ÇANKAYA UNIVERSITY
FACULTY OF ENGINEERING
COMPUTER ENGINEERING DEPARTMENT

Project Report

Version 1.0

CENG 407

Innovative System Design and Development I

P2017-16

Curious Cam for Video Lecture Recording Environment

Bahar ŞENGEZ

201511407

Elifnur ALTUNTAŞ

201311003

Alihan Doğuş YALÇIN

201611411

Advisor: Asist. Prof. Dr. *Abdül Kadir GÖRÜR*

Table of Contents

Abstract

Nowadays the use and importance of e-learning continue to increase, and it is well-known fact that one of the important components of e-learning is video lectures With video lectures students can view and study the instructor’s lectures as often as they wish until they understand the material. Therefore preparation of video lecture became an important issue. In its simplest form, the preparation of the video lesson requires a camera and a writing board. In order to increase the quality of video and to bring the traditional classroom environment to the video course environment, cameraman who will follow the lecturer movements is required. For some people, the presence of the cameraman can lead to stress and may degrade their teaching performance. In this respect design and implementation of a camera platform that mimics cameraman shooting techniques such as following the instructor movements will provide a more comfortable environment for video lecture recording. Therefore with this project, a microcontroller that will control camera platform using stepper/servo motors by continuously receiving inputs from motion sensors, and sound sensors is aimed to provide video lecture environment. Additionally, image processing subsystem for face recognition will also be integrated in order to let the camera to follow the instructor in case of more than one person in the shooting environment. In this paper, similarities and differences of similar works with such ideas are investigated with the projects of the past years.

Keywords:

E-learning, video recording, image processing, video processing, audio processing, Video processing, learning and teaching platforms, Raspberry-Pi in image processing.

Özet:

Günümüzde e-öğrenmenin kullanımı ve önemi artmaya devam etmektedir ve e-öğrenmenin önemli bileşenlerinden birinin video konferans olması iyi bilinmektedir. Video konferanslarla öğrenciler, öğretim görevlisinin derslerini istedikleri sıklıkta görüntüleyebilir ve inceleyebilirler. Onlar malzemeyi anlıyorlar. Bu nedenle video konferansının hazırlanması önemli bir konudur. En basit biçiminde, video dersinin hazırlanması için bir kamera ve yazı tahtası gerekir. Videonun kalitesini arttırmak ve geleneksel sınıf ortamını video kursu ortamına getirmek için öğretim görevlisinin hareketlerini izleyecek kameraman gerekiyor. Bazı insanlar için kameraman varlığı strese neden olabilir ve öğretme performansını düşürebilir. Bu bağlamda, eğitmen hareketlerini izlemek gibi kameraman çekim tekniklerini taklit eden bir kamera platformunun tasarımı ve uygulanması, video konferans kaydı için daha rahat bir ortam sağlayacaktır. Bu nedenle, bu proje ile hareket sensörlerinden ve ses sensörlerinden sürekli girdiler alarak step / servo motorları kullanarak kamera platformunu kontrol edecek bir mikro denetleyici, video konferans ortamı sağlamayı amaçlamaktadır. Buna ek olarak, yüz tanıma için görüntü işleme alt sistemi de çekim ortamında birden fazla kişinin olması durumunda kameranın eğiticiyi takip etmesini sağlamak için entegre edilecek.

Anahtar Kelimeler:

Elekronik öğrenme, video kayıt sistemi, görüntü işleme, video işleme, ses işleme, görüntü işlemede Rasperry-Pi kullanımı, öğrenme ve öğretme platformları.

1. Introduction

1.1 Motivation

We are a group of senior students in computer engineering department who are interested in hardware and innovative tools. Inspired by the Microprocessors course we were taking this semester, we decided to do the camera tracking system project we carried out in our senior project. Before graduation, we wanted to add a hardware project to our CVs.

First of all, what kind of camera do we want, what features we should have, and what type of equipment should we use, what should we use for the software. We searched these questions, read them, and found answers.

1.2 Problem Statement

Nowadays, many advanced universities have started to transfer their courses online as PDF Documents or video lectures. Thus, all the lessons given within the class hours can be accessed by people who are interested in the subject from all over the world. In addition, anyone who has missed the lesson or wishes to repeat the lessons learned during the lesson hours can easily access this information. However, according to recent researches, visual learning is more understandable on people, easier to follow and more intelligent is a more effective learning method. For this reason, people who want to follow classes prefer video lectures. As these people follow the video lectures, they need to focus on the lectures and have a cameraman to record the movements of the trainer and the environment in order to feel like pretend to.

Some instructors and students may be distracted by the presence of the cameraman. The cameraman's movements can prevent facial expressions and students from focusing on the lesson. For this reason, the interest and motivation of the instructors and the students may decrease. This is definitely not a wanted case. Today, the most important element of electronic learning is video lecture. In the solution statement section of this document, this probing solution proposal is produced.

1.3 Related Work

Curious Cam is a complex system that preforms three complex tasks: remote or automatic camera pointing, user tracking and video recording. According to our research, there are similar systems in the market, called Auto Trackers, for instance 1 Beyond Auto Tracker™ [10] (see Figure 1 and 2).

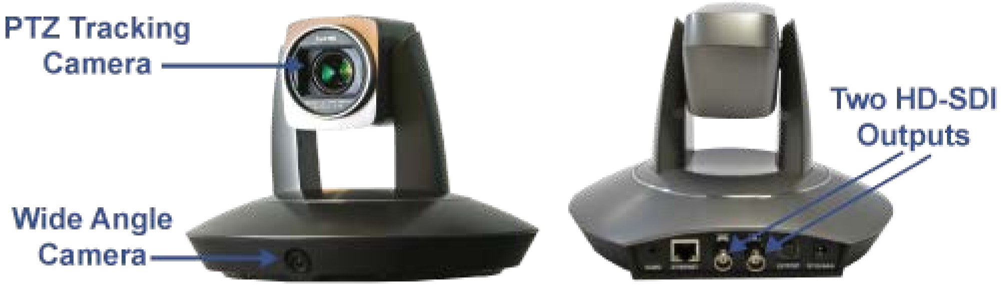


Figure 1) '1 Beyond Auto Tracker' - HD Automated Tracking Camera

Auto Trackers are similar systems and establish the standards or ideal features of Curious Cam. Those also uses image recognition and motion detection to find and track the subject. But, different from Curious Cam, most do the tracking in the camera itself and no needs extra. But, Auto Trackers use mostly a PZT (pan, zoom, tilt) [11] camera, as ready to use remotely controllable camera. In our project we will produce the necessary platform that can be used by any platform. There are also scientific studies for automatic lecture video recording [14].

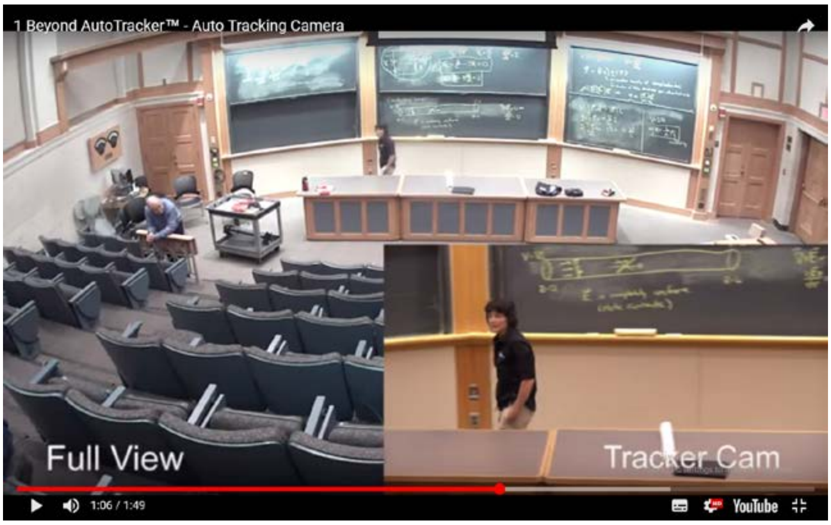


Figure 2) view from a lecture video recorded by 1 Beyond Auto Tracker.

Among the features of Curious Cam, Video Recording is more common. There is many software available on the market, from simple to complex, capable of recording video from a camera plugged in a computer and suitable to lecture recording. Screen capturing software is also a popular but not the concern of Curious Cam.

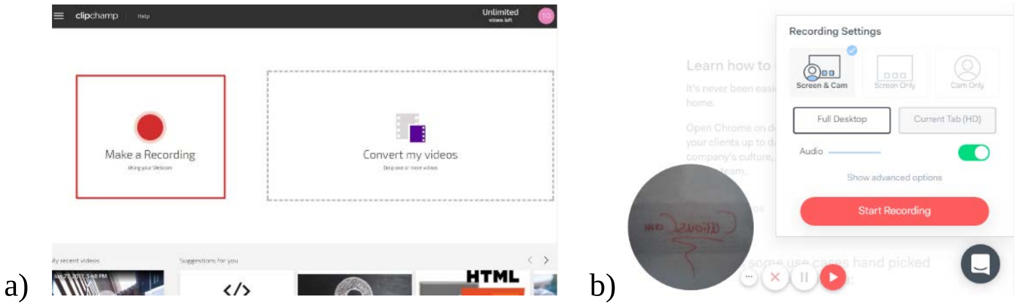


Figure 3) Screen captures of video recording software

a) Clip champ Online Webcam Video Recorder

b) Loom Video Recorder Chrome Plugin

The features of video recording software provide many insights to our project’s video recording capabilities and user interface. Even online recording systems, for instance Clip Champ Online Webcam Video Recorder, [1] and chrome plugins are available, for instance Loom Chrome Plugin [2] (see Figure 3).

