CLOUD-BASED LECTURE CAPTURING SYSTEM: CASE STUDY

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Department of Information Technology

Sri Lanka Institute of Information Technology

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DECLARATION

I declare that this is my own work and this dissertation1 does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

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ABSTRACT

Today, with the rapid growth of technology and usage of internet services, e-learning has become one of the latest trends in the education sector. As a result, students tend to prefer e-learning than being physically present in a lecture due to multiple reasons. This document examines an innovative approach in the form of smart cloud-based system to enhance the current e-learning procedures, particularly in universities. The "Lecture Capturing System" is a cloud-based web application which uses enhanced techniques to provide an interactive e-learning experience to users of the system. It has the ability to support multiple enterprise customers. It uses a facial recognition-based authentication process to allow remote users to login to the system. A Pan-Tilt-Zoom (PTZ) IP camera captures and tracks the lecturer during the lecture session and this is streamed live to remotely logged-in students. The lecturer can also share the computer screen if required. The camera intelligently identifies specific gestures performed by the lecturer to rotate towards the audience with the aid of gesture analyzing algorithms. Attendance of remote online students is marked automatically during a live-streaming lecture by using multiple facial recognition processes executing on the server. Offline recording of lectures is also supported after which the video is split into a series of chapters/thumbnails and the audio is converted to text; each chapter representing a presentation slide and the relevant text. Bandwidth and quota are managed intelligently to ensure the best possible transmission rate with minimum data consumption in order to avoid filling the link to capacity which would result in network congestion and poor performance of the network. This is a revolutionary system which is capable of taking e-learning to the next level as it provides a complete classroom experience and makes the whole learning and teaching process efficient and relaxing.

Keywords—biometric authentication, automated biometric attendance marking, bandwidth management.

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Table of Contents

DECLARATION 3
ABSTRACT 4
ACKNOWLEDGEMENT 5
LIST OF TABLES 7
LIST OF FIGURES 8
LIST OF ABBREVIATIONS 9
1. INTRODUCTION 10
1.1 Problem to be addressed 10
1.2 Background context 11
1.3 Literature Review 12
1.4 Research gap 13
1.5 Research Objectives 15
1.5.1 Main Objective 15
1.5.2 Specific Objectives 15
1.6 Research questions 15
2. BODY OF THE REPORT 17
2.1 Methodology 17
2.1.1 User Interfaces 28
2.1.2 Hardware Interfaces 30
2.1.3 Software Interfaces 31
2.1.4 Security 31
2.2 Research findings 32
2.3 Testing 32
2.3.1 Testing Plan 32
2.4.2 Testing Methods 33
2.4.3 Test Cases 33
3. RESULT AND DISCUSSION 37
3.1 Results 37
3.2 Discussion 38
4. CONCLUSION 39
5. REFERENCE 40

List of Tables

Table 1: Definitions 9
Table 2: Comparison with current systems 14
Table 3 : Use case scenario - Facial Recognition based login 21
Table 4 : Use case scenario - Edit User Profile 22
Table 5 : Use case scenario - Modify Student Attendance 24
Table 6 : Use case scenario - View Student Attendance 25
Table 7 : Use case scenario - Activate Attendance Marking Camera 26
Table 8 : Use case scenario - Bandwidth Monitoring Dashboard 27
Table 9 : Test Case – Face Login 33
Table 10 : Test Case - Unknown Face Login Effort 34
Table 11 : Test Case - Credential Based Login 34
Table 12 : Test Case - Attendance Marking 35
Table 13 : Test Case - Filter attendance of a student 35
Table 14 : Test Case – User Registration 36

List of Figures

Figure 1: Use case diagram - facial recognition functions 17
Figure 2 : LBP Algorithm Equation 19
Figure 3 : Face and label vectors 19
Figure 4 : Prepare Training data function 20
Figure 5 : Haar Cascade Recognizer function 20
Figure 6 : Prediction Implementation 21
Figure 7 : Face Login Interface 28
Figure 8 : Attendance Marking Interface 28
Figure 9 : User Registration Interface 29
Figure 10 : User List Interface 29
Figure 11 : Edit User Interface 29
Figure 12 : Bandwidth Managment Interface 30
Figure 13 : Dashboard Statistics Interface 30

List of abbreviations

Table 1: Definitions

Term	Definition
LCS	Lecture Capturing System
IP	Internet Protocol
LBP	Local Binary Patterns
SVM	Support Vector Machine
HOG	Histogram of Oriented Gradients
RTC	Real Time Communication
RGB	Red, Green and Blue

1. INTRODUCTION

1.1 Problem to be addressed

Today, e-learning platforms are used for knowledge transfer through electronic media. This transfer can address several learning contexts, ranging from conventional classroom delivery to online and offline distance learning tactics. There are a countless number of e-learning platforms which cover various aspects of learning such as video streaming, capturing the audience in the lecture hall if necessary, and screen sharing. But, the solution we propose is to handle advanced and enhanced features. Biometric recognition of participants to ensure authentication is proposed so that the attendance can be recorded. In addition to this, every lecture will be maintained as an mp4 video with the set of slides used, and the lecturer's voice relevant to each slide, which provides an easy way of reference to the students who missed a particular lecture. Another important aspect considered in this research is the way of interaction between the lecturer and the students who have any doubts to be cleared during the lecture. For this purpose, when the students who are physically present in the lecture hall are concerned, a gesture based system is proposed. Here, when the lecturer notices a specific student with the gesture of asking a question, the lecturer will have to perform a gesture for the camera to turn towards the audience and focus on the specific student who has the doubt by once again detecting the gesture performed by the student. When a remotely logged in user has a question for the lecturer, he/she has to signal the lecturer using a specific command, and then the lecturer has to decide whether to give video and/or audio control over to the specific user. As real time video streaming consumes a lot of quota and bandwidth, the system has to intelligently manage data usage by ensuring the best possible transmission rate with minimum data consumption.

1.2 Background context

Today, communicating with internet and doing things right from our home becoming more and more practical because it makes day today life very easier. People always try to find a way to use the easiest way to complete their tasks without taking too much time and energy.

