al., 2012; Hapfelmeier et al., 2012). All these methods were developed to help in solving difficult problems that involve knowledge, heuristics, and decision-making. Among all the available diverse techniques in the literature, the fussy expert system (Zhang, 2007) is employed in this work for efficient prediction of the final performance of candidates seeking admission into Nigerian higher institutions based on their scores in the three basic entry examinations.

Smart systems is such a technology that enables human being to collect and control the human experts' knowledge and expertise in a particular problem domain for further use to solve similar problems through computer system. As a result, there is always the need for storing expert's knowledge, especially into computer system for future references and usage.

The fuzzy expert system's model proposed in this work is designed to combine the knowledge and expertise of human beings with reasoning capabilities that will provide a great support to executives for decision-making in educational institutions.

Fuzzy Logic is generally regarded as a formal way to describe how human beings perceive everyday concepts. Bai and Chen (2006) presented a new method for evaluating students' learning achievement using fuzzy membership functions and fuzzy rules. Chang and Sun (1993) presented a method for fuzzy assessment of learning performance of junior high school students. Chen and Lee(1999) presented two methods for students' evaluation using fuzzy sets. Akinyokun (2002) presented a consortium of works on Neuro-Fuzzy Expert System for evaluation of human resource performance. Zimmermann (1996) presented a method for applying the fuzzy set theory and the item response theory to evaluate the learning performance of students. A proposal on intelligent framework for teachers' performance evaluations in higher education is presented by Amin (2009). The literature reveals that there is a vast potential of expert system and fuzzy logic in education as general and performance assessment, as a special case (Wu, 2003; Adebayo, 2009).

2. Materials and methods

A number of earlier works provided in the last section showed that the introduction of fuzzy logic in a field where subjective opinions play a primary role constitutes an interesting step for adapting mathematical tools to the human way of reasoning; thus providing an efficient way to cope with imperfect information (Chen and Lee, 1999; Mohammad, 2011).

In this paper, we present model for candidates' performance evaluation which depends solely on the UTME result, 'O' Level result (OLPOINT), and PUTME scores. The objective is to evaluate candidates' final performances based on the scores obtained and the priority lay on each of these examination types.

This methodology adopted here can be easily applied to numerous control problems in industry, business, finance and management.

2.1. The fuzzy logic control process

Fuzzy logic technique provides an easy way to map an input space to an output space. A fuzzy inference system interprets the values in the input vector and, based on some set of rules, assigns values to the output vector (Zhang, 2007).The mapping then provides a basis from which decision scan be made, or patterns discerned.

In the present context, the input variables are the scores obtained by the students at the Unified Tertiary Matriculation Examination (UTME),'O' level results point (OLPOINT) and their Post-UTME (PUTME) scores. These variable inputs shall be employed to classify the final performance of prospective applicants into Nigerian Universities using fuzzy logic control technique. The configuration of the fuzzy logic control system employed in this work was adapted from those that had been employed in the literature (Sugeno and Yasukawa, 1993; Zhang, 2007).This configuration, as adapted from the one used by Zhang (2007), comprises of four steps as follows:

- The range of all variables (both inputs and the output);

- The "if-then" rules of the inference system.
- Membership functions associated with each variable;
- The threshold effective priority.

The flowchart of the process adopted for developing the fuzzy logic control model for students' performance in this work is presented by Fig 1.

