

The Design of an Intelligent Healthcare Chatbot for Managing Ante-Natal Recommendations

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Abstract:-

Context:- Chatbot is an Artificial Intelligent technology (AI) that has been used in several computer assistive social interactions. They are designed to convincingly simulate how humans behave in a natural conversation with a partner. Information Technology and AI have been deployed in health care especially in medical information but such deployment can be enhanced with a chatbot in antenatal services. Maternal and newborn mortality is still on the rise in Nigeria and medical personnel are in short supply, hence a virtual expert that can assist the pregnant mothers in basic medical advice is suitable. A preliminary survey was conducted to ensure the desirability of the system where data obtained from two categories of respondents, medical experts and beneficiaries (pregnant mothers) were analyzed and the result shows that both categories of respondents generally agreed on the desirability of the antenatal chatbot. **Objective:** The proposed design in this paper suggests a Microsoft Azure server hosting and managing the knowledge-based back end. **Method:** It applies Deep Neural Network engine for analyzing the user queries and generating responses using Artificial Intelligence Markup Language (AIML). A good and implementable prototype from our design will ensure an ante-natal chatbot (Ante-natalbot) system that can analyze preferences of the users and be able to intelligently predict or provide better user-centric recommendations. **Result:** This intelligence will be achieved at the full implementation of the Ante-natalbot system with reference to the expert (physician) responses over time. **Conclusion:** This paper is an early step into exploring the concepts, and the acceptability of such a system by the practitioners and the beneficiaries (pregnant women). It serves as in-road into the implementation of a virtual system that simulate professional personnel services to the ante-natal service seekers.

Keywords:- Ante-Natal Care, Artificial Intelligence, ChatBot, Human Aware AI, Virtual Agents.

I. INTRODUCTION

The maternal neonatal fatality is alarmingly high in Nigeria and this is largely due to poor antenatal services. According to WHO, Nigeria is also the country where nearly 20% of all global maternal deaths happen. Between 2005 and 2015, it is estimated that over 600,000 maternal deaths and no less than 900,000 maternal near-miss cases occurred in the

country. In 2015, Nigeria's estimated maternal mortality ratio was over 800 maternal deaths per 100,000 live births, with approximately 58,000 maternal deaths during that year (WHO, 2019). By comparison, the total number of maternal deaths in 2015 in the 46 most developed countries was 1,700, resulting in a maternal mortality ratio of 12 maternal deaths per 100,000 live births. A Nigerian woman has a 1 in 22 lifetime risk of dying during pregnancy, childbirth, or postpartum/post-abortion; whereas in the most developed countries, the lifetime risk is 1 in 4900 (WHO, 2019). Quality health care delivery is not only important to individuals but to the growth and development of the human capital of a nation (Bhirud et al., 2019). The maternal and child/infant mortality rate that is unacceptably high in Nigeria is not unconnected to quality health services available to the vast population of the country especially in the rural communities (WHO, 2019). Several health centers, hospitals, nursing homes, and even private clinics are presently adopting Information Technology tools for quality services (ISD Design, 2018). However, this to a large extent is still limited to the aspect of record management. To be more adaptive and synergistically working with humans, a human-aware AI system must include aspects of intelligence, such as emotion, cognitive or social adaptation to assist humans to achieve in a given terrain. The early adoptions of AI in terms of patient care will add values and improve the quality and timely care.

The health care industry is evolving rapidly with large volumes of data and challenges in cost and patient outcomes. This is particularly challenging for the practitioners and the patients seeking health attention in less developed societies where the population of health seekers far outweigh the givers and the available facilities. Deploying a Chatbot for Ante-Natal services will be highly beneficial. Both the practitioners and the patient would be relieved of the burden of time and pressure for quality service. Chatbots are automated systems that replicate the user's behavior on one side of the chatting communication. They are mimic systems that imitate the conversations between two individuals. They provide a stimulating platform for effective and smart communications with the user on the other end (Bhirud et al., 2019). This is very suitable in health care especially bridging the gap between the number of health practitioners and patients.

