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Road Construction Fraud Detection System using Fuzzy Logic

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ABSTRACT
All over the world, fraud poses a serious threat to both the developing and developed economies, this is generally due to the large amount of resource it illegal take away from the state and advanced nature of technology which aids the scheme. Nigeria is not an exception in fraud and financial crime-related cases, however, road construction and infrastructural development related frauds are rarely checked. Through these frauds, large state resources is diverted. Using World Bank benchmark for road construction in Africa, this paper designed a Road Construction Fraud Detection System Using Fuzzy Logic. Contract cost, environment factors, and other contract details were compared against the standard benchmark of contract sum in such areas. Also fuzzy rules were used to determine whether a contract is fraudulent or not. This work would show that contract inflations and fraud in road construction can be detected and minimized with a good fraud detection system.

Keywords
Fraud detection, Road construction fraud, Fuzzy Logic.

1. INTRODUCTION
All over the world, fraud poses a serious threat to both the developing and developed economies, this is generally due to the large amount of resource it illegal take away from the state and advanced nature of technology which aids the scheme[1]. Nigeria is not an exception in fraud and financial crime-related cases; rather, they constitute serious threat to the nation's economy and development [2]. It is noteworthy to state that the challenge of fraud cut across almost all sectors of our national life, though more endemic in certain areas. The case of financial crime, cybercrime and other bank and credit card related fraud may have top the list of the most reported fraud in recent years. However, as in every developing economy, road construction is key aspect of Nigeria's infrastructural developmental project. Large portion of states and federal governments' budget is spent on different types of road construction annually. The projects could be fresh construction, rehabilitation, or other forms of work. Also, some development partners like World Bank, International Monetary Fund (IMF) have made several effort to finance infrastructural development like road construction to aid developmental agenda of the country. However, most of the project costs are alleged to be full of cases of high level fraud [2]

It is at the backdrop of these frauds that in the year 2000, World Bankcarried out comparative assessments of road construction contracts across 13 countries in Sub- Saharan Africa. The result showed that of 109 roads and bridges, and 76 construction consultancies sponsored by World Bank, "the highest cost overruns were observed in Nigeria. In the course of time, the contracts increased their original value by an average of 39.7 per cent during implementation while no cost overruns were incurred in Ethiopia,Uganda and Kenya. In fact, in South Africa, the average cost of constructing a kilometre of road falls within the World Bank road construction benchmark.

The result of the above analysis impacted a further work by World Bank to publish a benchmark of road construction work in Africa using terrain, geological features, international market, exchange rate and other important variables. While it's true that there are differences in geological and environmental features across Nigeria which may account for different cost in road project, the benchmark was designed to take cognisance of that, allowing the benchmark to set a ceiling price for all. However, several of the projects seem to have massive cost that are sometimes questionable.

[3] Noted that the cost of constructing a kilometre of road in Nigeria is one of the costliest in the world. A report on Road Infrastructure Development in Nigeria (2009-2013) which compared the cost of road construction in Nigeria against some African countries showed a remarkable difference that suggests an abnormality in Nigeria. Also, based on word Bank benchmark in year 2000, [4]conducted a study on road construction project in Nigeria, the findings showed average cost of 400 million to 1 billion Naira per kilometre, this was considered too large and far from reality. This was confirmed by a case study of Ibadan Township road which was about 609.24 million naira per kilometre and the Abuja/Abaji/ Lokoja road which was averagely about 591 million naira. These projects were awarded at a time that the inflation was a single digits and the exchange rate was less than 180 naira to a dollar; these projects exceeds the upper bound benchmark cost of $1,374,429.60 per kilometre recommended by the World Bank as cost of constructing a kilometre of paved road. The overall analysis leaves the projects at a questionable point of excess cost.

These fraud and frequent cases of contract inflation and manipulation makes it a very crucial aspect that needs the proper attention and solution. Several billions of money is diverted to private individuals through the avenue of these fraudulent contracts and road projects. Hence, this paper presents a fuzzy logic based road construction fraud detection system to confront this problem with a system that will detect fraud in the contracts awarded.

