

AUGMENTED REALITY BASED LAB ASSISTANT SYSTEM

P.J.D.C. Fernando

(IT10010822)

Bachelor of Science Special (Honors) in Information Technology

Department Of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

August 2013

AUGMENTED REALITY BASED LAB ASSISTANT SYSTEM

P.J.D.C. Fernando

(IT10010822)

Dissertation submitted in partial fulfillment of the requirements for the
degree of Science

Department Of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

August 2013

DECLARATION

This research proposal is my original work which any part of it was not a copy of a document done by any organization, university, and institute or earlier research group and has not presented for a degree in any other university, I hereby grant to Sri Lanka Institute of Information Technology the non exclusive right to reproduce and distribute my dissertation, in whole or in part in print, electronic or other medium. I retain the right to use this content in whole or part in future works (such as articles or books).

P.J.D.C Fernando : Date :

The above candidate has carried out research for the B.Sc Dissertation under my supervision.

Signature of the supervisor : Date :

ABSTRACT

Modern day Scientific and engineering equipment is required in undergraduate education as Most of the time laboratory practical based on machines. Normally students get support from lab assistants and instructors to learn how to use them. But it is very difficult and time consuming to teach each and every student separately. Also some equipment is very expensive and there are only limited numbers of machines per university. Most probably the students are not allowed to use these machines as they prefer. Therefore students at the introductory level learn how to use them by referring device's user manuals/online resources. But when the device is not around the students, it is difficult to learn by referring and print a user manual for each and every student is not practical. The ARLAB system has been developed as a solution for these problems. The ARLAB system has two main components. The backend is a web service where any user can create a user manual for any device by adding pictures and descriptions. For this application, Support Vector Machine(SVM) has been used as the machine learning algorithm. SVM are supervised learning models with associated Augmented Reality Lab Assistant System learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. The front end is a mobile application with several options. One option is a corresponding user manual which can use by students when the device is not available physically at the moment. The other option is a corresponding user manual which can use when the device is available physically at the moment. In that case when a student focuses his phone's camera towards a specific controller and after capturing the image of that controller, the description of it will be shown on the phone display. Apart from above two major options there is another useful option where user can search for tutorials which demonstrate some specific tasks. This functionality enables students to search videos that are available in the internet. Therefore by using this application the students will be able to learn about a device and also it will be convenient for the instructors as well, because they can save their time.

ACKNOWLEDGMENT

I deeply grateful to my supervisor Mr. Bathiya Lakmal Priyadarshana and our co-supervisor Mr. Sheron Dinushka Lecturers of Sri Lanka Institute of Information Technology whose suggestions, constant encouragement and support in the development of this research. I consider myself very fortunate for being able to work with a very considerate and encouraging supervisors like them. Without their offering to accomplish this research, I would not be able to finish my study at SLIIT. And also extremely grateful to Mr. Jayantha Amararachchi, Senior Lecturer/ Head- SLIIT Center for Research who gave and confirmed the permission to carry out this research and for all the encouragement and guidance given.

Im much obliged to my group members Dinusha kalhan, Miren Gomez and Dilani Jayawickrama .Their enlightening suggestions and encouragements made me feel I was not isolated in my research. I owe many thanks to my classmates and all of my friends who were always supportive and give full attention for me to solve my problems. They always help me in exchanging any ideas and give the enjoyable studying environment. They made my life at SLIIT a truly memorable experience and their friendships are invaluable to me.

Contents

DECLARATION	ii
ABSTRACT	iii
ACKNOWLEDGMENT	iv
TABLE OF CONTENT	v
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS	x
1 INTRODUCTION	1
1.1 Research Background	1
1.2 Research Problem	3
1.3 Research Questions	5
2 METHODOLOGY AND RESEARCH FINDINGS	7
2.1 Addressing the Literature	7
2.2 Methodology	9

2.3	Process behind the activities	11
2.3.1	Web site to 'Add, Update and Delete devices'	11
2.3.2	Image capturing	12
2.3.3	Handling the communication between Mobile Application and the Remote Server	12
2.3.4	Feature extraction	13
2.3.4.1	Color Histogram extraction	14
2.3.4.2	Edge Extraction	15
2.3.5	Analyze data and recognize patterns, used for classification and regression analysis (Machine learning)	15
2.3.6	Offline mode for tutorial searching	18
2.3.7	Video streaming	19
2.3.8	Research Findings	20
3	RESULT AND DISCUSSION	22
3.1	Results	23
3.1.1	Mobile Application	24
3.1.2	Web Assistant	25
3.2	Evidence	25
3.2.1	Test cases for Mobile Application	26
3.2.2	Test cases for Web Application	33
3.3	Discussion	38
3.3.1	How the system achieved excising problems.	38
3.3.2	Special requirements for the system	39
4	CONCLUSION	41

REFERENCES	44
appendices	46
A Activity Diagrams	46
B Sequence Diagrams	50
C Use case diagram	52
C.1 Use case scenarios	53
C.1.1 Use case scenarios for overall web application activities . . .	53
C.1.2 Use case Scenarios for Overall Web Application Activities . .	59
D Classes diagram	63
D.1 Mobile application	63
D.2 Web application	64

List of Tables

C.1	Register User	53
C.2	Login To The System	54
C.3	Add New Device To The System	55
C.4	Update Device Details In The System	57
C.5	Delete Device From The System	58
C.6	Load The Application	59
C.7	Capture Image Using Mobile Device	60
C.8	Search Tutorials	61
C.9	Video Tutorials	62

List of Figures

2.1	system diagram of the Augmented Reality Based Lab Assistant system	10
2.2	Canny edge detection	16
2.3	Sample code of LibSVM works	18
2.4	Train files for the machine learning	18
2.5	video streaming life cycle	20
3.1	ARLab WCMS Overview	24
A.1	Login	46
A.2	Add Devices	47
A.3	Update Device	48
A.4	Delete Device	49
B.1	Add, Update And Delete Device	51
C.1	Use case Diagram	52
D.1	Class Diagram Of Mobile Application	63
D.2	Class Diagram Of Web Application	64

LIST OF ABBREVIATIONS

ARLAB	Augmented Reality Based Lab Assistant
ARLAB Mobile Application	Application developed to run in Android environment with aid of Smart phone.
ARLAB Web Application	Web site where Users or Lectures can get register with the system.
Database	Collection of all the information monitored by this system.
Software Requirements Specification	A document that completely describes all of the functions of a proposed application and the constraints under which it must operate. For example, this document.
User	Any person uses both ARLAB Mobile Application and Web Application.
Online mode	When the user is near the device the system is using the device to identify components (With the device).
Offline mode	When the user is not near the device use searching facility to get the information of the device (Without the device).
WCMS	Web Content Management System

Chapter 1

INTRODUCTION

1.1 Research Background

In 1968 Ivan Sutherland creates the first augmented reality (AR) system. It was also the first virtual reality (VR) system. It uses an optical see-through head mounted display that is tracked by two different 6DOF trackers. There were a mechanical tracker and an ultrasonic tracker. Because very limited computing power of computers at that time, this system only displayed simple wireframe drawings in real time [1].

Augmented Reality is a type of virtual reality that aims to duplicate the world's environment in a computer. An augmented reality system generates a composite view for the user that is the combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information. The goal of Augmented Reality is to create a system in which the user cannot tell the difference between the real world and the virtual augmentation of it. How the technology could be applied in an architectural and design setting for Mobile phone AR application was discovered in 2006. In late 2006 and 2007 Nokia researches were exploring how

a mobile phone could be used to replace massive wearable computers and still provide a compelling outdoor AR experience. With the help of advanced AR technology (e.g. adding computer vision and object recognition) the information about the surrounding of the real world of the user becomes interactive and digitally manipulable.

Mobile video streaming is the practice of providing video to a mobile device through wireless digital signals. This fairly new kind of technology has been applied to mobile phone and cell phone devices, as well as to some other kinds of wireless devices that can receive digital broadband signals through the air. Video streaming video is now quickly becoming part of what customers expect from a mobile device, and electronics companies are racing to deliver a greater variety of traveling devices that will showcase the ability to stream digital video.

Mobile video streaming has some of the same conventions that were always associated with receiving video through digital connection. One of these is buffering, in which the digital display has to temporarily stop in order to help the receiving technology catch up with receiving and ordering all of the digital data in the video production. Another has to do with formatting, where videos and nonstandard formats may not have the same kinds of accessibility as video in established formats like MPEG-4, a common video format for mobile streaming.

Watching streaming web video is possible due to many advances in mobile phone displays and fast broadband connections over cellular service. 3G and 4G services have boosted on-the-go video entertainment, and are expected to grow. Some phones are adding streaming video technology via Adobe Flash and Microsoft's Silverlight software.

Machine learning has become one of the most active and exciting areas of computer science research, in large part because of its widespread applicability to problems as diverse as natural language processing, speech recognition, spam detection, search, computer vision, gene discovery, medical diagnosis, and robotics. At the same time, the growing popularity of the Internet and social networking sites like Facebook has led to the availability of novel sources of data on the preferences, behaviour, and beliefs of massive populations of users [2].

