
**BACHELOR OF SCIENCE IN SOFTWARE DEVELOPMENT**

**FINAL YEAR PROJECT 1 : BSD 3106**

# REALTIME MEDICAL IMAGE ANALYZER

**MAKINDU TRAUMA CENTER**

**BY**

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**PROJECT PROPOSAL DOCUMENT SUBMITTED IN PARTIAL FULFILLMENT FOR THE REQUIREMENTS FOR THE AWARD OF A DEGREE IN SOFTWARE DEVELOPMENT**

**PRESENTED TO : DR. LUCY MBURU**

**Declaration**

I declare that this project is my original work and has not been presented in any other college or University for the award of a Diploma or Degree.

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Signature ……~~*FMK*~~……

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## 1. BACKGROUND

Advanced technologies in healthcare industry are increasingly becoming crucial to enhancing efficiency in care and raising the quality of care. Digitization of healthcare services has enhanced some efficiencies in the delivery of these services; for example, integration of seamless multiple payment methods in hospitals through the inclusion of mobile money transfer, NHIF cards (now SHIF in Kenya), among others.

Though there is a technological advancement in the health sector, some services that require experts pose a challenge to the major stakeholders who are the patients that don't have the capacity to interpret images such as CT Scans, MRI Scans, X-rays among others, hence they are forced to wait for experts in these fields to come probably late in diagnosis hence delaying service delivery.

I'm a netizen from Makueni County, which has just set a precedent for integrating health management through an integrated health management system called afyaMakueni by adopting technology in managing healthcare data and processes across county facilities.

Yet, with this improvement, X-ray-based medical image analysis challenges doctors and patients to this day to some extent. Most times, the ability of doctors to get proper X-ray interpretation is always delayed, mostly in situations where patients have been transferred to their care from other institutions with their X-ray images, thus delaying diagnosis and treatment of such patients. Equally disturbing is a patient's limited access to information about his or her medical condition, which often results in confusion and anxiety.

And, influenced by a recent experience besides the problems discussed above, the decision to develop a Real-time Medical Image Analysis System was made. This system aims to alleviate the issues presented above by offering an artificial intelligence-based platform where doctors and patients can instantly upload and analyze X-ray images. It will also suggest real-time diagnosis and recommendations to decrease the waiting time for X-ray interpretations while enhancing clinical decision-making.

This will also be useful for learning purposes for the medical students in tertiary institutions to understand various X-ray patterns and conditions.

## 1.1. PROBLEM STATEMENT

Most of the healthcare systems across the country, and even in my home county, always experience some delays in interpreting medical images such as X-rays, particularly in resource-constrained settings. This is because it always depends on radiologists or specialists who may not be available at that time, hence taking a lot of time before a diagnosis is actually made and the care provided to the patient.

Also, the process has been more cumbersome since there are variable interpretations of X-ray pictures, largely due to human variables and skills variations.

Whereas, the patients having limited accessibility to the diagnostic information and often are anxious due to unexplained medical conditions, methods in traditional image analysis do not provide feedback in real time, further aggravating the time taken for clinical decisions so vital to the welfare of patients. So, the key issues to be entertained in this digital saga are:

- **Delay in Diagnosis** - The existing medical image interpretation system is sluggish and very often takes time to arrive at a diagnosis, especially in rural or under-resourced settings.
- **Inconsistency in Analysis** - Human inconsistencies and skill variance may lead to different analyses of the same X-ray films, hence giving different diagnoses, as found in current systems.
- **Access to Information by the Patient** - there is no timely or even detailed information about the patient's condition and diagnosis progress, this acts as a limiting factor toward understanding their welfare state medically.
- **Lack of Real Time Analysis Tools** - There is very little or no real-time system available that performs on-the-spot analysis of X-rays with doctors and patients to aid quick decision-making.

## 1.2. LITERATURE REVIEW

In the recent past, Artificial Intelligence (AI) has represented a bright hope for inefficiencies in diagnosis and treatment. Several studies have looked at the application of AI to the analysis of medical images, especially X-rays, where automation can substantially lighten the workload of the radiologist by improving both the accuracy and timeliness of the diagnosis.