2. MATERIALS AND METHOD

2.1 Fuzzy Logic

In the real world, objects are often classified into different categories like low, moderate, or high, etc, all of which convey linguistic vague information [5]. The idea of fuzzy set aims to deal with vague information. Fuzzy set theory is an extension of classical set theory in which an element either belongs to a set or does not belong to a set. An element may partially belong to a set using membership function that state the degree with which it belong to a set [6][7].

Fuzzy logic permits expression of imprecise and qualitative information in a precise and quantitative way [8]. One good example of applying fuzzy set theory is to formulate human knowledge, often in the form of natural language, in a systematic and mathematically rigorous manner. For example, "very beautiful person" or "tall people". To transform such imprecise information into a fuzzy set, a membership function is design that maps the object into the set, at a certain degree of truthfulness. With the definition of a fuzzy set and fuzzy membership function, the described fuzzy object becomes precise [7]. However, specification of an appropriate membership function is quite subjective, this accounts for varying membership function for the same object or concept. For example, "fast" or "high," by different people may vary considerably [7].This subjectivity originates from the nature of abstract concepts rather than randomness. In fact, the subjectivity and non-randomness of fuzzy sets are the primary difference between fuzzy set theory and probability theory, which deals with the objective treatment of random phenomena.

The architecture of a fuzzy expert system consist of several modules: fuzzification, knowledge-based, inference engine and deffuzification. The fuzzification module transforms the physical values of the current process to a normalized fuzzy subset consisting of interval for the range of the input values and an associate membership function describing the degrees of the confidence of the input belonging to this range. Generally, the fuzzy subset and the membership function has to be selected by the designer according to the particular application at hand.

A knowledge-based system consists of a knowledge that represents facts about the world and an inference engine that can reason about those facts and use rules and other forms of logic to deduce new facts or highlight inconsistencies [5]. Since the premises of the rules and the consequences of these if-then rules are associated with fuzzy concepts, the rules are expressed as fuzzy rules.

The inference engine applied logical rules to the knowledge base and deduced new knowledge. This process would iterate as each new fact in the knowledge base could trigger additional rules in the inference engine. Inference engines work primarily in one of two modes: forward chaining and backward chaining. Forward chaining starts with the known facts and asserts new facts. Backward chaining starts with goals, and works backward to determine what facts must be asserted so that the goals can be achieved

Defuzzification is the process of producing a quantifiable result in fuzzy logic, given fuzzy sets and corresponding membership degrees. It interprets the membership degrees of the fuzzy sets into a specific decision or real value. A common and useful defuzzification technique is center of gravity. First, the results of the rules must be added together in some way.

2.2 Review of Related Literature

[8] Developed Fuzzy Logic Systems based fraud detection in debit cards. The system learnt its fuzzy sets parameters from data using Fuzzy C-means (FCM) clustering as well as learning the FLS rules from data. The system has the potential to result in highly accurate automatic fraud-detection for the Sudanese financial institutions and banking

[9] Used fuzzy database to detect credit cards fraud. Fraud detection involves monitoring user's behaviour to estimate, detect or avoid undesirable behaviours. To correctly identify a transaction as legitimate or fraudulent has been considered a data mining problem. The results indicates that the ANN method is 33% more accurate than the fuzzy logic.

[10] Proposed detection of by-passing fraud in international call by user profiling and using fuzzy logic. Fuzzy logic was used in decision making process by utilizing fuzzy logic membership function. A real database from mobile operator company AlmadarAljadid in Libya is used in this investigation. Five features are extracted and employed as detection patterns in the proposed technique. The five features or detection patterns are, subscriber's mobility, incoming to outgoing calls ratio, suspicious cell activity, irregular calls, and service type.

[11] Published a work on credit card fraud detection using Hidden Markov Model (HMM). In the work, they modelled the sequence of transactions in credit card processing using an HMM and used clusters that are generated by using k-means clustering algorithm as for observation symbols. Finally, they implemented the design using spending ranges of cardholder that are low, medium, and high, whereas the type of item have been considered to be states of an HMM. HMM is trained with Baum-Welch algorithm for each cardholder. A set of probabilities for amount of transaction was assigned to each cardholder. Amount of each incoming transaction was then matched with card owner's category. If it justifies a predefined threshold value then the transaction was judged to be legitimate else declared as fraudulent.