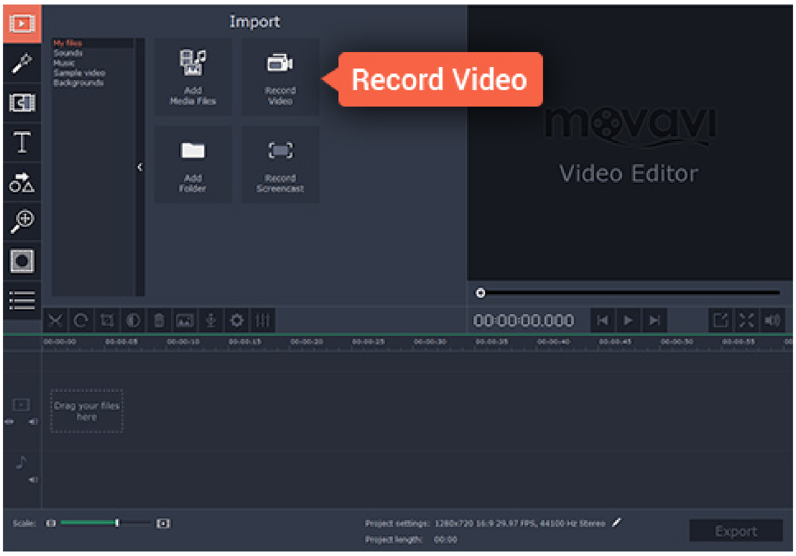
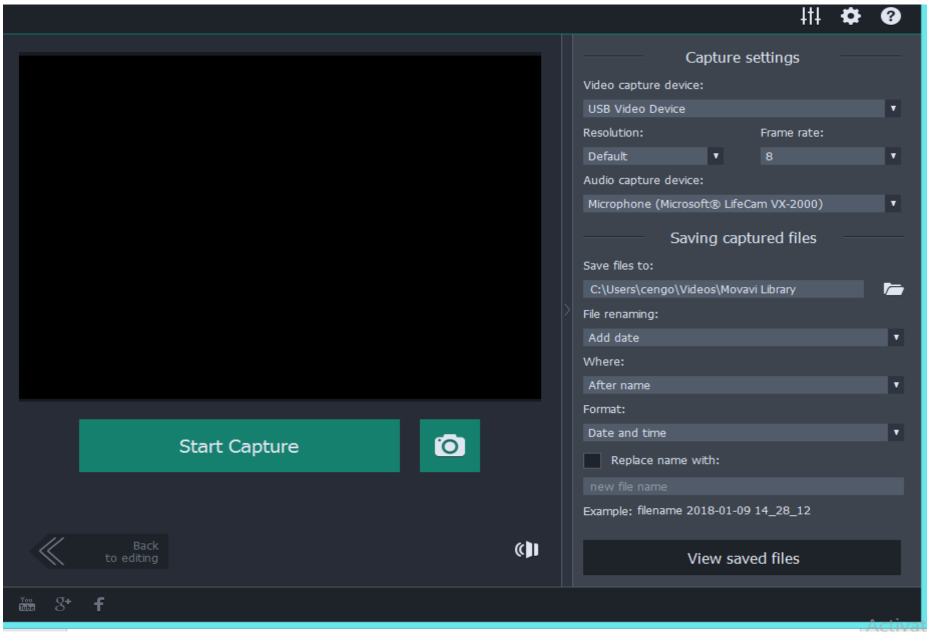


Figure 4) Main window of Movavi

A more professional software to record video using a web cam is Movavi [3] (see figure 4). It provides functionalities to user customizing video and mainly bases out project in terms of video recording features. As shown in Figure 5, the user can start and stop video recording and do settings from selection of video source to save directory.



Capture settings

Video capture device: USB Video Device

Resolution: Default

Frame rate: 8

Audio capture device: Microphone (Microsoft® LifeCam VX-2000)

Saving captured files

Save files to: C:\Users\cengo\Videos\Movavi Library

File renaming: Add date

Where: After name

Format: Date and time

□ Replace name with: new file name

Example: filename 2018-01-09 14_28_12

Figure 5) Video Recording windows of Movavi

Curious Cam’s, perhaps, the most interesting part is the platform to control camera orientation or point, remotely or automatically. For the platform, we have a Raspberry Pie [4] based electronic platform using step motors, in which we discuss it in the literature search section. When it comes to currently available products that has the capability, one can find motorized tripods in the markets [7, 8]. Those products allow users to manually control the camera mounted on them remotely by the user, like Curious Cam (see Figure 6.a).

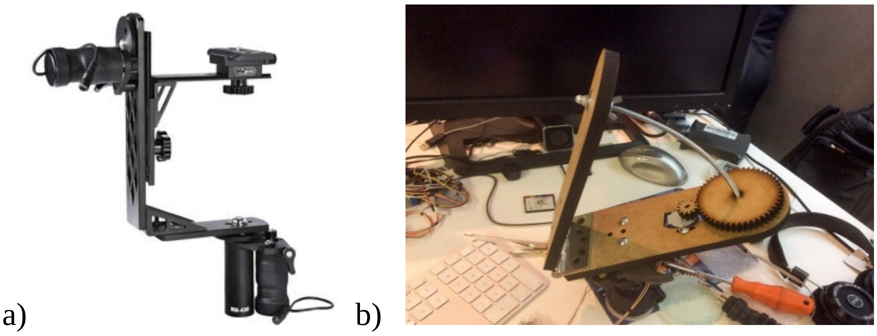


Figure 6) Camera Orientation Controllers

a) Vidpro Motorized Pan & Tilt Gimbal Head

b) Astro Tracker

Additionally, amateur works as in [6, 9] also provides our project with technical insights (See figure 4.b). In [6], an Astro Tracker is implemented using Arduino and step motors. An Astro Tracker is a device that is used to compensate rotation of the sky of stars in long-exposures. The system change camera rotation accordingly.

The third main feature of the Curious Cam is user or human tracking in space. This part provides Camera Controller with the information of user's position to let the controller adjust camera orientation accordingly. User tracking is used in many systems from security surveillance [12] to web cam applications for entertainment [13]. More than a standalone product, it's mostly a scientific [5] and technical issue that we discuss in the literature review.

1.4 Solution Statement

In this section, we will share our solutions to the problems that are mentioned in section of Problem Statement. The design and implementation of a camera platform that simulates cameraman shooting techniques, such as tracking instructor movements, will provide a more comfortable environment for video lecture recording, as the presence of a cameraman in the classroom can interfere with the trainer's and students' focus. Thus, while taking the record, there will be no element to distract the instructor and students throughout the lesson. Thanks to this camera, the interest and motivation of the trainer and the student will not decrease during the lesson. For this reason, this project will create an autonomous cameraman system that records video by continuously receiving input from motion sensors and sound sensors. If there are more than one person on the stage outside the instructor, there will be no confusion with the face recognition technology that the camera has.

2. Literature Search

2.1 Video Recording in E-Learning

Technology is constantly evolving according to today's conditions and needs. Today, we use many areas of technology. Examples are health, education, communication, transportation. As shown in the example, from the time children start school age, education and technology are progressing together. When technology and training words combine, the e-learning term becomes inevitable. E-learning; web-based education, learning and information management activities carried out via internet technologies. E-learning is contemporary, colorful, fun, there is no time and space limitations, its results are measurable, interactive, and efficient. As it has been shown in [1] with e-learning, the lives of institutions and employees are becoming easier. It facilitates the internal education processes of the institutions and supports the dynamic institutional culture. Trainings can be accessed from anywhere, only via internet connection, does not require a physical environment. E-learning technology has many materials. Trainings can be accessed from anywhere, only via internet connection, does not require a physical environment. There is no obligation to train at a certain time. It removes the necessity for the educator and the employees to be in the same environment and at the same time. It provides employees with an alternative education that can arrange the time and the space. Employees can access the course / training / topic content repeatedly whenever they want.

Every day new qualities are added to the qualities of qualified human power that the age needs. For this reason, learning becomes a lifelong necessity and becomes an indispensable part of our daily life. As knowledge and learning gain importance, questions about how information is presented and how the learners are adapted also begins to gain importance. While technological innovations continue to do so without slowing down, e-learning solutions are also becoming more diverse. These approaches are; computer based education, internet based education; synchronous training, mobile learning; from mixed education to social learning. E-learning has many materials. [3] These are videos, support materials, social learning, and virtual classes.

With the development of technological facilities and the impact of social media, which is growing at an incredible rate, videos that are becoming increasingly easier to produce, shares, and access, have begun to take an important place in our lives. In video sharing sites, news and information portals, mobile communication tools, billions of videos are watched throughout the day. Such vastly demanding and interesting videos are indispensable in the field of e-learning, as it makes information easier to learn by making it more permanent.

The popularity of the video, which means "I see" in Latin, has increased considerably with the Internet becoming an important part of our daily lives and facilitating access and sharing. The number of videos watched daily on YouTube, the world's largest video sharing site, surpassed 3 billion. Video viewing rates on both YouTube and other video sharing sites are also increasing day by day. In fact, it is estimated that in the coming years, 60 percent of the data on the internet will generate videos. As a result of this huge demand for video, the use of video is essential for almost every topic in the news and information portals. According to research, learning by watching video is a more memorable method because it appeals to human brain both visually and visually. The videos not only make learning permanent, but they also provide great convenience in understanding complex information. Using a picture and plain text, it is possible to express a sentence in 10 minutes or so with a 20 second video in a much easier and more effective way. The combination of both visual and auditory elements in videos allows for a fun storytelling that allows key messages to be presented in an entertaining way, minimizing motivation and focus problems. Even when the videos are watched again, they can show the same effect.

2.2 Video Mechanics in Video Lecture Literature

Video lectures are attainable for the ordinary non IT lecturer’s usage. When using a computer, lecturer can generate it very swiftly and effortless. Video lectures are not recordings of classroom lectures; they are more like cover lecture material while screen demonstrates of content files with additional of audio narrative. Video lectures can be produced before the semester starts and they can add additional ones if some students have hard time understanding the topic of the lecturer told them.

Video lectures are Windows Media video files created using Microsoft Producer as encoding software and Microsoft Office files for topic content. This encoding software consists of capturing data from classroom lecture materials and audio from microphone which is connected to the computer. This can be produce in the lecturer’s home or office without any exclusive set up. Video lectures are not just a technologically sophisticated lecture notes.

Rather than that, they capture whole of it lecturer quality instruction for all of the topics from beginning to end in the course.

In every video, the lecturer navigates to displaying the topic content file and conveys the audio lecture with the microphone. Chalkboard writing is simulating by the lecturer using of mouse and keyboard pointing the mouse for highlight and write comments on the screen [8].

2.3 Object Detection and Tracking

Object tracking systems is an essential topic when one is interested in shooting videos without a human cameraman. The need for automated tracking comes in handy especially in the making of e-learning lecture videos, when the lecturer is not comfortable with the presence of another human in the video shooting environment. Therefore, we made a survey on the literature relating to Object Tracking Systems to be used in e-learning video lectures. In this paper we aim to summarize our findings in an organized way. We tried to research many different object tracking systems techniques that have been published. Our starting point and major guide line was Google scholar site.

2.3.1 Main Findings

In the simplest form, tracking can be defined as the problem of estimating the trajectory of an object in the image plane as it moves around a scene. There are many different techniques in this field, but our survey showed us that the below techniques are the major ones.

2.3.2 Color Tracking

Rasmussen, Toyama and Hager state in their 1994 publication that the quickest and easiest method to track an object is based on its color[1]. If an object and its background have significant difference, then its relatively easy to detect and track this object. This basic technique can be successfully applied to tasks such as head and hand tracking. The authors state that their technique also works well for tracking faces in many indoor lighting situations, both from fixed and mobile camera platforms.

