Full Length Research Paper

Formulating a virtual magnetic resonance imaging laboratory as teaching aid

*Atenga D. Victor and John V. H

Department of Biomedical Engineering, University of Ghana, Legon, Accra, Ghana.

Students in developing countries like Ghana do not have easy access to sophisticated medical equipment like Magnetic Resonance Imaging (MRI), Computer Tomography (CT) and Ultra sound Scanners. This is due to the fact that these imaging equipment are highly expensive. As a result of this, the students lacked the requisite practical experiences in these equipments during their training. In addition, the understanding of the basic concepts behind the operation of these equipments becomes difficult as they only have to imagine what is written in the books. To address this problem, a virtual laboratory has been designed as a teaching aid to resolve the problem. In this work, the MRI machine was used as a case study where the student logs in into the virtual MRI laboratory and will undergo the necessary tutorials on the mode of operation and design features of the MRI machine. The virtual laboratory, as teaching aid, saves time and would help the students in learning basic and advanced concepts through remote experimentation (Chu, 1999). Other medical imaging equipment can also be incorporated into this design.

Key words: Magnetic resonance imaging (MRI), computer tomography (CT), virtual laboratory, Log, tutorial.

INTRODUCTION

Lack of resources makes teachers unable to perform experiments, especially when it involves the use sophisticated instruments. To address some of these problems, virtual labs are designed. A virtual lab means a laboratory that can be accessed via the internet through a browser or as a stand-alone application (Rahman et al., 2002).[2] This means that, activities happening in the physical laboratories can now be simulated using computer technologies. This in comparison with the physical laboratory, allows the students to perform the experiments remotely at any time. In addition, experiment-oriented problems can be conducted without the overheads incurring for the maintenance of a physical lab. The Objectives of the Virtual Labs include: To provide remote-access to laboratories in various disciplines and to enthuse students to conduct

experiments which would help them in understanding the basic and advanced concepts (http://www.vlab.co.in).

The Magnetic resonance imaging (MRI) is a medical imaging technique used to visualize internal structures of the body in details using a strong magnetic field (http://en.wikipedia.org/wiki/Magnetic_resonance_imaging). It is one of the most critical diagnosis device that enable the Physician to be able to examine the exact situation inside the body. Understanding the principles of operation and how the MRI machine works is very crucial in the training of biomedical Engineers.

Physical distances and the limited number of MRI machines in Ghana make students unable to get access to them throughout their training period. For instance in Ghana, there are about four (4) functional MRI machines (three in Accra (the capital city) and the other in Kumasi (the second biggest city in Ghana) (http://kbth.gov.gh/index.php?id=20; World Class Diagnostic Centre, 2014; http://www.fidelitybank.com.gh/en/media-center/social-responsibilities.php?sr=7; Amissah, 2014). For biomed-

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*Corresponding author. E-mail: victor.atenga@gmail.com

ical Engineering students, having a visual look at the MRI machine would help to better appreciate the concepts and principles pertaining to design features, operation and maintenance.

The Virtual MRI lab simulates a list of various activities in a typical MRI room so that the user feels that he/she is actually in the real world of MRI room. To make Virtual MRI Lab accessible and useful, one can take advantages of various internet technologies so that a user can access all data online and view all activities that occurs in the MRI room at any place and at any time either online or offline according to his/her needs. The Virtual MRI lab is designed in such a way that both student and lecturer can use the lab for teaching and learning purposes through a computer.

SYSTEM DESIGN

For the virtual MRI lab, two main structures were considered. These are the Use Case (UC) and the System Architecture.

Use case (UC)

The Use Case (UC) of the system is designed to capture the functionality of the system in addition /in relation to its users. The UC provides a simplified view of the system by identifying the main users or actors in the system and how they utilize or are related to the system functions. It also indicates some of the constraints imposed on the users of the system and the kind of functionality they can achieve with the system. Three main functions were identified for the system and use cases derived from each of them (Figures 1 to 3). The use cases are elaborated below.

System architecture

The architecture of the system is the conceptual model that defines the structure, behaviour and more views of the system (Hannu and Bernhard, 2011). The structure of the system comprises system components, the externally visible properties of those components and the relationships between them. It provides a plan to implement the overall system.

Several system architectures are available for use; however the commonly used one for web design is the three-tier architecture which has three (3) main parts. The parts are **the presentation or client layer, the logic layer and the database layer** (Figure 4). This architecture splits the system into a form which allows the various parts of the system to be implemented separately and then integrated. This attribute of the system is suitable for the system being developed as per the specifications of the design; the system was to be easily maintained and adapted. In this instance therefore, the various parts of the system can be maintained or

modified without having a significant impact on other parts. Figure 1 shows a representation of the three-tier architecture.

