

Developing an Expert Artificial Intelligence (AI) System for Early Diagnosis and Management of Stroke

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ABSTRACT

Stroke, a critical medical emergency, necessitates swift attention due to its interruption of blood supply to the brain. Early and accurate diagnosis is pivotal in its management. This study proposes an expert artificial intelligence (AI) system to aid in the early diagnosis and management of stroke, addressing the challenges associated with the disease. The system, implemented as a web-based platform, employs human-like reasoning for diagnosis and offers interactive management suggestions. By utilising technologies such as MySQL, PHP, JAVA, HTML, XML, and CSS, the system is hosted on a web domain for easy access. Clinicians in Nigeria can potentially utilize this system to predict and differentiate between stroke types accurately. The system's ability to diagnose, learn from users, and provide reliable predictions offers significant advantages in stroke diagnosis. Upon diagnosis, results are immediately generated and emailed to users. This expert AI system presents a promising approach to enhance stroke management, offering timely and accurate support to healthcare professionals.

Keywords: Stroke Diagnosis; Expert AI System; Web-based Platform; Healthcare Management

Introduction

An artificial intelligence (AI) system called an expert system is designed to replicate the processes applied to take or make decisions just like that of a human expert in a particular field¹. Algorithm and sets of rules are used by expert systems to analyse data and now use the same result to give judgment.

A stroke is a medical disorder that develops when there is a blockage or blood vessel rupture that interrupts the flow of blood to the brain. This disruption, which may also result in the death or destruction of brain cells, may have a variety of neurological symptoms. Ischemic stroke and hemorrhagic stroke are the two kinds of stroke that are the leading cause of mortality worldwide².

Medical personnel will be able to immediately identify possible stroke cases by using an expert system to analyze a variety of data from people who attend the hospital, including medical history, symptoms, and results of diagnostic tests, which points to initial detection of stroke³⁻⁷. The next step is for advice to be issued by suggesting more testing resulting to the best courses of action.

The research aims to develop a robust and reliable artificial intelligence system that aids medical practitioners in promptly identifying different types of stroke, thus enhancing patient health outcomes and treatment quality. The objectives outlined in the study include conducting a comprehensive review of existing literature on stroke and available treatments, developing algorithms capable of efficiently assessing patient data to

provide accurate diagnostic recommendations, designing a user-friendly interface for healthcare professionals to input patient information and receive diagnostic advice, validating the system's correctness and dependability through rigorous research, and ultimately improving the effectiveness and quality of stroke diagnosis and care.

The main focus of the research was to create a web-based expert artificial intelligence system tailored to the needs of stroke experts and clinicians in Nigeria. This system aimed to facilitate the early detection of various types of stroke in their preliminary stages, thereby enabling timely intervention and management. However, it's was noted that the treatment of stroke itself falls outside the scope of the research. By leveraging advanced technology and incorporating expert knowledge, the proposed system has the potential to significantly enhance the diagnostic capabilities of healthcare professionals, leading to better patient outcomes and overall healthcare quality in the context of stroke management.

4. Materials & Methods

Various research approaches and philosophies were discussed to guide the development of an expert AI system for stroke diagnosis and management. The research onion model by ⁹ was employed to understand the layers of research design. Philosophical underpinnings such as positivism, realism, interpretivism, and pragmatism were explored, with a pragmatic approach chosen to combine quantitative and qualitative methods effectively. This approach aims to generate robust findings for the analysis of the expert system.

The research strategies included surveying experts in the healthcare field through questionnaires and interviews, employing a case study approach focused on the Nigerian healthcare system, and implementing a mixed-method approach to combine quantitative and qualitative data. This comprehensive strategy ensures a thorough understanding of the research problem and facilitates informed decision-making for the development of the expert AI system.

Regarding the time of research, a cross-sectional approach was adopted with a defined start and finish date. Techniques and procedures for data collection and analysis were outlined, encompassing both primary and secondary data sources. Additionally, common technology design methodologies such as stop-wise style, bottom-up design, and object-oriented design were discussed, providing a framework for the systematic development of the expert AI system.