Since Artificial information about the environment and its objects can be overlaid on the real world we thought to come up with an AR application which will help to improve user interactive with the AR technologies

1.2 Research Problem

The initial idea of the proposed research project came out as a result of the problems that have been found in day to day activities, while the students of SLIIT were using new devices for the first time. When someone finds a new device for the first time it is very hard and complicate to handle the device by himself. In that case students always need someone to instruct them, who knows about the device very well. Therefore it might be really an embarrassment for the students who are using numerous devices for their education such as engineering students. To solve that problem augmented reality lab assistant system comes as a solution.

Augmented reality is a vast developing technology in this era. But still the existing systems have certain problems and drawbacks. Some general problems are,

1. Unable to track matching components. When the time goes on the device wont

be same anymore and certain notations fade away. Situations like that, the application find very hard to identify the device components correctly.

2. Poor signal strength in different locations cause low efficiency. This can occur due to low strength of internet connection. Because the mobile application is totally depend on the backend which is hosted in the internet. So the application need fast internet connection to transmit real time data.

This project is based on identifying selected components. To do this we have to go through in two different areas. Such as image segmentation and machine learning.

Image segmentation is an image processing technique which is used to identify the components separately from its background. There are number of algorithms available to do image segmentation. Since this is a real time system among those algorithms, this project needs an efficient algorithm to process the image very quickly.

Within our project the purpose of using machine learning is to identify the components of a device or a machine according to the given samples. But the problem is when we take different versions of same machine they may represent controllers in different ways. As the time goes different versions of same machine will be created. In those different versions the color, shape of the controllers will be changed and also new features, functions will be introduced. In that case the application wont be able to identify the components according to the samples that have been fed to the system previously.

Even though there are such problems this project will be implemented in such a way to overcome those problems as much as possible.

1.3 Research Questions

Mobile Application

1. Get the live images continuously from the camera.
2. Send the images to the backend server using a web service.
3. Retrieve the relevant information about the images which you sent to the web-server.
4. Point out the controllers and display the information using augmentation reality technique.
5. After user select a particular controller display the information and small video about the controller if available.

Problems of mobile application

1. Show the description and mark the controllers using augmentation reality technique.
2. Mobile app video streaming.

Back end (Web service)

1. Get the image from the mobile.
2. Identify the controller separately from the background using image segmentation and detect the edges.
3. Match the current image using some of other image processing techniques with our Database
4. Using machine learning techniques tell computer how to identify the controllers

under any circumstances.

Problems of back end

1. What is the most suitable image segmentation technique that we should use?
2. How to detect the edges and perform feature matching.
3. Predict whether the controller is a controller of the relevant machine or not, identify chafed controllers using machine learning techniques.

Chapter 2

METHODOLOGY AND RESEARCH FINDINGS

When we talk of research methodology we not only talk of the research methods but also consider the logic behind the methods we use in the context of our research study and explain why we are using a particular method or technique and why we are not using others so that research results are capable of being evaluated either by the reader himself.

2.1 Addressing the Literature

Mobile learning, or "m-learning", offers modern ways to support learning process through mobile devices, such as handheld and tablet computers, MP3 players, smartphones and mobile phones [3]. In other words it means any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of the learning opportunities offered by mobile tech-

nologies. Therefore by using mobile learning, learners can learn anywhere and at any time.

Today's learners expect information to be available at all times, not just in the classroom. Companies such as Apple recognize this phenomenon and provide ways for teachers to distribute multimedia course content to their students in non-traditional [4]. Now, learning can take place anywhere, from the bus to the home.

The concept of the undergraduate student as an experimenter is fundamental to engineering education and to the role of a practicing engineer. The undergraduate student should become an experimenter in the laboratory, which should provide him with the basic tools for experimentation, just as the engineering sciences provide him with the basic tools for analysis.

The primary goal of The Augmented Reality Based Lab Assistant system is to identify controllers of some specified set of machines using an android phone which can be used by students as a self-learning tool. It consists with two main options, online mode(with the device) which will identify controllers and provide a description of them in real time and, the offline mode(without the device) which provide facilities to search tutorials and video playback.

After commencing the research a survey was carried out to identify that there are any other research have done in this area. Internet, books, university lecturers were the foremost resources of this survey. In accordance this survey done by using Internet there were no similar applications found but there were applications similar in some of the functionalities.

- Contextual Mobile Learning System for Saudi Arabian Universities

With the help of this system, the students can learn just in time in their daily lives

whenever they need to learn; using mobile computing devices like Tablet PCs and Smart Phones. The main principles and the essential components such as functional modules and context databases are presented [5].

- Augmenting Memory for Student Learning : Designing a Context-Aware Capture System for Biology Education

This is a context-aware capture system for undergraduate biology students. This system will enable students to automatically capture virtually all of their personal educational information such as lecture notes, slides, videos, lesson plans, and assigned readings, as well as paper drafts, assignments, brainstorming on whiteboards, or images and artifacts from field trips. It describes an alternative approach that can both reduce complexity and improve retrieval of captured digital educational information [6].

The Augmented Reality Based Lab Assistant system provides an effective, accurate, reliable and real-time mobile application as a self-learning tool which can be used to identify the operations of a machine. The System is designed especially for the students who deal with the advanced machineries which has lots of operations.

2.2 Methodology

Modern day Scientific and engineering equipment is required in undergraduate education as Most of the time laboratory practical based on machines. Since some machines have lots of operations students find it hard to remember each and every operation of those machines. Normally students get support from lab assistants and instructors to learn how to use them. But it is very difficult and time consuming to teach each

and every student separately. Also some equipment is very expensive and there are only limited numbers of machines per university. Most probably the students are not allowed to use these machines as they prefer. Therefore students at the introductory level learn how to use them by referring device's user manuals/online resources. But when the device is not around the students, it is difficult to learn by referring and print a user manual for each and every student is not practical. The ARLAB system has been developed as a solution for these problems.

The system is implemented in such a way to include a mobile application as a self-learning tool which is used to identify the operations of a machine. The System is designed especially for the students who deal with the advanced machineries which has lots of operations. This system provides a web site which gives the opportunity to add any kind of machine with its operations and user can get a detailed description about the operations of the machine using a smart phone by pointing the smart phone to the particular machine and capturing images of its controllers. Figure 2.1 illustrates the system diagram of the Augmented Reality Based Lab Assistant system.

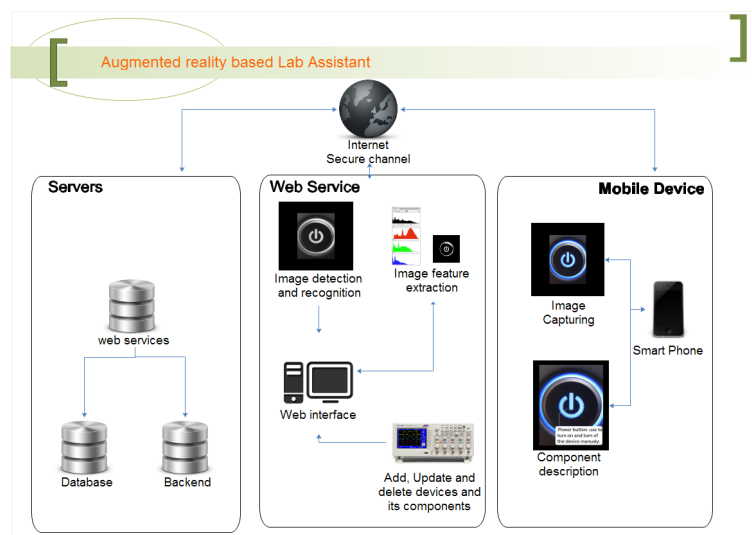


Figure 2.1: system diagram of the Augmented Reality Based Lab Assistant system

2.3 Process behind the activities

The Augmented Reality Based Lab Assistant System has a front end mobile application and a back end implementation. The functionalities of the overall system can be classified as follows,

- Web site to 'Add, Update and Delete devices'
- Image capturing
- Handling the communication between Mobile Application and the Remote Server
- Feature extraction
- Analyze data and recognize patterns, used for classification and regression analysis (Machine learning)
- Offline mode for tutorial searching
- Video streaming

2.3.1 Web site to 'Add, Update and Delete devices'

By using this website any user can create a user manual for any selected device. In order to do that first of all user should provide the name of the device, an image of the device a description and You Tube URL's for the device, after that user can provide the details of the components (controllers). In that case for each controller user must provide a set of negative and positive images. Here negative images mean images which are not images of that particular controller, positive images mean images of that particular controller taken under different light conditions, different angles etc.

Using this images the system will extract certain features such as colour histogram

and edge extraction and convert it to a metric and feed it to the system as samples to that particular device component. which will help in image identifying process. Once a device and its component added to the system user can update and delete its information any time user want.

2.3.2 Image capturing

In order to use this application in online mode the student should capture the image of the controllers. Then the image will be passed to the backend web service and the controller will be identified using LibSVM. Using Object recognition technique the system recognize the controllers that are available in the current image. After that the description related to that particular controller and the recognized controllers will be passed to the front end mobile application and mobile application will show it on its display.