As shown in Figure 4, the data tier or layer is represented by the database which is going to store all the information. The information can be stored on a CD/DVD, a flash drive or a hard drive.

The presentation or the client layer for the virtual MRI lab consists of the browser with which the system user would access the system and also the formatted web pages. This design focuses on the formatting of the web pages as there are already a lot of browsers available for use. Since a new browser is not going to be developed, the system was tested with as many of the browsers available to ensure compatibility and correct rendering of the pages.

The bulk of the system development was with the logic layer. This forms the brain house of the system as it is the logic layer that performs most of the system's transactions and without it the database and the presentation layer would have no interaction. The logic layer consists of programming language code. Action script 3.0 was used. Some of the things Action script code can do include controlling the play head of a timeline, move things around, play sounds, control video, manage data (xml, lists, etc.), communicate with server-side systems (e.g., web servers), create and manage user interfaces.

TOOLS USED IN DEVELOPING THE VIRTUAL MRI LAB

Autodesk Maya

The 3D MRI model in the 3D simulation page of the system was modeled with 3D animation software called Autodesk Maya. This software delivers a comprehensive creative feature set with tools for animation, modeling, simulation, rendering, match moving and compositing on a highly extensible production platform (Autodesk Maya, 2014). It is used to create interactive 3D systems including video games, animated films, TV series or visual effects. The product is named after the Sanskrit word Maya, the Hindu concept of illusion (Sangeetha, 2014). The renderer was the main accessory that helped in creating the 3D simulation. Rendering is basically the process of creating an image or sequence of images from a scene. During rendering, Maya generates a two dimensional image or series of images from a specific view of a three dimensional scene and saves it as an image file (Expert rating - MAYA Tutorial, 2014).

