DEVELOPMENT OF AN ENHANCED CHATBOT SYSTEM FOR STUDENT INTERACTION USING FUZZY ALGORITHM

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Abstract
Management of students' information such as academic records and other information in Nigeria tertiary institution faces a lot of challenges due to various factors. This therefore generally affects the organization, preservation and access of students' information. It is therefore important for tertiary institutions management to leverage on technology to cope with student information management challenges. The aim of this study is to develop an enhanced student's information management system using chatbot. The system developed in this study is enhanced chatbot system for students' interaction which integrates a fuzzy algorithm that mimics how information is processed inside human brains. The architecture of the enhanced system includes. Chatbot, the Fuzzy-Deep learning system, Context identification component, AIML Response component and Query analysis and response component. The key advantages of the enhanced system over the existing system are: It ensures real time response to all recurring questions. It is available 24 hours. The conversation intelligence is personalized. Swift web, mobile, messaging application implementation and it eliminates tedious time consuming tasks. Students' Information System using Chatbot is better than the existing system hence it is recommended that the management of institutions should adopt the application of fuzzy logic to the development of a robust students' information system via the application Chatbot technology

Keywords: Chatbot, student, information management system

1.0 INTRODUCTION

1.1 Background to the Study

Management of students' information is a key aspect of tertiary institution administration. Information system in any organization is an essential element for efficiency and growth. For this purpose, many organizations spend resources to secure a good information system in order to have reliability and flexibility in their organization. Many invented systems are focused on user friendly elements such as easy document printing, availability on mobile platforms, and flexible accessibility. The information system is also important for collecting data of all staff in an organization (Hashim and Mohamed, 2020)

In the tertiary institution, there are alarming complexities involved in the management of students' information. This is because; a Student Information System deals with all kinds of student details, academic related reports, college details, course details, curriculum, batch details and other resource related details. It tracks all the details of a student from beginning to end of the course and can be used for all reporting purposes such as tracking of attendance, course progress, completed semesters activities, curriculum details, exam details, results, etc.

More than ever before, Nigerian schools are adopting electronic information systems to improve and automate many processes that were once manual. With this large-scale movement towards Information Communication Technology (ICT) and the increasing pressure on schools to apply technology to improve their students' performance, many schools are looking for robust learning management systems as a way to enhance student learning. Recent surveys show that electronic information systems are a rapidly growing phenomenon (Annette and Abdel, 2018)

For any student, it is important to have up to date information about current exercise assignments, lectures, upcoming appointments and other daily activities. This is especially true for new students who are still unfamiliar with current routines and practices. They may also have trouble finding their way around campus, often with hundreds of different auditoriums and

rooms spread across a large area. In such situations it is important to have correct information available. Sometimes the communication of information can make use of a more active approach instead of asking the student to locate the information needed. The information can be "pushed" to the person concerned based on his profile, requiring less effort and intervention from the user. Examples of these can be updates about class, courses, automatic e-mail notifications, reminders from friends, schoolmates, or similar (Muhammad and John, 2018).

Information Systems (IS) involve a variety of information technologies (IT) such as computers, software, databases, communication systems, the Internet, mobile devices and much more, to perform specific tasks, interact with and inform various actors in different organizational or social contexts. However, the information system field is not primarily concerned with the technical and computational aspects of information technologies. In other words, what matters to an information system is how technology is appropriated and instantiated in order to enable the realization of information systems that fulfill various actors' requirements with respect to specific goals and practices (Sebastian and Dubravka, 2015)

In addition, an Information system can be defined in terms of two perspectives: one relating to its function; the other relating to its structure. From a functional perspective; an information system is a technologically implemented medium for the purpose of recording, storing, and disseminating linguistic expressions as well as for the supporting of inference making. The focus of this paper is the development and deployment of an Enhanced Student Information System using Chatbot.