2.3.3 Handling the communication between Mobile Application and the Remote Server

This application uses KSOAP as the communication protocol. KSOAP was specially designed or developed to deal with small embedded device like mobile devices .And also KSOAP is a lightweight and efficient SOAP library for the Android platform. KSOAP toolkit provides not only small size and great functionality, but also relative simplicity and ease of use for the developer. Using KSOAP, a developer can develop complex SOAP Web services clients in a remarkably short time. By Consider those advantages of the KSOAP was chosen as the communication protocol for this application.

After capturing the image, the captured image will be converted into Base64 string and then the application will pass it to the backend web service. After receiving the Base64 String the web service will convert it back to a real image. Then the required processing will be done to the image and then the final result will be passed to the mobile application as an xml file.

2.3.4 Feature extraction

In image processing, a method of pattern recognition in which patterns within an image are measured and then classified as features based on those measurements.

The goal of feature extraction is to improve the effectiveness and efficiency of analysis and classification. This may be done by:

1. Eliminating redundancy in the image data.
2. Eliminating variability in the image data that is of little or no value in classification -even discarding entire images if that is appropriate.
3. Restructuring the data (in feature space) in order to optimize the performance of the classifier.
4. Extracting spatial information (texture, size, shape,) which is crucial to target identification.

That is, one would like to

1. Minimize the number (and detail) of the features,
2. Maximize pattern discrimination

When the input data to an algorithm is too large to be processed and it is suspected

to be notoriously redundant (e.g. the same measurement in both feet and meters) then the input data will be transformed into a reduced representation set of features (also named features vector). Transforming the input data into the set of features is called feature extraction. If the features extracted are carefully chosen it is expected that the features set will extract the relevant information from the input data in order to perform the desired task using this reduced representation instead of the full size input [7].

Colour histogram and edge extraction are the main key features that is use by the ARLab to train and identifying device component. When it comes to the training process it's totally done in the WCMS, which is extracted when the sample images uploading to the system to train the system. Apart from that colour histogram, edge extraction has to be extracted again for the identifying process. This also extracted inside the WCMS. Because still mobiles have less processing power so it will make the application slower. There for the image that has been captured from the device will be transferred as Base64 string. After producing the actual image from the Base64 string the web application will consider each pixel's intensity value of that image and extract a color histogram and edge based on that. After that the application will compare it with the color histograms and edges of the images which were added while adding the device to the system.

2.3.4.1 Color Histogram extraction

The histogram provides a compact summarization of the distribution of data in an image. The color histogram of an image is relatively invariant with translation and rotation about the viewing axis, and varies only slowly with the angle of view [8]. By comparing histograms signatures of two images and matching the color content of one image with the other, the color histogram is particularly well suited for the problem of

recognizing an object of unknown position and rotation within a scene. Importantly, translation of an RGB image into the illumination invariant rg-chromaticity space allows the histogram to operate well in varying light levels.

2.3.4.2 Edge Extraction

The purpose of edge detection in general is to significantly reduce the amount of data in an image, while preserving the structural properties to be used for further image processing. Several algorithms exist, and this worksheet focuses on a particular one developed by John F. Canny (JFC) in 1986 [9]. Even though it is quite old, it has become one of the standard edge detection methods and it is still used in research [10] [11].

The AForge.NET framework has been used for the edge detecting process. AForge.NET framework provides number of edge detection filters, which may suite different tasks providing different performance. ARLab uses the canny edge detector to detect the edges. What AForge.Net filter does is searches for objects' edges by applying Canny edge detector. Figure 2.2 illustrates the Canny edge detection.

2.3.5 Analyze data and recognize patterns, used for classification and regression analysis (Machine learning)

Machine learning is the science of getting computers to act without being explicitly programmed. It focuses on prediction, based on known properties learned from the training data. Training the system by giving number of samples is done in machine learning. According to purpose of this research, application should be able to identify



Figure 2.2: Canny edge detection

images of the controllers under different lighting conditions and it should be able to identify chafed controllers as well.

For this application Support Vector Machine(SVM) has been used as machine learning algorithm. Support vector machines are supervised learning models with associated learning algorithms that analyze data and recognize patterns, used for classification and regression analysis. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the output, making it a non-probabilistic binary linear classifier. Given a set of training examples, each marked as belonging to one of two categories, an SVM training algorithm builds a model that assigns new examples into one category or the other. An SVM model is a representation of the examples as points in space, mapped so that the examples of the separate categories are divided by a clear gap that is as wide as possible. New examples are then mapped into that same space and predicted to belong to a category based on which side of the gap they fall on.

Since the machine learning part is run in WCMS LibSVM library has been use to do

machine learning. ARLab uses a clean .NET conversion of libsvm 2.89, specifically from the Java version. Full functionality and efficiency is maintained, but the object structure has been modified to be more appropriate for the .NET platform (including C and VB.NET). Sample code of LibSVM works illustrate in Figure 2.3.

```

//First, read in the training data.

Problem train = Problem.Read("ala.train");
Problem test = Problem.Read("ala.test");

//For this example (and indeed, many scenarios), the default
//parameters will suffice.
Parameter parameters = new Parameter();
double C;
double Gamma;

//This will do a grid optimization to find the best parameters
//and store them in C and Gamma, outputting the entire
//search to params.txt.

ParameterSelection.Grid(train, parameters, "params.txt", out C, out Gamma);
parameters.C = C;
parameters.Gamma = Gamma;

//Train the model using the optimal parameters.

Model model = Training.Train(train, parameters);

//Perform classification on the test data, putting the
//results in results.txt.

Prediction.Predict(test, "results.txt", model, false);

```

Figure 2.3: Sample code of LibSVM works

Train files for the machine learning is illustrate by figure 2.4

```

[label] [index]:[value] [index]:[value] ...
...

```

Figure 2.4: Train files for the machine learning

2.3.6 Offline mode for tutorial searching

This functionality can be used when the device is not physically available at the moment. In that case the application will show available devices and the user has to select the device he wants to learn. Then the application will show an image and a description

of the device. Furthermore if the user wants to learn the controllers of the device, the application provides him the functionality to search the tutorials related to that device.

2.3.7 Video streaming

Augmented Reality Based Lab Assistant consists with video streaming facility which gives the user to use the smart phone to search and watch for available video tutorials regarding the machine that they need to study. Streaming video is content sent in compressed form over the Internet and displayed by the viewer in real time. Video streaming has a big advantage since with the streaming video or streaming media a user does not have to wait to download a file to play it. Instead, the media is sent in a continuous stream of data and is played as it arrives. As mentioned early in this document this research application targets the laboratory students who have to deal with machines with lots of operations. Therefore it is very useful for them to learn about the machine by watching video tutorials using their smart phone. This application provide that facility, when the user use this application in order to identify the operations a particular machine and at the same time the user can search for online video tutorials regarding that machine. Figure 2.5 illustrates the video streaming life cycle.

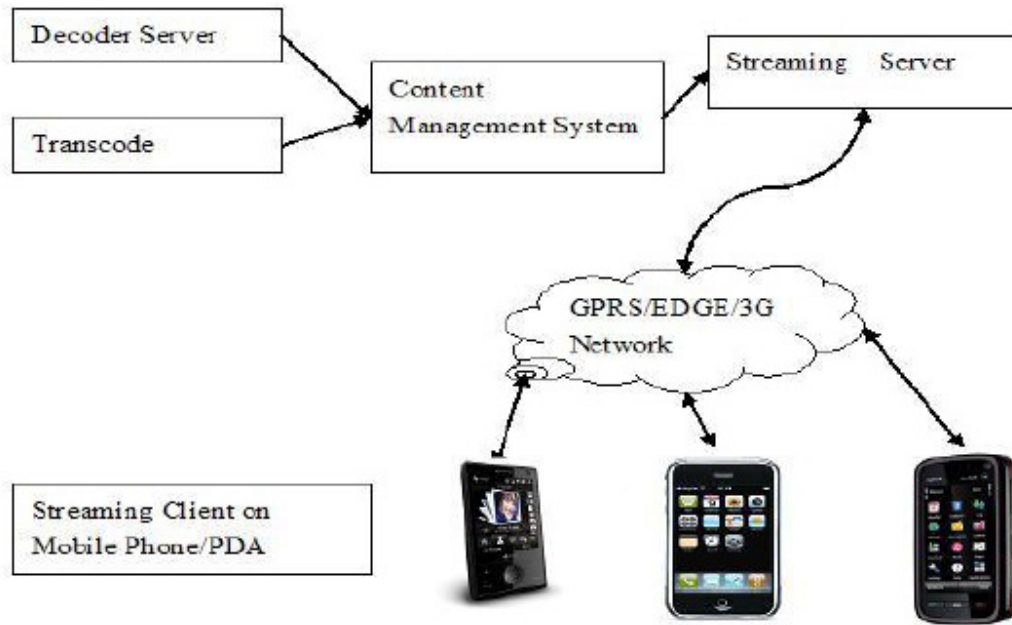


Figure 2.5: video streaming life cycle

2.3.8 Research Findings

This document propose an innovative mobile device learning system specially designed for undergraduate students who are using number of devices for their studies. Many irrelevant topics have to be examined and filtered before the real research reading could be done. But all this relevant content had to be read over and over again for it to be made clear and to be used in the design stage of the development.