[12] Used artificial neural networks to detect frauds and thefts in the electric utilities. They implemented the design with data from a Brazilian electric power distribution company and classified the process of consumers to be inspected to either fraud or not fraud.

A work by [13] integrated classification, clustering and apriori of web mining to represent the sequence of operations in credit card transaction processing and used them for the detection of frauds. Initially, web mining techniques were trained with the normal behaviour of a cardholder. When an incoming credit card transaction is not accepted by the web mining model with sufficiently high probability, it is considered to be fraudulent. At the same time, but the system try to ensure that genuine transactions was not be rejected. Using data from a credit card issuer, a web mining model based fraud detection system was trained on a large sample of labelled credit card account transactions and tested on a holdout data set that consisted of all account activity. They concluded by saying that the proposed system will be able to detect frauds by considering a cardholder's spending habit without its significance and reduce the number of False Positives transactions.

[14] studied tax collection per month in other to understand

how people have develop new ways to evade the current methods of fraud detection and to understand the strength of the fraud detection systems. In the study case, they analyzed some of the current methods for fraud detection, as Rule-Based Systems and Neural Networks classifiers. In the conclusion of their work, they proposed the use of Neural Networks predictors for detecting fraud in time series data of the SPU.

[15] Reviewedof classification scheme on the application of data mining techniques for the detection of financial fraud. Their findings show that data mining techniques have been applied most extensively to the detection of insurance fraud, although corporate fraud and credit card fraud have also attracted a great deal of attention in recent years but noted a distinct lack of research on mortgage fraud, money laundering, and securities and commodities fraud. The main data mining techniques used for FFD are logistic models, neural networks, the Bayesian belief network, and decision trees, all of which provide primary solutions to the problems inherent in the detection and classification of fraudulent data

[16] Analysed the fraudulent traffic from SIM boxes operating with a large number of SIM cards in a telecommunication network. It processes hundreds of millions of anonymized voice call detail records (CDRs) from one of the main cellular operators in the United States. In addition to overloading voice traffic, fraudulent SIM boxes were observed to have static physical locations and to generate disproportionately large volume of outgoing calls. Based on these observations, novel classifiers for fraudulent SIM box detection in mobility networks were proposed. Their result was that the outputs from the proposed algorithm were optimally fused to increase the detection rate and they concluded that the operator's fraud department confirmed that the algorithm succeeds in detecting new fraudulent SIM boxes.

[17] Modelled the sequence of operations in credit card transaction processing using a confidence-based neural network. Receiver operating characteristic (ROC) analysis technology was also introduced to ensure the accuracy and effectiveness of fraud detection. A neural network was initially trained with synthetic data. When an incoming credit card transaction was not accepted by the trained neural network model (NNM) with sufficiently low confidence, was considered to be fraudulent. The conclusion of their paper was that confidence value, neural network algorithm and ROC can be combined successfully to perform credit card fraud detection.

[18] Developed a hybrid approach consisting of pre-processing, clustering, and classification phases to detect fraud in telecommunication subscription in which usage type is in contradiction with subscription type. They employed data mining techniques and adopting knowledge discovery. In the clustering phase SOM and K-means were combined, and in the classification phase decision tree, neural networks, and support vector machines were used as single classifiers and bagging, boosting, stacking, majority and consensus voting as ensembles. The results showed that support vector machines among single classifiers and boosted trees among all classifiers have the best performance in terms of various metrics. The research findings show that the proposed model has a high accuracy.

3. FRAUD DETECTION SYSTEM DESIGN

3.1 Fraud Detection System Design

Based on World Bank bench mark for road construction cost for Africa, geological and environmental conditions, and the nature of the work; the Road construction fraud detection system was designed. The following variables were used as input to the system

1.There type of Road: there are different kinds of road work which could be paved or unpaved road. This variable is necessary to allow cost comprising with various types of work and benchmarks

2. Type of work: the types of work are a function of type of road project. There are various types of work that can be done on various road types.