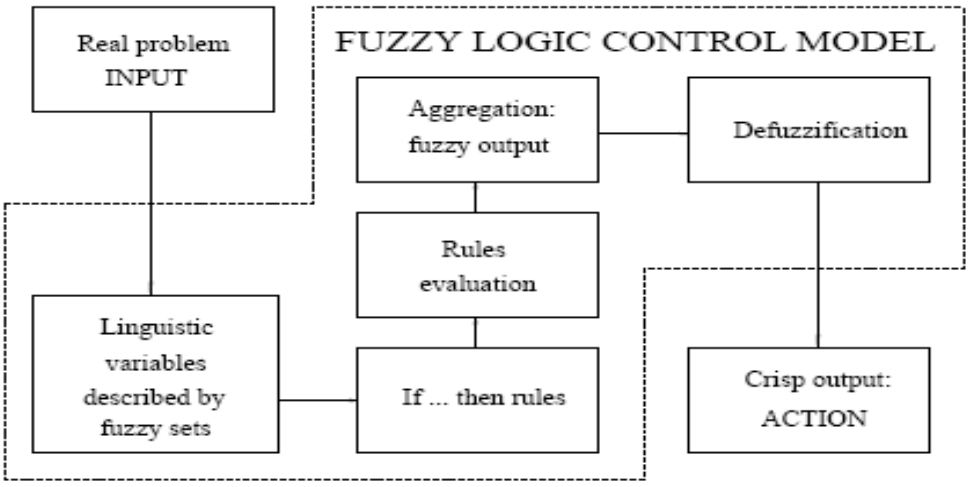


Fig. 1. The Flowchart of a Typical Fuzzy Logic Control Process.

The basic assumptions for designing an efficient Fuzzy Control System include the following:

i. A solution exists.
ii. The input and output variables can be observed and measured.
iii. An adequate solution (not necessarily an optimum one) is acceptable.
iv. A linguistic model can be created based on the knowledge of a human expert.

Let us assume that the two input variables (UTME/ 'O' Level Point and Post-UTME) and one output variable (final output performance) are defined on psychometric scale [0,100] as shown in Figs 2 - 4.

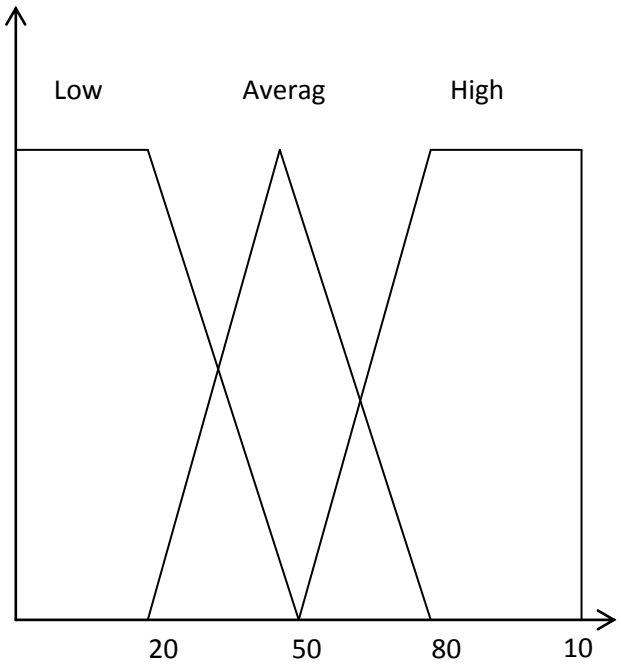


Fig. 2. Terms of the input UTME/ 'O' Level Point.