Utilizing the power of AI Chabot for human services can greatly assist pregnant women to gain access to useful information when required hence reducing maternal and newborn casualties. This system has not been fully achieved in the current online medical management system being

deployed to most hospitals and health centers in Nigeria. Since the revolution in telecommunication has brought the use of the Internet closer to the people, taking advantage to implement a third-tier system that can render simple services to communities devoid of adequate health personnel and facilities will make a significant impact. This paper is an early step into exploring the concept, the design, and the acceptability of such a system by the practitioners and the beneficiaries (pregnant women). It serves as in-road into the design and implementation of virtual system (chatbots) that simulate professional personnel services to the ante-natal service seekers.

II. REVIEW OF RELATED LITERATURE

Computer programs conducting a conversation via textual methods are contributing to identifying symptoms, managing medications, and monitoring chronic health problems (Akma, Hafiz, et al 2018). Smartphone utilization along with the rising adoption of health applications, IoT, telehealth, and other similar technologies are contributing to market growth. Chatbots are already widely used to support, expedite, and improve processes in other industries, such as retail, and now, the technology is gaining traction in health care, where it is helping patients and providers perform myriad tasks (Bates, 2019).

Chatbot system has been widely adopted in many fields such as education, healthcare, and business industries, particularly for marketing purposes. Apparently due to its flexibility (Akma et al., 2018). For example, there are several companies that embedded Chatbot into their system environment like Facebook (Facebook Messenger), Google (Google Assistance), Apple (Siri), and Microsoft (Cortana) (Akma et al., 2018). In the education field, Chatbot can be an intelligent tutor for the online learner (Doshi, Pawar, et al 2017). The Chatbot can analyze natural language and this reflects the accuracy of conversation. When conversation flow is accurate, that makes Chatbot one of a tool of education.

Chatbot is used to assist the healthcare expert to gives support to the patient through computer and application medium. There are a lot of existing Chatbots for the healthcare domain serving different functionalities (Bates, 2019). For instance, the AI-Chatbot (Fadhil & Gabrielli, 2017) works as a conversational assistant to facilitate long term adherence to health promotion interventions. In this case, bot act as a bi-directional channel between the healthcare expert and user in consulting user from gaining weight by advising on healthy diet habits, physical activities, food preparation, and purchasing (Fadhil & Gabrielli, 2017).

Endurance is a Chatbot which deals with users suffering from Dementia (disease). The Chatbot Casper helps people suffering from insomnia to pass their nights which are sleepless due to loneliness. MedWhat is a question-answering Chatbot that gives answers to basic healthcare FAQs and also provides information about various diseases and their symptoms. The problem with these Chatbots is that they simply provide monotonous answers to users' questions. They are not capable of establishing a smart communication with

the user just as a doctor does. These systems are also not able to predict the problems (diseases) faced by the user (Bhirud et al., 2019). An intelligent bot that will serve the purpose of antinatal issues should learn over time from the queries of the users and the responses of the physicians which is achieved in a reinforcement learning approach.

➤ *Chatbots Design Techniques*

Several reviews of studies on Chatbots designs show that there are many techniques and approaches for designing a Chatbot. Among the most popular techniques used by developers itemized in (Akma et al., 2018) are;

AIML: This is one of the core techniques using markup language created by Dr. Richard S. Wallace (Krantz & Lindblom, 2017), often used by the developers. The main objective of AIML language is to direct processing conversational modeling into a stimulus-response process. This process is also familiarly known as frequent tags. Since AIML does not require expert skills in a specific programming language, therefore, this technique is of utmost facilitates the development of Chatbots.

Pattern Matching: Basically, this technique deployed matching patterns to generate appropriate responses from user's questions, depending on the matching types such as simple statements, natural language, or semantic meaning of enquires. This technique is adopted by many Chatbots (Abdul-Kader & Woods, 2015).