This system has been developed and implemented using various algorithms, such as histogram based color extraction, edge extraction and Support Vector Machine for controller identification. The test results show that the system works well for most cases. However, some improvements are still necessary in working towards a reliable system. Controller identification in uncontrolled environment was a very difficult task due to

the large number of variable conditions affecting to the quality of the image. Lighting conditions, angle of the image taken were some of them. To control the effect of lighting conditions, the system was trained using number of images of the same controller under different lighting conditions.

When detecting the controllers, sometimes those controllers are chafed .So it introduces a great deal of dissimilarity between the test image (image of the chafed controller) and the sample images already in the system. Using machine learning algorithms the system is able to deal with those types of situations for a certain degree.

Limited computational power of the mobile phones was also a major problem because Augmented Reality Based Lab Assistant application needs high performance RAM and processor to implement the Image processing algorithm. Therefore RAM and the processor of the mobile phones are going to be a limiting factor. Because of this problem the Image Processing part was shifted to the backend.

Finally group members successfully developed and tested the application which is based on SVM, edge detection and color detection algorithms. As part of the future work, the developed team would like to develop the complete solution to be run inside the mobile phone. Accuracy of the result gives from Color detection module depends on the quality of the image and the lighting conditions. Develop the color detection module to work with all the images even with very low quality images and explore better algorithms for controller identification to improve this as a very efficient and accurate application are going to be the future improvements to the system.

Chapter 3

RESULT AND DISCUSSION

The main result that can be mentioned after the research into this project is the development of a self-learning application that can help SLIIT students and teachers about the Lab devices. This application is mainly focusing on following key aspects.

- Implement an Effective Lab assistant System to SLIIT.
- By motivating the students to self-learning, reduce the workload of the lectures.
- Save the precious time of the Instructors as well as students of SLIIT.
- Introduce the concept of Augmented Reality to the students of SLIIT.
- Provide detail information about the devices which are in the labs very efficiently.

A great amount of effort on C#, Lib SVM, Android and relevant algorithms have created the way into successfully understanding the research parts of the project. It helped the team to develop a successful Augmented Reality based lab assistant system.

Evidence plays an important role in any software product. Because from that end user and other external parties related to the project development can get an idea of final outputs and the quality of the final products. This verifies the final output verification and the validation. Evidence helps to prove main concept of the whole project. Discussions support the user to get an idea about the project. Evidence can be collected from different ways throughout the development life cycle. According to the evidence, discussions can be performed to better outputs. In any software these can be many bugs before release or after release of the product. There is no software which has no bugs or defects. That is why the evidence and discussions are needed, to minimize the bugs of the product before releasing it.

End user satisfaction is one of the goals on any software product and the product should be well suited for the user as well. To accomplish the above target, evidence and discussions are very helpful. Discussions or the test cases can be set at different phases in the software life cycle.

3.1 Results

The main purpose of ARLab is motivating the students of the SLIIT to self-learn in an interactive way. It is designed to be a personal assistant to a user to serve his or her need for not only learning basic things about the devices that are in the lab but also it gives the additional knowledge about the devices him or her working with. By labeling the device components around him/her, it will assist the users how to operate the device correctly by merging the real world with the digital content on the mobile display creating an Augmented Reality (AR).

Apart from that AR lab assistant will have a web application. It will mainly act as a

Web Content Management System (WCMS), which provides an excellent way of organizing distributing data among the core components of ARLab. Users can register themselves with ARLab WCMS and get facility to access its core services once registration is done. Figure 3.1 illustrates the ARLab WCMS overview.

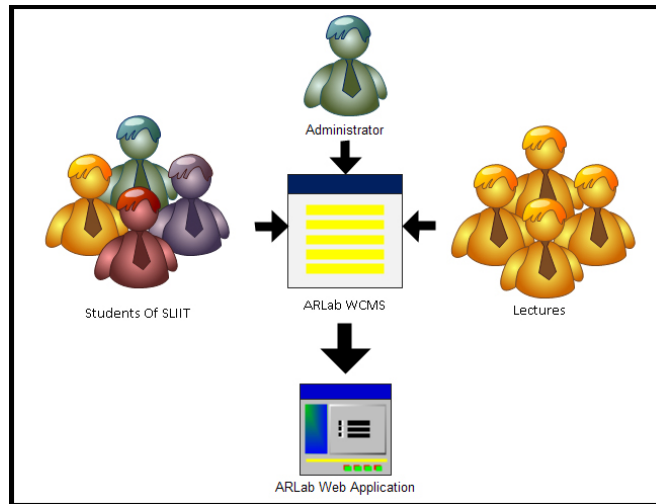


Figure 3.1: ARLab WCMS Overview

3.1.1 Mobile Application

This module mainly acts as a client application, which will connect with the web application. This module is responsible of providing the information regard to the devices added on the WCMS. Once the image is taken it provides the information correspond to that device by communicating with WCMS.

3.1.2 Web Assistant

This module mainly acts as a Web Content Management System, which provides an excellent way of organizing & distributing data among the core components of ARLab. Users can register themselves with ARLab WCMS and get facility to access its core services, once registration is done. Users could also add certain devices to the system by him self.

3.2 Evidence

A software testing needed to be handled to discover the accuracy of the newly created application. Even though it can be time consuming it would be useful to avoid or lower the possibility for unnecessary retesting or debugging.

Software testing is a method of assessing the functionality of a software program. There are many different types of software testing but the two main categories are dynamic testing and static testing [12].

Dynamic testing is an assessment that is conducted while the program is executed; static testing, on the other hand, is an examination of the program's code and associated documentation. Dynamic and static methods are often used together [12].

To review the capabilities or features on a certain function, a set of test cases would be created. This would be a set of conditions or steps and inputs to achieve a particular goal. To determine the exact requirement or objective of a functionality of the application more than one test case would be required.

Here is a sample of the test cases that has been applied to test the ARLab. The format

of the test case is as follows;

- Test ID number - Rationale.
- Steps to follow.
- Expected outcome.

3.2.1 Test cases for Mobile Application

Test ID 1: Welcome Screen - Start up.

Steps to follow:

1. Tap the ARLAB icon.

Expected Outcome:

1. Display the ARLAB Welcome Screen.

Test ID 2: Main Interface Select Lab Assistant view.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the "Lab Assistant" icon available in the main interface.

Expected Outcome:

1. If the mobile device connected to the internet display the Lab Assistant screen successfully.
2. If the mobile is not connected to the internet display "No internet connection" Message and open the "Mobile network setting" window.

Test ID 3: Main Interface select Available machines.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the "Machines" icon available in the main interface.

Expected Outcome:

1. If the mobile device connected to the internet display the Available Machines screen successfully.
2. If the mobile is not connected to the internet display "No internet connection" Message and open the "Mobile network setting" window.

Test ID 4: Main Interface selects Tutorial.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the "Tutorial" icon available in the main interface.

Expected Outcome:

1. If the mobile device connected to the internet display the Tutorial screen successfully.
2. If the mobile is not connected to the internet display "No internet connection" Message and open the "Mobile network setting" window.

Test ID 5: Main Interface selects Quick Search.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the "Quick Search" icon available in the main interface.

Expected Outcome:

1. If the mobile device connected to the internet display the Quick Search screen successfully.
2. If the mobile is not connected to the internet display "No internet connection" Message and open the "Mobile network setting" window.

Test ID 6: Main Interface selects Instructions.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the Menu icon of the Mobile phone inside the main interface.
3. Tap on the "Instructions" button available in the Menu.

Expected Outcome:

1. Display the Instructions screen successfully.

Test ID 7: Main Interface selects About us.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the Menu icon of the Mobile phone inside the main interface.
3. Tap on the "About us" button available in the Menu.

Expected Outcome:

1. Display the About us screen successfully.

Test ID 8: Main Interface selects Exit.

Steps to follow:

1. Repeat Test ID 1.
2. Tap on the Menu icon of the Mobile phone inside the main interface.
3. Tap on the "Exit" button available in the Menu.

Expected Outcome:

1. Exit from the application.

Test ID 9: Lab Assistant Interface selects AR view.

Steps to follow:

1. Repeat Test ID 2.
2. Set the Screen size by Tapping on the combo box available in the interface.
3. Tap on the "Still Mode" icon & point out the mobile Camera to the particular controller.
4. Tap on the "Tap Here" icon.

Expected Outcome:

1. Display a detailed description of the particular controller of the machine according to the AR View.

Test ID 10: Lab Assistant Interface selects Camera Information.

Steps to follow:

1. Repeat Test ID 2.
2. Tap on the Menu button of the mobile phone.
3. Tap on the "Camera information" button on the menu.

Expected Outcome:

1. Display the camera information.

Test ID 11: Machines Interface selects Machine.

Steps to follow:

1. Repeat Test ID 3.
2. Tap on the List (Available machines will be display in the list).

Expected Outcome:

1. Display a detailed description of the machine with an image.

Test ID 11: Machines Interface selects Machine.

Steps to follow:

1. Repeat Test ID 3.
2. Tap on the List (Available machines will be display in the list).

Expected Outcome:

1. Display a detailed description of the machine with an image.

Test ID 12: Machines Interface search Machine.