2.3.3 Face Recognition

Matthew Turk and Alex Pentland, have developed a near-real-time computer system that can locate and track a subject’s head, and then recognize the person by comparing characteristics of the face to those of known individuals. [2] The system functions by projecting face images onto a feature space that spans the significant variations among known face images. The noteworthy features are known as "eigenfaces," because they are the eigenvectors (principal components) of the set of faces; they do not necessarily correspond to features such as eyes, ears, and noses. Some particular advantages of this approach are that it provides for the ability to learn and later recognize new faces in an unsupervised manner, and that it is easy to implement using a neural network 'architecture.

2.3.4 Contour Tracking Method

J. Denzler, H. Niemann have developed a two-stage real time object tracking system[3]. In the first stage, the moving object is detected, and the active contour is initialized. In the second stage, the object is tracked by active contour models. The parameters of the camera and the frame grabbing device are continuously updated in such a way, that the moving object will always be kept in the center of the image.

2.3.5 Kernel-Based Object Tracking

This is another technique and is developed by Comaniciu, Ramesh and Meer [4]. It is based on an algorithm related with an isotropic kernel. Kernel is object’s shape and appearance and objects are tracked by computing the motion (parametric transformation such as translation, rotation, and affine) of the kernel in consecutive frames.

2.3.6 Sparsity-Based Collaborative Model

Zhong, Lu and YangRobust propose a robust appearance model that exploits both holistic templates and local representations [5]. They have developed a sparsity-based discriminative classifier (SDC) and a sparsity-based generative model (SGM). Both of these modules are key factors in their algorithm to effectively track objects.

2.3.7 Self-Adaptive Heterogeneous Multi-Core Architecture

In this architecture a real-time capable video object tracking application based on a multithreaded framework for implementing SMC methods on hybrid CPU/FPGA platforms have been introduced [6]. This algorithm can be treated as an extension to the Sequential Monte Carlo system.

2.3.8 Active Contours

Allili and Ziou have developed an effective way to track objects especially in color. [7] Their algorithm is making use of Kullback–Leibler divergence.

2.4 Conclusion

There are many techniques available regarding the object tracking systems. However, some of them are way too complex for our purpose of using them in e-learning video lectures. Most of them are very complicated and it is not easy to compare their advantages and disadvantages. Below are the major complexities in tracking objects:

- Noise in images
- Complex object shapes / motion
- Scene illumination changes

Since the video lectures will be shot in a controllable environment, it is under our control not to face these complexities. We are unlikely to suffer noisy images, complex motions and bad lightning. Thus, some of the surveyed algorithms we will definitely not need. So, our conclusion is that, algorithms like Sparsity-based Collaborative Model, Self-adaptive heterogeneous multi-core architecture and Active contours seem to be over complex. Thus, we need a simple and most common used algorithm, such as color tracking or face recognition.

2.5 Embedded System

Today, smart devices are beginning to be used by everyone. Cellular phones, computers now only store information to us instead of communicating. The devices in the environment were now completely designed with electronic circuits. We can say there are computers in all of these devices. In other words, there are embedded computers. Embedded systems refer to the entirety of electronic hardware and software contained within any system that gives the system "intelligence". The software referred to here is, unlike general purpose software in our computer, software that indirectly interacts with the user, but usually performs a single task. Software and hardware work together in embedded systems. In this sense, we can say that there is a multi-disciplinary structure.

The design requirements for embedded systems are:

- ► Operation Power
- ► Memory
- ► Development Cost
- ► Unit Production volume
- ► Expected life span
- ► Reliability

Two types of cards have been developed to work with embedded systems. These are Arduino and Raspberry Pi. Raspberry Pi is a mini computer with a credit card size, which is usually used in the Linux operating system and is programmed in Python language and used by ARM microprocessors. Arduino is a platform where ARM microcontrollers are used, various sensors can be read, motor or any movement can be controlled. Arduino offers an easier experience to use and programming than Raspberry Pi. As the description shows in [23] Raspberry Pi is more advantageous because of its features like superior image processing and image processing unit.

3. Software Requirements Specification

3.1 Introduction

3.1.1 Purpose

The purpose of this document is to explain the camera system we have designed. This ccamera system, without the need for any cameraman, speaker's attention is conceived in order to distribute, creates a more comfortable environment by following the movements of the instructor. This document includes detailed information about requirements of the project. It reflects the defined constraints and recommended software functions. What's more, the SRS document explains how the user interacts with the camera. This document explains how concerns of the stakeholders are met.

3.1.2 Scope of Project

Today, the use and prominence of e-learning continues to increase and it is well known that one of the key components of e-learning is video conferencing. With video conferences, students can view and review the lectures of instructors as often as they desire. They understand the material. For this reason, preparing the video conference is an important issue. In its simplest form, a video and a writing board are required to prepare the video lesson. In order to improve the quality of the video and bring the traditional classroom environment to the video course environment, the cameraman will follow the movements of the instructor.

For some people the cameraman may cause the presence of stress and decrease the teaching performance. In this regard, the design and implementation of a camera platform that mimics the camcorder's shooting techniques will provide a more comfortable environment for video conferencing recording, such as tracking the trainer's movements.

The camera was designed to detect only one instructor on stage. This camera will be tracked and recorded by the camera as long as s/he is on stage.

For this reason, this project aims to provide a microcontroller, video conferencing environment that will control the camera platform using step / servo motors by continuously receiving inputs from motion sensors and sound sensors. In addition, the image processing subsystem for face recognition will be integrated to allow the camera to follow the trainer in case of multiple people in the shooting environment.

3.1.3 Glossary

TERM	**DEFINITION**
Participant	**The user who interacts with the camera environment. Trainers, speakers, private companies.**
Stakeholders	**Any person who has contribution in the project.**

3.1.4 Overview of Document

The second part of the document describes functionalities of the Curious Cam for Video Lecture Recording Environment, informal requirements are described and it is a context for technical requirement specification in the Requirement Specification chapter. Requirement Specification chapter is written for software developers and details of the functionality of the camera are described in technical terms. In addition hardware tools are explained. Both of the sections describe the functionalities of the same product.

3.1.5 Overall Description

Video Conferencing Enrollment Enthusiast Camera is a hardware project that will take trainer and video recordings in environments such as conference, distance learning or e-learning platforms.

3.1.6 Development Methodology

For developing the project, we have planned to use incremental and iterative method. Embedded systems are complex systems, as mentioned in [4]. It requires a team work. This was important to us because we identified the materials to be picked up at the beginning of the project and prepared a timeline for ourselves. For this reason, it was ensured that everyone in the project group was in control of the project. The obvious goal of a design process is to create a product that does something useful. The obvious goal of a design process is to create a product that does something useful. Typical specifications for a product will include functionality, for instance, this camera, manufacturing cost, performance, power consumption, or other properties. Of course, a design process has several important goals beyond function, performance, and power. Also, this development methodology makes it possible to create quality products at the time of planning.

3.1.7 User Characteristics

3.1.7.1 User

1) S/ He must be the only one on stage.
2) A participant speaker or instructor must be a specialist in the field in another sense.
3) S/ He have a prepared operating manual.

3.1.7.2 Admin

1) She /he should has information about the camera's hardware products.
2) S/ He have a prepared operating manual.

3.2 Requirements Specification

3.2.1 External Interface Requirements

3.2.1.1 User interfaces

The software has a graphical user interface that will be worked on Microsoft Windows Family operating systems.

3.2.1.2 Hardware interfaces

The software requires a webcam for video recording and user tracking. A Raspberry Pi 3 and electric motors (servo and step) are also required to develop camera orientation control mechanism.

In the project, these components, which are listed in below, are planned to use**.**

1. Raspberry Pi 3 Model B
2. Raspberry Pi 3 Camera Module
3. Raspberry Pi Universal Power Supply
4. Servo Motors
5. Pan/Tilt Bracket Kit
6. 5V 1A Power Supply
7. Breadboard
8. Breadboard Power Module
9. Female/Male Jumper Wires
10. Male/Male Jumper Wires

3.2.1.3 Software interfaces

The software (video recorder and user tracker) will work in Windows but the camera orientation controller will basically work on Raspberry Pi. Since these two separate computer systems contact through network, socket programming will be used for data transfer between these two.

3.2.1.4 Communications interfaces

The software uses wired Ethernet connection to ensure the communication between Raspberry Pi and PC.

3.2.2 Functional Requirements

3.2.2.1 Profile Management Use Case

Use Case:

- Update User Information
- Select User Photo
- Remove User Photo
- Capture User Photo from Camera

Diagram:

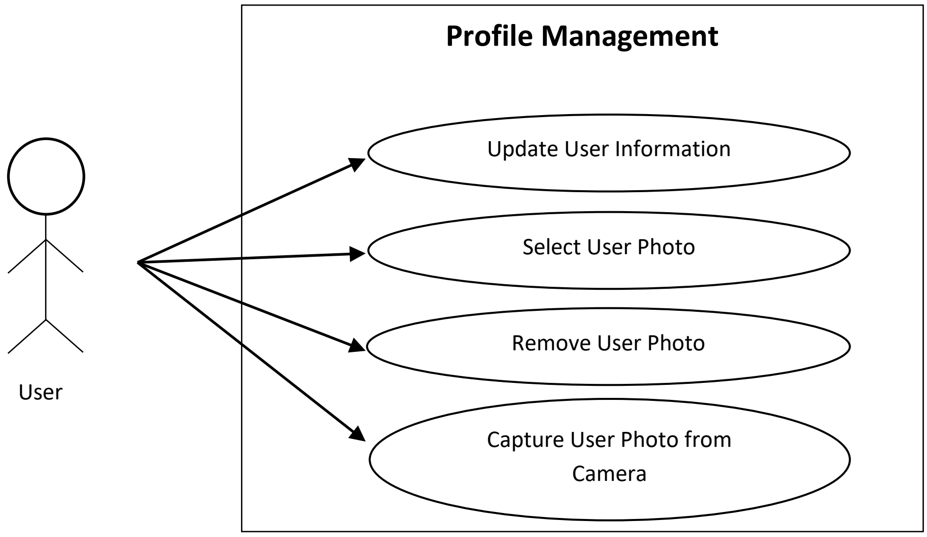


Figure A Profile Management Use Case

Brief Description:

The Profile Management Diagram (Figure A) shows the basic operations related to the management of the user personal information and user authentication. User personal information will be used to set video file properties, including owner, producer and copyright information. User photo is to optionally add on videos, as a small image at a corner of the video frame.