Language Tricks: Four language tricks are usually used including a model of personal history, canned responses, no logical conclusion, typing errors, and stimulating keystrokes. This technique used sentences, phrases, or paragraphs in Chatbots to add variety to the knowledge base and that would make it more convincing (Mladenic & Bradeško, 2012).

Chat script: It is a technique used when there are no matches occur in AIML. This technique concentration is on giving the best syntax to build a sensible default answer. It gives a set of functionalities such as variable concepts, facts, and logical and/or.

Parsing: This is the technique used to analyze text or a string of symbols either by using natural language or computer language. Besides, in computational linguistic, parsing is a technique used to analyze either a sentence or another set of strings into its elements that could contain semantic or other information. This technique used Natural Language Processing (NLP) functions such as trees in Python Natural Language Toolkit (NLTK).

SQL and relational database: It is a recent technique used in Chatbots to ensure Chatbots remember previous conversations. The algorithm from SQL-based Chatbot used to enhance the capability of Chatbot's keyword and pattern matching by providing ways of storing data as well as improving the process performance.

Markov Chain: This is a technique used in Chatbots to build responses that are more applicable probabilistically and, consequently, are more correct. The idea of Markov Chains is that there is a fixed probability of occurrences for each letter or word in the same textual data set (Mladenić & Bradeško, 2012).

There is no one all fit technique or approach for an enhanced Chatbot for ante-natal this research intends to achieve. A combination of techniques will therefore suffice. The ideal system is one that is capable of learning and making predictions based on responses of the ante-natal service seekers. A reactive system of such is adaptive and easily acceptable by the users who see it as realistic and believable.

The concepts of Chatbots were defined and its usage explored. The merits and constraints of the system were extensively laid. The various Chatbot techniques and approaches pave the way for the next chapter on methodology for the survey to obtain the need and applicability of a Chatbot system in ante-natal services and finally describing the method for the design.

III. METHODOLOGY

This study is driven by two objectives which is to survey the desirability of the anti-natalbot and designing the basics for the prototype of the Bot. To carry out these objectives a top-down approach that drills down from the general to the specific will be used. This is referred to as a deductive approach which is typically associated with scientific investigation (Sekaran & Bougie, 2016). Using this approach, the concept of Chatbot design and implementation in health particularly at the antenatal will be investigated through a survey.

The four process by which this study is conducted are, 1) Concept and Design exploration, 2) Need requirement study, 3) the basic design for the prototype and 4) implementation and evaluation of the system. While the first three phases are captured as subjects in this paper, the actual implementation and evaluation phase are extensions to be captured in further publications.

➤ *Concepts and Design Exploration*

This phase was captured in the literature review where important concepts on Chatbot and its implementation in health were reviewed. Some of the popular designs were presented.

➤ *Need Requirement Study*

This phase is very important in system designs especially in agile environment to better understand the view of the users of a proposed system and to carry them along throughout the system development life cycle. In this study a survey was carried out to get the views of the main users of the Bot. The study was conducted using a quantitative approach where key variables are defined to be verified by the respondents using a self-administered questionnaire. The key variables of the instrument were meant to measure the acceptability, understanding, believability, cost-effectiveness, process

simplification, wider access, and considerably high degree of secrecy. The questionnaire was designed and administered directly to the two categories of respondents (Expert Physicians and Pregnant Mothers) by the researcher. The completed questionnaires were obtained directly, collated and analysed using simple descriptive statistics method.

➤ *Basic Design of Prototype*

This is the conceptual analysis and design for the proposed prototype. This is achieved by critically evaluating the working relation of the major components of the bot. The design of the proposed Ante-natalbots is based on the working process depicted in Figure 2.