Steps to follow:

1. Repeat Test ID 3.
2. Enter the machine name in search field and Tap on the front button to the search field.

Expected Outcome:

1. If the machine is available within the system database it will display detailed description of the machine with an image.
2. If the machine is not available within the system database, "Sorry! The machine is not available" message will be shown and gives the web search opportunity.

Test ID 13: Machine Interface Clear search field.

Steps to follow:

1. Repeat Test ID 3.
2. Tap on Menu button of the mobile phone
3. Tap on "Clear" button of the Menu.

Expected Outcome:

1. Search field cleared.

Test ID 14: Tutorial Interface selects Machine.

Steps to follow:

1. Repeat Test ID 4.
2. Tap on the List (Available machines will be display in the list).

Expected Outcome:

1. Display the Video list Screen.

Test ID 15: Tutorial Interface search Tutorial.

Steps to follow:

1. Repeat Test ID 4.
2. Enter the machine name in search field and Tap on the front button to the search field.

Expected Outcome:

1. If the machine is available within the system database it will display detailed description of the machine with an image.
2. If the machine is not available within the system database, "Sorry! Tutorial for this machine is not available" message will be shown and gives the YouTube Search opportunity.

Test ID 16: Tutorial Interface Clear search field.

Steps to follow:

1. Repeat Test ID 3.
2. Tap on Menu button of the mobile phone.
3. Tap on "Clear" button of the Menu.

Expected Outcome:

1. Search field cleared.

Test ID 17: Video List Interface Select Video Tutorial.

Steps to follow:

1. Repeat Test ID 14.
2. Tap on the List (available video Tutorials for selected machine will be shown in the list).

Expected Outcome:

1. Play the selected video.

Test ID 18: Quick Search Interface select Quick search.

Steps to follow:

1. Tap on the "Quick Search" icon and speak the machine name.

Expected Outcome:

1. Display the web search result according to the voice search.

3.2.2 Test cases for Web Application

Test ID 1: Home page (Welcome Screen) - Start up.

Steps to follow:

1. Launch any available web browser.
2. Add security exception.

Expected Outcome:

1. If security exception were not added to browser before, a warning message will be displayed due to un-trusted SSL certificate.

2. Else Home page will be loaded in to web browser.

Test ID 2: Home page (Welcome Screen) Log in.

Steps to follow:

1. Repeat Test ID 1.
2. Click on "logIn" button which appear in right upper corner navigation web page.
3. Type User name & Password in relevant text boxes.
4. Click on "LOGIN" button.

Expected Outcome:

1. If user gets authenticated successfully, User will be redirected to Home page.
2. Name of the user will be displayed in right upper corner of web page.
3. If user gets failed to authenticated, the "Login not successful. Please check the username and password" message will be displayed.

Test ID 3: Home page (Welcome Screen) Crate New ARLab Account.

Steps to follow:

1. Repeat Test ID 1.
2. Click on "logIn" button which appear in right upper corner of web page.
3. Click on "Register" link button which appear in left upper corner below the navigation bar of web page.
4. Type User Name, e-mail address, password & confirm password & answer in relevant text boxes.
5. Click on "SUBMIT" button.

Expected Outcome:

1. If user account created successfully, User will be redirected to Home page.
2. Name of the user will be displayed in right upper corner of web page.
3. If user enters invalid e-mail address, "Invalid e-mail address" message will be displayed.

Test ID 4: Add New device to the system.

Steps to follow:

1. Repeat Test ID 1& 2.
2. Click on "Device" button which appear in navigation panel of web page.
3. Add device name, description
4. Add device tutorial URL and click on "Add" button
5. Click on "Select File" button and file chooser will appear. Select device images related to the device and click on "Open" button.
6. Click on "Next" button.
7. Add component name, component description.
8. Choose one radio button between two choices. Positive or Negative.
9. Click on "Select File" button and file chooser will appear. Select device component images related to the device positive or negative and click on "Open" button.
10. Click on "Add Device Component" button to add component to the particular device.

11. If user want to add another component click on "Add New Componet" button.

Expected Outcome:

1. If user enter a invalid url "Invalid URL" message will be displayed.
2. Add device component interface will appear.

Test ID 5: Update device information.

Steps to follow:

1. Repeat Test ID 1& 2.
2. Click on "Device" button which appear in navigation panel of web page.
3. Click on "Update Device" button located at left navigation bar.
4. Select the device name from the Dropdown box.
5. Information related to the particular device will shown inside corresponding text boxes.
6. Update description
7. If user want to add new URL's Add device tutorial URL and click on "Add" button
8. If user want he or she can delete current URL's correspond to that particular device.
9. Click on "Select File" button and file chooser will appear. Select device images related to the device and click on "Open" button.
10. Click on "Next" button. Then Update device component interface will appear.
11. Select the component name from the Dropdown box.

12. Update component description.
13. Choose one radio button between two choices. Positive or Negative.
14. Click on "Select File" button and file chooser will appear. Select device component images related to the device positive or negative and click on "Open" button.
15. Click on "Update Component" button to add component to the particular device.
16. If user want to add another component click on "Add Component" button.
17. If user want to delete particular component that is currently added in the system click on "Delete Component" button.

Expected Outcome:

1. If user enter a invalid url "Invalid URL" message will be displayed.
2. Add device component interface will appear.

Test ID 6: Delete a device from the system.

Steps to follow:

1. Repeat Test ID 1& 2.
2. Click on "Device" button which appear in navigation panel of web page.
3. Click on "Delete Device" button located at left navigation bar.
4. Select the device name from the Dropdown box.
5. Click on "Delete Device" button to delete a particular device.

Expected Outcome:

1. User will be redirected to "Add Device" page.

3.3 Discussion

The discussion part is mainly focused on discuss about problems faced during the project design and implementation and how those issued are solved. This section also describes how the successful achievements are gained. Most of the software products consist of different kind of bugs. It is our responsibility to minimize the number of bugs before releasing the product to the end user.

3.3.1 How the system achieved excising problems.

The project was started on 6th January 2013. On that day group members were formed. This is the final year project in the degree program and it is indispensable to have a research part in the project. We analyzed the problem through several weeks. After collecting requirements and adding the research parts we came up with a solution. Since we are Information Technology students we had to do our analysis part and designing part in a tremendous manner. Therefore we allocated more time to analyze the problem.

To find out the reason for this situation we went through many web sites, blogs, journals and articles that are mentioned in references. According to that literature survey we identified that there were no similar products available but there were some products which had same functionality but they were not designed for the purpose we were looking for.

In order to provide a solution we categorized overall content of the solution into four functionalities. According to that we designed out the architectural diagram and discussed what were the technological aspects needed to be considered. After that we

identified what are the suitable algorithms for developing the each of the functionality. Then we started designing content of each. We decided to start on basic design diagrams in order model the system and its architecture. Documentation was carried out throughout the duration of the project along with the problem analyzing, system designing.

The testing phase was mainly done for the UI interfaces. This was done in two ways. Namely they are Black box testing and white box testing. The development code was reviewed by peers and followed industrial standards. The functionality was checked by system designers with developers who were in the team. The final outcome of the entire project will be the combination of the work done by each member. Each members' work will finally be plugged to form the final system.

Apart from that we used some newly introduced technologies like Image processing and web services in order to success our target. When considering about the parts the image processing content is combination of two major parts. They are color extraction and edge detection. Also there is a web services which is used for handling the communication between the mobile phone and the remote server.

3.3.2 Special requirements for the system

The following are the minimal requirements we recommend for the smooth operation of the system.

- Dual Core CPU 1GHz processor or higher.
- 3.5 Or bigger display with 240dpi.
- 5MP camera or better.

- The application requires minimum of 30MB free space from the SD card in order to run the application successfully.
- 512mb of RAM during the processing time of the application.
- Wi-Fi / 3G / 4G / HSPDA or any kind of internet connectivity.

Chapter 4

CONCLUSION

The Augmented Reality Based Lab Assistant was developed mainly as an android application but it facilitates the communication between the remote server and the mobile application using web services. In the mobile application, after capturing a particular image it will send the image information to the backend web service. Also the android application use augmented reality technology to show the respond which come from the backend after comparing the information sent from the android application with the images already in the database. In the offline mode the mobile application will provide functionalities like searching tutorials and video playback as well. Apart from comparing images, the backend is provided for creating/modifying user manuals.

The system will basically give all the necessary instruction to the user in order to achieve productive experience with this application. So the user must have to follow all the instructions.

Main benefits of the system

- **User friendliness.**

The ARLab is design in a simple way that any student can learn the system very easily. And also the web application may consist with simple interfaces that the backend users can easily perform its tasks.

- **Accuracy.**

The system may identify controllers with 95% accuracy.

- **Self-learning facility.**

It is much easier to use this device and learn about the device by the student himself, rather than browsing internet to find out how to use device or asking someone to instruct.

- **Time saving.**

ARLab helps to save precious time of the Instructors as well as students when conducting lab sessions.