Adobe creative suite

Adobe Creative Suite is a collection of graphic design, video editing, and web development systems made by Adobe Systems. The collection consists of Adobe's
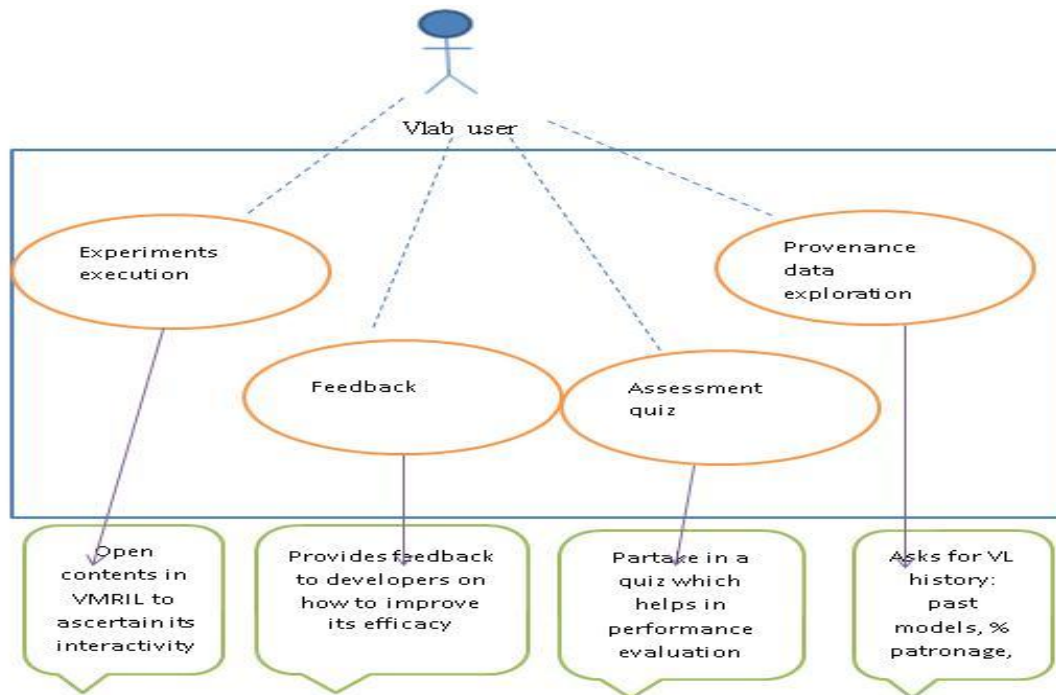
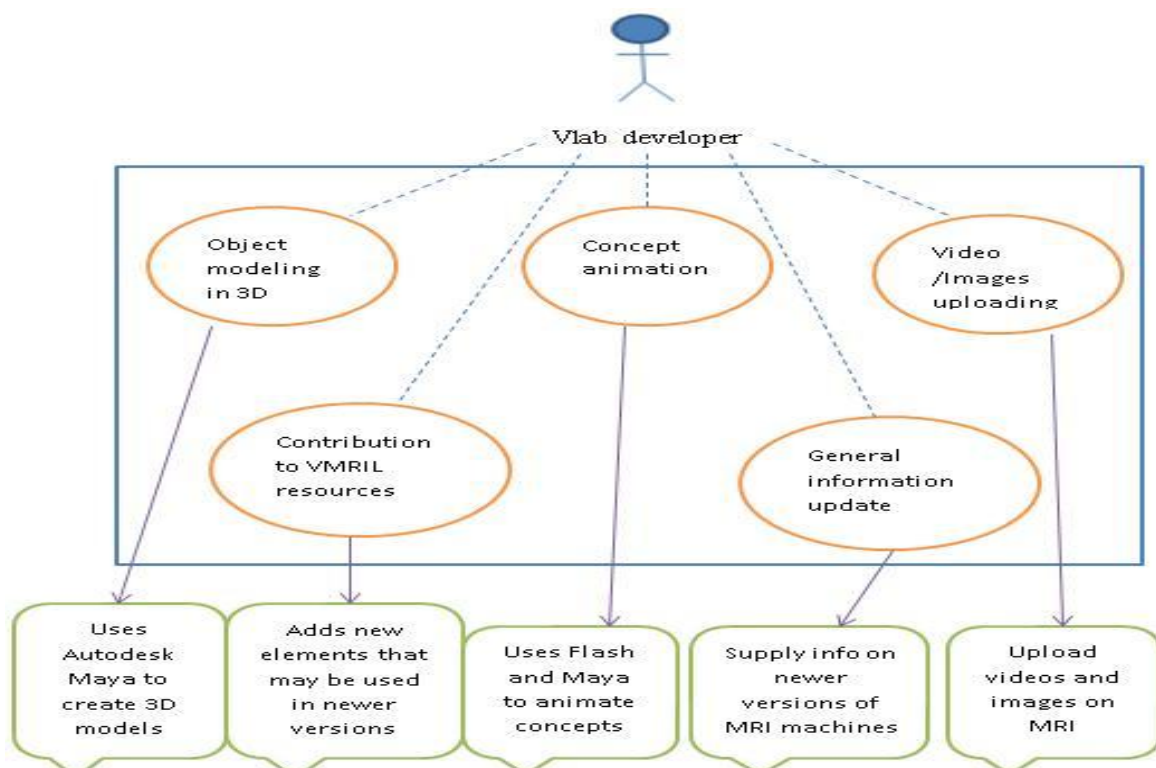**Figure 1.** Use case diagram for virtual lab user.

Figure 2. Use case diagram for virtual lab developer.