### 1.2.1. AI and ML in Medical Image Analysis

Techniques developed for deep learning, such as those discussed by Geert Litjens et al. in 2017, have given outstanding performance for medical image analysis, particularly in anomaly detection like fracture, pneumonia, and cancer. These CNN-based AI models, in particular, outperform the conventional methods for feature detection that usually cannot be captured by the human naked eye. Multi-label classification for identifying multiple conditions from a single image has been discussed in the study, which coincides perfectly with my project.

Xilin Shen et al. (2017) also highlighted the ability of the analysis of chest X-rays in the detection of lung diseases such as pneumonia and lung cancer in their survey on deep learning applications in medical imaging. This falls in line with the aim of the proposed project, which

seeks to analyze X-rays for multiple conditions in real time. The study went on to say that this could help bridge the gap between large patient populations and limited medical professionals with real-time diagnostics.

### 1.2.2. Limitations in the Available Medical Diagnosis Systems

Diagnosis delays are a common thing in rural and underdeveloped healthcare systems due to the total unavailability of radiologists. According to W Tania Rahman et al., 2019, the lag in X-ray interpretation is an important issue that causes delayed treatment and misdiagnosis, increasing patient mortality rates. This research hence may mean that the engagement of AI systems in such environments could reduce diagnostic turn-around times and thus allow physicians to make decisions more promptly. Further, a study by Chan GCK, et al. in 2018 explained AI-enabled tools that reduce the workload for medical personnel by automating routine diagnostic tasks. Although such tools sound very promising, their practical deployment is slow due to questions regarding their accuracy, trustworthiness, and regulatory clearances. It suggested that with extensive validation and more explainable AI, this might gain acceptance in clinical settings.

### 1.2.3. Existing Solutions and Gaps

Some of the diagnostic systems based on artificial intelligence include Google DeepMind, Zebra Medical Vision, and others that provide automated image analysis tools. However, most of these systems are either not real-time or aren’t designed to provide only patient-friendly interfaces for direct queries.

Another comparative analysis of existing AI solutions in respect of Esteva et al. (2019) concludes that though most systems exist to assist the clinicians, hardly any solutions provide the patient with direct access to diagnostic information. But even so, most existing AI systems remain disease-specific or symptom-specific, rather than multi-label, which would help in real-time diagnosis of multiple conditions from one X-ray.

The above-mentioned gap, therefore, points toward developing an integrated and real-time system for diagnosis related to fractures, pneumonia, and lung cancer among others,in the initial prototype, that will be intuitively accessible to one seeking answers.

Although great improvement has been achieved with AI-based diagnostic systems, most of them have failed to deliver real-time, multi-condition diagnostic tools to clinicians and patients themselves. Much of the solutions developed focus on specific medical conditions and exclude the use of interactive interfaces to engage patients directly. This proposed undertaking shall leverage deep learning for multi-label classification and real-time streaming technologies, such as Apache Kafka and Spark, towards a more comprehensive diagnostic system.

## 1.3. PROPOSED SYSTEM

The proposed system will be a real-time platform for the analysis of medical images through AI and machine learning from X-ray images and sending instantaneous outputs on the diagnosis of conditions, such as but not limited to fractures, pneumonia, and lung cancer. The minimum viable product will be built with Streamlit, Apache Kafka, Spark, and GCP tools like PubSub and Bigquery etc.

The system will also include a user-friendly interface through Streamlit that will enable doctors, patients, and medical students to upload X-rays and get immediate and accurate diagnostic feedback. It will also have an option for chatting,which will basically use explainable AI for further queries. Thus, the proposed system can contribute to reducing diagnosis delays and enhancing clinical decision-making while supporting medical education.

## 1.4. JUSTIFICATION OF THE PROPOSED SYSTEM

The proposed medical image analysis system shall deliver the following benefits to the community for improved health experiences and medical education:

- **Immediate Diagnostic Feedback** - The system will reduce waiting time for diagnosis to take place, thereby allowing rapid clinical decisions.
- **Improved Accuracy** - State-of-the-art AI algorithms shall be employed in the system to give improved diagnoses with minimal human error.
- **Accessibility of medical insights** - It will grant access to medical information and analysis directly to the patients and healthcare professionals.
- It would also serve as an important tool in teaching medical students about the patterns of diseases and imaging techniques.
- **Improved communication** will be ensured, as the system will provide an option of querying the AI system, making comprehension of the conditions around the case much easier.
- **Efficiency Enhancement in workflows** - The system will handle workflow management at the facilities, thereby allowing doctors to focus more on the patients than on paperwork.
- **Cost-effective** - It will reduce the number of consultations and tests and, therefore, will be cost-effective, both for patients and health care providers.
- **Multimorbidity Cover** - The system will be able to handle multiple medical conditions, making it an instrument of wide versatility in various clinical settings.
- **Data-driven decision making** - The platform will present healthcare professionals with evidence-based knowledge to help improve treatment strategies.