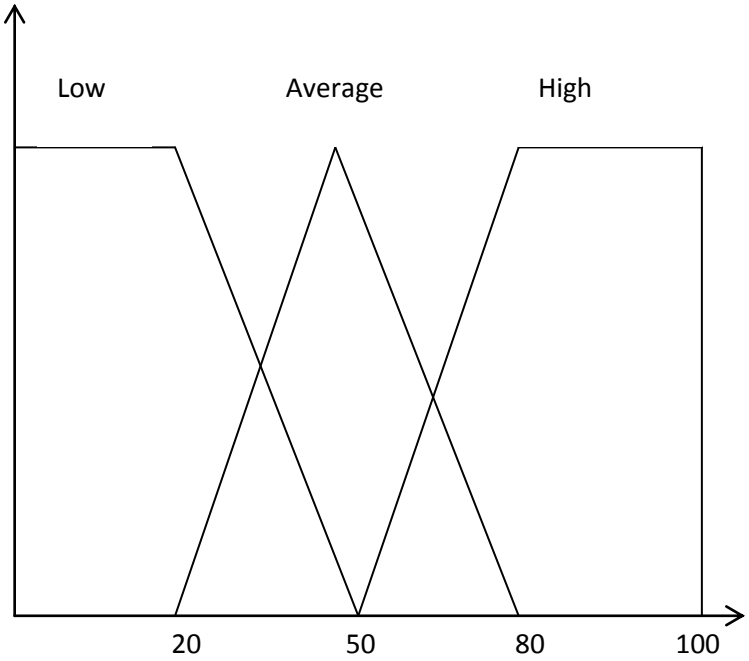


Fig. 3. Terms of the input Post-UTME.

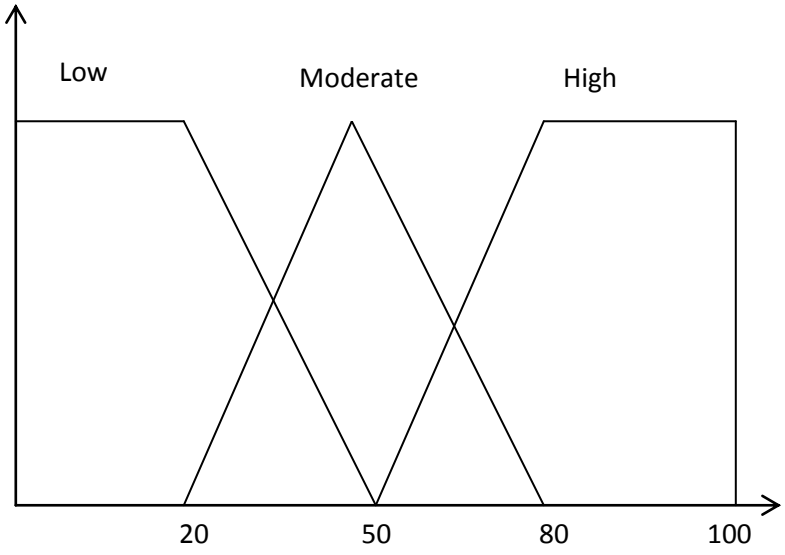


Fig. 4. Final Output Performance.

3. Applications

This section presents the application of the fuzzy expert system developed above for evaluating the final performance of candidates seeking admission into higher institutions in Nigeria based on scores obtained from the three basic entrance examinations – 'O' level, UTME and PUTME results.

i. 'O'level results

Candidates' performances in the best five 'O' level subjects that are relevant to the intended course of studies as required by the universities for admission are graded (according to WAEC grading system) as follows:

$A_1 \rightarrow$ 6 points
$B_2 \rightarrow$ 5 points
$B_3 \rightarrow$ 4 points
$C_4 \rightarrow$ 3 points
$C_5 \rightarrow$ 2 points
$C_6 \rightarrow$ 1 point

The maximum marks obtainable by any candidate from 'O' level results is 30. This is the point that a candidate with A_1 in all the five relevant 'O' level subjects would obtain.

ii. Utme results

The Joint Admission and Matriculation Examination Board is the body responsible for examining candidates in the subjects relevant to the candidate's course of study in Nigeria. Candidates are tested in English Language and three other subjects that are relevant to the intended courses of study. The total mark obtainable under this examination is 400.

iii. Post ume exam

Candidates are tested in three major areas of knowledge. These include English Language, Mathematics and General paper. Although, the format adopted on the areas to be tested slightly varies from one institution to another. The total mark obtainable in this examination is 100%.

3.1. Control variables

In the implementation of the fuzzy expert system developed here, the performance evaluation control variables have two inputs – i.) UTME/'O' Level point ii.) Post-UTME and one output performance variable (candidates' final performance). The control objective is for any given inputs to reflect the state of candidates' performance.