1.2 Statement of the Problem

The task of managing an Information System in a school environment poses unique challenges. For instance, one of the greatest challenges facing individual schools is the lack of Chatbot integration between various information systems. The present situation in many schools is that there are many disconnected systems managing many different tasks. Systems with differing levels of functionality run independently of one another, causing multiple problems for the school's overall Information System. Furthermore, many difficulties arise from inconsistently registered data; duplicate manual data entry, the extra time needed to manage multiple user accounts for one user, and non- productive time spent on technical support. In addition to these problems, the task of maintaining each individual system is time consuming. This study will help to proffer solution to the challenges identified

1.3 Aim and Objectives of the Study

The aim of this study is to develop an Enhanced Student Information System using Chatbot. The specific objectives of the study include to:

i) design a web-based mobile application model for instant messaging
ii) train the proposed web-based mobile application model with Fuzzy-Deep Learning
iii) implement the proposed web-based mobile application model with Hypertext Pre-processor (PHP) and MySQL

2.0 LITERATURE REVIEW

2.1 Conceptual review

The understanding of the following concepts will help in comprehending and appreciating the context of the subject matter.

i) **Student:** A person who is studying at a university or other place of higher education.

ii) **Information System:** An Information system (IS) is a formal, sociotechnical, organizational system designed to collect, process, store, and distribute information. In a sociotechnical perspective, information systems are consist of four components: task, people, structure (or roles), and technology.

iii) **Chatbot:** A chatbot is a software application used to conduct an on-line chat conversation via text or text-to-speech, in lieu of providing direct contact with a live human agent. In addition, a chatbot is a type of software

that can automate conversations and interact with people through messaging platforms.

iv) **Fuzzy Logic:** Fuzzy Logic is a branch of machine learning that is being utilized to determine partial truth of a computing process using Boolean value which includes 0 and 1.

v) **Deep Learning:** Deep Learning is a neural network with more than one hidden layers. Deep neural networks facilitate the learning of complex function by a machine through representation-learning method

2.2 Overview of Student Information System

A student information system (SIS), student management system, school administration software or student administration system is a management information system for education establishments used to manage student data. Student information systems provide capabilities for registering students in courses; grade documentation, transcripts of academic achievement and co-curricular activities, and the results of student assessment scores; forming student schedules; tracking student attendance; and managing other student-related data needs in an educational institution. Information security is a concern, as universities house an array of sensitive personal information, making them potentially attractive targets for security breaches, such as those experienced by retail corporations or healthcare providers (Chen, 2016)

Student information systems (SIS) store and track all student information, including grades, attendance records, and more. The software functions as a digital drop box for school-related information. SIS software has become a vital tool for educational institutions as well as parents and students who use it to gain access to student information, make payments, and communicate with school functionaries. SIS products are used by teachers, students, and parents to access all relevant information pertaining to a student's schooling. SIS software is leveraged for a few different functions; the main two being as a channel of communication and as a place to store student information (Danilo et al, 2016)

They key Benefits of SIS Software includes the following:

- Improve management of prospective and enrolled student data
- Increase communication between divisions
- Maintain data of stakeholders when transferring records between departments
- Provide a unified resource location for relevant stakeholders, including alumni, faculty, support staff, and donors
- Standardize data formats among divisions
- Ease the transfer of data to external institutions
- Reduce the time spent on maintaining and organizing student records

SIS software houses many types of student information, consolidating all records in one place so they can be easily accessed by school officials, parents, and the students themselves. In a single system, a school official can view student attendance, financial aid status, class rosters, student enrollment, and more. On the other side, students can see unofficial transcripts, enroll in classes, check tuition fees, and access a schedule builder. Keeping all student information in a single system allows users to make and track changes, as well as maintain a holistic view of both individual students and the student body as a whole. Information in an SIS is not stored in disparate systems, which makes organization easier overall (David and Graham, 2012)