3. Exchange rate: the exchange of naira to United States dollar, this variable for allow the rule to judge the cost of contract

4. The total sum of the contract.

5. Inflation Rate

6. The length of the road in kilometres

While some of the variables are used for internal calculation of the system, some are directly used to formulate fuzzy rules for inference engine which will categorize the contract into fraud or no fraud. Table 1 contains the various form of road construction work, Table 2 is for linguistic variable for exchange rate, Table 3 is the inflation variable and Table 4 is the internal variable of the difference between the World Bank bench mark and the contract cost.

Table 1: Roads and their types of road work

Type of road	Type of work
PAVED ROAD	Seal
	Functional Overlay
	Structural overlay
	Rehabilatation
	construction
UNPAVED ROAD	Regravelling
	Rehabilitation
	Improvement
	Paving

Table 2: Linguistic variable of Exchange rate

Exchange rate	Linguistic Variables
₦1 ≤ x ≤ ₦100	Low
₦100 ≤ x ≤ ₦200	Moderate
Above ₦200	High

Table 3: Linguistic variable of Inflation

Inflation	Linguistic Variables
$0.1 \leq x < 5.0$	Low
$5.0 \leq x < 10.0$	Moderate
10 and above	High

Table 4. Linguistic variable of Difference between World Bank cost and the cost of the Road contract

cost % differece	Linguistic Variables
$1\% \leq x < 10\%$	Low
$10\% \leq x < 50\%$	Moderate
50% and above	High

3.2 Fuzzy Rules for fraud detection

The rules to be used in categorizing whether a road contract is fraudulent or not are given in the tables below, the inflation, exchange rate, and the difference between the standard cost and the cost of the contract are used to make conclusion whether a contract is fraud or not.