Overall, the methodology provided a structured framework for conducting the research, integrating various research approaches, strategies, and design methodologies to ensure the effectiveness and reliability of the expert system for stroke diagnosis and management.

4.1 Research Question 1 (RQ1)

What are the key factors influencing the development of an expert system for early diagnosis of stroke in Nigeria⁸?

From this research question, three (3) interview questions and eight (8) questionnaire questions were generated to answer the question explicitly.

4.1.1. Findings from the Survey

- 50% of respondents are good users of computer systems.
- 30% are very familiar, 35% are familiar and 25% are somewhat familiar with diagnostic standards of stroke.

- Most responses were Hypertension, Diabetes, and Smoking.
- 88% are aware of the advancement of stroke treatment, 11% are unaware and 1% did not respond.

4.1.2. Findings from the Interview

- Nigeria lacks exceptionally good infrastructures and professionals in healthcare, and this has impacted negatively on the timely treatment of stroke patients.
- Not all hospitals can fully diagnose a patient with the kind of stroke affecting them because they do not have these devices such as the CT-scan and MRI machines.
- Integration is seen as a problem.

4.1.3. Findings from Secondary data.

The screenshot below shows a display of the findings from the secondary data used for stroke prediction.

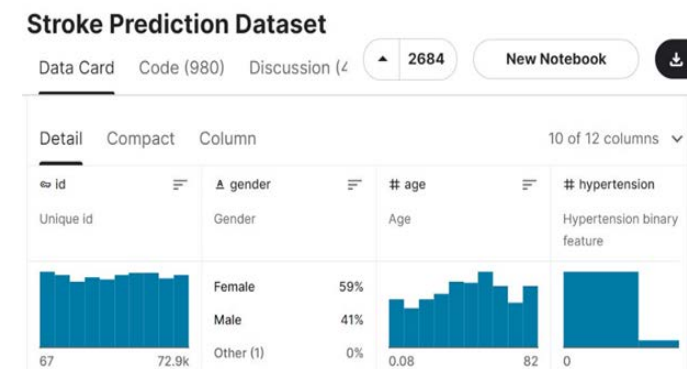


Figure 1: Screenshot of Stroke Prediction Dataset.

59% of females are recorded to have a stroke while 41% of males. This means that females are more likely to have stroke than men.

The major sign of stroke is seen to be hypertension.

The Age ranges from 8 to 82 years, but people who are more likely to have a stroke are more elderly as presented in the graph in Figure 5 above.

4.1.4. Summary of the findings

The key factors influencing the development of an expert system in Nigeria are the age, gender, stroke signs, and symptoms exhibited. These are very key factors to be displayed in the expert system.

4.2 Research Question 2 (RQ2)

In what way can an expert AI system be created for early stroke diagnosis and management and how can the system be implemented effectively in the Nigerian healthcare system⁸?

This includes five (5) interview questions, and six (6) questionnaire questions generated to answer the question explicitly.

4.2.1. Findings from the Survey

Findings from the survey showed that the most effective way for stroke detection is the use of CT-scan and MRI which are the existing technologies currently being used in the healthcare sector. This means there is a welcome development in the use of technology in healthcare. The survey report shows a lack of confidence in diagnosing stroke on the part of healthcare practitioners without technology. Late presentation of stroke cases, funding, and access to available technologies result in the

cause of death for the patients. The stroke signs and symptoms should be factored into the expert system as these will easily prompt a stroke case when presented on the system.

4.2.2. Findings from Interview

Technologies are currently being utilized in the field of AI for healthcare in Nigeria. For the Nigerian healthcare sector to accept and fully implement the system, there must be collaboration with technology experts. Adoption of the new system might be a bit of a challenge as there might be doubts if the system will accurately give results that are real or false. All stroke factors should be collected and fed into the system for training.

4.2.3. Findings from Secondary data

The secondary data sets already have these stroke factors present and will be used to build the system for testing.

4.2.4. Summary of the findings

The expert AI system should be trained with stroke signs and symptoms which are the factors causing stroke so that when such cases are fed into the system, the system will be able to detect that the patient is having a stroke and the next line of action will be given to the patient. For the system's implementation, a parallel approach should be used whereby an expert in stroke uses it so that anomalies can be easily detected.