2.3. Chatbot as information communication tool

A chatbot is a software application used to conduct an on-line chat conversation via text or text-to-speech, in lieu of providing direct contact with a live human agent. A chatbot is a type of software that can automate conversations and interact with people through messaging platforms. Designed to convincingly simulate the way a human would behave as a conversational partner. Chatbot systems typically require continuous tuning and testing, and many in production remain unable to adequately converse or pass the industry standard Turing test. The term "ChatterBot" was originally coined by Michael Mauldin (creator of

the first Verbot) in 1994 to describe these conversational programs. Chatbots are used in dialog systems for various purposes including customer service, request routing, or information gathering. While some chatbot applications use extensive word-classification processes, natural language processors, and sophisticated AI, others simply scan for general keywords and generate responses using common phrases obtained from an associated library or database (Panichella et al, 2013)

Most Chatbots are accessed on-line via website popups or through virtual assistants. They can be classified into usage categories that include: commerce (e-commerce via chat), education, entertainment, finance, health, news, and productivity. Interface designers have come to appreciate that humans' readiness to interpret computer output as genuinely conversational—even when it is actually based on rather simple pattern-matching—can be exploited for useful purposes. Most people prefer to engage with programs that are human-like, and this gives chatbot-style techniques a potentially useful role in interactive systems that need to elicit information from users, as long as that information is relatively straightforward and falls into predictable categories (John et al, 2019)

Many high-tech banking organizations are looking to integrate automated AI-based solutions such as Chatbots into their customer service in order to provide faster and cheaper assistance to their clients who are becoming increasingly comfortable with technology. In particular, Chatbots can efficiently conduct a dialogue, usually replacing other communication tools such as email, phone, or SMS. In banking, their major application is related to quick customer service answering common requests, as well as transactional support (Mel et al, 2012)

2.4 Internet of Things as an Embedded Chatbot Tool for Student Information System

The Internet of Things (IoTs) is the interconnection via the internet of computing devices embedded in everyday objects, enabling them to send and receive data. By the Internet of Things, objects recognize themselves and obtain intelligent behavior by making or enabling related decisions taking to the fact that they can communicate information about themselves. These objects can access information that has been aggregated by other things, or they can be added to other services. The Internet of Things is the interconnection of physical objects such as vehicles, home appliances, and other items embedded with electronic software, sensors, and connectivity which enable these objects to connect and exchange data. Secondly, the general concept of the Internet of Things is to effectively manage big data of physical objects on the internet. Internet of Things is a new technology of the Internet accessing. By the Internet of Things, objects have the ability to recognize themselves and obtain intelligence behavior via signaled communication (Frederick et al, 2017)

2.5 Fuzzy Logic as an Embedded Chatbot Tool for Student Information System

Fuzzy logic is a branch of science that is extended to handle the concept of partial truth, where the truth value may range between completely true and completely false as shown in Figure 2.1 and Table 2.1. Fuzzy logic may be applied to many fields, including control systems, neural networks and artificial intelligence (AI). Fuzzy logic can be used to describe how information is processed inside human brains. For example, it can be argued that humans do not know the difference between fat and thin. Five people may be fat and not have the same severity of fatness. Or, one person may appear thin, compared to another, while both are actually fat. Using fuzzy logic, you can assign different logic values for fatness, ranging from 0 to 1, according to severity of fatness. Variables between the extremes of zero and one are closer to the concept of probability, which means there is a major correlation between the science of probability and fuzzy logic. However, fuzzy logic refers to intensity of truth, while probability refers to likelihood. Fuzzy logic is an extension of Boolean logic by Lotfi Zadeh in 1965 based on the mathematical theory of fuzzy sets, which is a generalization of the classical set theory.

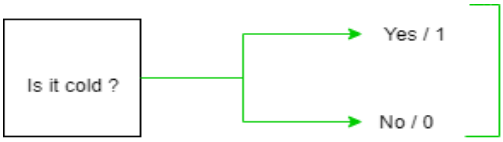

Figure 2.1 Illustration of Fuzzy Logic (**Source:** Mchillson *et al*, 2019)

Table 2.1: Further illustration of Fuzzy Logic (**Source:** Mchillson *et al*, 2019)

If the light is red….	If my speed is high…	And if the light is close…..	Then I brake hard….
If the light is red….	If my speed is low…	And if the light is far…..	Then I maintain my speed…
If the light is orange..	If my speed is average	And if the light is far…..	Then I brake gently…
If the light is green…	If my speed is low…	And if the light is close…..	Then I accelerate….