The art of learning should evolve over time. Even today with the technology we have, we are still used to physically going to a lecture and listening to the lecturer in real-time and making notes of his/her teachings, what the lecturer sketches on whiteboards or his/her presentation. So, there is a higher chance that students forget what the lecturer said or taught the very next day if they were not properly documented. What if a student gets sick or due to unavoidable circumstances, misses a lecture, how is he/she going to learn the missed session? Something like a live streaming with recording sessions of a lecture would help all the students even if they were present in the lecture itself. The ability to see what they have missed if the student comes to the lecture after it has started, a way to refresh their memories before attending the next lecture would result in a huge academic improvement.
E-Learning helps learning become possible to anyone who wants to learn something right from their home. Main purpose of this system is to give a better effective way to help the students to get learning materials and information from anywhere and to quickly recap any forgotten or absent lectures via the earlier recordings of the sessions.
A system and method for an interactive, Internet-based video conferencing multicast operation which uses a video production studio with a live instructor giving lectures in real-time to multiple participating students. The video conference multicasting permits the students to interact with the instructor and other installations during the course of the lecture and to later browse the recorded session without a hassle.
There are many added such as sharing lecturer's computer screen with students in real time, lecture communicating with students either by voice, video or both on request of the student. In our system we have added smart features such as intelligent bandwidth management to make sure that we use the least possible data bandwidth to

transfer the videos to the students.

Web Application development skills, Image processing, Machine learning and techniques are essential. In addition, some basic knowledge on lecturing process and student behavior process are also required throughout the development of the system.

1.3 Literature Review

Several work exist in facial recognition based authentication, attendance marking and bandwidth management areas. Haar classifier for face detection, Eigen face algorithm for face recognition, image normalization and histogram normalization for image and contrast enhancement is proposed. [9] The system uses IP Camera mounted in front of a classroom which continuously capture image of the entire class at set interval, throughout the period of a lecture and sends the images over the internet to a cloud server for processing. The server processes the images by detecting the human faces contained, extract the faces and matches them with the enrolled faces of the students stored on the database. Before the images are used for detection and recognition purposes, the images are normalized or converted to gray scale which enhances the accuracy of face detection and recognition. Histogram normalization is then proposed for contrast enhancement. [9]

Sujata G. Bhele and V. H. Mankar has described wide range of methods used for face recognition which includes Principal Component Analysis (PCA), Linear Discriminant Analysis (LDA), Independent Component Analysis (ICA) and Gabor wavelet soft computing tool like Artificial Neural Networks (ANN) for recognition and various hybrid of this techniques. In addition, the methods that challenges face recognition such as pose variation, illumination and facial expressions are described further. [10]

In terms of accuracy and speed of face detection and recognition processes, a new approach is proposed by evaluating various face detection and recognition methods such as Haar-like features, LBP, SVM, Adaboost algorithm, Gabor features and HOG by performing tests on face rich databases in terms of subjects, pose, emotions, race and light. [11] AdaBoost classifier is used with Haar and Local Binary Pattern (LBP) features whereas Support Vector Machine (SVM) classifier is used with Histogram of Oriented Gradients (HOG) features for face detection evaluation in [11]. Haar-like features is the proposed face detection solution in [11] which has reported relatively well than LBP method. In terms of recognition, Gabor method is the proposed solution in [11] as it's qualities overcome datasets complexity.

Traditionally in live streaming, data is served by putting a huge network load on the servers. A new approach is proposed which introduce two new WebRTC-based communication protocols [13] known as WebPeer and CodedWebPeer designed especially for browser based P2P streaming. [12] Two network metrics called network health to measure overall data saturation and network stability to show if the peers in the network are able to serve each other without the help of the server are proposed. The study [12] shows through measurements that by applying network coding, network health is increased by up to 100% without changing the cache size or number of peers. Furthermore, network stability is achieved using up to half the cache compared to the other approaches, without increasing the servers load. A caching system is proposed to reduce bandwidth costs when live streaming. [12]

1.4 Research gap

The following table shows a comparison between the proposed system and other systems in the marketplace. Facial recognition based login and attendance marking feature is a unique and novel feature when compared with the other systems in the market place.

Table 2: Comparison with current systems

Features	BigBlue Button	Panopto	Kaltura	Echo360	Lecture Capturing System
Facial recognition based Login					✓
Bandwidth Management		✓		✓	✓
Facial recognition based Attendance Marking					✓

Echo360 use laptop's in-built web camera for video capturing but the system doesn't have facial recognition processes which use the built-in web camera. [5] In terms of facial recognition, Lecture capturing system's facial recognition features plays a major part when considering the uniqueness.

Echo360 provides administrators a complete view of its system environment and cloud platform. Echo360 bandwidth management dashboard let administrators to monitor levels of system use as well as individual capture points on the network. It also provides system information, cloud usage, student activity etc. [1]

Panopto uses modern http streaming which also called the adaptive bitrate streaming provides faster ways of live streaming, minimal buffering and faster start-up of videos which is widely used by Netflix. [2] Panopto also provides real time analytics of servers, video usage, user analytics etc. [3]

However, most of the bandwidth management features in Lecture Capturing System exist in Echo360 and Panopto systems, yet the bandwidth optimization techniques used in the Lecture Capturing system's server will differ from other systems. Gzip compression in NGINX load balancer will be used in the Lecture Capturing System to speed the transmission of data between client and server.

1.5 Research Objectives

1.5.1 Main Objective

The main objective of this research is to implement a cloud-based smart e-learning platform for university students, and lecturers to facilitate lecture delivering and participating in lectures through real-time video streaming while ensuring that, the maximum possible level of interaction between parties is achieved using image processing and machine learning techniques.

1.5.2 Specific Objectives

1. To ensure authentication through face recognition along with basic login information and session management.
2. To mark attendance of students through face recognition and to provide an interface where lecturers can filter, view, edit or delete attendance details and students can view their attendance by providing relevant filtering options.

1.6 Research questions

Lecture Capturing System is not another web based e-learning applications. It contains unique features which addresses the questions that are there in current systems and uniquely bundle together a well performing e-learning system. Below are some of the main problems that lead to the development of Lecture Capturing System.