## 1.5. OBJECTIVES OF THE PROJECT

### Overall Objective

The core objective will be to make a medical image real-time analysis system that enables immediate decisions at a clinical level and enhances X-ray image interpretation by patients, doctors, and students.

### System Objectives:

- **Real-time Image Analysis** - Develop a system to perform real-time analysis of medical images, especially X-rays, for immediate diagnostic feedback.
- **Multi-Label Classification** - Implement a machine learning model capable of multi-label classification for multiple medical conditions, including fractures, pneumonia, and lung cancer.
- Employ **Streamlit to provide a simple interface** for users to interact with the application in an easy, navigational manner.
- **Chat Functionality** - This will involve the patients/doctors/students in asking questions and requesting clarification about the conditions portrayed in medical images and the diagnosis results.
- Offer a more **secure means of registration and login**, along with a guarantee of privacy and protection for the patients' data.
- **Progress Visualization** – I will design dynamic circular/linear progress bars to visualize the diagnostic results clearly, enhancing user understanding of their medical status at a glance.

### Project Objectives:

- **Improve Patient Care** – The system will enhance the quality of patient care by reducing wait times for diagnosis and improving access to medical information.
- **Medical Training Facilitation** – The system will also be aimed at the capability to provide a learning platform for medical students on disease identification and diagnostic procedures.
- **Improve Communication in Healthcare** – The system will enhance the communication between doctors and patients about their conditions and choices of treatment.
- **Data to Drive Healthcare Forwards** - The delivery of precise diagnostic insights promotes data-driven decision-making in clinical practices hence better healthcare.
- Introduce **the most advanced technology in diagnosis** to smoothen health operations and also make healthcare delivery systems efficient.
- **Empower public health programs** to enhance community health through appropriate interventions and information on prevalent medical disorders.

## 1.6. METHODOLOGY

### System Requirement Specification

In this phase, I will further seek the elaborated system requirements from stakeholders: doctors, patients, and students of medicine. This includes a functional and non-functional analysis in such a way that I make sure the solution handles real-life needs, such as analyzing X-ray images in real time, securely allowing users to authenticate themselves, and providing user-friendly interfaces.

### System Analysis

The system will be analyzed to identify key components and their interactions, and to make sure the architecture supports the model of machine learning and real-time image processing. This phase includes existing workflow analysis in hospitals and understanding current problems in hospitals that the system is supposed to solve, for example, delays in diagnosis and inefficient communication.

### System Design

The system architecture design shall be elaborated during this phase, comprising of data pipelines, model integrations, and the user interface. In system development, the division of state blocks will be modular, entailing user management, image processing which will be real-time, and chat functionality. More attention shall be paid in UI design with Streamlit to make it intuitive while having a strong backend for real-time data processing with model predictions.

### Testing and Validation

The system is to be tested and validated against set requirements before actual deployment. This shall include functional testing, whereby aspects such as image upload and subsequent analysis for correctness shall be checked, and non-functional testing, which includes but is not limited to testing the performance of the system, security, and usability. This ensures the reliability of the system in real-world usage.

### Implementation and Maintenance

The system will be deployed in a controlled environment once fully tested for real-time use by medical professionals, students and patients. After deployment, the system will continuously be maintained with regard to issues, updating of features, and keeping abreast with user needs. This includes system performance monitoring and periodic model retraining with new data for improved accuracy.