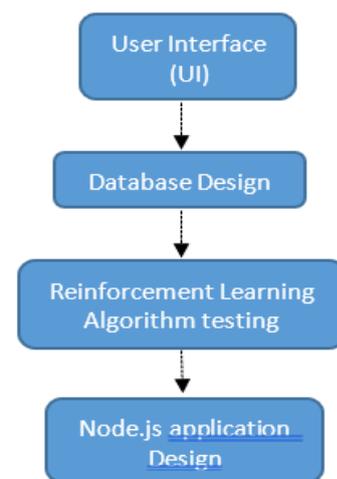


Fig 2. Chatbot Process Design

IV. RESULTS

This section presents the results of the survey and the conceptual design of the proposed prototype of the Anti-natal bots.

➤ *Instrument Design*

The instrument is a 5-Likert scale defined as (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly agree. This scale considered more reliable and high quality than the others (Revilla et al., 2014). The instrument has two main sections 1) demographic information, and 2) critical leading questions. The first section contains respondents or expert information such as name, gender, age, highest educational level, and years of experience.

Respondents were asked to use the point scale to rate the relevance and the need for the Chatbot in the antenatal activities. For example, the key factor the questions centers on are Trust, Accuracy, Dynamism, Privacy, Cost-effectiveness, and Distance. The general comment area is meant to take the overall comment and suggestions of the respondents to the general idea and the proposed items.

Sample participants are categorized into two, the experts ($N=20$) which comprise of medical doctors, midwives and nurses and the beneficiaries ($N=30$) which are the pregnant women.

The instrument was administered directly to the respondents at the 44 Residence Hospital, Kaduna. The researcher seeks an appointment with the doctors and explained the study to them and directly administered the questionnaire to the willing doctors. Since the instrument has only 5 items that can easily be completed and returned. Some senior nurses and midwives were also administered the instrument.

On the other hand, the beneficiaries were met on the days of antenatal. They were contacted individually and properly briefed in either English or Hausa language according to their choices. The educated amongst the beneficiaries are handed the questionnaires to answer with a guide. The non-educated were asked the questions and the answers provided used to complete the instrument.

➤ *Data Analysis*

The data collected through the questionnaire was analyzed and discussed in this section. The descriptive analysis helps to summarize the data collected into tables for better understanding of the reader and for the researcher to take a position.

The survey research described in the previous section seeks to answer the research main question on the justification of the implementation of a Chatbot for antenatal services. The summary of the responses coded from the instrument administered to both the practitioners and the beneficiaries are shown in Tables 1 and 2 below.

Table 1. Summary of the practitioner’s responses to the questionnaire

	Item	Strongly agree	Agree	Undecided	Disagree	Strongly Disagree
1	The current ante-natal system is cumbersome and stressful	15	5	0	0	0
2	Applying technology (Chatbot) in ante-natal to connect doctor and pregnant mothers will be helpful	5	10	3	2	0
3	The chatbot may be very safe to communicate	5	5	3	5	2
4	The chatbot will enhance the speed of medical access	6	10	0	2	2
5	Chatbot will reduce medical cost	7	7	0	4	2

Table 2. Summary of the pregnant mother’s responses to the questionnaire

	Item	Strongly agree	Agree	Undecided	Disagree	Strongly Disagree
1	The current ante-natal system is cumbersome and stressful	27	2	1	0	0
2	Applying technology (Chatbot) in ante-natal to connect doctor and pregnant mothers will be helpful	9	11	8	2	0
3	The chatbot may be very safe to communicate	0	8	16	4	2
4	The chatbot will enhance the speed of medical access	4	14	6	4	2
5	Chatbot will reduce medical cost	6	17	4	2	1

Fig 3 and 4 represents the charts for the physician and pregnant mothers responses to the instrument.