Initial Step by Step Description:

1. The user information fields (name, surname, institution, contact details) will be filled with string “Unknown” by default.
2. The user photo will be a general portrait drawing by default.
3. The user can update personal information.
4. The user can select a photo or any image to be optionally used in video recordings
5. The user can select a photo from a file in the hard drive.
6. The user can capture the photo from camera.

3.2.2.2 *Device Settings Use Case*

Use Case:

- Select camera
- Set Camera Properties
- Test camera
- Select Microphone
- Set Audio Properties
- Test Microphone
- Test Camera Orientation Controller

Diagram:

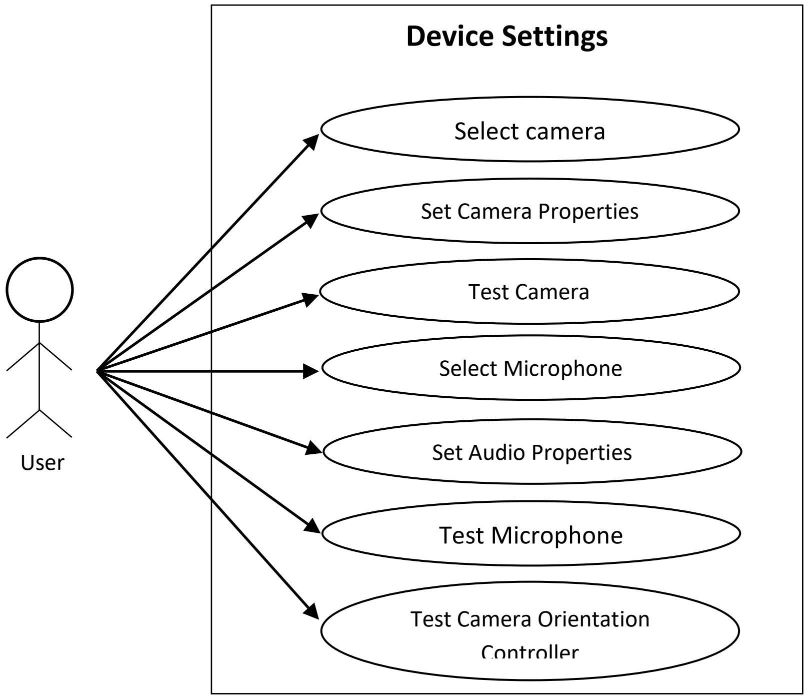


Figure B Device Settings Use Case

Brief Description:

The Device Settings diagram (Figure B) demonstrates the basic operations (selecting, testing and settings) related to the external devices used by the software. If they are already installed, the software will use operating system default camera and microphone. The user can also select any camera or microphone installed on the system. The user can test the selected devices if they work properly. Similarly, the user can test the Camera Orientation Controller.

Initial Step by Step Description:

1. The user can select a video source.
2. When the user presses “Test Camera” button, a preview will be displayed to the user.
3. When the user presses the “Video Properties” button, operating system provided basic video properties window will be shown to the user.
4. The user can select an audio source.
5. If a microphone selected properly, the audio level sensed by if will be shown on the window.
6. When the user presses the “Audio Properties” button, operating system basic audio properties window will be shown to the user.
7. When the user press “Test Camera Orientation Controller” button, the message about the system is shown, including, “Test Successful” or “Test Unsuccessful”.

3.2.2.3 Video Recording Settings Use Case

Use Case:

- Select default video “Save” directory
- Set Video Quality
- Set Audio Quality
- Activate Audio Filtering
- Deactivate Audio Filtering
- Enable User Tacking
- Disable User Tracking
- Enable Manual Camera Orientation
- Disable Manual Camera Orientation
- Set Text on Video
- Remove Text on Video
- Put User Photo on Video
- Remove User Photo from Video

Diagram:

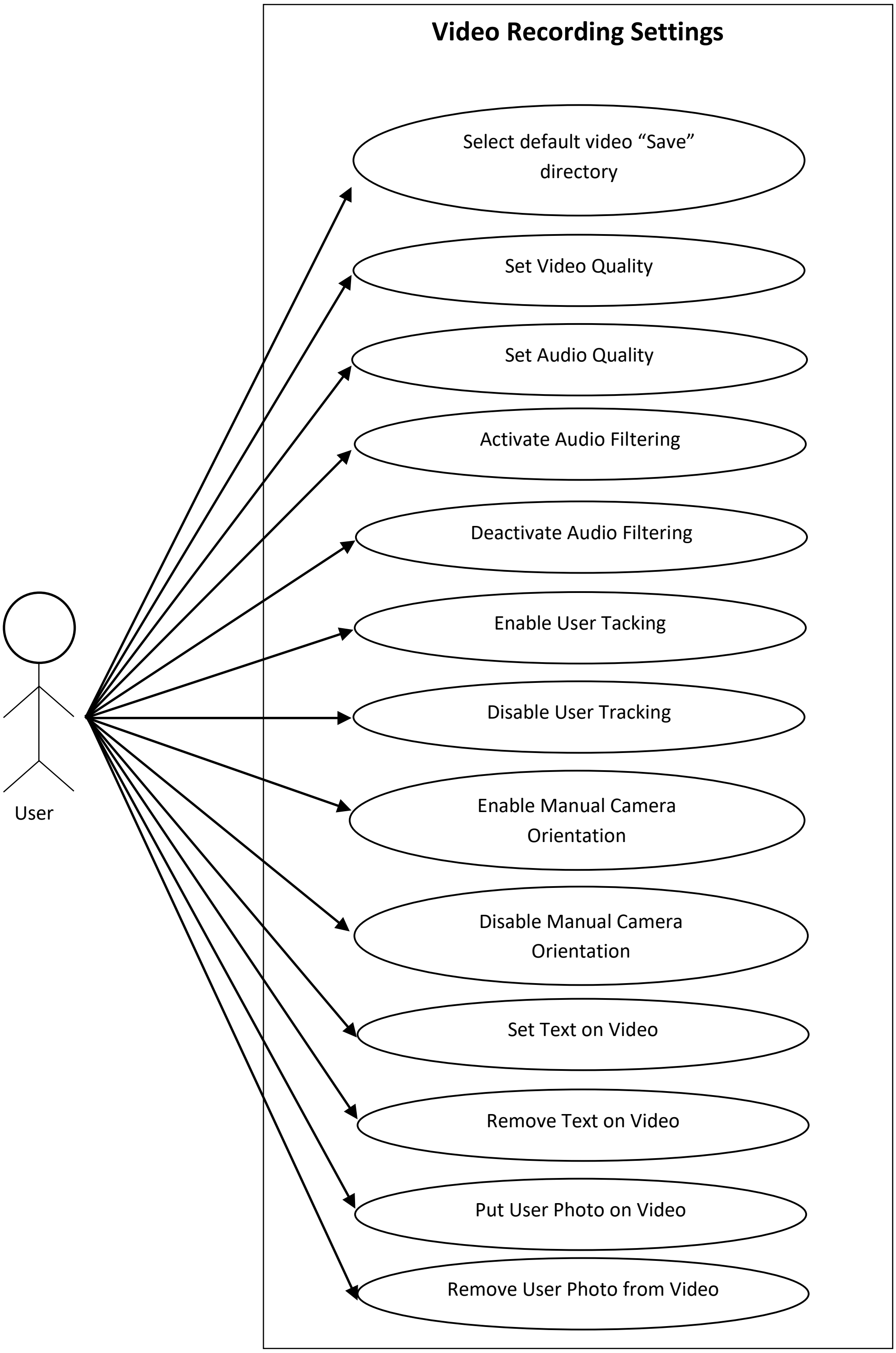


Figure C Video Recording Settings Use Case

Brief Description:

The Video Recording Settings diagram (Figure C) demonstrate the basic operations related to video recording, including video file save location, video quality, audio quality, customizing video output, user tracking and camera orientation. The user can set video quality or resolution and audio quality (mono or stereo). The user can also customize video frame by putting any text, date and time or his or her photo on the frame. The user can start or stop user tracking and activate audio filter to get clearer videos. The user can use manual or automatic camera orientation. In manual mode the user can change the camera orientation using the mouse.

Initial Step by Step Description:

1. The software save video in “C:\videos” folder by default.
2. The user can change “save” directory, by pressing the “Change Directory” button.
3. The user shall select video quality.
    a. The system should record video in various resolutions.
4. The user shall select audio quality.
    a. Video should be recorded mono or stereo.
    b. Video should be recorder in various frequencies.
5. When the user press “Activate Audio Filtering” button, video is recorded by filtering background noise out.
6. When the user press “Deactivate Audio Filtering”, audio filtering is not applied during video recording.
7. When the user press “Enable User Tracking” button, video is recorded by tracking the user.
8. When the user press “Deactivate Use Tracking”, user tracking is deactivated.
9. As the user tracking is activated the camera orientation controller functions automatically.
10. As the user tracking is disabled, the camera orientation controller can still function manually.

    a. When the user presses on “Manual Camera Orientation” button, the controller can be set manually.

b. When the user presses on “Disable Manual Camera Orientation” button, the controller cannot be set manually.

11. Put Text on Video
    a. The user can add date, time or any text on the video frame.
    b. The user can remove the texts from video.
12. When the user press “Put my Photo” button, the user’s photo is put on the video.
13. When the user press “Remove my Photo” button, the user photo is removed from the video.

3.2.2.4 Video Recording Use Case

Use Case:

- Start Recording
- Pause Recording
- Continue Recording
- Stop Recording

Diagram:

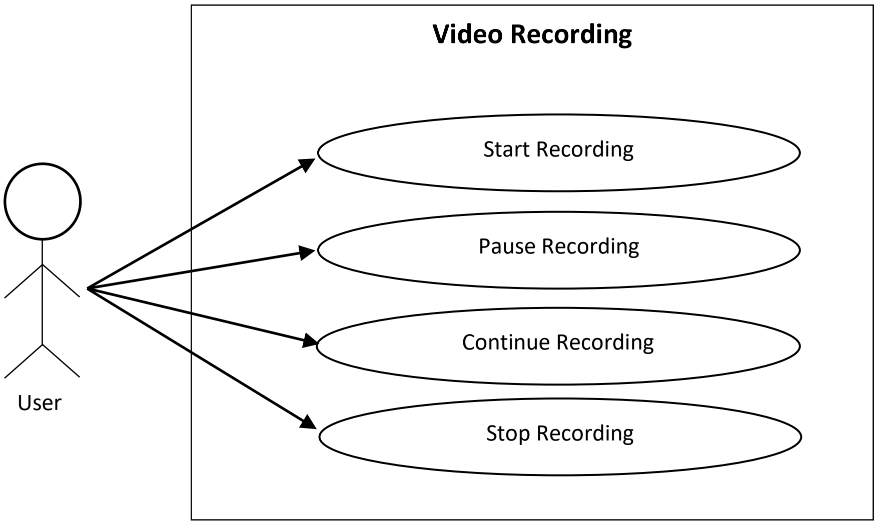


Figure D Video Recording Use Case

Brief Description:

Figure D shows the basic operations of video recording. The user can start, pause, continue and stop video recording. The user does these operation by conventionally pressing buttons and alternatively clapping his or her hands. Recording starts or continue after a 5s count-down.