The UTME/'O' Level point is determined by combining a candidate's score at UTME with his score in his best five 'O' level subjects using the following statistic:

$$\mathrm{UTME/'O'LP} = \frac{\mathrm{U} + \mathrm{O}}{\mathrm{U_{max}} + \mathrm{O_{max}}} \times 100 \qquad (1)$$

where;

U = Candidate's score at UTME,

O = Candidate's score in the best five 'O' level subjects,

$\mathrm{U_{max}}$ = The maximum score obtainable by the candidate at UTME (i.e. 400)

$\mathrm{O_{max}}$ = The maximum score obtainable by the candidate in the best five 'O' level subjects (i.e. 30).

By the representation in (1), the condition that $0 \leq \mathrm{UTME/'O'LP} \leq 100$ holds.

3.2. Description of inputs and output variables

We describe the two input variables ($\mathrm{UTME/'O'LP}$ and Post-UTME) and the output variable (Final performance) using the terms in the triangular and trapezoidal shapes in Figs 2 – 4 as follows;

$\mathrm{UTME/'O'LP} \triangleq \{\mathrm{Low}, \mathrm{Average}, \mathrm{High}\}$,
Post-UME $\triangleq \{\mathrm{Low}, \mathrm{Average}, \mathrm{High}\}$,
Final Performance $\triangleq \{\mathrm{Low}, \mathrm{Moderate}, \mathrm{High}\}$,

3.3. Simulation scheme

For clear demonstration of the fuzzy expert system developed here for determining the final performance (eligibility) of prospective candidates into higher institutions of learning in Nigeria, hypothetical random samples of $\mathrm{UTME/'O'LP}$ (X) and Post-UTME scores (Y)for eleven candidates seeking admission into Nigeria Universities were simulated from Gaussian densities with means 50 and 60 each with standard deviation of 5 (i.e. $\mathrm{X_{n=11}} \sim \mathrm{N}(50, 5)$; $\mathrm{Y_{n=11}} \sim \mathrm{N}(60,5)$). All the simulated scores as presented in Table 1 were rounded up to integer values for simplicity.

Candidate	1	2	3	4	5	6	7	8	9	10	11
UTME/'O'LP(X)	50	50	50	60	65	57	60	60	60	60	80
Post-UTME scores (Y)	66	67	70	50	50	56	64	70	40	45	45

4. Results

Based on the simulation results in sub-section 3.3, let the UTME/'O'LPand Post-UTME of the first candidate in the sample be given as x_0 = 50 and y_0 = 66 respectively. Then, matching the readings 50 and 66 against the appropriate terms of membership functions in Fig 5 and Fig 6 respectively gives the fuzzy reading inputs.

In order to evaluate the candidates' final performance status (low, moderate or high) for their eligibility for admissioninto Nigeria University based on UTME/'O'LP and Post-UTME scores, the following nine IF … THEN rules are used:

1. IF (UTME/'O'LPis Low) and (Post-UME is Low) THEN (Performance is Low)
2. IF (UTME/'O'LP is Low) and (Post-UME is Average) THEN (Performance is Low)
3. IF (UTME/'O'LPis Low) and (Post-UME is High) THEN (Performance is Moderate)
4. IF (UTME/'O'LPis Average) and (Post-UME is Low) THEN (Performance is Moderate)
5. IF (UTME/'O'LPis Average) and (Post-UME is Average) THEN (Performance is Moderate)
6. IF (UTME/'O'LPis Average) and (Post-UME is High) THEN (Performance is High)
7. IF (UTME/'O'LPis High) and (Post-UME is Low) THEN (Performance is Low)
8. IF (UTME/'O'LPis High) and (Post-UME is Average) THEN (Performance is Moderate)
9. IF (UTME/'O'LPis High) and (Post-UME is High) THEN (Performance is High)