To a student who is enrolled in a lecture

- Entering the credentials to log in to a system is not fully efficient, more vulnerable to password attacks and more security risks. If a password is forgotten by a user, there will be many login attempts, password reset requests through email and other security checks that should be done to authenticate the user, thus leading to more password attacks such as brute-force attacks to crack passwords.
- In current systems such as Panopto and Echo360, the session expiration time is too long leading to more security attacks due to the hassle of entering the credentials to log in to the system.
- The lack in awareness of password best practices when creating or updating passwords. Students or people in general follows a common formula or pattern which is using words with numbers and a special character at the end. These patterns make it easier to remember the credentials while hackers are also aware of the common pattern used to create passwords. As a result, hackers can use this knowledge to input how their brute-force systems run through password combinations or crack passwords by making an educated guess.

To a lecturer who is teaching a course

- Tracking the real attendance of the students is not fully accurate as friends of the students mark the attendance for absent people.
- The lecturer is not aware of a student's arrival and departure time from a lecture session.
- The lecturer is not aware whether a student in the lecture session or classroom have access to the lecture session, authorized or enrolled to the course.

2. BODY OF THE REPORT

2.1 Methodology

This section describes the face recognition based authentication and attendance marking functionalities in the LCS system, their flow in the system and the technologies used for their implementation.

The Figure 1 shows the use case diagram for face recognition based login and attendance marking functions.

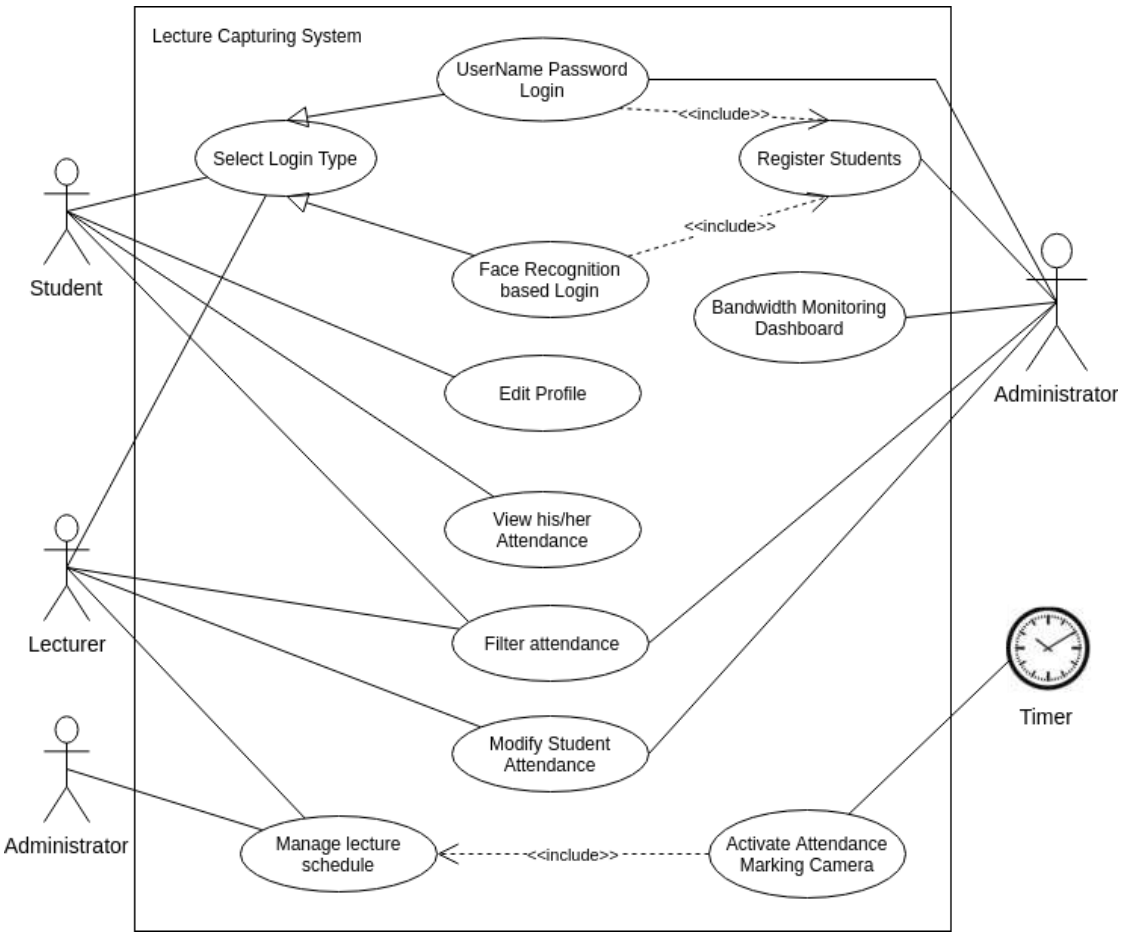

Figure 1: Use case diagram - facial recognition functions

1. Facial Recognition based user login.

A student or a lecturer can login to the system using the webcam. Initially, the administrator of the Lecture Capturing System should register the user by uploading quality images and relevant details of the user. After registering a user, the server will train the face recognition classifier with the newly uploaded images of a user along with the existing images of users. Thereafter the user will be authenticated from the face recognition process through the webcam only if the confidence threshold of the face recognition classifier is greater than 90%. If it is less than 90%, the user will not be authenticated. In terms of security, session handling will take place after face recognition based login.

In terms of the general architecture of the face recognition based login function, two steps are considered

1. **Detection stage**
   LCS system search for the face region (displayed by rectangle) in the whole video stream
2. **Recognition stage**
   Contrasting the face image obtained above to the face image trained in the database, and predicting the user registered.

If the system face recognition is successful, the recognition result will be displayed in white text inside a green rectangle on the webcam feed along with the confidence percentage. If failed, system will pop a warning. Face Recognition used in the system follows three main steps.