In fuzzy logic, which is also sometimes called diffuse logic, there are not just two alternatives but a whole continuum of truth values for logical propositions. A proposition can have the truth value 0.4 and a complement value of 0.5. According to the type of negation operator that is used the two truth values must not be necessarily add up to 1. Fuzzy logic has a weak connection to probability theory. Probabilistic methods that deal with imprecise knowledge are formulated in the Bayesian framework, but fuzzy logic does not need to be justified using a probabilistic approach. The common route is to generalize the findings of multi-valued logic in such a way as to preserve part of the algebraic structure (Mchillson *et al*, 2019)

Fuzzy logic can be used as an interpretation model for the properties of neural networks, as well as for giving a more precise description of their performance. It can bel shown that fuzzy operators can be conceived as generalized output functions of computing units. Fuzzy logic can also be used to specify networks directly without having to apply a learning algorithm. An expert in a certain field can sometimes produce a simple set of control rules for a dynamical system with less effort than the work involved in training a neural network. A classic example proposed by Zadeh to the neural network community is developing a system to park a car. It is straightforward to formulate a set of fuzzy rules for the task, but it is not immediately obvious to build and train a network to do the task. Fuzzy logic is now being used in many products of industrial and consumer electronics for which a good control system is sufficient and where the question of optimal control does not necessarily arises. The difference between crisp (i.e., classical) and fuzzy sets is established by introducing a membership function. Consider a finite set

$$X=\{x_1,x_2,...,x_n\} \quad (2.1)$$

which will be considered the universal set in what follows. The subset A of X consisting of the single element x_1 can be described by a 1-dimensional membership vector

$$Z(A) = (1, 0, 0, ...,0) \quad (2.2)$$

where the convention has been adopted that a 1 at the *ith* position indicates that x_i belongs to A. The set B composed of the elements x_1 and x_n is described by the vector

$$Z(B)=(1,0,0,...,1). \quad (2.3)$$

Any other crisp subset of X can be represented in the same way by an n-dimensional binary vector. But what happens if we lift the restriction to binary vectors? In that case we can define the fuzzy set C with the following vector description:

$$Z(C)=(0.5,0,0,...,0) \quad (2.4)$$

In classical set theory such a set cannot be defined. An element belongs to a subset or it does not. In the theory of fuzzy sets we make a generalization and allow descriptions of this type. In our example the element x_1 belongs to the set C only to some extent. The degree of membership is expressed by a real number in the

interval [0, 1], in this case 0.5. This interpretation of the degree of membership is similar to the meaning we assign to statements such as "person x_1 is an adult". Obviously, it is not possible to define a definite age which represents the absolute threshold to enter into adulthood. The act of becoming mature can be interpreted as a continuous process in which the membership of a person to the set of adults goes slowly from 0 to 1. Fuzzy sets are a further development of the mathematical concept of a set. Sets were first studied formally by the German mathematician Georg Cantor (1845-1918). His theory of sets met much resistance during his lifetime, but nowadays most mathematicians believe it is possible to express most, if not all, of mathematics in the language of set theory.