4.3 Research questions 3 (RQ3)

In what way can we analyse the impact of an expert system for early diagnosis of stroke on patient outcomes in Nigeria⁸?

From the research question, four (4) interview questions and twelve (12) questionnaire questions were generated to answer the question explicitly.

4.3.1 Findings from Survey

- Accurate diagnosis using the risk factors should be present in the expert system.
- It is essential for the AI system to provide very prompt and accurate diagnostic recommendations.
- All relevant stroke factors, and imaging from already existing technologies in use (CT-Scan and MRI).
- Most responses were for the system to be on a single page with a drop-down arrow having questions ready to be answered. The interface should be simple and user-friendly.
- It is particularly important for the interface to be easy to use and navigate through.
- All stroke risk factors should be present in the system
- There should be privacy of users' data for security reasons
- 75% of respondents agreed there should be specific regulatory or ethical considerations that the AI system should adhere to.
- 90% of respondents said the AI system needs to undergo rigorous validation and testing before implementation.
- Only 55% are likely to adopt and use an AI system for stroke diagnosis and management.

4.3.2. Findings from Interview

The findings from the interview conducted aim to help Nigerian policy decisions and the treatment of stroke patients.

They offer insightful information on how efficient the stroke AI systems will be to resource optimisation plans, healthcare professional training programs, and stroke management.

4.3.3. Findings from Secondary data

Content in secondary data was not applicable in this case.

4.3.4 Summary of the findings

In summary, findings from both the questionnaire and interview conducted, point to several viewpoints that should be considered while designing an expert system for stroke early detection in Nigeria. The system ought to give a careful diagnosis based on risk factors a priority, as well as all stroke factors and imaging from already available technologies like CT-Scan and MRI. The user interface should be simple to use, easy to navigate, and accessible. Although the requirement for anonymous data entry adheres to regulatory and ethical considerations, privacy, the system requested by clinicians in Nigeria is that patient data should be on display but privacy and data security are vital. Before installing the AI system, careful validation and testing are required.

5. Summary of the Research Findings

In summary, the research findings provide valuable insights for the development of an expert system for early diagnosis and management of stroke in Nigeria. Key factors influencing the system's development include age, gender, and stroke signs and symptoms, and should be incorporated into the system for accurate diagnosis. The system should be trained with relevant stroke signs and symptoms to enable prompt detection and appropriate next steps for patients.

To ensure effective implementation, a parallel approach is recommended, where the system is used in conjunction with expert stroke clinicians who can detect any anomalies and provide necessary interventions. The system should prioritise risk factors, including all relevant stroke factors, and the user interface should be user-friendly, simple, and easy to navigate to facilitate ease of use.

Data privacy and security are crucial, requiring adherence to regulatory and ethical considerations. Rigorous validation and testing should be conducted before implementing the AI system to ensure its reliability and accuracy.

By considering the key findings from all three research questions, the development of the expert system can be informed by the need for comprehensive data analysis, user-friendly interface design, effective implementation strategies, and strict adherence to privacy and security protocols. The expert system aims to improve stroke diagnosis and management outcomes in Nigeria by leveraging the power of AI technology.

6. Results and Discussion of Findings

In chapter one, three research questions were designed to develop the proposed expert AI system. The summary of findings from all three questions as stated below will be discussed.

RQ₁ What are the key factors influencing the development of an expert system for early diagnosis of stroke in Nigeria?

RQ₂ In what way can an expert AI system be created for early stroke diagnosis and management and how can the system be implemented effectively in the Nigerian healthcare system?

RQ₃ In what way can we analyse the impact of an expert

system for early diagnosis of stroke on patient outcomes in Nigeria?

It is noted that the key factors: Age, gender, and the signs and symptoms of a stroke are the main variables affecting the development of an expert system in Nigeria. These are highly important factors that the expert system should convey.