systems (e.g., Photoshop, Acrobat, InDesign), that are based on various technologies (e.g., Postscript, PDF, Flash) (http://en.wikipedia.org/wiki/Adobe_Creative_Suite). Some components of the creative suite three (CS3) were
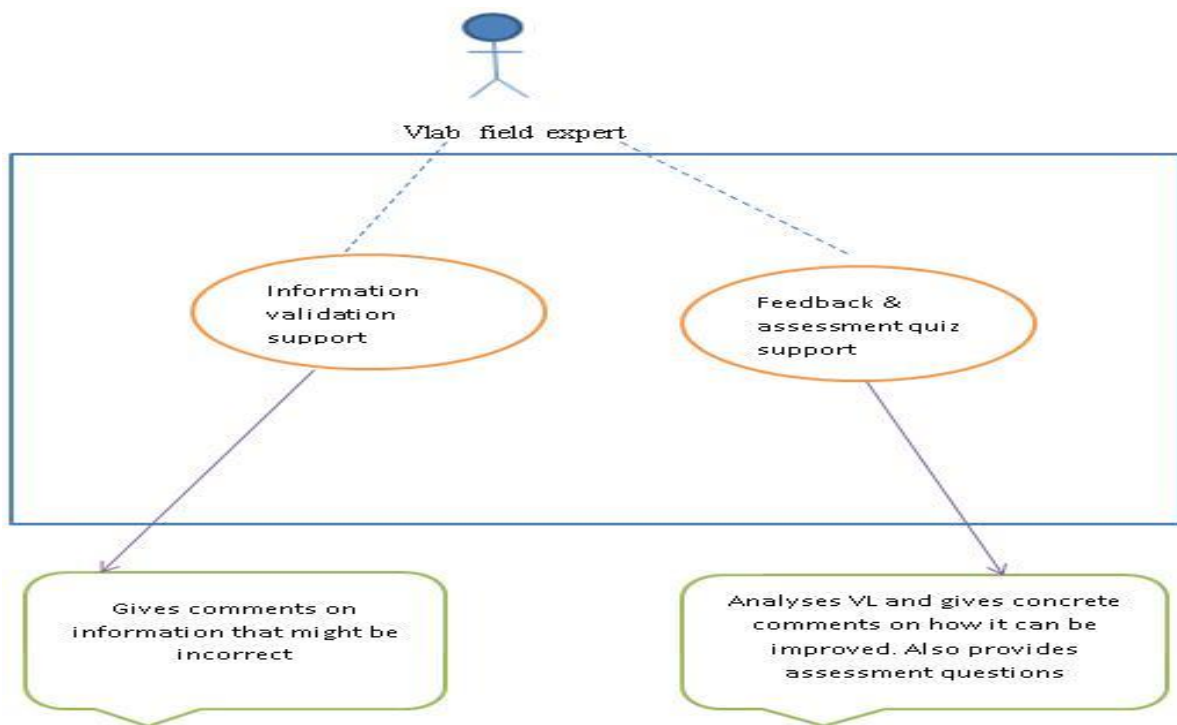
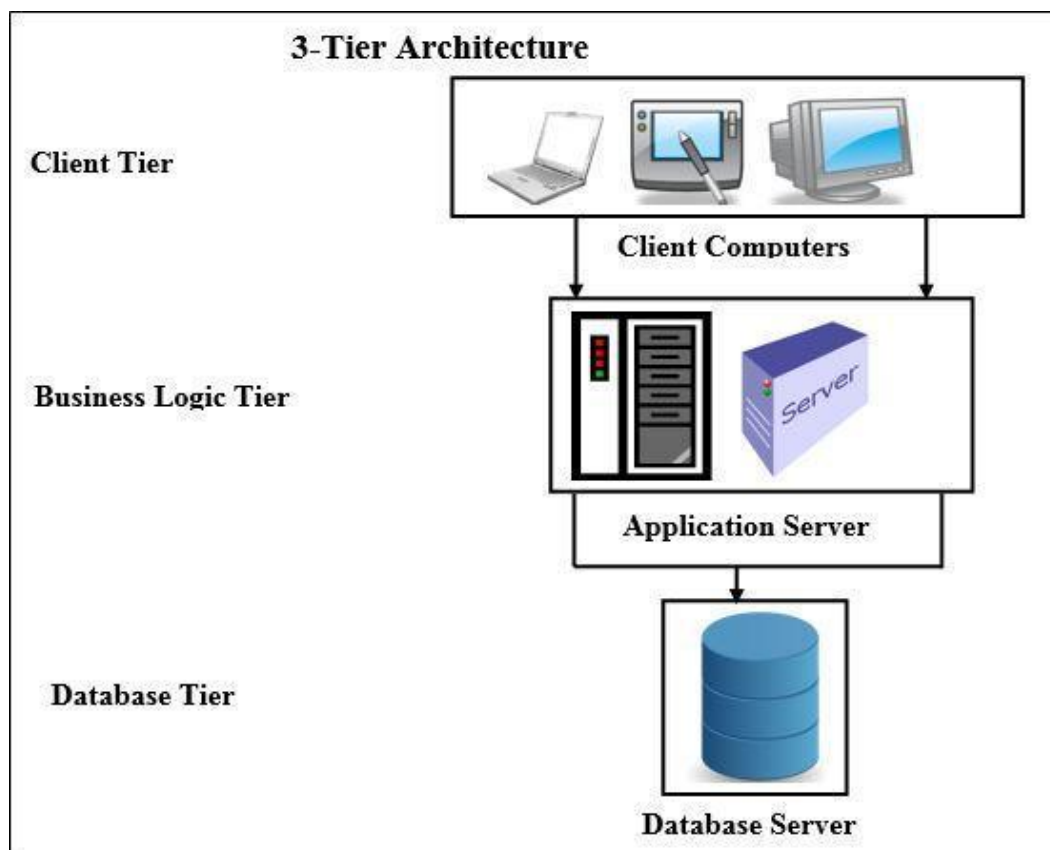**Figure 3.** Use case diagram for the expert in MRI.