1. IF inflation is LOW AND Exchange-rate is LOW AND difference is NO-DIFF THEN Fraud is NO-FRAUD

2. IF inflation is LOW AND Exchange-rate is LOW AND difference is LOW THEN Fraud is LOW

3. IF inflation is LOW AND Exchange-rate is LOW AND difference is MODERATE THEN Fraud is MODERATE

4. IF inflation is LOW AND Exchange-rate is LOW AND difference is HIGH THEN Fraud is HIGH

5. IF inflation is LOW AND Exchange-rate is MODERATE AND difference is NO-DIFF THEN Fraud is NO-FRAUD

6. IF inflation is LOW AND Exchange-rate is MODERATE AND difference is LOW THEN Fraud is NO-FRAUD

7. IF inflation is LOW AND Exchange-rate is MODERATE AND difference is MODERATE THEN Fraud is LOW

8. IF inflation is LOW AND Exchange-rate is MODERATE AND difference is HIGH THEN Fraud is MODERATE

9. IF inflation is LOW AND Exchange-rate is HIGH AND difference is NO-DIFF THEN Fraud is NO-FRAUD

10. IF inflation is LOW AND Exchange-rate is HIGH AND difference is LOW THEN Fraud is NO-FRAUD

11. IF inflation is LOW AND Exchange-rate is HIGH AND difference is MODERATE THEN Fraud is LOW

12. IF inflation is LOW AND Exchange-rate is HIGH AND difference is HIGH THEN Fraud is LOW

13. IF inflation is MODERATE AND Exchange-rate is LOW AND difference is NO-DIFF THEN Fraud is NO-FRAUD

14. IF inflation is MODERATE AND Exchange-rate is LOW AND difference is LOW THEN Fraud is NO-FRAUD

15. IF inflation is MODERATE AND Exchange-rate is LOW AND difference is MODERATE THEN Fraud is LOW

16. IF inflation is MODERATE AND Exchange-rate is LOW AND difference is HIGH THEN Fraud is LOW

17. IF inflation is MODERATE AND Exchange-rate is MODERATE AND difference is NO-DIFF THEN Fraud is LOW

18. IF inflation is MODERATE AND Exchange-rate is MODERATE AND difference is LOW THEN Fraud is NO-FRAUD

19. IF inflation is MODERATE AND Exchange-rate is MODERATE AND difference is MODERATE THEN Fraud is LOW

20. IF inflation is MODERATE AND Exchange-rate is MODERATE AND difference is HIGH THEN Fraud is MODERATE

21. IF inflation is MODERATE AND Exchange-rate is HIGH AND difference is NO-DIFF THEN Fraud is NO-FRAUD

22. IF inflation is MODERATE AND Exchange-rate is HIGH AND difference is LOW THEN Fraud is NO-FRAUD

23. IF inflation is MODERATE AND Exchange-rate is HIGH AND difference is MODERATE THEN Fraud is LOW

24. IF inflation is MODERATE AND Exchange-rate is HIGH AND difference is HIGH THEN Fraud is MODERATE

25. IF inflation is HIGH AND Exchange-rate is LOW AND difference is NO-DIFF THEN Fraud is NO-FRAUD

26. IF inflation is HIGH AND Exchange-rate is LOW AND difference is LOW THEN Fraud is NO-FRAUD

27. IF inflation is HIGH AND Exchange-rate is LOW AND difference is MODERATE THEN Fraud is LOW

28. IF inflation is HIGH AND Exchange-rate is LOW AND difference is HIGH THEN Fraud is MODERATE

29. IF inflation is HIGH AND Exchange-rate is MODERATE AND difference is NO-DIFF THEN Fraud is NO-FRAUD

30. IF inflation is HIGH AND Exchange-rate is MODERATE AND difference is LOW THEN Fraud is NO-FRAUD

31. IF inflation is HIGH AND Exchange-rate is MODERATE AND difference is MODERATE THEN Fraud is LOW

32. IF inflation is HIGH AND Exchange-rate is MODERATE AND difference is HIGH THEN Fraud is LOW

33. IF inflation is HIGH AND Exchange-rate is HIGH AND difference is NO-DIFF THEN Fraud is NO-FRAUD

34. IF inflation is HIGH AND Exchange-rate is HIGH AND difference is LOW THEN Fraud is NO-FRAUD

35. IF inflation is HIGH AND Exchange-rate is HIGH AND difference is MODERATE THEN Fraud is LOW

36. IF inflation is HIGH AND Exchange-rate is HIGH AND difference is HIGH THEN Fraud is MODERATE

3.3 Fuzzy membership functions

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
The membership functions for all the linguistic variables use in the fuzzy rules generated above are given in the figures below. Figure 1 represents a triangular membership function design to normalise the inflation-rate variable into *Low*, *Moderate* or *High*. The figures 2 and 3 are for the exchange rate, and the difference between actual contract cost and the World Bank standard bench mark for road construction cost in Nigeria. Figure 4 is the class diagram of fraud detection system.

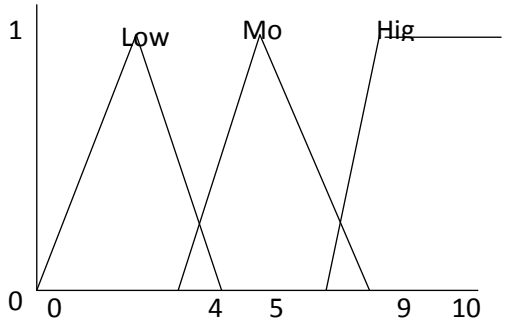

Fig. 1: Fuzzy membership function of rate of inflation

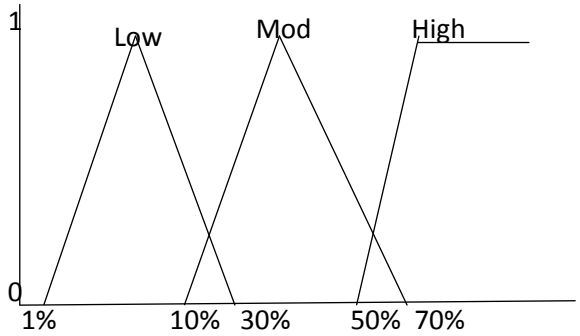

Fig. 2: Fuzzy membership function difference between contract cost and the world bank bench mark