It is of very high priority for the expert AI system to be trained with stroke signs and symptoms, which are the elements that cause stroke so that when situations like these are sent into the system, it will be able to determine that the patient is/will/ or will not be suffering a stroke and will tell the patient what to do next. The system should be implemented in parallel, with a stroke specialist using it so that irregularities can be quickly identified.

A thorough diagnosis based on risk factors, in addition to all relevant stroke variables and imaging from currently accessible technologies like CT-Scan and MRI, ought to be given priority by the system. An accessible, user-friendly, and straightforward user interface is necessary. Data security and privacy are essential due to the need for anonymous data entry and adherence to legal and ethical requirements. Careful validation and testing are necessary before the AI system is installed.

In conclusion, the research results offer insightful information for the development of an expert system for the early detection and treatment of stroke in Nigeria. Age, gender, and stroke signs and symptoms are important characteristics that should be considered when developing the system to provide an appropriate diagnosis. To enable fast diagnosis and suitable next measures for patients, the system should be trained with stroke signs and symptoms. A thorough diagnosis based on risk factors should be prioritised by the system, together with consideration of all relevant stroke variables and imaging using currently available technologies like CT and MRI⁹.

The technology should be utilised in conjunction with skilled stroke physicians who can see any irregularities and administer the appropriate therapies to ensure effective deployment. The user interface should be straightforward, easy to use, and user-friendly to encourage ease of use. The system should prioritise risk variables, including all important stroke factors.

Several important suggestions arise when comparing the outcomes of the research stated with those of other studies in the literature review.

The significance of demographic parameters like age and gender in the diagnosis of stroke is highlighted by both the research findings and the literature review. It is essential to incorporate these traits into the expert system to deliver a more precise diagnosis (Powers, 2019).

Emphasis was made on Stroke Signs and Symptoms. The researchers talked about the importance of including stroke signs and symptoms in the training of the expert system. This aligns with the findings in the literature review, which emphasise the need for comprehensive data on stroke signs and symptoms to improve the system's diagnostic capabilities.

The research and literature review agree on the necessity of incorporating imaging technologies like CT and MRI into the expert system⁹. These imaging modalities play an important role in stroke diagnosis, and their integration enhances the system's diagnostic accuracy.

Both the mentioned findings from the research and the literature review promote collaboration between the expert system and stroke experts. Clinicians and healthcare professionals can use the system to help them make well-informed decisions.

In conclusion, the findings from the research add to the understanding discovered through the review of the literature. A user-friendly interface, thorough stroke signs and symptoms, the integration of imaging technologies, close cooperation with experts in stroke care, and careful evaluation of demographic aspects are all necessary for the creation of an expert system for stroke diagnosis in Nigeria. The expert system can be a useful tool in enhancing early identification and treatment of stroke, which would improve patient outcomes, by being in line with the existing research areas considering the Nigerian Hospitals used as a Case study¹⁰.

7. System Design

In building the system, the secondary datasets from Kaggle.com. were analysed and the following steps were taken:

Step 1 - Pre-configure and load the healthcare dataset for stroke diagnosis.

Step 2 - Capture the patient or user data and store it for subsequent diagnosis. The input data include id, gender, age, hypertension, heart disease, ever married, work type, residence area/type, average glucose level, BMI, smoking, and smoking status as stated in the secondary datasets from Kaggle.com.

- **Gender:** There is not much difference between stroke rates between male and female gender.
- **Age:** When it comes to stroke management, age is not just a number; it is an incredibly significant factor in determining stroke diagnosis. People aged more than 60 years tend to have strokes.
- **Hypertension:** Hypertension can cause a stroke. The data set has quite little data on patients having hypertension. The AI machine will need to learn more.
- **Heart Disease:** People having heart disease tend to have a higher risk of having a stroke if proper care is not taken.
- **Ever Married:** Going by the data, people who are married have a higher stroke rate.
- **Work Type:** Various kinds of work have various kinds of problems and challenges which can be the probable reason for excitement, thrill, stress, etc. Stress is never good for health.
- **Residence Type:** Based on the data, whether you live in an Urban or Rural area has no significant effect on Stroke.
- **Average Glucose Level:** From the data plot, people having stroke have an average glucose level of more than 100.
- **BMI:** Body Mass Index is a measure of body fat based on height and weight. BMI above 24 for people above 18 years affects the chances of having a stroke.
- **Smoking Status:** Going by the data set, we can see there is not much difference in the chances of stroke irrespective of smoking status.