- **Motivate students to self-learning.**

- **More attractive than typical lab sessions.**

- **Less complexity.**

Assumptions and Limitation

- User must have a mobile phone running on Android OS version 2.3.3 or higher with 5.0 MP camera or better.
- Any Internet connection technology (Wi-Fi / 3G / 4G / HSDPA) should be available with the smart phone in order to get connected to the mobile web.
- User should select the best window size in order to capture the controller.
- User must follow the instructions before use this application.

Future Directions

- Future versions of this application shall work on many devices.
- Future versions of this application shall operate on Smart phones running on iOS.
- Future versions of this application will facilitate to add a new device through the mobile phone.
- Future versions of this application will allow organizations which are willing to promote their products to the public and would like to build up awareness about their businesses on general public.

REFERENCES

- [1] I. Sutherland, "A Head Mounted Three Dimensional Display", Proceedings of Fall Joint Computer Conference, 1968, pp.757 764. [Download: 26th January 2013].
- [2] Andrew Ng, Associate Professor Stanford University,"Machine Learning", [HTML] Available: <https://www.coursera.org/course/ml> [Accessed: 21st August 2013].
- [3] United Nations Educational(UNESCO),"ICT in Education - Mobile Learning", [HTML].Available : <http://www.unesco.org/new/en/unesco/themes/icts/m4ed/> [Accessed: 21st August 2013].
- [4] eHow Developers,"Mobile-Based Learning", [HTML].Available: http://www.ehow.com/about_5475157_mobilebased-learning.html [Accessed: 24th March 2013].
- [5] T. Altameem, 4, May 2011,"Contextual Mobile Learning System for Saudi Arabian Universities", [HTML].Available: <http://www.ijcaonline.org/volume21/number4/pxc3873377.pdf> [Accessed: 21st August 2013].
- [6] Deborah Barreau, Abe Crystal, Jane Greenberg,*janeg@ils.unc.edu, and Anuj

Sharma, School of Information and Library Science, University of North Carolina at Chapel Hill Michael Conway, John Oberlin, Michael Shoffner, Information Technology Services, UNC-CH Stephen Seiberling, Biology Department, UNC-CH, "Augmenting Memory for Student Learning: Designing a Context-Aware Capture System for Biology Education", [HTML].Available: <http://www.ils.unc.edu/mrc/pdf/barreau06augmenting.pdf> [Accessed: 21st August 2013].

- [7] Wikipedia, the free encyclopedia, 23 July 2013,"Feature extraction", [HTML].Available: http://en.wikipedia.org/wiki/Feature_extraction [Accessed: 21st August 2013].
- [8] Shapiro, Linda G. and Stockman, George C,"Computer Vision" Prentice Hall, 2003, ISBN 0-13-030796-3.
- [9] John Canny. A computational approach to edge detection. Pattern Analysis and Machine Intelligence, IEEE Transactions on, PAMI-8(6):679698, Nov. 1986.
- [10] F. Mai, Y. Hung, H. Zhong, and W. Sze. A hierarchical approach for fast and robust ellipse extraction. Pattern Recognition, 41(8):25122524, August 2008.
- [11] Sergei Azernikov. Sweeping solids on manifolds. In Symposium on Solid and Physical Modeling,pages 249255, 2008.
- [12] "Software Testing", Margaret Rouse, December 2012, [HTML].Available: <http://whatis.techtarget.com/definition/software-testing> [Accessed: 21st August 2013].