Many researchers are looking at the consequences of' fuzzifying' set theory, and much mathematical literature is the result. For control engineers, fuzzy logic and fuzzy relations are the most important in order to understand how fuzzy rules work. Fuzzy Logic (FL) poses the ability to mimic the human mind to effectively employ modes of reasoning that are approximate rather than exact. In traditional hard computing, decisions or actions are based on precision, certainty, and vigor. Precision and certainty carry a cost. In soft computing, tolerance and impression are explored in decision making. The exploration of the tolerance for imprecision and uncertainty underlies the remarkable human ability to understand distorted speech, decipher sloppy handwriting, comprehend nuances of natural language, summarize text, and recognize and classify images. With FL, we can specify mapping rules in terms of words rather than numbers. Computing with the words explores imprecision and tolerance. Another basic concept in FL is the fuzzy if–then rule. Although rule-based systems have a long history of use in artificial intelligence, what is missing in such systems is machinery for dealing with fuzzy consequents or fuzzy antecedents. In most applications, an FL solution is a translation of a human solution.

Thirdly, FL can model nonlinear functions of arbitrary complexity to a desired degree of accuracy. FL is a convenient way to map an input space to an output space. FL is one of the tools used to model a multi-input, multi-output system. Soft computing includes fuzzy logic, neural networks, probabilistic reasoning, and genetic algorithms. Today, techniques or a combination of techniques from all these areas are used to design an intelligence system. Neural networks provide algorithms for learning, classification and optimization, whereas fuzzy logic deals with issues such as forming impressions and reasoning on a semantic or linguistic level (Alward *et al*, 2017)

2.6. Analysis of Fuzzy Logic Algorithm

Fuzzy logic algorithm is a soft computing paradigm built around human thinking and natural occurrences that offers predicates which are present in nature and similar to those either big or small. This theory simulates human thinking as to how a person makes faster decision. Fuzzy logic is a superset of conventional (Boolean) logic that has been extended to handle the concept of partial truth, and also truth values between "completely true" and "completely false". Furthermore, it can be implemented in hardware, software, or a combination of both. In the present competitive scenario the fuzzy logic system are being adopted by the automotive manufacturers for the improvement of quality and reduction of development time and the cost as well. Fuzzy logic was conceived as a better method for sorting and handling data but has proven to be an excellent choice for many control system applications (Singh and Mishra, 2015).

The potentials and ability of fuzzy logic controls and system to imitate and epitomise human knowledge are strongly determined by guesses and error operator. Singhala, Shah and Patel (2014), opined that fuzzy logic constitutes a non-linear mapping of inputs dataset to a scalar output. Furthermore, they also stated that fuzzy logic basically consist of four components known as fuzzifier, rules, inference engine and defuzzifier. In addition, Gursel (2016) argued that the following fuzzy rules should be infused

into the knowledge base and database of a system.

a) Fuzzifier: This component is responsible for the translation of the fuzzy crisp into fuzzy values. The fuzzifier is responsible for the fuzzification of crisp which is the method of transforming a crisp object into a fuzzy set, to a grade of membership function for linguistic variables of fuzzy sets

b) Knowledge base (Rules): This includes the knowledge and decision rules captured from expert know-how of the application area managing the relations between the fuzzy input and output. The rule base consist of the IF-THEN conditions based on expert knowledge.

c) Inference Engine: It has the uncertain rational intelligence to get the fuzzy output. Human decision making is simulated to constitute the engine. The processing of the fuzzy set is carried out here according to the rules of the rule base.

d) Defuzzifier: Here the fuzzy output is further translated into a crisp value which are more useful and comprehensible values deployed in real world scenario. The crisp output are values constructed by taking into account all parameters in the fuzzy output interval by employing high degree of membership values.

Membership functions are functions that assign a number or value to each element μ(x) of an input space. By implication, it is a function that maps an input value to its membership value.

Therefore, the membership function for a given value ***x*** indicates the degree of its membership to the fuzzy set. There are different forms of membership such as triangular, trapezoidal, Gaussian or singleton. The type of membership function can be context dependent and can be randomly chosen based on user's experience as shown in Table 2.2.

In addition, a fuzzy set is also an extension of classical set characterized by a membership or characteristics function which gives to individual object a grade of membership that ranges between zero and one. A fuzzy set therefore have more than 'either or' methodology for membership. For example, the set considers a set of tall people in the following ways, an individual with the height of 200cm may belong to a set and another of 110 cm does not.