Step 3 - Use the case file to analyse patient data. To diagnose stroke, each parameter of a factor in the patient data such as gender, age, and other relevant vitals was compared to the dataset

of cases to find the best matching pattern, and then decide on the diagnosis based on the stroke value for the best match¹¹.

Step 4 - The last step was to present the diagnosis report on screen and send the report to the given email (Figure 2 and Figure3).

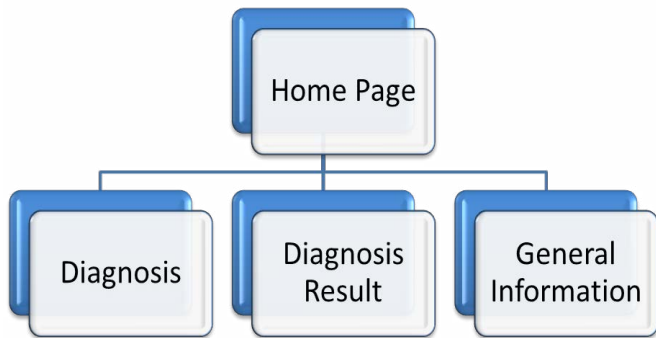


Figure 2: Proposed web-based design of the intervention.

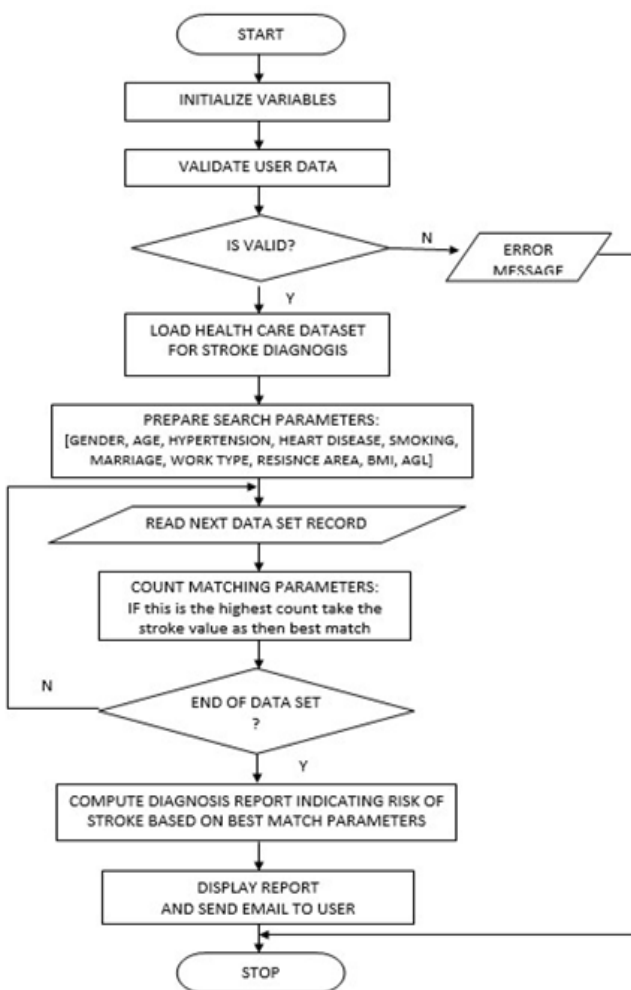


Figure 3: Proposed Diagnostic coding flow chart.