1. Prepare training data

OpenCV computer vision library, Python and Numpy is used as dependencies to implement face recognition function in the system. [1] OpenCV provides two

pre trained and ready to be used face detection classifiers called Haar classifier and LBP classifier. [2] Haar Cascade classifier is used as the face recognition classifier and Local Binary Patterns (LBP) classifier is used as the face recognition classifier to detect and recognize faces in this system. LBP is a type of visual descriptor used for classification in computer vision. [3] The LBP classifier is used due to its main advantages such as shorter training time, high accuracy rate in difficult lighting conditions which will be useful when detecting faces through the webcam and computationally simple and fast. [4] A formal description of the LBP algorithm is given in Figure 2.

$$LBP(x_c, y_c) = \sum_{p=0}^{P-1} 2^p s(i_p - i_c)$$

Figure 2 : LBP Algorithm Equation

Source: *https://www.superdatascience.com/opencv-face-detection/*

The training dataset consists 30 images for each user and each user is assigned a label (e. g. s1, s2) upon registering to the system. Furthermore, this step will read all the images of a person and apply face detection to each one using LBP classifier. Then, add each face to face vectors with the corresponding person label extracted. Finally, the data preparation step will produce following face and label vectors. [4]

FACES	LABELS
person1_img1_face	1
person1_img2_face	1
person2_img1_face	2
person2_img2_face	2

Figure 3 : Face and label vectors

```
# function to get the images and label data
def getImagesAndLabels(path):

    imagePaths = [os.path.join(path,f) for f in os.listdir(path)]
    faceSamples=[]
    ids = []

    for imagePath in imagePaths:

        PIL_img = Image.open(imagePath).convert('L') # convert it to grayscale
        img_numpy = np.array(PIL_img,'uint8')

        id = int(os.path.split(imagePath)[-1].split(".")[1])
        faces = detector.detectMultiScale(img_numpy)

        for (x,y,w,h) in faces:
            faceSamples.append(img_numpy[y:y+h,x:x+w])
            ids.append(id)

    return faceSamples,ids
```

Figure 4 : Prepare Training data function

2. Train face recognizer

The face and label vectors returned from the data preparation step (according to Figure 3 'getImagesAndLabels' function) will be converted to a Numpy array and passed to the OpenCV Haar Cascade face recognizer for training. [4] The statistical data returned from the face recognizer will be saved in a YAML file.

```
print ("\n [INFO] Training faces. It will take a few seconds. Wait ...")
faces,ids = getImagesAndLabels(path)
recognizer.train(faces, np.array(ids))

# Save the model into trainer/trainer.yml
recognizer.write('trainer/trainer.yml')
# Print the numer of faces trained and end program
print("\n [INFO] {0} faces trained. Exiting Program".format(len(np.unique(ids))))
```

Figure 5 : Haar Cascade Recognizer function

3. Prediction

Once the user is navigated to the login page, the server automatically detects the face from the Haar classifier, predicts the face by calling the trained OpenCV Haar face recognizer, returns the predicted name of the user associated with the label and live streams the response from the server (recognized face plot, name of the user, confidence threshold) to the login page. Thereafter, the user will get logged in to the system after the user clicks the face login button.

```
for(x,y,w,h) in faces:

    cv2.rectangle(img, (x,y), (x+w,y+h), (0,255,0), 2)

    id, confidence = recognizer.predict(gray[y:y+h,x:x+w])

    # Check if confidence is less them 100 ==> "0" is perfect match
    if (confidence < 100):
        id = names[id]
        global globalId
        globalId = str(id)
        confidence = "  {0}%".format(round(100 - confidence))
    else:
        id = "unknown"
        globalId = str(id)
        confidence = "  {0}%".format(round(100 - confidence))
    # print("Camera.get_frame() global : ",globalId )
    cv2.putText(img, str(id), (x+5,y-5), font, 1, (255,255,255), 2)
    cv2.putText(img, str(confidence), (x+5,y+h-5), font, 1, (255,255,0), 1)
if s:   # frame captures without errors...ss
    cv2.imwrite("stream.jpg", img)  # Save image...
return self.frames.read()
```

Figure 6 : Prediction Implementation

Table 3 : Use case scenario - Facial Recognition based login

Use Case No	1
Use Case Name	Facial Recognition based login
Actor	Student, lecturer

Pre-Conditions	The student or lecturer is logged into the system.
Main Success Scenario	1. The student or lecturer should select the facial recognition based login option from the two login options. 2. The system runs the facial recognition process to authenticate the student's face through the webcam. 3. The student logs into the system.
Post Conditions	The student or lecturer logs into the system after successfully authenticating student's face.
Extensions	2a. The student or lecturer clicks the face login button. 2a1. The system grants access to the webcam. 2b. The internet connection is interrupted during the face authentication process. 2b1. The system displays an error "Authentication failed. Please try again or try the credential login option.

Table 4 : Use case scenario - Edit User Profile

Use Case No	2
Use Case Name	Edit Profile
Actor	Student
Pre-Conditions	The student is logged into the system.

Main Success Scenario	1. The student selects the 'Edit Profile' tab. 2. The student can edit input values such as Student Name, address, phone number and add a profile picture. 3. The student clicks the 'Update' button.
Post Conditions	Updated student profile information will be stored in the database.
Extensions	2a. The student enters an invalid phone number. 2a1. The system displays an error "Invalid phone number"

2. Automated Facial Recognition based Attendance Marking.

Using facial recognition, the attendance is marked automatically for the students who are present in the lecture room and also the students who are logged in remotely through the Lecture Capturing System during the live streaming lecture session. The administrator and the lecturer is able to view, modify and filter attendance of students. A student is able to view his/her attendance with the aid of the filtering options available. Some noticeable advantages of this feature is that it will add an extra layer of security to the system to ensure that only authorized persons gain access to the university's content. A comprehensible advantage of this method of biometric authentication of students can be noted during the time of an online exam to verify that the person on the other end is actually who they claim to be. Also, this feature will solve the problem of students marking attendance for other students.