Table 2.2 Fuzzy Logic Algorithm (**Source:** Mchillson *et al*, 2019)

S/No	ALGORITHM	FUZZY LOGIC COMPONENT INVOLVED / ACTION
1	Define linguistic values and terms	Initialization
2	Construct membership function	Initialization
3	Construct rule base	Initialization
4	Convert crisp into fuzzy values using the membership function	Fuzzification
5	Evaluate the rules in the rule base	Inference
6	Combine the result of each rule base	Inference
7	Convert output to non-fuzzy values	Defuzzification

3.1 METHODOLOGY

Many system methodologies are available to structure, plan and control the overall activities involved in the optimization of the existing system or development of the new system. These methodologies combine set of principles, practices and processes that allows the development of systems quickly and properly. This research work on an Enhanced Student Information System Using Chatbot was achieved following the Object-Oriented System Development Methodology (OOSDM). This was aimed at viewing, modeling and implementing conceived system as a collection of interacting classes and objects. OOSDM was adopted

because it is more effective, efficient, reliable, reusable and a faster way of developing systems.

Furthermore, the Object-Oriented System Development Methodology (OOSDM) is a technical approach for analyzing and designing an application, system, or business by applying object-oriented programming as well as using visual modeling throughout the software development process to guide stakeholder communication and product quality.

In addition, the Object-Oriented System Development Methodology (OOSDM) for this research work is diagrammatically illustrated in Figure 3.1 and involves the following phases:

I. Analysis
II. Design
III. Implementation

3.2 Design of the Enhanced Students' Information System

The study developed an Enhanced Students' Information System using Chatbot (Figure 3.1). The chatbot is a function of a hybridized technology (i.e: Fuzzy-Deep Learning). The chatbot is a computer program that simulates human conversation through voice commands or text chats or both. Chatbot, short for chatterbot, is an artificial intelligence (AI) feature that can be embedded and used through any major messaging applications. There are a number of synonyms for chatbot, including "talkbot," "bot," "IM bot," "interactive agent" or "artificial conversation entity." It can only respond to a set number of requests and vocabulary and is only as intelligent as its programming code. The architectural design of the developed student information system is presented in Fig 3.1