8. Summary and Conclusions

The project work started by reviewing literature on what other authors have done regarding systems for early diagnosis and management of stroke using Artificial Intelligence (AI) driven tools. It was noted that no known AI system had been built regarding this, hence the reason for this project work. Datasets were gathered from both primary data gathering sources through Jisc online survey platform and secondary data sources using Kaggle.com. The reason for the secondary data sets was to train the expert system to have that human-live reasoning form to enable it to respond to queries by generating prompt and

reliable stroke results when fed with patients’ stroke signs and symptoms. Feedback from surveys and interviews helped fine-tune the expert system making it bespoke as it was developed according to how clinicians in Nigeria wanted. The expert system was developed as web-based for easy use by healthcare professionals from across Nigeria. The system was developed using PHP (Hypertext Preprocessor) language, hosted on an Apache web server with support for MySQL database server for the backend while HTML (Hypertext Markup Language) and CSS (Cascading Style Sheet) were used in implementing the front end. Testing was carried out on the system to ascertain its reliability, accuracy, and promptness in generating results on each diagnosis and it was noted that when the developed expert system is fully implemented for use in Nigerian hospitals, there will be a low death rate of stroke patients as early detection will help save lives.

9. Recommendation

The recommendation for this project work will be that the expert system should be fully implemented in hospitals in Nigeria and should be used by stroke experts and clinicians handling stroke patients. Usage should be in parallel and not total phasing out of the traditional methods of stroke detection and treatment.

The current system built is web-based. The expert system may be seamlessly integrated with current health applications through collaboration with mobile health app developers, reaching a larger patient and healthcare provider audience.

Management of the Nigerian hospitals implementing the use of the expert system should essentially follow current standard guidelines and always observe patient privacy of data.

10. Future Work

In building the expert AI system, several factors were incorporated into the system for it to be effective. Participants from the survey requested that micro imaging systems like CT-scan and MRI should be embedded into the AI system. This has not been implemented in this project as it was beyond scope. However, this can serve as a future work to be done which will make stroke detection results more robust and accurate. To improve access to specialised care, the expert system can be incorporated into telemedicine platforms to provide remote consultations and assessment of stroke patients in underserved or remote areas.

11. Student Reflections

The Gibbs reflective model was used as a framework to assess the success of the project work and the master’s program. The framework consists of six (6) stages as illustrated in the diagram below (Figure 4).

12. Lessons Learned

During the development of the expert AI system for early diagnosis and management of stroke, I learned a lot of valuable lessons as listed below:

The importance of collaborating with specialists in stroke care, clinicians, and healthcare professional, thereby ensuring a successful development and implementation of the system.

The gains from use of the mixed method approach, its guide to information for decision-making on how to implement this AI systems for use in healthcare.

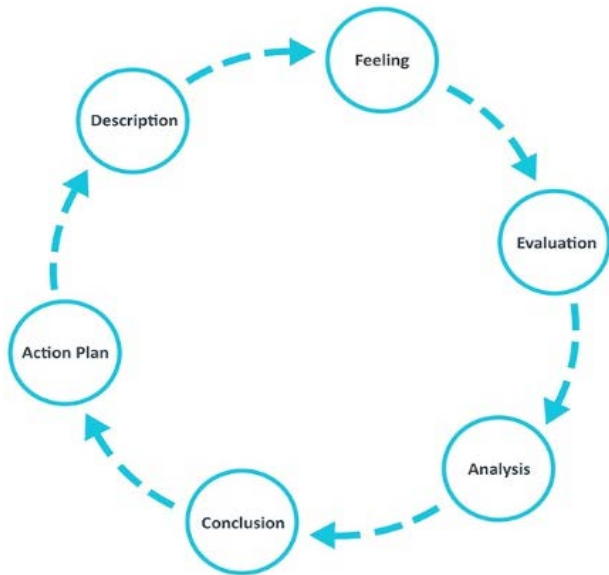


Figure 4: Gibbs reflective model.

The utmost necessity to obtain ethics approval before a project can be done to ensure data protection and privacy guidelines are followed judiciously.

Data needed to build the expert system could be obtained from an open-source data repository to ensure using datasets that are already cleaned and free from personal data.

It was necessary to get feedback from participants during the data collection phase and from users of the system to enhance the expert system. This helped improve the performance and usability of the system.

There was great need for the system's interface to be user-friendly, to ensure clinicians and healthcare professionals in Nigeria could effectively utilise the system in their clinical practice.

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