Initial Step by Step Description:

1. The video files are named automatically named using [user name + sequence no].
2. The sequence no is a time stamp that will be taken from the system.
3. The system shall record video from a webcam.
4. Video recording shall start or continue after 5s countdown with a beep warning.
5. The user can increase the countdown duration.
6. The user can decrease the countdown duration.
7. The user shall start video recording by pressing “Start” button.
8. The user can pause video recording by pressing “Pause” button”.
9. The user can continue video recording by pressing “Continue” button”.
10. The user can stop/end video recording by pressing “Stop” button”.
11. The user can start video recording by clapping hands.
12. The user can pause video recording by clapping hands.
13. The user can continue the video by clapping hands.

3.2.2.5 File Management Use Case

Use Case:

- List Video Files
- Remove Video File
- Rename Video File
- See Video File Properties
- Change Video File Properties

Diagram:

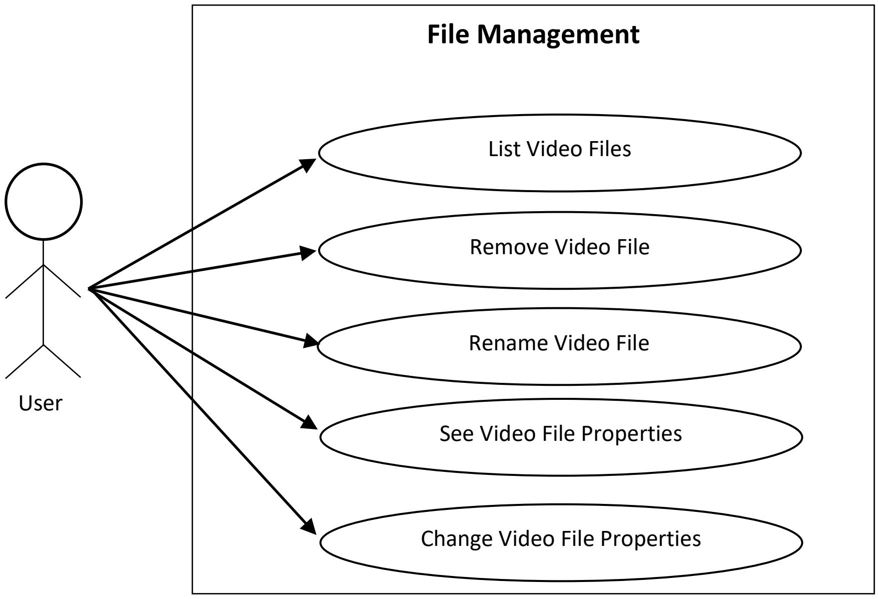


Figure E File Management Use Case

Brief Description:

The Video File Management Use Case (see Figure E) demonstrates operations listing and removing video file generated by the software of existing in the “Save” directory. The user can also see or change the basic information of a video file, including, owner, director, producer, etc.

Initial Step by Step Description:

1. The user can remove previously recorded video files.
2. The user can rename previously recorded video files.
3. The user can see video file properties, including psychical properties and producer, copyright etc.
4. The user can change video file properties.

3.2.2.6 Video Playing Use Case

Use Case:

- Start playing
- Pause playing
- Stop playing
- Fast Forward playing
- Fast Backward playing
- Play video after a selected time
- Toggle full screen

Diagram:

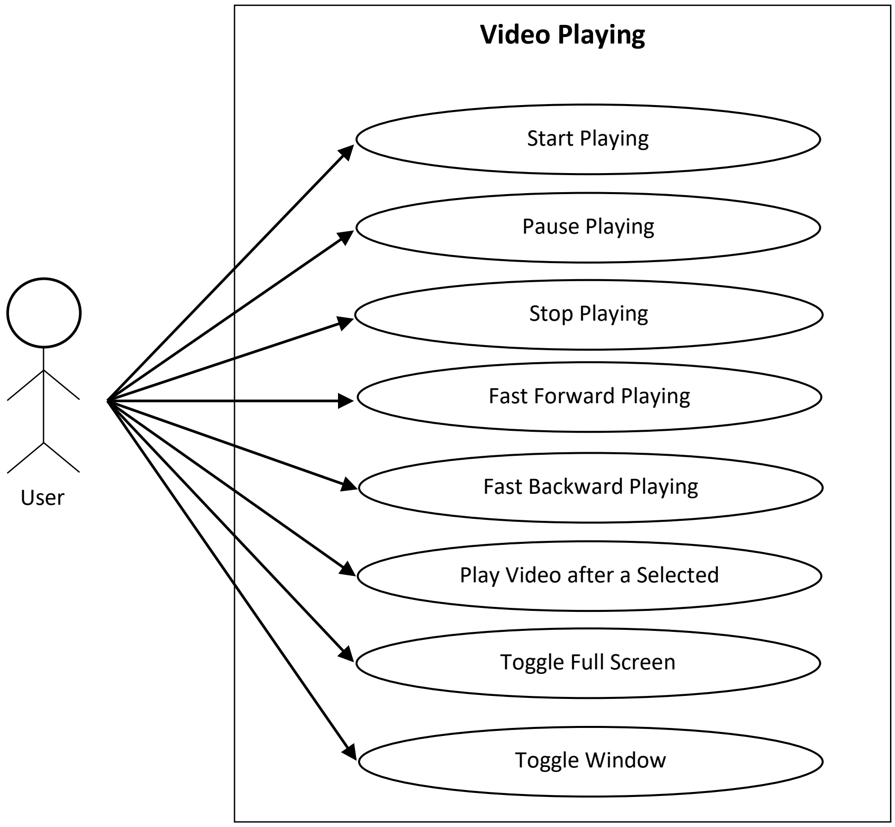


Figure F Video Playing Use Case

Brief Description:

Figure F shows Video Playing Use Case diagram. The diagram demonstrates basic video playing operations.

Initial Step by Step Description:

1. The user shall watch the recorded videos.
2. When the user press “Play” button, the video is played.
3. When the user press “Pause” button, the video is paused.
4. When the user press “Continue” button, the video is continued.
5. When the user press “Stop” button, the video is stopped.
6. When the user press “Fast Forward” button, the video is played faster.
7. When the user press “Fast Backward” button, the video is played faster backward.
8. When the user clicks at location on time slider, the video will be continued to be played after that time point
9. When the user press “Full Screen” button, the video is displayed full screen.
10. When the user press “ESC” at full screen mode, the video is displayed back in the window.

3.2.2.7 Camera Orientation Controller Use Case

Use Case:

- Turn Camera Left
- Turn Camera Right
- Increase Turning Step Length
- Decrease Turning Step Length
- Reset Camera Position

<u>Diagram:</u>

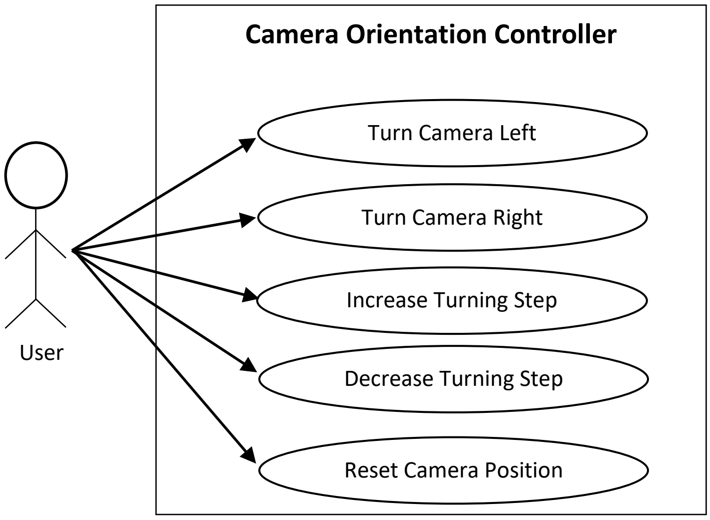


Figure G Camera Orientation Controller Use Case

<u>Brief Description:</u>

Camera Orientation Controller Use Case diagram (Figure G) demonstrates the basic operations of Raspberry Pi based orientation controller. If the automatic mode is disabled, the user can change the camera orientation from software and reset the camera position to specified starting location. The mouse buttons will be used to turn camera right and left

<u>Initial Step by Step Description:</u>

1. The user selects a camera turning step length from 1 to 5 degrees.
    a. When the user press "Increase" button, step length is increased 1 degree.
    b. When the user press "Decrease" button, step length is decreased 1 degree.
2. When the user presses the "Left" button, the camera turns a step left.
3. When the user presses the "Right" button, the camera turns a step right.
4. During video recording
    a. When the user presses the left button of the mouse, the camera turns a step left.
    b. When the user presses the right button of the mouse, the camera turns a step right.
5. When the user pressed the "Reset" button, the camera turns back to its initial position.

3.2.3 Performance Requirements

Video recording frame rate should be 25 per second at least even if user tracking is on. This requirement is depended on many aspects of the user pc. Minimum requirements for running the software are:

1. CPU: Intel i5-4590/AMD FX 8350 equivalent or better
2. RAM: 4 GB or more
3. USB port: 1x USB 2.0 or better port
4. Regular Video Graphic Card
5. Regular Webcam
6. Operating system: Windows 7, Windows 8, Windows 8.1, Windows 10

3.2.4 Software system attributes

3.2.4.1 Portability

- The software will be developed in a manner to work on Microsoft Windows Family operating after Windows 7, 8 and 10.
- The software will be developed in 32bit mod.
- The software can function with a common webcam.
- User tracking will be based on Image Processing, so it does not require any additional hardware.
- A special mechanism will be developed using Raspberry Pi and electric motors to realize camera orientation control system. It is therefore unique.
- Most of the webcams should be able to be mounted to the orientation mechanism.

3.2.4.2 Performance

- Video recording frame rate must be 25 frames per second.
- The video file size should not be restricted by the software.
- The recording should be paused if no audio and movement is detected for 5 seconds.
- User tracking must be fast enough to ensure the desired video frame rate.
- Camera orientation controlling must be fast enough to ensure the desired video frame rate.

3.2.4.3 Usability

- The software should be designed "usable" in general.
- The software should have a modern aesthetic design to compete its opponents.
- The camera should be easily mounted to the mechanism.
- When the video recording is started, paused or continued, appropriate audio and visual feedback should be given to the user.
- The user should be able to ready the software video recording in a minute.