Appendix A

Activity Diagrams

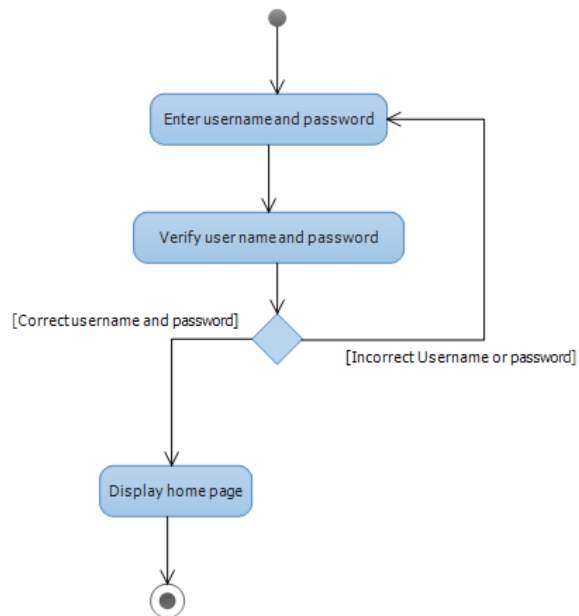


Figure A.1: Login

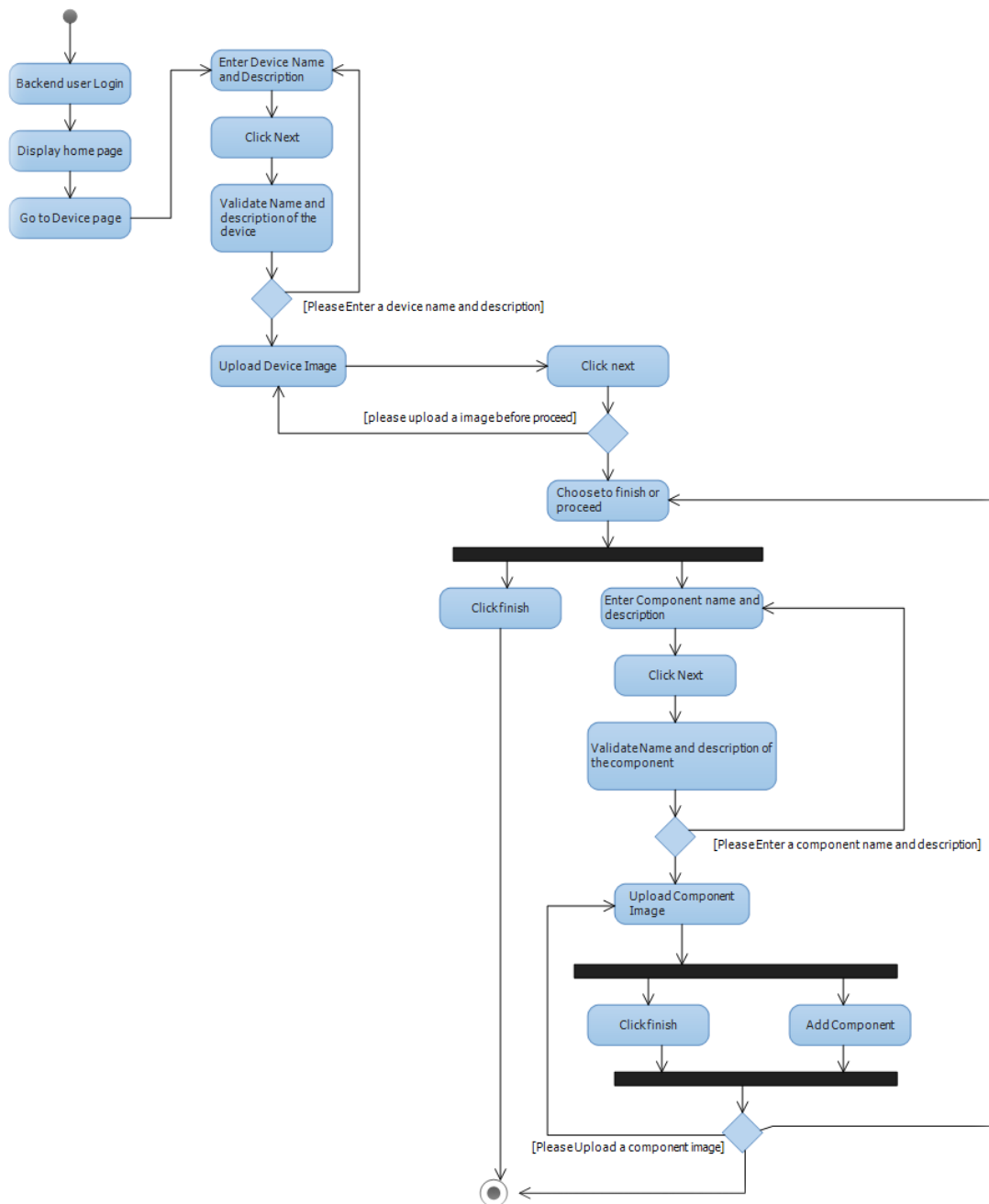


Figure A.2: Add Devices

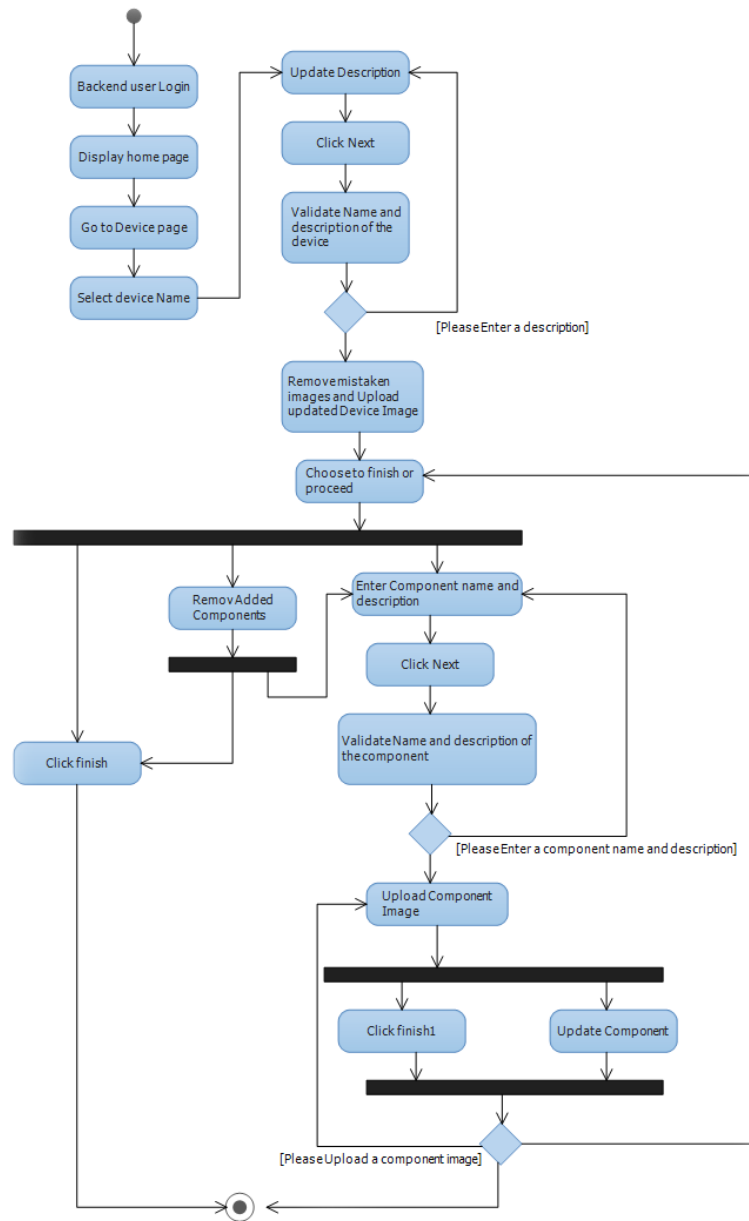


Figure A.3: Update Device

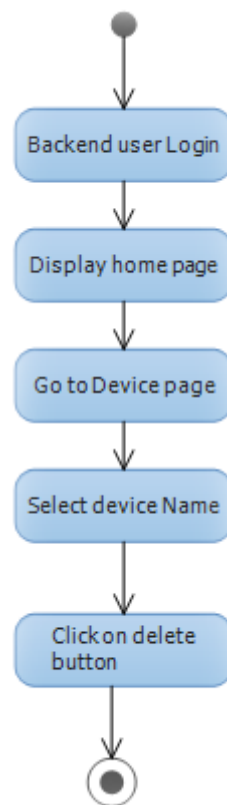


Figure A.4: Delete Device

Appendix B

Sequence Diagrams

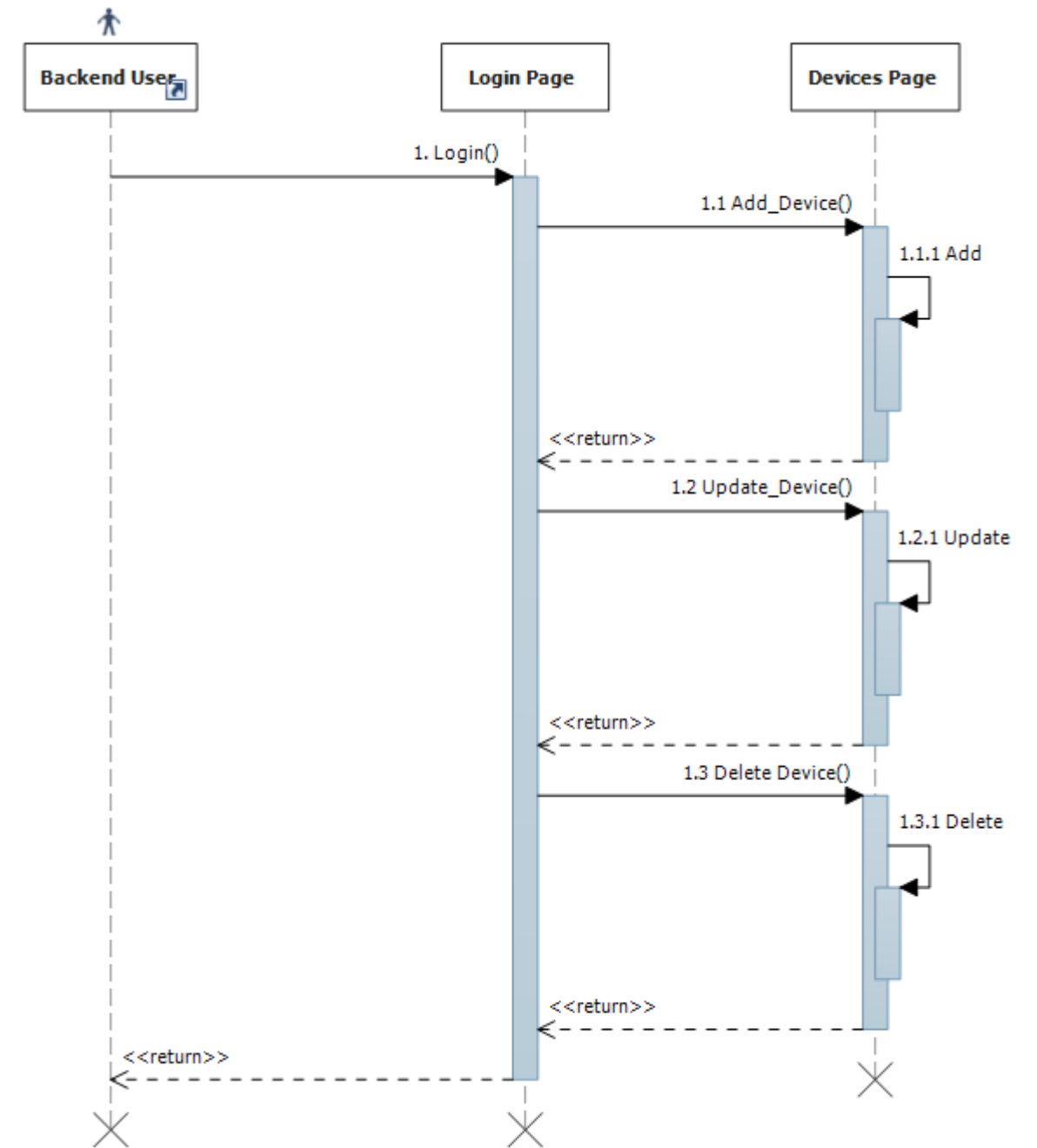


Figure B.1: Add, Update And Delete Device

Appendix C

Use case diagram

Figure C.1 illustrates the use case diagram for overall mobile application and Web application activities.

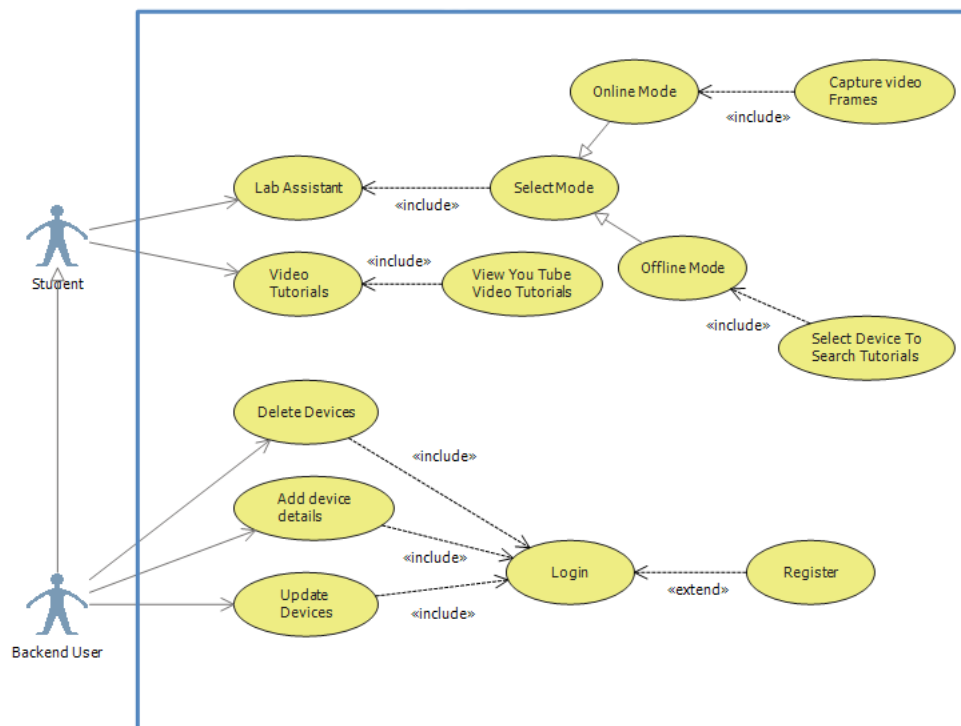


Figure C.1: Use case Diagram

C.1 Use case scenarios

C.1.1 Use case scenarios for overall web application activities

Use case 1	Register user
Goal	Allows users to register with the system.
Scope and Level	General
Preconditions	Database should be created and it should be connected with the backend web service.
Primary actors	Primary user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when a user clicks 'Register' option. 2. User fills the necessary details. 3. User clicks 'Submit' button. 4. Use case ends after Redirecting the user to the login page.
Extensions	4a. If the user leaves some necessary fields empty or if he has given some incorrect information an error message will be shown telling what he has done wrong.