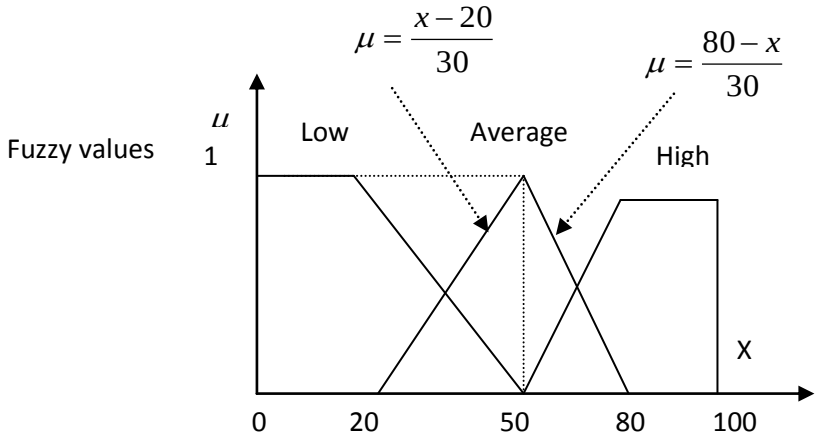


Fig 5. UTME/'O'LP

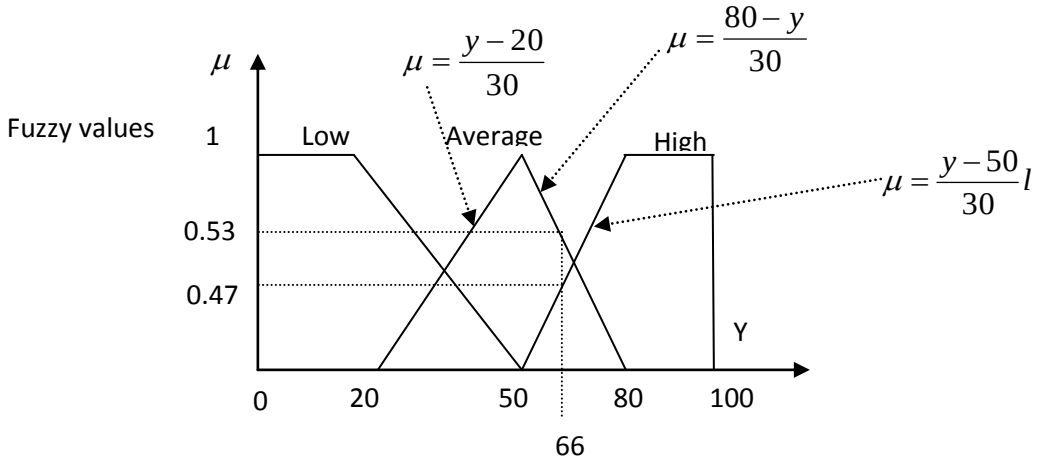


Fig. 6. Post-UTME.

The fuzzy values based on the respective matching in the triangular and trapezoidal shapes in Figs 5 and 6 are:

$$\mu_{Average}(50)=1,\ \mu_{High}(50)=0,\ \mu_{Average}(66)=0.47,\ \mu_{High}(66)=0.53$$

The control output of each rule is defined by the operation conjunction applied on its strength and conclusion as shown in the confusion matrix below:

$\alpha_{i,j} \wedge \mu_{C_{i,j}}(Z)$	$\alpha_{i,j+1} \wedge \mu_{C_{i,j+1}}(Z)$
$\alpha_{i+1,j} \wedge \mu_{C_{i+1,j}}(Z)$	$\alpha_{i+1,j+1} \wedge \mu_{C_{i+1,j+1}}(Z)$

The minimum value of the outputs from the fuzzy operation in each cell in the above confusion matrix is then taken. That is:

$\alpha_{i,j} \wedge \mu_{C_{i,j}}(Z) = \min\left(\alpha_{i,j},\ \mu_{C_{i,j}}(Z)\right)$