3.2.4.4 Adaptability

- The software shall record video files in mpeg format.

3.2.4.5 Scalability

- There is no scalability requirement for the software.

3.2.4.6 Safety Requirements

- The user should be careful with the camera adjustment system. It includes electric motors and has a swinging system. It can cause the user's hair or fingers to be damaged.

4. Software Design Description

4.1 Introduction

4.1.1 Purpose

The purpose of this Software Design Document is providing the details of project titled Curious Cam for Video Lecture Recording Environment. This camera system, without the need for any cameraman, speaker's attention is conceived in order to distribute, creates a more comfortable environment by following the movements of the instructor. This document includes detailed information about requirements of the project. It reflects the defined constraints and recommended software functions. What's more, the SRS document explains how the user interacts with the camera. Today, the use and prominence of e-learning continues to increase and it is well known that one of the key components of e-learning is video conferencing. With video conferences, students can view and review the lectures of instructors as often as they desire. They understand the material. For this reason, preparing the video conference is an important issue. In its simplest form, a video and a writing board are required to prepare the video lesson. In order to improve the quality of the video and bring the traditional classroom environment to the video course environment, the cameraman will follow the movements of the instructor.

For some people the cameraman may cause the presence of stress and decrease the teaching performance. In this regard, the design and implementation of a camera platform that mimics the camcorder's shooting techniques will provide a more comfortable environment for video conferencing recording, such as tracking the trainer's movements.

The camera was designed to detect only one instructor on stage. This camera will be tracked and recorded by the camera as long as s/he is on stage.

For this reason, this project aims to provide a microcontroller, video conferencing environment that will control the camera platform using step / servo motors by continuously receiving inputs from motion sensors and sound sensors. In addition, the image processing subsystem for face recognition will be integrated to allow the camera to follow the trainer in case of multiple people in the shooting environment.

4.1.2 Scope

This document contains a complete description of the design of Curious Cam for Video Lecture Recording Environment project.

OpenCV is used in this project. OpenCV (Open Source Computer Vision) is an open source image processing library. Developed by Intel in 1999, the development process continues with the support of companies and communities such as Itseez, Willow, NVidia, AMD, and Google. The first version, OpenCV alpha, went on the market in 2000. In the first place, it started to be developed with the C programming language, and later many algorithms were developed with the C ++ language. Open source is an open source library and is developed under BSD license.

Having a BSD license means that you can use this library free of charge in the project you want. OpenCV is a platform independent library that can run on Windows, Linux, FreeBSD, Android, Mac OS and iOS platforms. OpenCV applications can be easily developed with Perl and Ruby programming languages through different wrappers developed by the community through Visual Basic.Net, C # and Visual C ++ languages via C ++, C, Python, Java, Matlab and EmguCV libraries.

Phyton is preferred as programming language. As described above, OpenCV is compatible with Phyton. Most popular modules in Phyton are:

- PIL (Pillow)
- Numpy
- Matplotlib
- OpenCV

OpenCV is probably the most recognized, reputable, and reputable among these 4 modules. It can also be used on C ++, Python does not have "image" restrictions like PIL, and video processing support. In short, many operations return through OpenCV. The one of the important point is face detection. Face detection is photo / picture taking technology used in camera and new generation mobile phone models. It is the technology that enables the human to perceive the face and find out the facial lines more clearly.

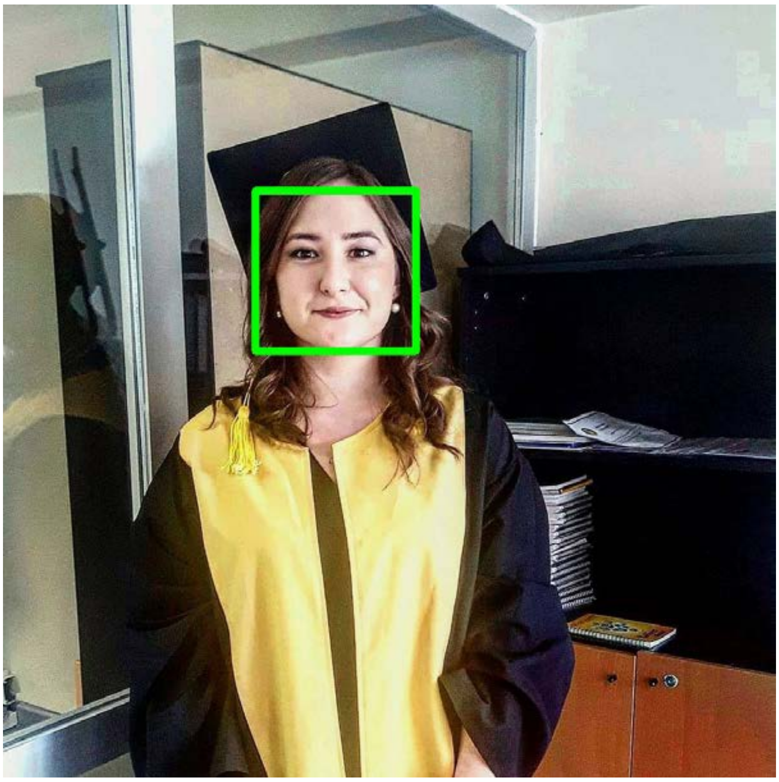


Figure 1: Detected Face

The picture shown in Figure 1 is a trial run for the demo at the end of the semester. Face recognition technology has been used by the camera in the photo, and the program has been received by the program within a hundred-square frame of the recognized image.

4.1.3 Glossary

TERM	DEFINITION
Participant	The user who interacts with the camera environment. Trainers, speakers, private companies.
Stakeholders	Any person who has contribution in the project.

4.1.4 Overview of document

The remaining chapters and their contents are listed below. The remaining chapters and their contents are listed below. Section 2 is the Architectural Design which describes the project development phase. Also it contains class diagram of the system and architecture design of the project which describes actors, exceptions, basic sequences, priorities, pre-conditions and post conditions. Additionally, this section includes activity diagram of scenario generator. Section 3 is Use Case Realization. In this section, a block diagram of the system, which is designed according to use cases in SRS document, is displayed and explained. Section 4 is related to Environment. In this section, the environmental conditions for the use of the camera are explained.

4.1.5 Motivation

We are a group of senior students in computer engineering department who are interested in hardware and innovative tools. Inspired by the Microprocessors course we were taking this semester, we decided to do the camera tracking system project we carried out in our senior project. Before graduation, we wanted to add a hardware project to our CVs.

First of all, what kind of camera do we want, what features we should have, and what type of equipment should we use, what should we use for the software. We searched these questions, read them, and found answers.

4.2 Architecture Design

We planned to use a phased and iterative method for the development of the project. Embedded systems are complex systems as described in the SRS document. Team work is required. This was important to us because we identified the materials to be collected at the beginning of the project and prepared a timetable for ourselves. For this reason, everyone in the project group was made to control the project. The clear aim of the design process is to create a product that does something useful. The clear aim of the design process is to create a product that does something useful. Typical features of a product will include functions such as, for example, this camera, production cost, performance, power consumption or other features. Of course, a design process has several key goals beyond its function, performance and power. In addition, this development methodology makes it possible to create quality products at the planning stage.

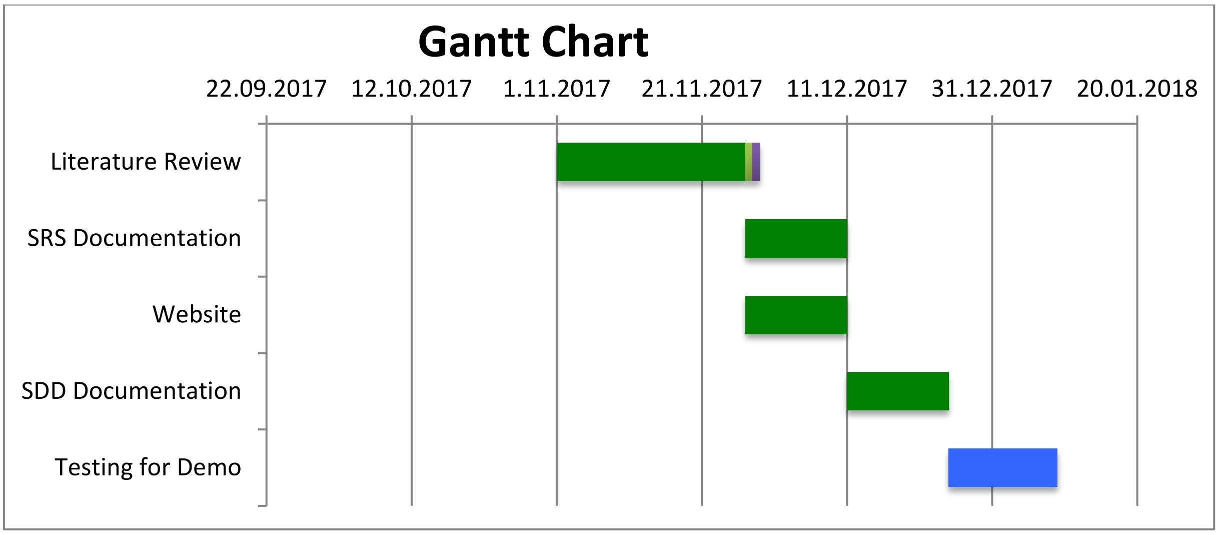


Figure 2: Gantt chart

In the Gantt chart shown in Figure 2, the distribution of the transactions performed during the period is shown. This chart is an intersection of the timeline chart on the page of the senior project and the schedule chart that we have grouped in the beginning of the semester.