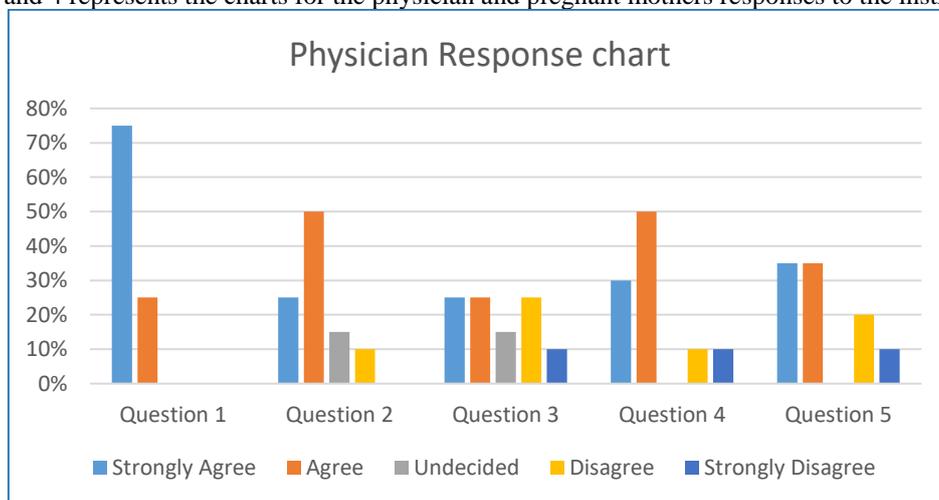


Fig 3. Physicians’ response chart

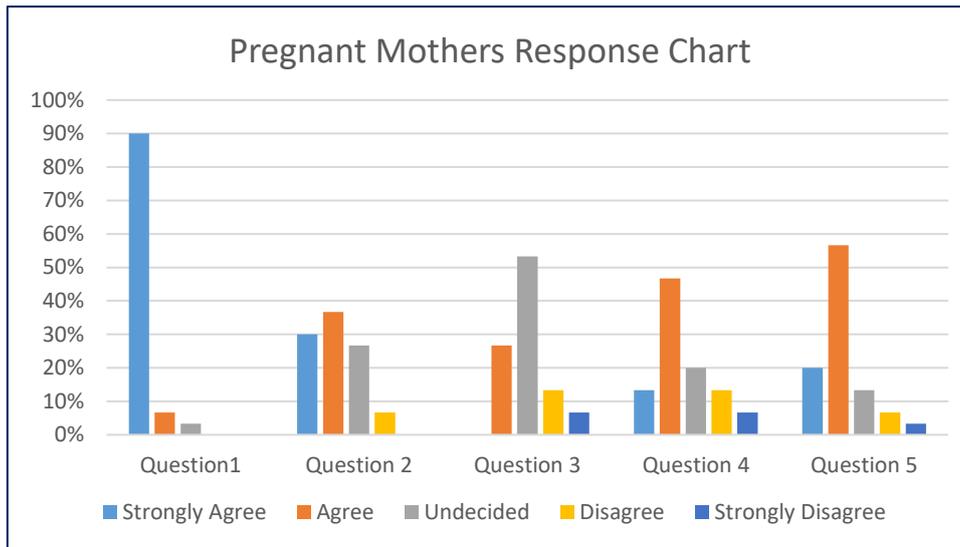


Fig 4. Pregnant mothers’ response chart

The data in the tables above as represented in the chart show that the respondents generally agreed that the current system of antenatal is very cumbersome with over 90% on the Likert. While there is a spread of opinion on the application of chatbot technology, on a general note over 60% agreed on the implementation of the technology. This pattern is observed on the other variables concerning safety, speed, and cost. It can be summarized therefore that both the two categories of our respondents generally agree to the need and implementation of chatbot systems for the antenatal services in our health facilities.

➤ *Prototype Architectural Design*

The internal and external design architecture is as depicted in Figure 3. The system consists of three main modules: The interface design rendered using a web or mobile app, a knowledge base which is the heart of the chatbot, and the intelligent engine. AIML is the building technique, MySQL for the knowledge base to support learning and DNN as the Machine learning and AI algorithms to provide intelligence. The System takes input in a text form from the user and analyses that input using DNN techniques to obtain deep understanding of what the user is trying to say or ask so as to make relevant responses accordingly.

