Computer-Based Radiological Laboratory Diagnosis System

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ABSTRACT: It is the responsibility of every government to provide efficient healthcare services to its citizens. This enormous responsibility cannot be attained if the diagnoses system for ailment is not fully developed. To facilitate an efficient diagnosis system, this paper seeks to present a prototype designed for radiological diagnosis using images. The system enable the radiological images of a patient to be compared with existing images from a robust image database for a match using the images sizes and extracted graphics features thus making search and diagnosis of ailment accuracy and efficient. The methodology used in this research is the Object Oriented approach. The system design involved the use of UML Use Case diagram and the Data Flow Diagram. Java Programming Language was used to develop the radiographic diagnosis system and Java Server pages (JSP) as the front end technology while Enterprise JavaBean business logic was used for the coding. The backend was developed using MYSQL relational database. The databases were constructed from a pool of x-ray images. The results from test implementation show that efficiency, speed and accuracy can be achieved in both diagnosis and recommended treatment to patients.

KEYWORDS: radiology, diagnosis, prototype, medical laboratory, cad, pacs

1. INTRODUCTION

The health of an individual is most paramount as the saying goes “health is wealth”. Although ill health cannot be avoided due to the existence of microorganisms, stress, man-made and other environmental factors, there are stages in the diagnosis and treatment of every ailment depending on its degree. Most times patients are referred to a laboratory to carry out tests as an aid to proper investigation on the presence, type and source of the ailment the patient is suffering from. A laboratory tests can confirm a diagnosis or provide valuable
information about a patient status and response to therapy. Most often, test results provide information along with the patient’s history and other medical information which helps the physician work with the patient so they can decide what might be the appropriate actions for additional testing or treatment. On some occasions, the information from a single test is enough to convince physician specialists that a cascade of sophisticated medical interventions are in order; and sometimes it is all that is needed to end them. More often, diagnostic tests provide information that, along with other tests and observations, helps shed light on whether or not a disease is present, has progressed, or has changed its course so that a judgment can be made on what treatment regimen might be most appropriate for a particular patient at a given time.

Relevance of medical laboratory service in diagnosis of ailments, treatment monitoring, prognosis determination and identity testing is well acknowledged [7]. Since the discovery of x-rays by W C Roentgen in 1895, medical imaging has contributed significantly to progress in medicine [5]. Radiology is a specialization that involves medical imaging services, including diagnostic imaging and image-guided treatments. The primary diagnostic imaging modalities in the radiology enterprise include radiography, ultrasound, mammography, computed tomography (CT), nuclear medicine, magnetic resonance imaging (MRI), fluoroscopy and digital radiography. A radiologist is a doctor who specializes in imaging techniques. He/she is responsible for the interpretation of the image produced during the test, writes and sends report on the findings to the doctor.

It is very true that diagnostic accuracy corresponds to the outcome of radiologic examinations. Laboratory investigation is a very critical part of diagnosis and wrong diagnosis can lead to improper treatment. The present system of radiology diagnosis in Nigeria is basically manual and the output is analog, leading to series of manual comparison with several existing x-rays in order to find a match. This at times is dangerous as a laboratory attendant might conduct a wrong diagnosis due to fatigue thus wrong treatment will be administered to patient.

Information and Communication Technology (ICT) solutions (e.g. e-health, telemedicine, e-education) are often viewed as vehicles to bridge the digital divide between rural and urban healthcare centres and to resolve shortcomings in the rural health sector. Computerized health information systems can improve treatment of patients, management of health institutions, and provide up-to-date information for policy and decision making [8].