Table C.1: Register User

Use case 2	Login to the system
Goal	Allows registered users to login to the system
Scope and Level	General
Preconditions	User should have registered with the system.
Primary actors	Registered user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when a user clicks 'Login' option. 2. User fills the user name, password fields. 3. User clicks 'Login' button. 4. Use case ends after redirecting to the home page.
Extensions	<ol style="list-style-type: none"> 4a. If the user enters the user name or password incorrectly/if the user isn't a registered user an error message will be displayed and the system will prompt user to re-enter the user name and password.

Table C.2: Login To The System

Use case 3	Add new device to the system
Goal	Allows registered users to add new device details to the system.
Scope and Level	General
Preconditions	<ol style="list-style-type: none"> 1. Database should be created and it should be connected with the backend web service. 2. User should have registered with the system.
Primary actors	Registered user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user clicks 'Add device' tab. 2. User adds new device name and it's details. 3. User click 'Next' button. 4. Then user has to upload the necessary images of the device. 5. User click 'Next' button. 6. User add component name and description of the device. 7. User click 'Finish' button. 8. Use case ends after showing a message saying "Device added successfully".
Extensions	<ol style="list-style-type: none"> 1a.If the user isn't a registered user will be redirected to the login page. 7a. If the new device details weren't inserted successfully, an error message will be shown.

Table C.3: Add New Device To The System

Use case 4	Update device details in the system
Goal	Allows registered users to modify device details in the system.
Scope and Level	General
Preconditions	<ol style="list-style-type: none"> 1.Database should be created and it should be connected with the backend web service. 2.User should have registered with the system. 3.Device should be already in the system.
Primary actors	Registered user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user clicks "Update device" tab. 2. User select the device name. 3. User modifies device details. 4. User click 'Next' button. 5. If the images are incorrect remove the current images and upload new images. 6. User click 'Next' button. 7. Add new components if there any. 8. Remove the component information that has mistaken. 9. User click 'Finish' button. 10. Use case ends after showing a message saying "Device updated successfully".

Extensions	<ol style="list-style-type: none">1. Use case starts when the user clicks 'Modify device' tab.10a. If the device details weren't modified successfully an error message will be shown.
------------	---

Table C.4: Update Device Details In The System

Use case 5	Delete device from the system
Goal	Allows registered users to delete device details from the system.
Scope and Level	General
Preconditions	<ol style="list-style-type: none"> 1. Database should be created and it should be connected with the backend web service. 2. User should have registered with the system.
Primary actors	Registered user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user clicks 'Delete device' tab. 2. User select the device name 3. User click 'Delete Device' button. 4. Use case ends after showing a message saying "Device deleted successfully".
Extensions	<ol style="list-style-type: none"> 1a.If the user isn't a registered user will be redirected to the login page. 4a. If the new device details weren't inserted successfully, an error message will be shown.

Table C.5: Delete Device From The System

C.1.2 Use case Scenarios for Overall Web Application Activities

Use case 6	Load the application
Goal	Allows user to handle the application.
Scope and Level	General
Preconditions	Application needs to be installed in the mobile phone.
Primary actors	Primary user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user clicks the AR based lab assistant application icon. 2. Use case ends after showing the welcome screen.
Extensions	No

Table C.6: Load The Application

Use case 7	Capture image using mobile device
Goal	Allows users to capture image of a controller.
Scope and Level	General
Preconditions	<ol style="list-style-type: none"> 1. Database should be created and it should be connected with the backend web service. 2. Device should be already in the system.
Primary actors	Registered user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user selects online mode. 2. User focuses his mobile camera towards a controller. 3. Use case ends when the mobile display shows the description of the controller using AR technique.
Extensions	<ol style="list-style-type: none"> 3a. If the device is not included in the system an error message will be shown.

Table C.7: Capture Image Using Mobile Device

Use case 8	Search tutorials
Goal	Allows users to search tutorials of a controller.
Scope and Level	General
Preconditions	1. Mobile phone should be able to connect to the internet.
Primary actors	Primary user
Main success scenario steps	<ol style="list-style-type: none"> 1. Use case starts when the user selects offline mode. 2. User selects a device. 3. User search for tutorials. 4. Use case ends when the mobile devise displays available information regarding particular device.
Extensions	3a. If the mobile device is unable to connect to the internet an error message will be shown.

Table C.8: Search Tutorials

Use case 9	Video Tutorials
Goal	Allows users to search tutorials of a controller.
Scope and Level	General
Preconditions	1. Mobile phone should be able to connect to the internet.
Primary actors	Primary user
Main success scenario steps	1. Use case starts when the user selects video tutorial. 2. User selects a device. 3. User search for vedio tutorials. 4. Use case ends when the mobile devise displays available video tutorial information regarding particular device.
Extensions	3a. If the mobile device is unable to connect to the internet an error message will be shown.

Table C.9: Video Tutorials

Appendix D

Classes diagram

This section describes the classes that are used for design phase of the ARLab application.

D.1 Mobile application

Figure D.1 illustrates the class diagram of mobile application

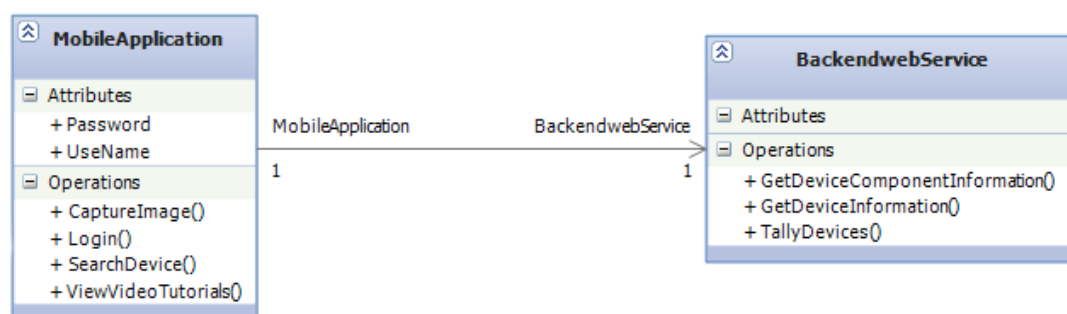


Figure D.1: Class Diagram Of Mobile Application

D.2 Web application

Figure D.2 illustrates the class diagram of web application

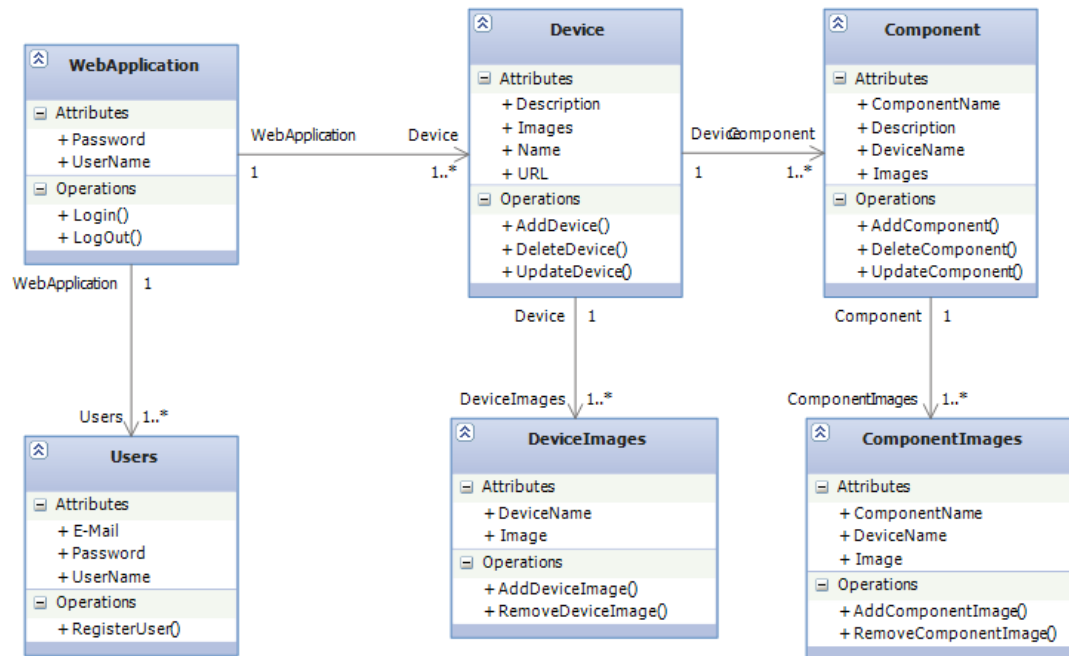


Figure D.2: Class Diagram Of Web Application