$\alpha_{i,j+1} \wedge \mu_{C_{i,j+1}}(Z) = \min\left(\alpha_{i,j+1},\ \mu_{C_{i,j+1}}(Z)\right)$

$\alpha_{i+1,j} \wedge \mu_{C_{i+1,j}}(Z) = \min\left(\alpha_{i+1,j},\ \mu_{C_{i+1,j}}(Z)\right)$

$\alpha_{i+1,j+1} \wedge \mu_{C_{i+1,j+1}}(Z) = \min\left(\alpha_{i+1,j+1},\ \mu_{C_{i+1,j+1}}(Z)\right)$

The outputs of the fuzzy logic control system as can be obtained from Fig 5 and Fig 6 for the two input variables UTME/'O'LP and Post-UTME are presented in Table 2.

Table 2

The fuzzy logic rule strength for the two input terms UTME/'O'LP and Post-UTME.

UTME/'O'LP	Fuzzy Value	Post-UTME	Fuzzy Value
$\mu_{Average}(50)$	1	$\mu_{Average}(66)$	0.47
$\mu_{High}(50)$	0	$\mu_{High}(66)$	0.53

The application of the above rules and the fuzzy values obtained using the rule strength on the simulated data for the performances of candidates seeking admission into Nigerian Universities in UTME/'O'LP and Post-UTME yielded the following results:

$\mu_{Average}(50) \wedge \mu_{Average}(66)$ = min (1, 0.47) = 0.47

$\mu_{Average}(50) \wedge \mu_{High}(66)$ = min (1, 0.53) = 0.53

$\mu_{High}(50) \wedge \mu_{Average}(66)$ = min (0, 0.47) = 0

$\mu_{High}(50) \wedge \mu_{High}(66)$ = min (0, 0.53) = 0

The control outputs of the rules are presented in the active cells in Table 3.

Table 3

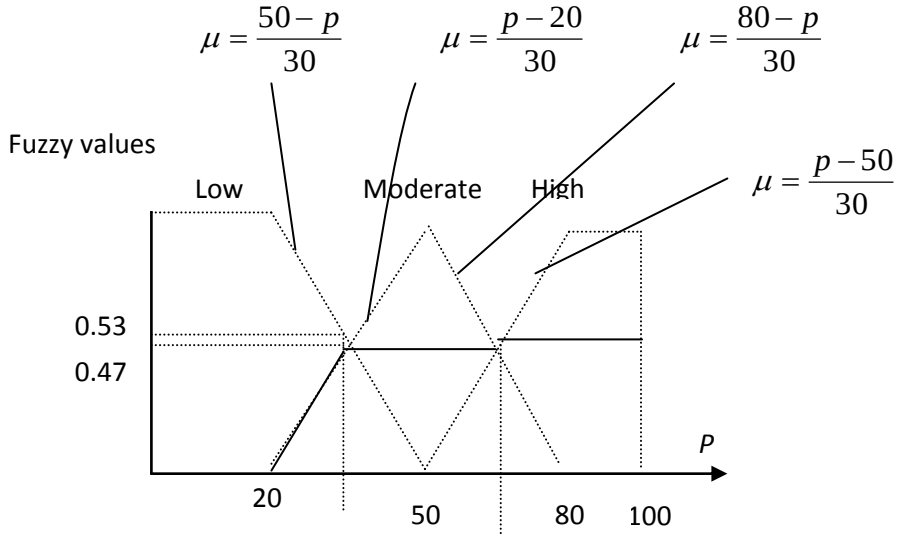
Control outputs of the rules obtained from Table 2.

$0.47 \wedge \mu_{\text{moderate}}(P)$	$0.53 \wedge \mu_{\text{High}}(P)$
$0 \wedge \mu_{\text{High}}(P)$	$0 \wedge \mu_{\text{High}}(P)$

The output in the active cells in Table 3 is aggregated. The results obtained is

$$\mu_{agg}(p) = \max\{\min(0.47, \mu_{\text{moderate}}(p)), \min(0.53, \mu_{\text{High}}(p))\} \quad (2)$$

The aggregated output in Table 3 is defuzzified by using Height Defuzzification Method (HDM).