Table 5 : Use case scenario - Modify Student Attendance

Use Case No	3
Use Case Name	Modify Student Attendance
Actors	Admin, Lecturer
Pre-Conditions	Admin, lecturer is logged into the system.
Main Success Scenario	1. The admin, lecturer selects the 'Student Attendance' tab. 2. The admin, lecturer provides filter details such as student id, month, date, year, semester and subject to retrieve the attendance of a student. 3. The system displays the attendance details according to the provided filtering details. 4. The admin or lecturer can edit the attendance of a student by entering either 'Present' or 'Absent'.
Post Conditions	Updated attendance information will be stored in the database.
Extensions	2a. The admin or lecturer provide a incorrect student id number to the search bar. 2a1. The system displays an error "Student ID not found" 4a The admin or lecturer provides a word other than 'Present' or 'Absent'. 4a1. The system displays an error "Invalid Input! Expected Absent or Present"

Table 6 : Use case scenario - View Student Attendance

Use Case No	4
Use Case Name	View Student Attendance
Actors	Student
Pre-Conditions	Student is logged into the system.
Main Success Scenario	1. The student selects the 'Attendance' tab. 2. The system displays all the attendance details of the logged in student throughout the degree program duration. 3. The student provides filtering details such as month, date, year, semester and subject to filter the attendance details from the database. 4. The system displays the filtered attendance details to the student.
Post Conditions	The system displays the filtered attendance details to the student.
Extensions	4a. The system doesn't find attendance data according to the given filter details. 4a1. The system displays an error "No records found"

Table 7 : Use case scenario - Activate Attendance Marking Camera

Use Case No	5
Use Case Name	Activate Attendance Marking Camera
Actors	Timer
Pre-Conditions	Set up lecture time schedule information
Triggering events	The camera will recognize and detect students' faces
Main Success Scenario	1. Timer turns the camera on. 2. Camera will detect and recognize faces. 3. Camera sends the captured image to the server for image processing.
Post Conditions	Captured image is sent to the server.
Extensions	1a. The timer turns the camera on 1a1. If the faces (objects) are not identified for a longer period, the timer will turn the camera off.

3. Bandwidth Management.

Initial step is to manage bandwidth in the server of the system using bandwidth optimization techniques such as compression, clustering etc. to reduce bandwidth costs. The goal is to reduce the data size which will be passed from client to server and vice versa. The next outcome is a bandwidth monitoring dashboard which will consist of traffic usage, system information, CPU load, alerts to notify exceeded predefined threshold settings and attacks etc. which will only be accessible to the administrator of the system.

Table 8 : Use case scenario - Bandwidth Monitoring Dashboard

Use Case No	6
Use Case Name	Bandwidth Monitoring Dashboard
Actors	Admin
Pre-Conditions	1. The Admin is logged into the system.
Main Success Scenario	1. The administrator selects the "Bandwidth Management" tab. 2. All the bandwidth details such as traffic, memory and system usage details etc are displayed in the dashboard using graphs and tables. 3. The administrator selects the 'alerts' tab. 4. In the alert page, the system will display alerts when traffic usage and bandwidth utilization exceeds pre-defined threshold settings.