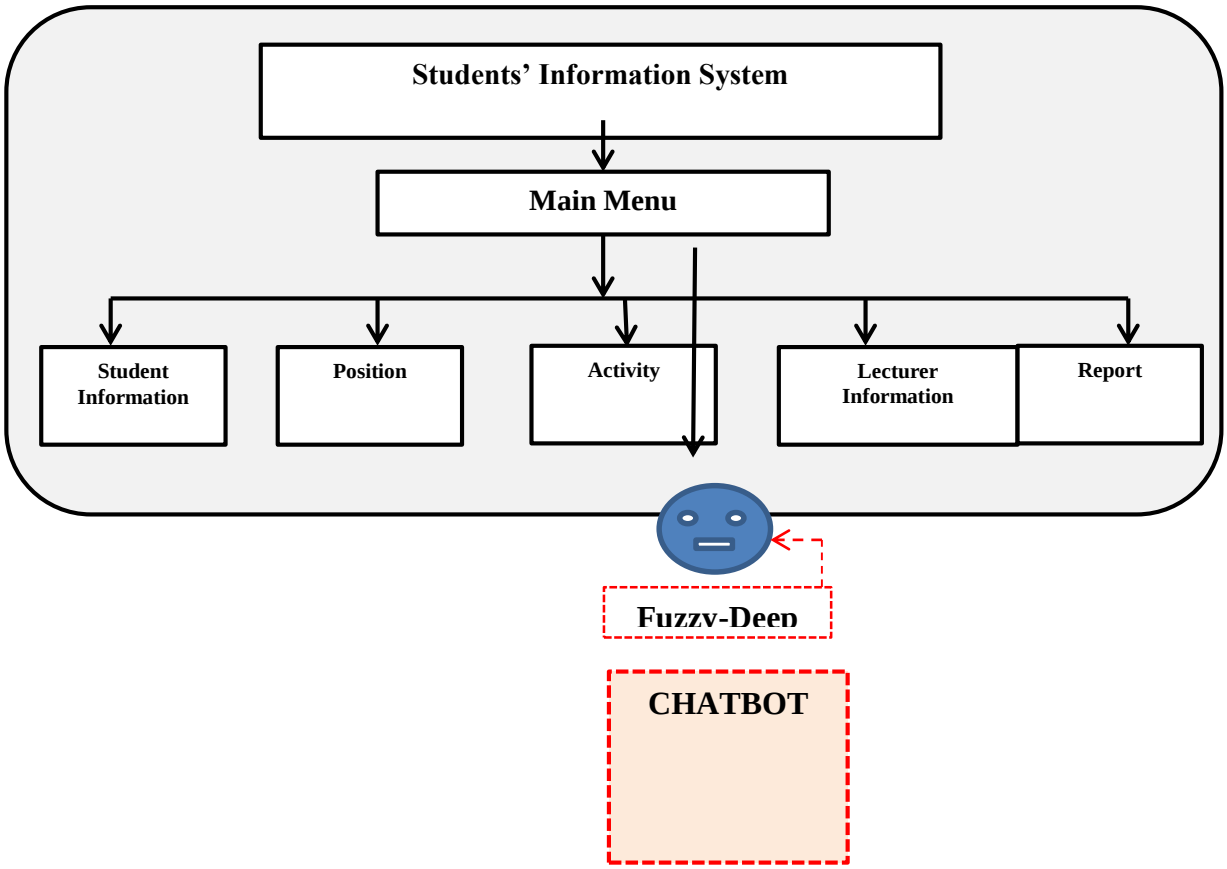

Figure 3.1: Architecture of an Enhanced Students' Information System using Chatbot

The activity model of the enhanced students information system using Chtbot is presented in Figure 3.2. It shows the various activities that takes place in the operation of the system.

Step 1:	Start
Step 2:	Declare Variables
Step 3:	SIS, NUR, UN, PW, UAV IR, SR
	WHERE:
	SIS; Student Information System, NUR; New User Registration, UN;

Figure 3.2: Activity Model of the Enhanced Students' Information System

The data model of the Enhanced Students' Information System is presented in Figure 3.3. It shows the sequence of data movement and processing in the system.