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2. REVIEW OF RELATED LITERATURE

A medical laboratory is a physical location with installed medical equipment where tests are carried out on clinical specimens in order to extract information about the diagnosis, treatment, and prevention of disease. Radiographic diagnosis is one major operation carried out in a laboratory. Radiographic images can be obtained from fluoroscopy and angiography, DSA, x-ray CT, CT angiography, MR imaging, MR angiography, functional MRI, perfusion MRI, diffusion MRI, scintigraphy, SPECT, PET. An x-ray is used to view the internal anatomy of a human body. This can be used to detect fractures, tumors etc. internally which is not visible by mere observation. A physical property measured by an imaging device and presented as a picture must meet three conditions to be useful. It has to penetrate the human body, it must not unduly interfere with it, and it must be meaningful for answering some medically relevant question [14]. Since the invention of medical imaging, radiology has found its application in medicine and has been established as an essential tool for diagnosis and therapy. Radiology can be used to diagnose cancer in its early stages, or lump (tumor) if a person has symptoms, it sometimes help predict whether a tumor is likely to be cancer, and most times used to plan treatment. Medical radiology is divided into two main types namely treatment radiology and diagnostic radiology. Treatment radiology may be used to eradicate cancer (curative treatment) or to alleviate symptoms (palliative treatment). The principal mode of treatment is teletherapy, in which external beams of radiation are focused onto a target treatment volume [11].

The most widely use of radiation remains diagnostic radiology, which involves imaging with x-rays. In the 1970s, diagnostic radiology was literally revolutionized with the development of computed tomography (CT). CT represents one of the earliest forms of digital x-ray imaging, in which images are captured and stored in a digital format. Such digital imaging provides key advantages in the manipulation, storage and transmission of images. The advances in imaging and in catheter technology have facilitated the development of interventional radiological techniques, in which imaging is used to help guide therapeutic procedures [11].

2.1 Errors in Diagnosis
Every radiologist worries about missing a diagnosis or giving a false reading. Diagnostic errors can be delayed, wrong or missed which appears to be the most common, most costly and most dangerous. The design of computer-based systems to aid diagnosis helps prevent errors in diagnosis. Diagnostic errors may result from failures related to test ordering before a radiologist is ever involved or in the ordering clinician’s use of the results after the radiologist’s work is complete. Diagnostic errors can be classified into two; Pre-analytical errors which includes inappropriate test request, Order entry mistakes, Patient/sample misidentification, Sample collection, Sample collection from infusion route, Inappropriate container, Sample handling, storage and transportation problems and Post-analytical errors which includes labeling errors, sorting and routing errors, pour-off errors and specimen-processing. Failure to inform patients of clinically significant abnormal test results or to record the delivery of relevant information is relatively common, occurring in 1 out of every 14 tests [6].

2.2 Image Processing

The goal of processing an image is to build a system that will take a vector as input and that will produce the identity of the vector image as output. Over the past few years, systems that can generate radiographic digital images without the need for radiography film have become available for use in clinical practice and are gaining popularity among practitioners. Such digital radiography can also reduce the radiation exposure [12].

According to Jordan et al (2006), the result of running a machine learning algorithm can be expressed as a function y(x) which takes a new digit image x as input and that generates an output vector y, encoded in the same way as the target vectors. After images are collected, they are passed to the radiologist for interpretation and diagnosis. In analog imaging system, the images produced are interpreted manually by the radiologist. Digital imaging allows image produced to be stored, matched and interpreted. A major advantage of imaging processing is the ability of images to be edited. According to Kunio [5], the most commonly used processing techniques for digital radiographic images have been aimed at enhancement of the digital images by removal or suppression of noise, and by increasing contrast and/or sharpness, such as the unsnap mask filtering used in FCR. The digitized images may enhance the conditions for diagnosis, treatment planning and follow-up compared to conventional radiographs, due to the availability of software [9].
One of the most useful advantages of digital radiography is the knack it provides to the clinicians to send images to practitioners in a matter of minutes [12]. Computer Aided Device (CAD) is another new imaging processing concept. The aim of CAD is to improve the diagnostic accuracy and the consistency of image interpretation by a radiologist who uses the computer output as a ‘second opinion’ [5].