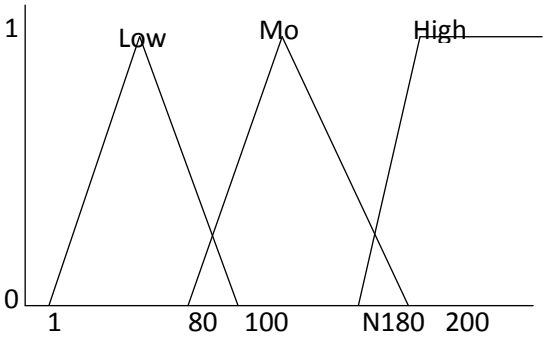

Fig. 3: Fuzzy membership function exchange rate

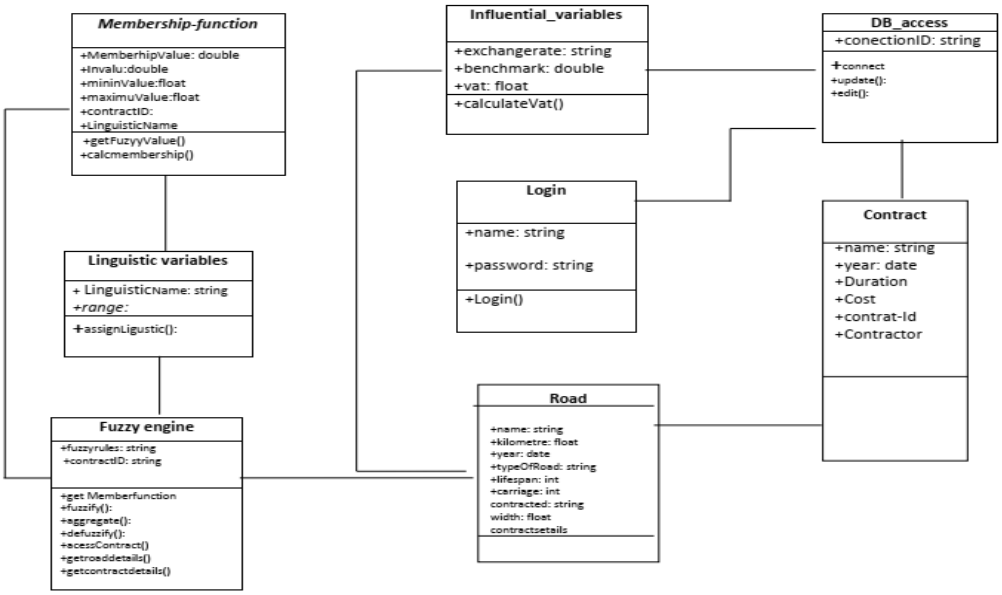

Fig. 4: Class diagram of the fraud detection system

3.4 Implementation of Fraud Detection

Figures5 and 6 below are the interface of the contract analysis system. The system compose of some necessary data input textboxes that are used for receiving information about the contract and other basic necessary inputs that will help in the analysis of the contract. The system uses the input of the type of road, type of work, total sum of the contract, and the length of the road as the basic input about the road. Using the World Bank standard benchmark for contract in Africa with some other parameters, a critical analysis of the contract claim is carried out using the fuzzy rules. At the end of the analysis, the output of the system is either fraud or no fraud.

In o The figure5, a road contract of paved road was analysed using the fraud detection system, the contract cost was 10 million naira for a 20 kilometre road with exchange rate of 1 dollar to the 180 naira. The system analysed the contract and gave an output of "no Evidence of fraud". The figure6is similar to 5, however, the contract cost was over 129 million naira for a 1 kilometre road with exchange rate of 1 dollar to the 400 naira. The system analysed the contract and gave an output of "there is possibility of high fraud".