Fi gat for the input terms.

The projections of the flat segments can be easily calculated using their height and the relevant equations of inclined segments indicated in Fig7. Then, using the HDM we have that

$$Z_k = \frac{0.47\left(\frac{34.01+65.99}{2}\right) + 0.53\left(\frac{65.99+100}{2}\right)}{0.47+0.53}$$

$$Z_k = \frac{0.47\left(\frac{100}{2}\right) + 0.53\left(\frac{165.99}{2}\right)}{0.47+0.53} = \frac{0.47(50) + 0.53(82.995)}{1} = 67.48735 \approx 67.5$$

This is the final output performance value of the first candidate with UTME/'O'LP and Post-UTME scores of 50 and 66 respectively.

Table 4
Candidates' performance evaluation using Fuzzy logic control process.

Candidate	UTME/'O' LP (%)	Post-UTME(%)	Output Performance(%)	Performance Status
1	50	66	67.50	High
2	50	67	68.98	High
3	50	70	73.33	High
4	60	50	50.00	Moderate
5	65	50	50.00	Moderate
6	57	56	55.79	Moderate
7	60	64	64.93	High
8	60	70	73.33	High
9	60	40	40.00	Low
10	60	45	44.50	Low
11	80	45	45.42	Low

The output performances of other candidates with their respective UTME/'O'LP and Post-UTME scores are computed in the same manner as shown in Table 4. The final output performance status using the 'if … then' rules defined in Section 4 are provided in the last column of Table 4. By this, the eligibility of a candidate for university admission can be determined using only the UTME/ 'O'LP and Post-UTME sores as input variables.

4. Discussion

Table 4 shows the candidates' performances based their UTME/'O'LP and Post-UTME scores respectively. Candidates under consideration here are those that scored at least 40% and at most 70% in their Post-UTME examination.

Results in Table 4 showed that candidates with at least 50% scores in Post-UTME have at least 50% final performance score while candidates with less than 50%Post-UTME scores obtained less than 50% final performance score irrespective of their UTME/'O'LPscores.

Without loss of generality, the most fundamental feature in the results of fuzzy logic expert system developed in this work as shown in Table 4 is that the final performance score of each candidate is majorly determined by the Post-UTME score. It can be observed from the results in Table 4 that significant increase in candidate's Post-UTME score results in better final performance score. In other words, the Post-UTME scores of candidates are positively correlated with their final performance scores ($\hat{\rho}$= 0.998, p-value < 0.001). This is better explained by the line graphs of the Post-UTME, final performance and UTME/'O'LPscores of all the eleven candidates after all the three scores have been sorted by the Post-UTME scores in increasing order of magnitude as shown in Fig 8. From the line graphs in Fig 8, it can be observed that candidates' performances increase as their Post-UTME scores increase irrespective the students' scores at the UTME/'O'LP.