2.1.1 User Interfaces

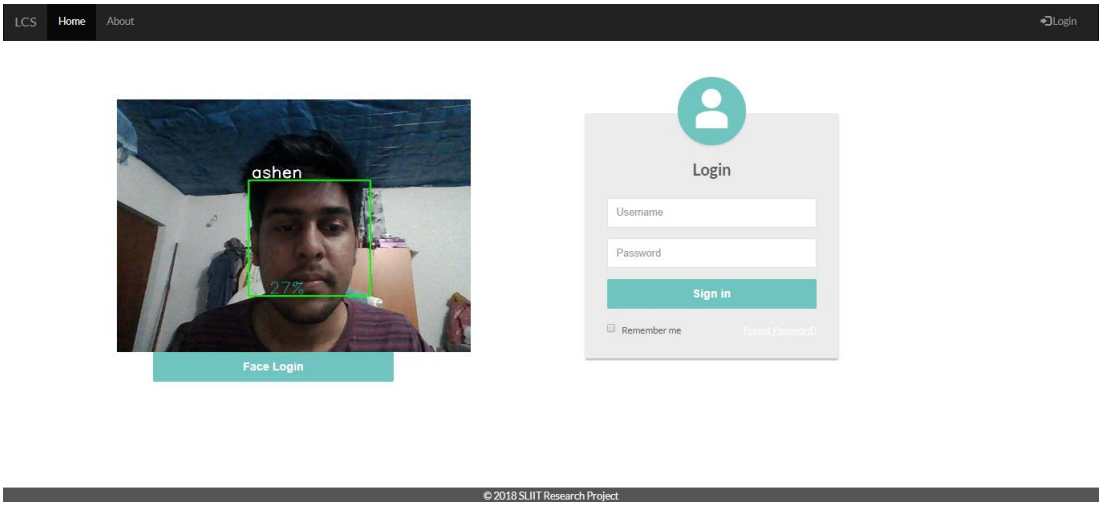

Figure 7 : Face Login Interface

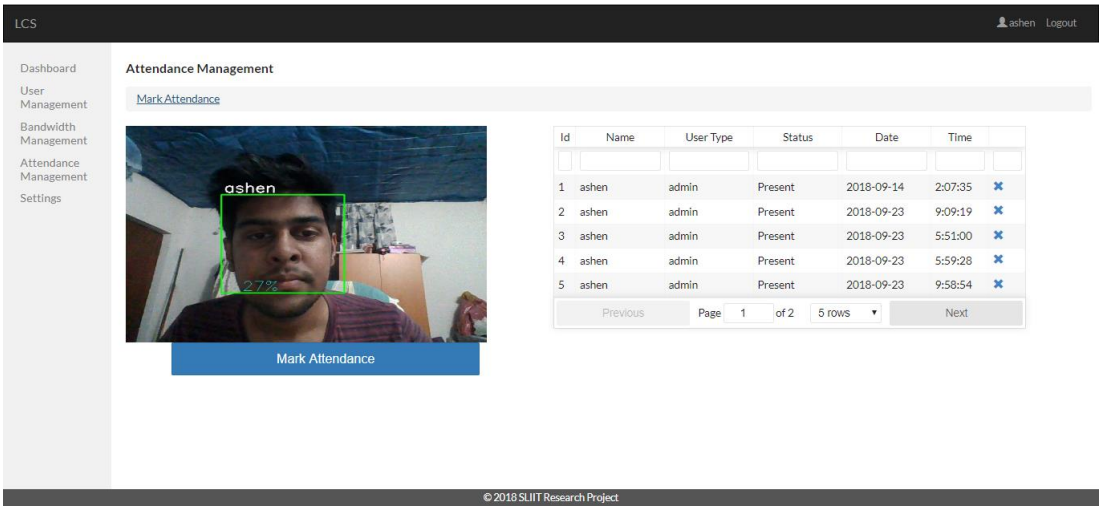

Figure 8 : Attendance Marking Interface

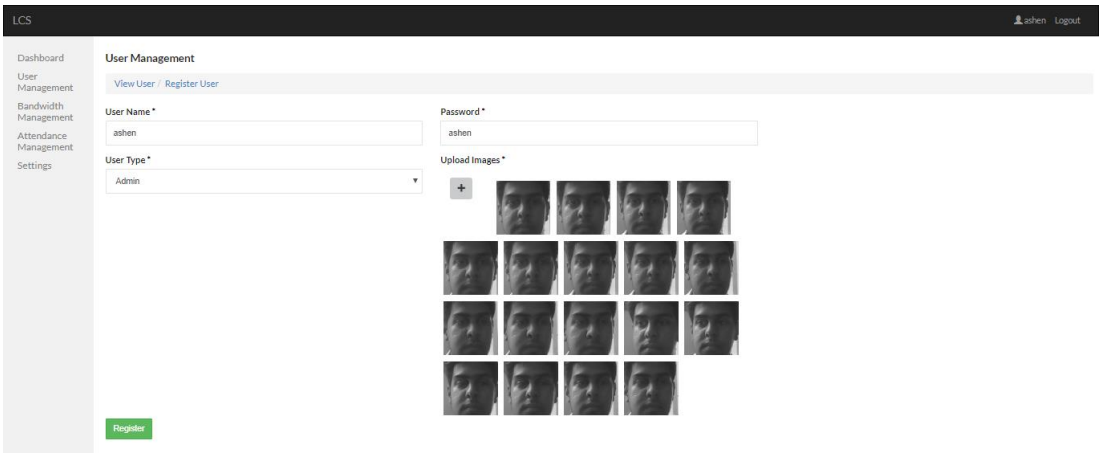

Figure 9 : User Registration Interface

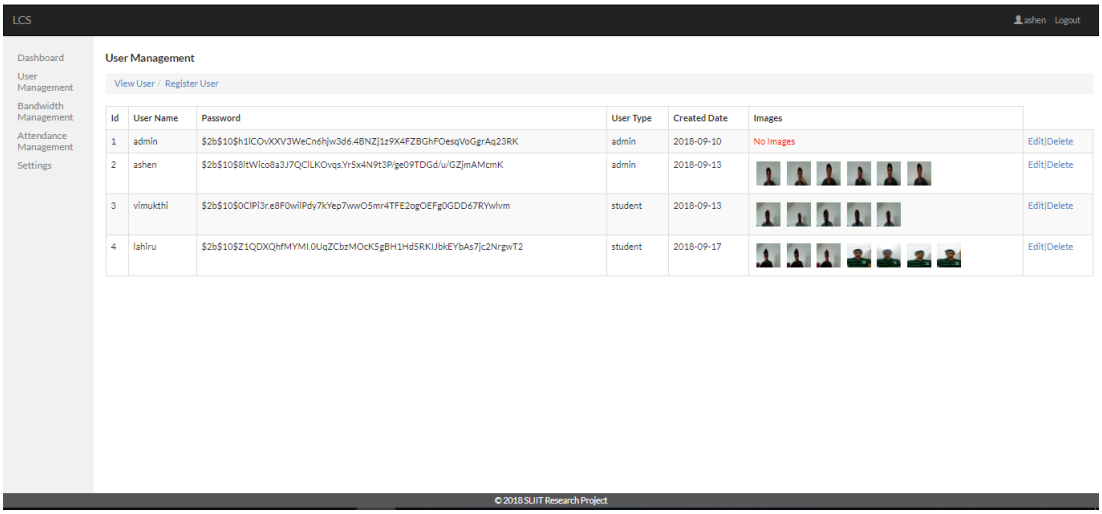

Figure 10 : User List Interface

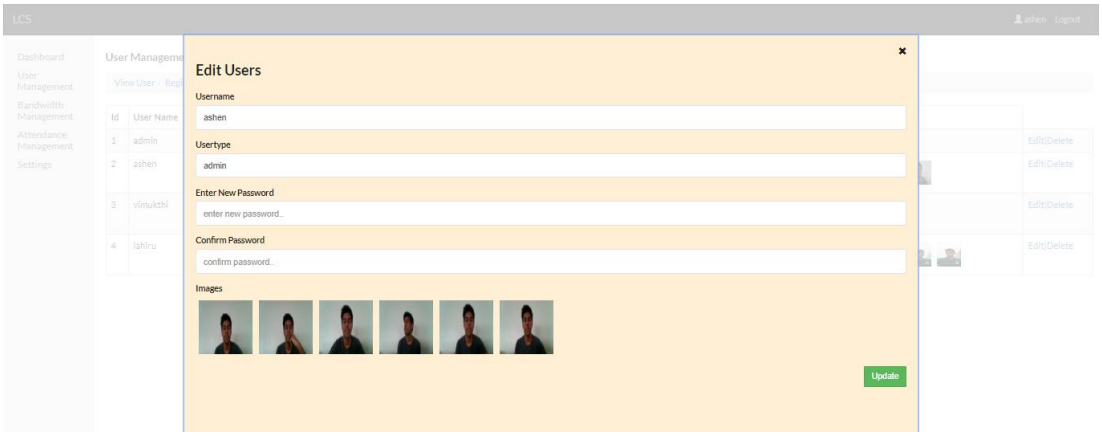

Figure 11 : Edit User Interface

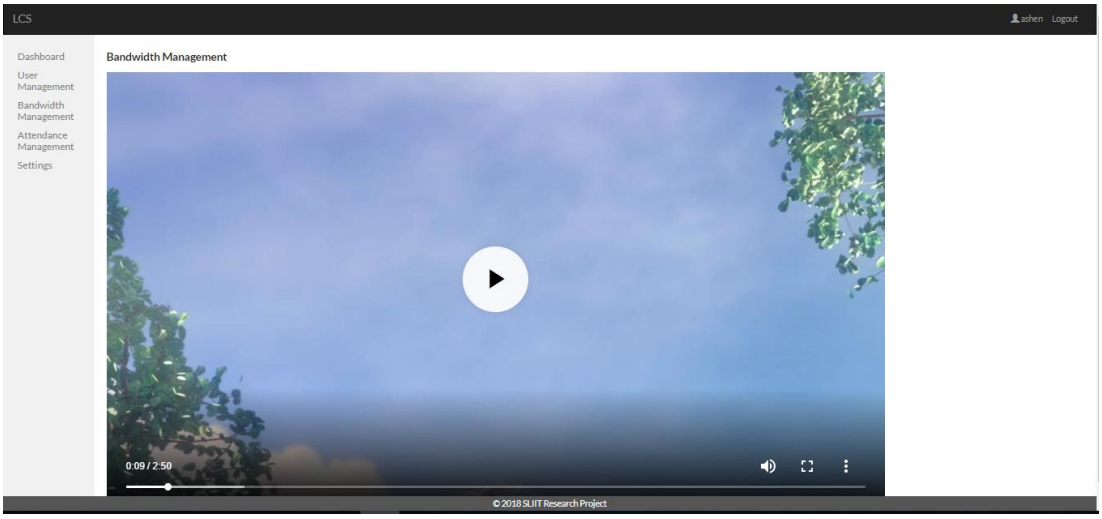

Figure 12 : Bandwidth Managment Interface

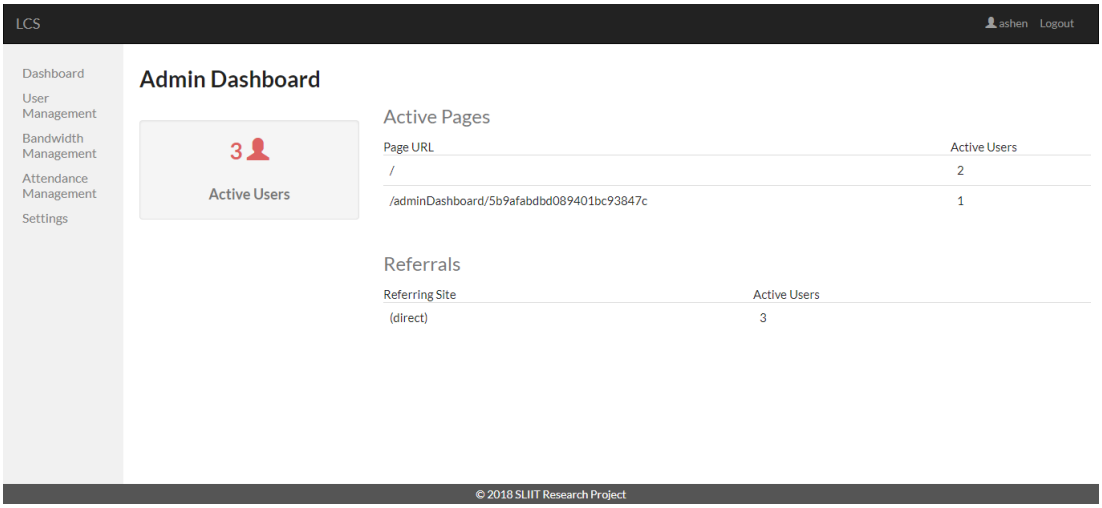

Figure 13 : Dashboard Statistics Interface

2.1.2 Hardware Interfaces

- Personal Computer or Laptop with Minimum configuration of 500GB Hard Drive and 8 GB of RAM.
- 4G Router/ADSL connection to facilitate internet connection.
- In build Web Camera on laptops to authenticate remote users.
- IP Camera to capture live audience to mark attendance.

2.1.3 Software Interfaces

- MongoDB
  MongoDB is used as the database management system. It will be used regularly for major operations of the system.

- Visual Studio Code
  Visual Studio Code will be used as the IDE for designing and implementing the face recognition functions in the LCS system.

- Web Browser
  Latest version of Google Chrome or Mozilla Firefox to access the web-application.

2.1.4 Security

User access to the system has to be controlled so that only authorized users can gain access to the university's content and resources.

- Users have to be authenticated by their valid username and password to access the web application.
- Passwords must be hashed before storing them in the database instead of plain text so that no unauthorized persons can access another user's account.
- User authorization verifies that users have access to information depending on their access roles/rights (e.g. Students cannot access resource materials of lecturers).