## 1.7. RESOURCES

The following are the resources that will be put into use:

### 1.7.1. Resources Needed for the System Development

- ✓ **Streamlit** - To design the user interface for user registration, uploading X-ray images and visualizing the results from the AI system.
- ✓ **Python-Django Framework** - for developing back-end logic and API integrations.
- ✓ **Machine Learning Libraries** like TensorFlow/Keras, Scikit-learn for developing the model for image analysis.
- ✓ **Apache Kafka & Spark** - For real-time data processing and stream analysis.
- ✓ **GCP (Google Cloud Platform)** - for storage, deployment, and all forms of computational resources.
- ✓ **PostgreSQL/MySQL** - It is the local Database management system for user data and X-ray image records.
- ✓ **Computing Hardware (Laptop/PC with high end processor, accelerated GPU, at least 8GB RAM and 256GB SSD)** for model training, testing, and running machine learning pipelines locally during development
- ✓ **Git/GitHub** for source control and collaboration.
- ✓ **Test Tools** like Selenium and Postman for Functional and Non-Functional Testing.
- ✓ **Email Server (SMTP Service)** for enabling email verification and password recovery features.

### 1.7.2. Resources needed to run the system

- ✓ **GCP (Google Cloud Platform** – to host, store, and run machine learning models on it.
- ✓ **Streamlit Hosting Platform** - This will host the user-facing application.
- ✓ **Database** like PostgreSQL/MySQL for maintaining data regarding user profiles, case history, and analysis reports.
- ✓ **GPU Servers** - Required for real-time X-ray image processing and analysis.
- ✓ **SMTP Email Service –** for account password recovery and user notifications.
- ✓ **Internet Connection** – This will facilitate the user to get access to the system, upload images, and fetch results from the deployed cloud application.
- ✓ **Storage of Medical Image Data** – Separate storage of medical X-ray images in the cloud or locally in a secure way will be needed.
- ✓ **Security Tools** like SSLs and Firewalls to ensure data privacy, protection and compliance with healthcare regulations.

## 1.8. CONSTRAINTS

- **Scarcity of Medical Data** - Privacy and confidentiality issues may restrict obtaining adequate and heterogeneous medical X-ray images to train the machine learning model.
- **Computational resource limitations** - Complex models need massive amounts of data, and not everyone has access to high-powered computers or the means to afford them.
- **Time Constraints** - It might be challenging to balance the tight deadlines of the project with the development stages, testing, and implementation in providing a robust system.
- **Issues in Integration** - Smooth interaction between different components of the system, such as Streamlit, Django, Kafka, Spark, GCP, etc., might raise some integration or compatibility challenges.
- **Security and Privacy Concerns** - Advanced security implementations are required such as securing sensitive data of patients and following rules laid down by regulations such as HIPAA, which can be quite complicated.

## 1.9. REPORT TO

The project progress shall be always communicated in regular basis to Dr. Lucy Mburu who is my Supervisor and Dr.Kitungo who is the Head Clinical Officer at Makindu Trauma Center.

## 2. PROJECT SCHEDULE

| Task | Description | Task Duration | Planned Start Date | Planned Completion Date | Deliverables |
|---|---|---|---|---|---|
| 1 | Project proposal design | 1 Week | 29/09/24 | 5/10/24 | Project Proposal |
| 2 | Requirements specification design | 2 weeks | 5/10/24 | 19/10/24 | System requirement specification document |
| 3 | System design specification document | 4 weeks | 19/10/24 | 15/11/24 | Design specification document |
| 4 | Preparation of progress report | 1 week | 15/11/24 | 22/11/24 | Presentation done |
| 5 | Test plan document design | 2 weeks | 22/11/24 | 6/12/24 | Test Plan document |
| 6 | System Coding and compiling | 12 weeks | 6/12/24 | 28/01/25 | Progress presentation |
| 7 | System testing | 2 weeks | 28/01/25 | 14/02/25 | Test results |
| 8 | Implementation strategy document design | 1 week | 21/02/25 | 21/02/25 | Implementation strategy document |
| 9 | User manual design | 1 week | | 28/02/25 | User manual |
| 10 | Compilation of complete system and final documentation | 2 weeks | 28/02/25 | 14/03/25 | Final project documentation and compiled system |
| 11 | Project presentation | 1 day | 14/03/25 | 16/03/25 | Present project |

## 3. CONCLUSION

This is proposed as my conclusion and general view, so as to enhance efficiency and effectiveness of the hospitals or health centers in Makueni County through X-ray interpretation. This system will ensure improved patient outcomes through the direct support of clinical decision-making and communication by practitioners with their patients. With a focus on user accessibility and real-time analysis, the system can be positioned to revolutionize how the medical professions interact with diagnostic images and, by extension, the healthcare being delivered. This will be a useful project upon implementation, for health professionals and students who are involved in the field to better understand medical imaging and all its ramifications.

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