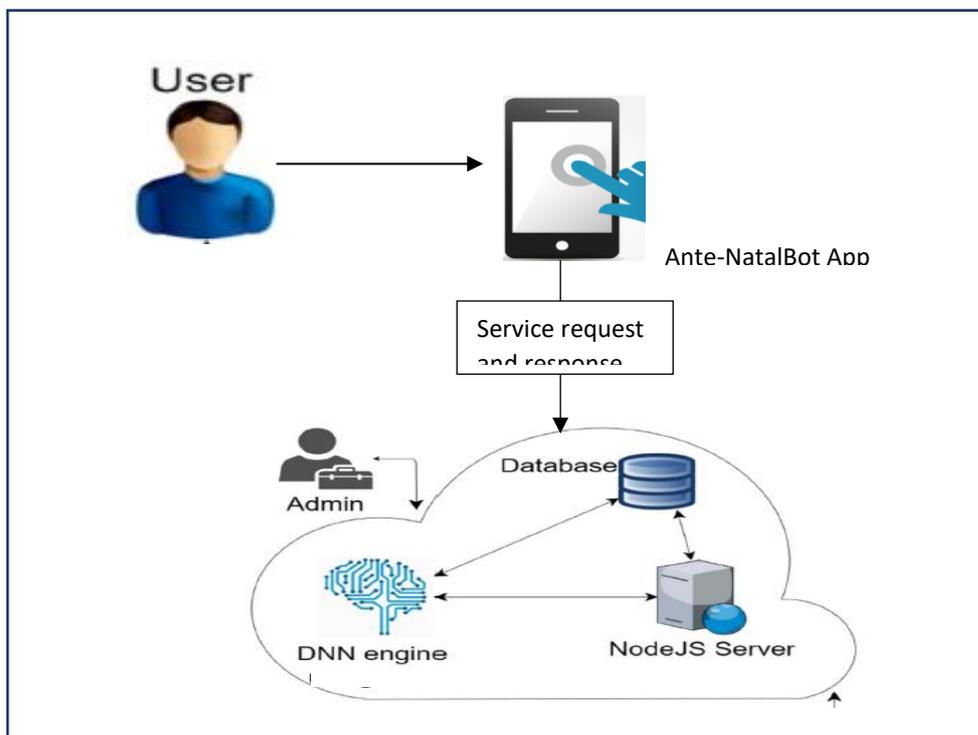


Fig 3. High-Level Architecture of Ante-NatalBot

The front end of the system is a web based app with desktop and mobile compatibility. The user interacts using the app which connect to the back-end of the system to be hosted on the cloud. The NodeJS server, hosted on our private server, powers the entire system. The database consists of a MySQL server hosting user sensitive information like the profile and health data. It is meant to manage the knowledge-based system. The DNN is the intelligent engine that enables the bot to learn from the previous conversations so as to provide reasonable responses from the knowledge based.

V. CONCLUSION

The chatbots system is widely used in various fields such as in businesses, education, healthcare, and many more. The design and development of chatbots involve a variety of techniques. In this study a few techniques for designing Intelligent Chatbots was presented to give an understanding of the relevant working components as well as the combination of approaches that will give the desirable system. The study conducted a preliminary survey to identify the need for the chatbot and the result shows a positive leaning towards the implementation of the technology for antenatal services. The design architecture of the proposed antenatal bot prototype consists of an interface design rendered using a web or mobile app, a knowledge base which is the heart of the Chabot, and the intelligent engine.

This study is meant to stimulate the actual research in this very important health assistive area. Full-time research with the attendant implementation of the designs in apps with language consideration will help in a large way to simplify antenatal services and attendance. Further studies should focus on how to include a Natural Language Processing (NLP) algorithm that will manage the language constraint of the current design. This will eliminate the barrier to the system in a multilingual society as ours where the bot will operate. Additionally, post-implementation survey for validating the effectiveness of the system should be conducted. Consistent monitoring and evaluation of the system will open the loose ends hence signaling corrections and enhancing usability.

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