- Biometric authentication in the form of facial recognition would be used to identify remotely logged in students to the system. This further ensures that the university's resources are not exposed to unauthorized persons.

2.2 Research findings

In face recognition function, converting the RGB images to gray scale or normalizing the images will increase the accuracy of the face detection and recognition processes. Suppose a user contains 12 face images which is trained and not in gray scale, the face detection algorithm will detect 40% from all the images. If the images are in gray scale or normalized, the detecting percentage is higher than 90%.

For face detection and recognition, Haar Cascade classifier is the better choice when compared and tested with LBP classifier in terms of accuracy. EigenFaces algorithm was also tested in face detection and recognition functions, However, EigenFaces algorithm considers illumination as an important feature. In consequence, lights and shadows are picked up by EigenFaces, which classifies them as representing a 'face'. Therefore, EigenFaces algorithm is not suitable for face recognition functions available in the LCS system when false predictions, lighting conditions and security standards are considered.

2.3 Testing

2.3.1 Testing Plan

The testing planning includes planning for several functions like

- Face Login
- Unknown face login effort
- Credential Based Login
- Attendance Marking
- Filter Attendance of a student
- User Registration

2.4.2 Testing Methods

Considering the scope of the project and the time limitations, we will be performing following tests.

a) Unit Test – This test verifies the program logic and is based on the knowledge of the program structure.

b) Integration Test– This test verifies the entire system's functionality according to the design specification.

c) Business Requirements This test verifies whether specific requirements of the customer are met.

d) Acceptance Testing This test verifies whether the system needs to meet the initial objectives and customer's expectations.