4.3 Software Design Approach

4.3.1 Class Diagram

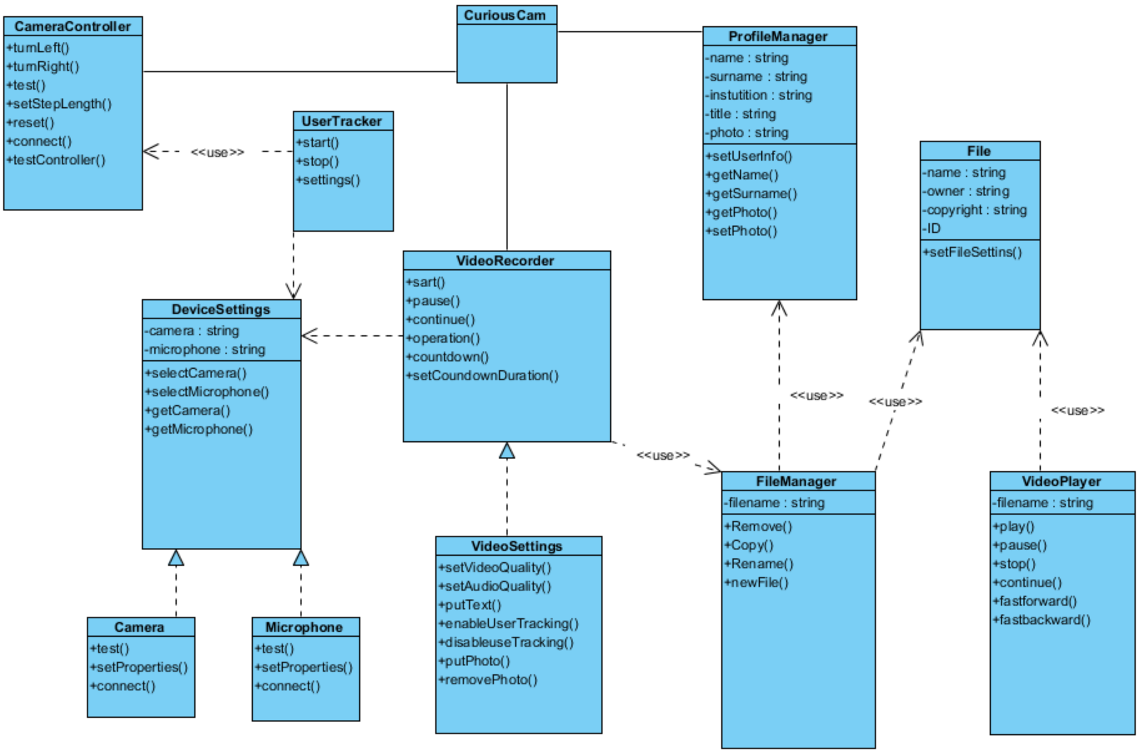


Figure 3 : Class Diagram of CuriousCam Project

Figure 3 shows the class diagram of CuriousCam project. The diagram depicts the connections between system components. CuriousCam class is the main class and responsible of managing the software in general. ProfileManager class hold the user personal information and provides other components with that information, particularly FileManager.

FileManager directs the video files generated by the system. It's also responsible of creating video files and serve them to VideoRecorder. Therefore, FileManager uses File class, which is a basic class that represent a video file.

VideoRecoder generates video files on the basis of properties given by VideoSettings and services given by DeviceSettings classes. CameraController class realizes the functionality of Camera Controller. It manages and make use the Rasberry Pi based camera controller system. UserTracker, when it's enabled during video recording, tracks the user and manage the automatic camera orientation using CameraController class.

4.4 Architecture Design of Software

4.4.1 Profile Management Use Case

Summary: Profile Management includes the basic operations related to the management of the user personal information (and user authentication if necessary). The user can set his or her personnel information and choice a photo. This information will then be available to be used in settig video file properties produced by the user, including owner, producer, copyright information, etc. User photo is to optionally be added on videos, as a small image at a corner of the video frame.

Actor: User

Precondition: User must run the program.

Basic Sequence:

1. The user information fields (name, surname, institution, contact details) are filled with string "Unknown" by default.
2. If it's not selected one by the user, user photo is a general portrait picture by default.
3. The user can update personal information.
4. The user can select a photo or any image to be optionally used in video recordings
5. The user can select a photo from a file in the hard drive.
6. The user can capture the photo from camera.

Exception: Camera might be unplugged during photo capturing. There might be problem with data files in which user information is saved.

Post Conditions: None

Priority: Low

4.4.2 Device Settings Use Case

Summary: The Device Settings system bases the camera recording system. It enables the user to determine basic settings of the devices plugged to computer, required by the software. If the required devices are already installed, the software will use operating system default camera and microphone. The user can also select any camera or microphone installed on the system. The user can test the selected devices if they work properly. Similarly, the user can test the Camera Orientation Controller.

Actor: User

Precondition: User must run the program.

Basic Sequence:

1. The user can select a video camera.
2. The can test camera and see a preview.
3. The user can see and change operating system provided basic video properties.
4. The user can select a microphone.
5. If a microphone selected properly, the audio level sensed by it will be shown on the window.
6. The user can change operating system basic audio properties.
7. The user can also test the Camera Orientation Controller if it’s connected to computer.

Exception: Devices might be unplugged.

Post Conditions: None

Priority: Medium

4.4.3 Video Recording Settings Use Case

Summary: The Video Recording Settings system determines the basic properties of the video to be recorded. It encompasses operations of selecting video file save location, setting video quality, setting audio quality, customizing video output, enabling user tracking and automatic camera orientation and manual camera orientation. The user can set video quality or resolution and audio quality (mono or stereo). The user can also customize video frame by putting any text, date and time or his or her photo on the frame. The user can start or stop user tracking and activate audio filter to get clearer videos. The user can use manual or automatic camera orientation. In manual mode the user can change the camera orientation using the mouse.

Actor: User

Precondition: User must run the program. Required devices must be plugged in.

Basic Sequence:

1. The software saves video in “C:\videos” folder by default.
2. The user can select another “save” directory.
3. The user can set video quality to different resolutions.
4. The user can change audio quality.
5. The user can select either mono or stereo video recording mode.
6. The user can activate or deactivate Audio Filtering option to filter out background noise out during video recording.
7. The user can enable or disable automatic user tracking to enable the software record video by automatically tracking the user.
8. As the user tracking is activated the camera orientation controller functions automatically.
9. As the user tracking is disabled, the camera orientation controller can still function manually.
10. The user can put text on the video.
11. The text that is to be put on the video can be date, time or any other text.
12. The user can select a position (corners of the video frame) for the text.
13. The user can out his or her photo on the video.

Exception: Devices might be unplugged.

Post Conditions: None

Priority: High

4.4.4 Video Recording Use Case

Summary: Video Recording is the system responsible of capturing and recording video. It therefore includes basic operations of video recording. The user can start, pause, continue and stop video recording. The user does this operation by conventionally pressing buttons and alternatively clapping his or her hands. Recording starts or continue after a 5s count-down.

Actor: User

Precondition: User must run the program.

Basic Sequence:

1. The video files are named automatically named using [user name + sequence no].
2. The sequence no is a time stamp that will be taken from the system.
3. The system shall record video from a webcam.
4. Video recording shall start or continue after 5s countdown with a beep warning.
5. The user can increase the countdown duration.
6. The user can decrease the countdown duration.
7. The user shall start video recording.
8. The user can pause video recording.
9. The user can continue video recording.
10. The user can stop/end video recording.
11. The user can start video recording by clapping hands.
12. The user can pause video recording by clapping hands.
13. The user can continue the video by clapping hands.

Exception: Camera might be unplugged. The hard drive might be full. There might be problem with the camera controller.

Post Conditions: None

Priority: High

4.4.5 File Management Use Case

Summary: The Video File Management system is a simple system to manage video files generated by the system. It has operations of listing and removing video files existing in the

“Save” directory. The user can also see or change the basic information of a video file, including, owner, director, producer, etc.

Actor: User

Precondition: User must run the program. User must be recorded some video.

Basic Sequence:

1. The user can remove previously recorded video files.
2. The user can rename previously recorded video files.
3. The user can see video file properties, including psychical properties and producer, copyright etc.
4. The user can change video file properties.

Exception: The video file might be already open.

Post Conditions: None

Priority: Low

4.4.6 Video Playing Use Case

Summary: Video playing system is simple system to display recorded videos. It encompasses the basic video playing operations, including start, pause, continue, stop, fast forward, back forward.

Actor: User

Precondition: The user must run the program. The user must be recorded a video.

Basic Sequence:

1. The user can play videos.
2. The user can pause videos
3. The user can stop videos
4. The user can fast Forward videos.
5. The user can fast backward videos.
6. The user can control the video playing using a time slider.

7. When the user clicks at location on time slider, the video will be continued to be played after that time point
8. The user can watch the video in full screen window modes.
9. The use end full screen mode by pressing ESC.

Exception: The video file might be corrupt. The selected video file might be unavailable.

Post Conditions: None

Priority: Low

4.4.7 Camera Orientation Controller

Summary: Camera Orientation Controller system realizes the basic operations of Raspberry Pi based camera orientation controller. If the automatic mode is disabled, the user can change the camera orientation from software and reset the camera position to specified starting location. The mouse buttons will be used to turn camera right and left.

Actor: User

Precondition: User must run the program. The camera controller must be plugged in and turned on.

Basic Sequence:

1. The user can manually turn the camera a step left.
2. The user can manually turn the camera a step right.
3. The user can select a camera turning step length from 1 to 5 degrees.
4. During video recording,
    a. When the user presses the left button of the mouse, the camera turns a step left.
    b. When the user presses the right button of the mouse, the camera turns a step right.
5. The user can reset the camera position to its initial position.

Exception: The camera controller might be unplugged or turned off.

Post Conditions: None

Priority: High

4.5 Activity Diagram

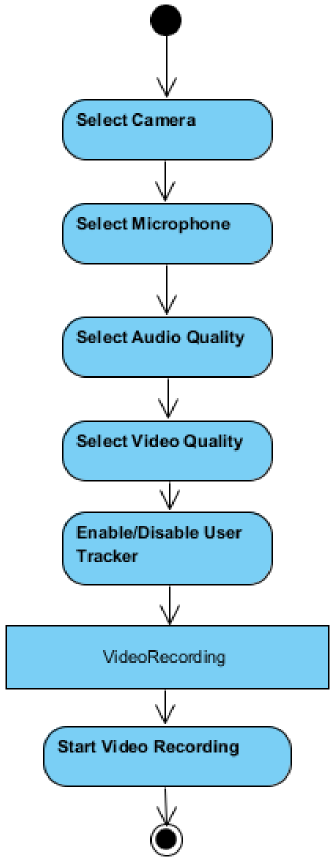


Figure 4 Activity Diagram of Video Recording

Figure 4 shows the activity diagram of video recording. It demonstrates how video recording works. When the user opens the software, it might select a camera and microphone, otherwise default camera and microphone is used by the system. After that, the user decides on video and audio quality. After selecting a proper video resolution and audio quality, the use decides on the automatic camera controlling or orientation. If the electronic camera controller is plugged in, the user can enable automatic user tracking to have the full potential of CuriousCam. Finally, the user starts video recording.