Figure 4. Example of three tier system architecture.

Figure 5. Welcome page.

Figure 6. Homepage.

used in developing the virtual MRI lab. Most significant of them were Photoshop and Flash professional.

HOW THE SYSTEM WORKS

The system works like any other web site. It recognizes three groups of users namely the virtual lab user, the virtual lab developer and the field expert within the domain (in this case, the MRI field expert). The distinction however comes into play depending on the user's actions.

The system is accessed primarily via two routes. The first route is through online where the user would type in the URL address of the system. The second route is through CD/DVD, flash drives or hard drives. Again the appropriate web page   would be displayed in the browser

or the flash player. Figures 5 to 7 show some pages within the virtual MRI lab.

Fundamentally, once the user has access to the system, he/she can then navigate using the links provided on the system. The user can obtain information on Magnetic Resonance Imaging (MRI) scanner such as the physics of operation, design principles and simulation of MRI. In addition to the links providing information on the MRI, the user also has the option to provide feedback about the system relating to the information it contains and any other concerns with regard to the system. The system also provides the user with MRI videos that contains succinct explanations on some concepts within the domain. Images of some scanned patients are also available in the system to give the users an idea of how certain parts of the body look like. The user can also
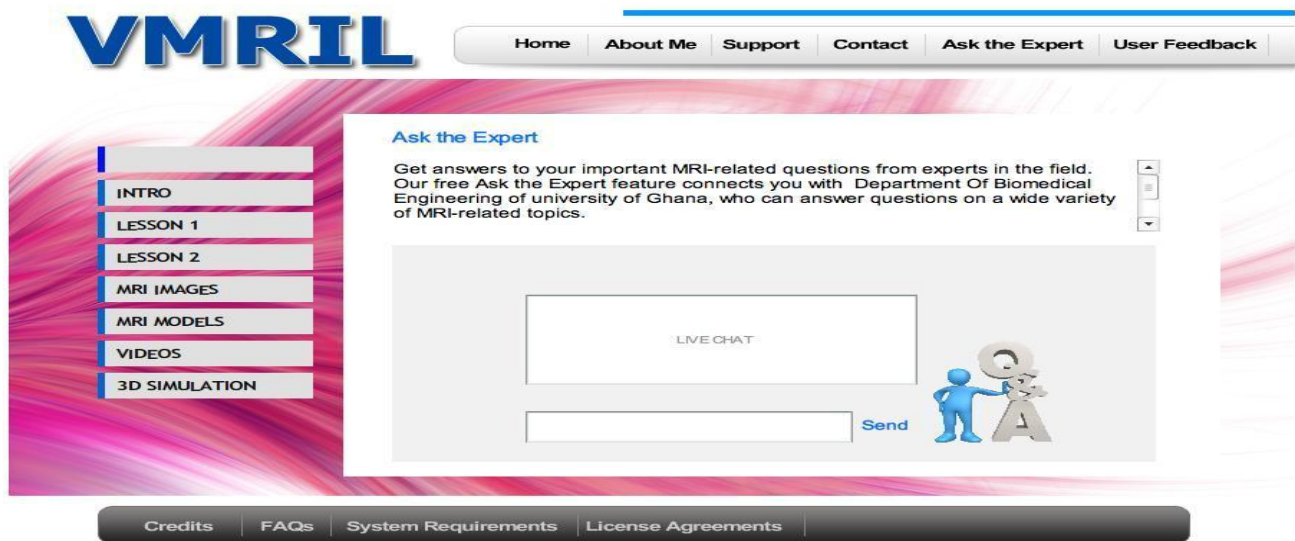
Figure 7. 3D Simulation page.

Figure 8. Ask the Expert page.

interact with an expert from the field to receive clarification on misunderstood concepts as shown in Figure 8.

The developer is responsible for the general information update within the system. The editing of the information, the uploading of new images and videos and the introduction of new features in the 3D simulation, are all the primary responsibilities of the developer. In consultation with the expert, the developer creates animations of related MRI concepts. This is important to make sure concepts being created through the animations

, portray the correct information.

CONCLUSION

Virtual lab is very useful as a complementary teaching aid. We have designed virtual MRI lab as teaching aid for Biomedical Engineering students. This virtual MRI lab will provide practical experience to the user. Some of our future possible works include virtual labs in computed tomography scanner, ultrasound scanner and anaesthesia machine. Using other multimedia techniques

or animation and with innovative concepts, education can be made easier and more attractive.

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