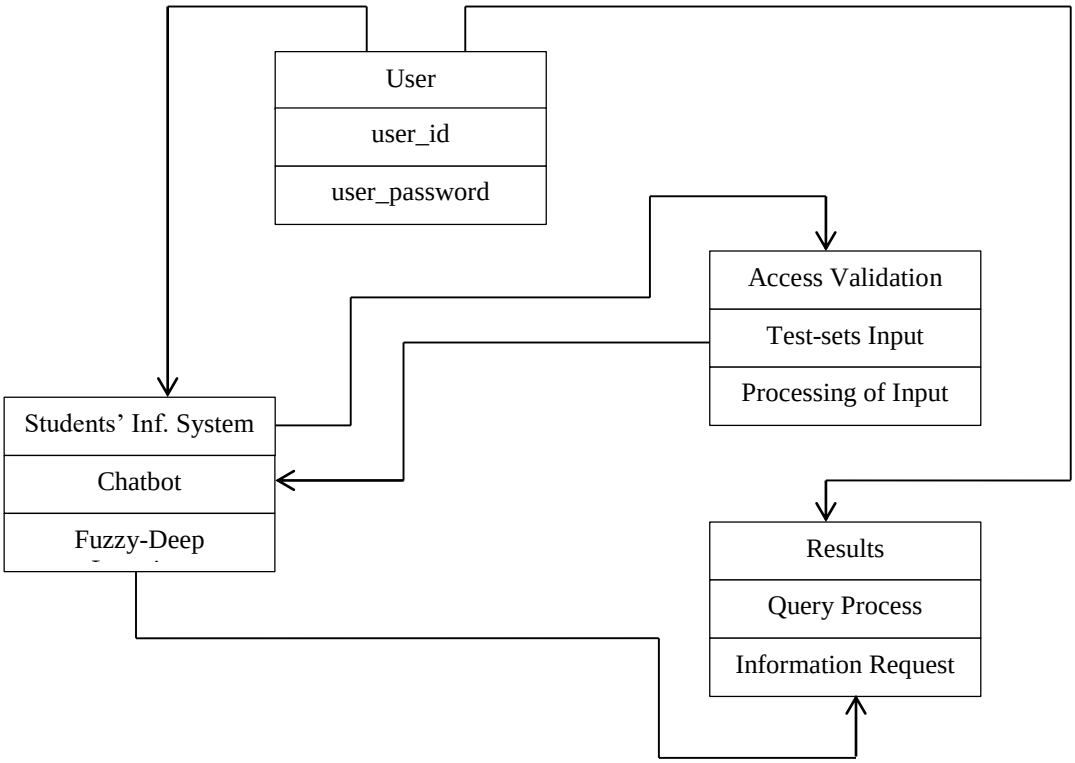

Figure 3.3: Data Model of the Enhanced Students' Information System

3.3.1 Explanation of the Enhanced Students' Information System Components

The purpose of a chatbot system is to simulate a human conversation. Its architecture integrates a language model and computational algorithm to emulate information online communication between a human and a computer using natural language. The following are the components and functions of the enhanced students' information system

(i) Chatbot

This component illustrates a software application that uses artificial intelligence and natural language processing to understand what a human want, and guides them to their desired outcome with as little work for the end user as possible.

(ii) Fuzzy-Deep learning

This component illustrates the combination of fuzzy logic. This combination trains the system to be intelligent and further optimizes performance.

(iii) **Context identification component**: In the context identification unit, the input text is pre-processed to standardize it according to the system's requirements. The proper context is detected based on the keywords used in the text.

(iv) **AIML Response component.** Here, the user attempts to have a normal conversation with the bot and the input is mapped to appropriate pattern in AIML Files. The user then receives the response if it is available

(v) **Query analysis and response component**. Here, upon receiving the personal queries like hey, hello, what are you doing? The input text is analyzed to extract keyword. The user's request for information is understood based on the keywords and the information is retrieved from the database. When a user wants information that he/she needs, that will be provided through this module. If the user's input matches a pattern in the AIML files, the user will receive the appropriate response. If the AIML files do not contain an item for that query pattern, keywords are retrieved from the input. If the sentence is retrieved with confidence >0.5, the answer of that question is return as a response. And if the bot did not understand what the user is given to, it will generate it is understand, give some information like that. Once the user is satisfied with the response which is generated by the bot and dos not wish to chat further, he/she has to say goodbye and terminate the activity. The advantages the Enhanced Students' Information System using Chatbot are:

I. It ensures real time response to all recurring questions.
II. It is available 24 hours
III. The conversation intelligence is personalized
IV. Swift web, mobile, messaging application implementation
V. It eliminates tedious time consuming tasks

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

In this work, we have developed an Enhanced Student Information System using Chatbot. A Chabot is a software application used to conduct an on-line chat conversation via text or text-to-speech, in lieu of providing direct contact with a live human agent. A chatbot can automate conversations and interact with people through messaging platforms. Designed to convincingly simulate the way a human would behave as a conversational partner, Chabot systems typically require continuous tuning and testing. The Enhanced Students' Information System using Chatbot is better than the existing system that was developed by Hashim and Mohammed in 2020, because it provides real time response to all recurring questions. It is available 24 hours since the need for human operation is eliminated.

4.2 Recommendations

In order to improve the management and communication framework in tertiary institutions, the study recommended the application of fuzzy logic to the development of a robust students' information system via the application Chatbot technology. This is because this system provides 24 hours service with minimal or no human interference or operation.

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