2.4.3 Test Cases

Table 9 : Test Case – Face Login

Id	TC01
Title	Face Login
Prerequisite	Server started User registered (Registration includes user's face data prepared and trained by the recognizer) in the system
Test Action	1. Start LCS application 2. Click the face login button
Expected Result	User will get automatically logged in to the application.

Table 10 : Test Case - Unknown Face Login Effort

Id	TC02
Title	Unknown Face Login Effort
Prerequisite	Server started User not registered in the system
Test Action	1. Start LCS application 2. Click the face login button
Expected Result	User will not be logged in to system and the user will get an error warning below the face login button.

Table 11 : Test Case - Credential Based Login

Id	TC03
Title	Credential Based Login
Prerequisite	Server started User registered in the system
Test Action	1. Start LCS application 2. Enter the username and password 3. Click the login button
Expected Result	User will get logged in to the application.

Table 12 : Test Case - Attendance Marking

Id	TC04
Title	Attendance Marking
Prerequisite	Server started User registered in the system. Students available in the class room.
Test Action	1. Start LCS application 2. Login to the application by face login or normal credential based login. 3. Navigate to Attendance Management Page by clicking the 'Attendance Management' tab in the navigation panel. 4. Click the 'Mark Attendance' button to mark the attendance of all students
Expected Result	The students who are registered and recognized by the application will be marked as 'Present' and the result will be immediately saved in the database and will be available in the attendance filtering table.

Table 13 : Test Case - Filter attendance of a student

Id	TC05
Title	Filter Attendance of a student
Prerequisite	Server started User registered in the system.
Test Action	1. Start LCS application 2. Login to the application by face login or normal credential based login. 3. Navigate to Attendance Management Page by clicking the 'Attendance Management' tab on the navigation panel.

	4. Enter the name, date, or time of a student in the filtering text boxes available in the table.
Expected Result	The related record will be filtered out and displayed to the user.

Table 14 : Test Case – User Registration

Id	TC06
Title	User Registration
Prerequisite	Server started User registered in the system.
Test Action	1. Start LCS application 2. Login to the application by face login or normal credential based login using admin credentials. 3. Navigate to User Management Page by clicking the 'User Management' tab in the navigation panel. 4. Click the 'Register User' link available in the tab. 5. Enter the username, password, select the user type from the dropdown and select the related face photos of the user and upload to the page by clicking the 'plus icon' in the registration form. 6. Click the 'Submit' button
Expected Result	A success message will be displayed to the user if the registration is successful, if not an error message will be displayed.

3. RESULT AND DISCUSSION

3.1 Results

Accuracy has been calculated by testing 30 faces for each user and accurate recognition rates are mentioned in the table below where rates are derived using the formula:

Accuracy % = 100 - Confidence Index

The confidence index will return zero if it will be considered a perfect match in detection or recognition. If not an 'unknown' label is put on the face.

Average	LBP classifier	Haar classifier
Accuracy of recognition	60%	90%
Processing time for encoding and training a user with 30 face images (in seconds)	1.8min	2.1min

Testing with different face datasets from 50 – 100 range when training images. A laptop with i7, 8th generation and 8GB RAM is used to obtain the below result.

Images per user	LBP Classifier	Haar Classifier
50 Images	2.5min	4min
80 Images	3.1min	5min
100 Images	3.9min	6.9min

Accuracy rate when input devices were switched between Webcam and IP-Camera.

Device	Accuracy
Webcam	Totally depends on the predefined resolution and fps on the camera.
IP Camera	Totally depends on the predefined resolution and fps on the camera.

Accuracy rate with training dataset containing with and without blur images.

Type of Image	Accuracy
With Blur Images	15%
Without Blur Images	80%

Amount of main memory which is used to execute the algorithm is defined as memory used and given in MB.

Algorithm	LBP Algorithm	Haar-Like Algorithm
Memory Used	123MB	290MB

3.2 Discussion

In terms of face recognition based login, the LBP classifier reported an accuracy level of 70.33% for a particular user in terms of face detection by maintaining a shorter training time. In contrast with the Haar classifier which reported 81.05% for a user and took a longer training time, LPB classifier has underperformed Haar classifier when detecting faces. Since the lecture capturing system face recognition-based login should be fast and should maintain a higher accuracy level greater than 80%, Haar classifier is the ideal solution which is used currently in the lecture capturing system. However, the results are derived by allocating 30 medium quality training images captured from a webcam for each user. Therefore, the results reported by the classifiers were not satisfactory and the accuracy can change if each user is allocated more high-quality images for training.

Comparison between Haar Classifier and LBP Classifier

1. LBP Classifier is faster than Haar classifier.
2. Haar classifier uses floats to do all the calculations while LBP classifier use integers.
3. LBP classifier is less accurate than Haar classifier.
4. Haar-like features in the Haar Cascade classifier work best for frontal face detection.
5. Haar features are good at detecting edges and lines which is effective in face detection.

4. CONCLUSION

This report examines an innovative approach that is best suited to develop a lecture capturing system that provides a complete classroom experience and much more to remotely logged in students. This system stands itself unique from other existing products and being as a comprehensive product that includes biometric authentication, gesture detection, live streaming of lectures, automated attendance marking, offline recording of lectures, bandwidth management and desktop screen capturing all in one.

This research work has been developed mainly for addressing the problems in Sri Lankan universities, specifically addressing the lack of interactivity between the lecturer and the students. Even though this research focuses on universities, it definitely has the potential to be used in other fields such as business conferencing. In next stage, in one hand, research team will be focusing on improving the accuracy of the face recognition and gesture detection models by testing other algorithms effectively. Furthermore, research team will focus on minimizing bandwidth costs by testing out bandwidth optimization techniques. It is hoped that for any person who expects to build a similar system or any other real-time system, results of this research will be an aid and will provide insight on the performance, accuracy and reliability level that can be expected with the combination of tools, technologies, programming approach considered in this paper.

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