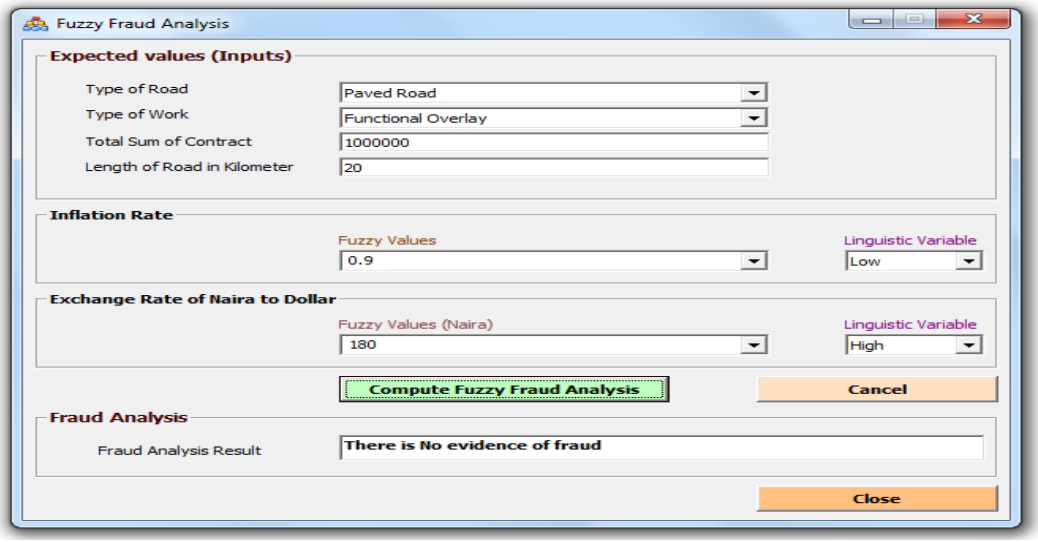

Fig. 5 interface of the contract analysis system

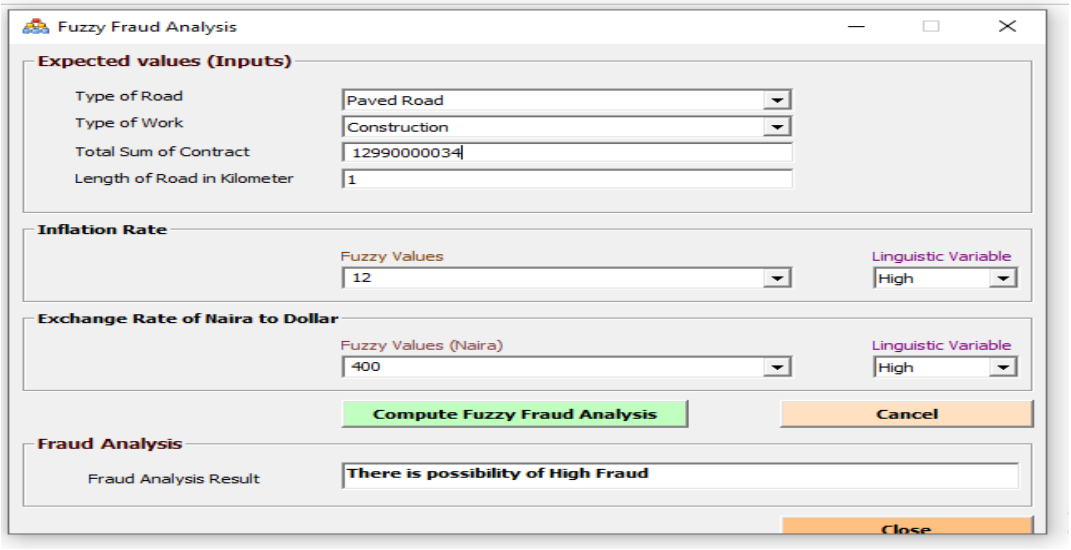

Fig. 6: interface of the contract analysis system

4. CONCLUSION

This paper developed fuzzy logic system to detect fraud in road construction contracts. Details of different types of Road construction projects, terrains, and a sample project-costing from Delta State Ministry of Works were obtained while World Bank benchmark standard cost for African countries on different types of road projects was also discovered from some of the published works.

The World Bank benchmark and some other factors like inflation, exchange rate, etc. were used to develop a fuzzy rule to determine whether a contract is fraudulent or not. The fuzzy rules have fuzzy values: *High*, *Moderate*, *and Low*. Using the rules, a software was develop using VB.net to categorize a contract whether fraudulent or not and with statements like "*there possible chance of high fraud in the contract*". The work can be a good tool for fraud detection in road contract and alsoshow that contract inflations and fraud in road construction can be detected and minimized with a good fraud detection system. Our further work will focus on breaking down contract and the cost to stages of the work to identify what portion of the contract is inflated. We intends to further use other machine learning algorithms to build fraud detection system to have better accuracy.

We recommend a policy of using software for analyses of road construction contracts in public sector in other to detect possible fraud, this will help in opening further investigation of the awards in other to ascertain the degree of fraud.

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