According to Dromain et al. [2], CAD is a neural network applying calcification and mass algorithms to highlight areas of suspicious findings to assist radiologists. Picture Archiving and Communication Systems (PACS) was also designed and used for archiving images which can be processed. After implementation in the university of California Davis health system (UCDHS), images were readily available and increased satisfaction was reported. Average image search time decreased, from 16 minutes to 2 minutes, saving 21.5 physician years, worth $1,034,140 annually [10].

From the review of concepts and researches on radiological diagnosis presented so far, a research gap such as developing either a hardware or software that can combine both the search and match of images with the interpretation of the diseases associated with the images are lacking. It is this gap that this paper seeks to address by developing a software based solution to address the gap. The software system to be developed is a combination of PAC and CAD as there is a database used as archive to store existing films (images) from patients and then during diagnosis, the current image is compared using the array size and patterns with images in the archive to find a match for diagnose and disease identification.

3. METHODOLOGY

The methodology used in this research is the Object Oriented approach. The discussion of this approach follows: The system design involved the use of UML Use Case diagram and the DFD (data flow diagram). A prototype (software) was developed using Java and test run with sample images obtained from a pool of x-ray images.

3.1 Use Case

The actors in the system are:
The radiologist who is responsible for, Logging into the system, Adding a new patient, Adding a new disease, Carrying out diagnosis, Viewing patient list and Viewing a list of diseases. Figure 1 shows the use case diagram for the radiology diagnosis system.

![Use Case Diagram for the Radiographic Diagnosis System](image)

**Figure 1 Use Case for the Radiographic Diagnosis System**

### 3.2 Data Flow Diagram

DFD shows the flow of data through a system. It views a system as a function that transforms the inputs into desired outputs. So a DFD shows the movement of data through the different transformation or process in the system. Figure 2 shows the DFD of the radiographic diagnosis system.
Figure 2 DFD of the Radiographic Diagnosis System

After the design phase, the prototype software was then developed based on the design. This stage helps translate the design to code. The radiology diagnosis system was developed using Rapid Application Development (RAD) iterative model.

In coding the system, Java Programming Language was used to develop the radiographic diagnosis system and Java Server pages (JSP) as the front end technology while Enterprise JavaBean business logic was used for the coding. The backend was developed using MYSQL relational database. This software collected all the data from the patients form and stores them for future use in a MYSQL relational database. Also the radiographic diagnosis system is designed in such a way as to store previous films in the database. Films are retrieved when necessary for comparison with new cases when diagnosis is carried out.
4. RESULTS AND DISCUSSION

Figure 3 shows the interface for registering new patient. Patients are registered in order to take radiographic images and to carry out diagnosis. Details concerning the patient such as patient ID, name, address, gender and date of birth are collected and entered into the database.

Figure 3 Patient Registration Dialog for the Radiographic Diagnosis System

Figure 4 Image collection Interface for the Radiographic Diagnosis System

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Figure 4 shows an interface where images are collected and then compared with other stored images in the database.

Figure 5 below shows the result of a given diagnosis. During the diagnosis process, the input images are compared with thousands or millions of other images stored in the database (this depends on the size of the database) and also the array size is checked. If there is a match in image and array size, the system diagnoses the patient with the disease that represents the matched images. As shown in Figures 5, the patient in our input images has been diagnosed with a pulmonary cancer.

**Figure 5 Diagnosis-Pulmonary Cancer from the Radiographic Diagnosis System**

4. CONCLUSION

The lack of computer-based systems in the medical laboratory for image interpretations in Nigeria is a major setback in the healthcare sector. The importance of an accurate diagnosis for a patient cannot be overemphasized. It will aid doctors provide a proper and accurate treatment for such patient. The present system is manual and most times diagnoses are inaccurate as a result of multiple/inefficient search for a match in a radiographic image sought in order to diagnose a patient. The consequences are no or lack of proper treatment.

In developed countries, systems such as CADS and PACS have been developed but are not sufficient by themselves. The radiology diagnosis system that was developed and presented in...
this paper will help increase the efficiency, speed and accuracy in the diagnosis of patients in order to improve health care services.

REFERENCES