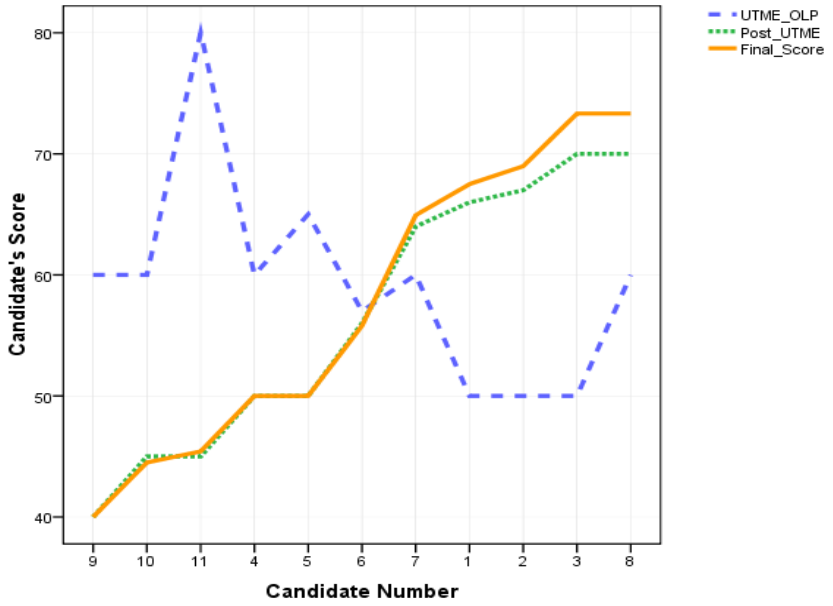


Fig. 8. Line graphs of the UTME/'O'LP, Post-UTME and Final performance scores of all the eleven candidates with all the scores sorted in increasing order of magnitude by the Post-UTME scores.

For instance, candidate3 in Table 4 with a UTME/'O'LP score of 50% and Post-UME scores 70 has a final performance score of 73.33% which is far above that of candidate 4 with higher UTME/'O'LP score of 60%but a lower Post-UTME score of 50 relative to that of candidate 3. Here, despite that the UTME/'O'LP score obtained by candidate 4 (60%) is relatively higher than that of candidate 3 (50%), the higher Post-UTME score (70%) obtained by candidate 3 enabled him to have a higher final performance score of 73.33% relative to a final performance score of 50% obtained by candidate 4that had a Post-UTME score of 50%.

The important role played by Post-UTME score at determining the final performance of candidates seeking admission into Nigeria University is clearly evident in the final performance scores 44.5% and 45.42%obtained by candidates 10 and 11 with UTME/'O'LP scores 60% and 80%respectively with the two candidates having the same Post-UTME score of 45%.It is observed from the results in Table 4 that, despite that the UTME/'O'LP score of candidate 11 (80%) is 20% higher than that of the candidate 10 (60%), the two candidates apparently have similar final performance scores. The difference of 20% with which the UTME/'O'LP score of candidate 11 is higher than that of candidate 10 only earned the candidate an insignificant increment of about 2% in his final performance score.

In terms of the final performance status of the candidates, it can be generally observed from the table of results that candidates with relatively high, average and low Post-UTME scores ended up with high, moderate and low final performance status as shown in Table 4. This further underscores the importance of the Post-UTME score as a key determinant of the admissibility of prospective applicants into Nigerian Universities.

5. Conclusion

In this paper, Fuzzy logic control decision system is used to evaluate candidates' performance for admission into the University. This method has been demonstrated to be an effective tool for determining the eligibility of admission seekers into Nigeria University system using the combination of scores from three entrance examinations – 'O' level results, UTME and Post-UTME scores – conducted by three different national examination bodies.

Results from the fuzzy logic control system based on the simulated data here perfectly conformed with the practical situations being experienced by virtually all the Universities in Nigeria during admission process. For instance, at the University of Ilorin, Nigeria, any admission seeker that scored below 50% at the Post-UTME is automatically disqualified for admission irrespective his scores at UTME and 'O' level points. This is the exact scenario provided by the results of the fuzzy expert system in Table 4.

From the results in that table, candidate 3 with relatively low UTME/'O'LP score of 50% but with a high score of 70% at the Post-UTME ended up having a final performance score of 73.33% (high performance status). This candidate automatically qualifies to be offered admission into the University.

On the other hand, candidate 11 with the highest UTME/'O'LP score of 80% but having a score of 45% at the Post-UTME ended up having a final performance score of 45.42% (low performance status) which automatically disqualifies the candidate from being offered admission into the University.

Finally, the fuzzy logic control system developed here would serve as useful tool to stakeholders in government, banking, industry and non-governmental organizations for determining future expectations based on known level of performances of major necessary key indicators that would serve as variable inputs.

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