4.6 Use Case Realization

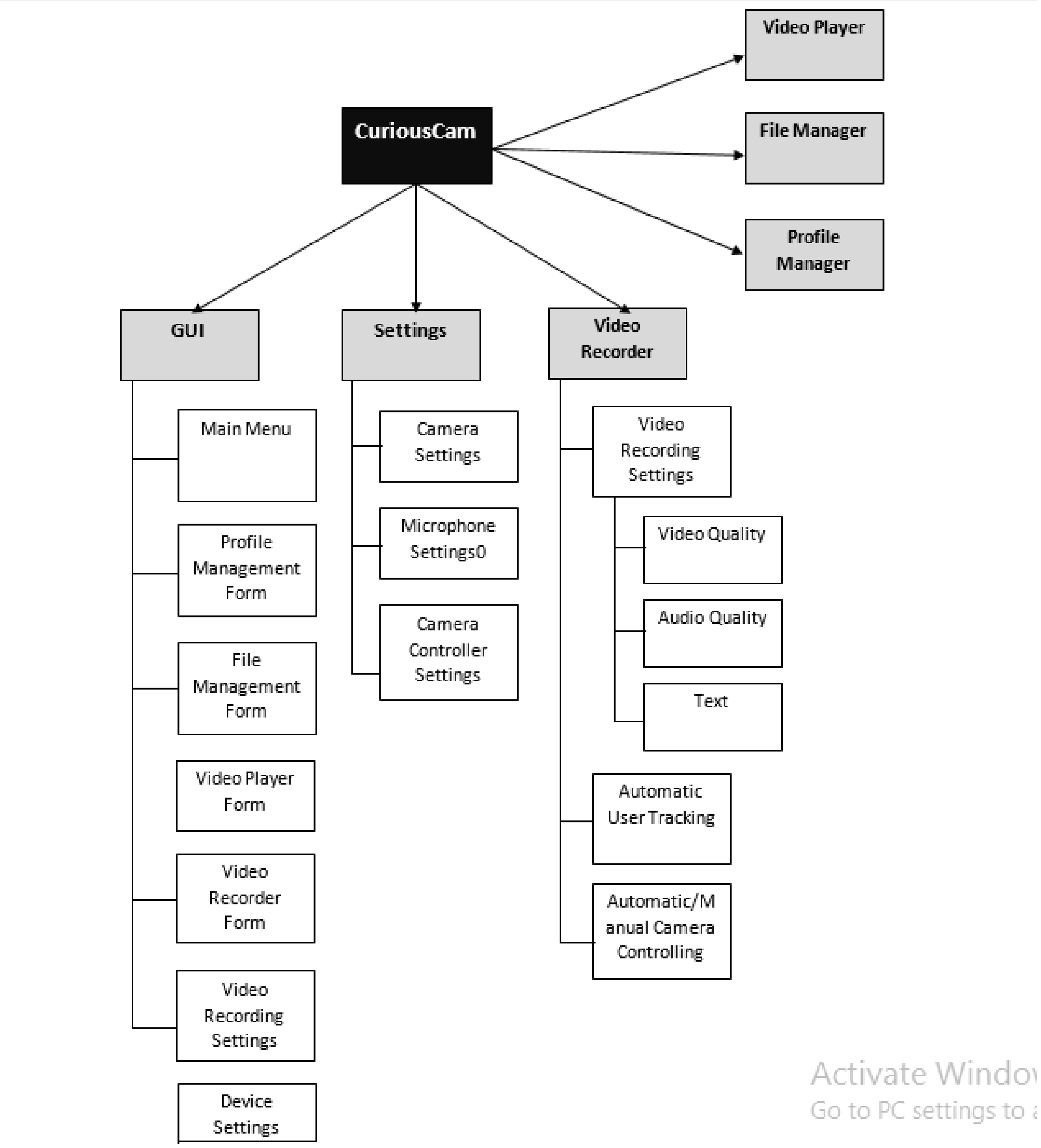


Figure 5 Project Components of CuriousCam Project

4.7 Brief Description of Figure 5

Components of the CuriousCam Project are shown in the Figure 5. All designed systems of the simulation are displayed in the block diagram in the figure. There are six main components of the system which have their own sub-systems.

4.7.1 GUI

GUI design is responsible for interaction between the user and the system. There are seven sub-systems in this design which are Main Menu, Profile Management form, File Management Form, Video Player Form, Video Recording Form, Video Recording Settings and Settings form. In short, as well as a main menu to start system's components, it includes a separate form for each main system component.

4.7.2 Settings

Setting is the component of the system like those of similar video recording software. There are three types of external devices used by the software, including a microphone for audio recording, a webcam for video capturing and a special design camera controller. Settings component is responsible of enabling the user to select suitable devices and set their basic properties.

4.7.3 Video Recorder

Video Recorder, in a sense, is the heart of the software and combines many important sub components. It includes 3 sub components: Video Recording Settings, User Tracking and Automatic/Manual Camera Controller. After some video, audio and display settings, Video Recording component allow the user to record the video captured. Additionally, user tracking with automatic camera controlling or manual camera controlling are directed thorough this component because these are designed for video recording.

4.7.4 Profile Manager

Profile Manager save the user personal information for further use. It provides file manager and video recorder with necessary user information. It has no sub system.

4.7.5 File Manager

File Manager is responsible of managing video files generate by the software. It provides the functionalities of listing, renaming, copying and removing video files. It can also change the user information of video files. It has no sub system.

4.7.6 Video Player

Video Player component is intended to allow the user to watch his or her video files generated by the system. It provides the functionalities of play, pause continue, stop, fast forward and fast backward video to the user. It has no sub system.

4.8 Environment

Since the system uses a large portion of the Raspberry-Pi3’s CPU, the CPU is quickly reaching high temperatures. As the CPU temperature increases, the image processing speed drops. To prevent high temperature, an aluminum heat sink and a fan are used on the CPU. In order to maximize the efficiency of the system, the system must be used at room temperature. The camera that we use to record images has 5MP, 3.6mm lens size and f / 2.9 apertures. The system should be used in an environment where the user's face and body are bright. Also, the quietness of the environment is a factor that allows video recording to be performed with full efficiency.

5. Conclusions

This document includes wide information about our project that titled as Curious Cam. In this document, we mentioned about our Literature Search, Software Requirements Specification and Software Design Document of our senior project which is named Curious Cam.

Acknowledgement

We are grateful for guidance we have received from Assist. Prof. Dr. Abdül Kadir GÖRÜR. The help we received from he was a great asset to improve this project and ourselves.

References

[1] Downes, S. (2005). E-learning 2.0. Elearn magazine, 2005(10),

[2] Enabling a Comprehensive Teaching Strategy

[3] Video Lectures: H. David Brecht and Suzanne M. Ogilby

[4] California State University, Sacramento, California, USA, volume 7, 2008, IIP -75

[5] MOVING OBJECT DETECTION, TRACKING AND CLASSIFICATION FOR SMART VIDEO SURVEILLANCE: Yiğithan Dedeoğlu, August, 2004, p: 19

[6] Cotton, D., & Gresty, K. (2006). Reflecting on the think-aloud method for evaluating e-learning. British Journal of Educational Technology, 37(1), 45-54.

[7] Dyson, L. E., Litchfield, A. J., Lawrence, E. M., Raban, R., & Leijdekkers, P. (2009). Advancing the m-learning research agenda for active, experiential learning: Four case studies. Australasian Journal of Educational Technology.

[8] Bates, A. T. (2005). Technology, e-learning and distance education. Routledge.

[9] Torrente, J., Moreno-Ger, P., Martínez-Ortiz, I., & Fernandez-Manjon, B. (2009). Integration and deployment of educational games in e-learning environments: the learning object model meets educational gaming. Journal of Educational Technology & Society, 12(4), 359.

[10] Vossen, G., & Jaeschke, P. (2003, July). Learning objects as a uniform foundation for e-learning platforms. In Database Engineering and Applications Symposium, 2003. Proceedings. Seventh International (pp. 278-287). IEEE.

[11] Christopher Rasmussen, Kentaro Toyama, and Gregory D. Hager. Tracking Objects by Color Alone. Yale University, 1994.

[12] Matthew Turk, Alex Pentland. Eigenfaces for Recognition. Massachusetts Institute of Technology, 1991.

[13] Denzler, H. Niemann. A Two Stage Real-Time Object Tracking System. Universitat Erlangen-Nurnberg, 1994.

[14] Dorin Comaniciu, Visvanathan Ramesh, Peter Meer. Kernel-Based Object Tracking.

[15] Rutgers University, 2003.

[16] Wei Zhong, Huchuan Lu, Ming-Hsuan Yang. Robust Object Tracking via Sparsity-based Collaborative Model. Dalian University of Technology

[17] Markus Happe, Enno Lubbers, Marco Platzner. A self-adaptive heterogeneous multi-core architecture for embedded real-time video object tracking. 2011

[18] Mohand Said Allili, Djemel Ziou. Active contours for video object tracking using region, boundary and shape information. 2007

[19] Christopher Rasmussen, Kentaro Toyama, and Gregory D. Hager. Tracking Objects by Color Alone. Yale University, 1994.

[20] Matthew Turk, Alex Pentland. Eigenfaces for Recognition. Massachusetts Institute of Technology, 1991.

[21] J. Denzler, H. Niemann. A Two Stage Real-Time Object Tracking System. Universitat Erlangen-Nurnberg, 1994.

[22] Dorin Comaniciu, Visvanathan Ramesh, Peter Meer. Kernel-Based Object Tracking.

[23] Rutgers University, 2003.

[24] Wei Zhong, Huchuan Lu, Ming-Hsuan Yang. Robust Object Tracking via Sparsity-based Collaborative Model. Dalian University of Technology

[25] Markus Happe, Enno Lubbers, Marco Platzner. A self-adaptive heterogeneous multi-core architecture for embedded real-time video object tracking. 2011

[26] Mohand Said Allili, Djemel Ziou. Active contours for video object tracking using region, boundary and shape information. 2007

[27] Wolf, W., Ozer, B., & Lv, T. (2002). Smart cameras as embedded systems. Computer, 35(9), 48-53.

[28] Bramberger, M., Doblander, A., Maier, A., Rinner, B., & Schwabach, H. (2006). Distributed embedded smart cameras for surveillance applications. computer, 39(2), 68-75.

[29] Clipchamp Online Webcam Video Recorder, https://clipchamp.com/en/webcam-recorder, 09.01.2018

[30] Loom Video Recording Chrome Plugin, https://www.useloom.com/, 09.01.2018

[31] Movavi Video Edit and Recording Software, https://www.movavi.com/tr/, 09.01.2018

[32] Raberry Pi World, https://www.raspberrypi.org/, 09.01.2018

[33] Hongliang Bai, Jianping Wu, Changpin Liu, "Motion and haar-like features based vehicle detection", Multi-Media Modelling Conference Proceedings 2006 12th International, pp. 4 pp.-, 2006

[34] Alex Kuzmuk, DIY. An Astro Tracker in Two Nights, https://kukuruku.co/post/diy-an-astro-tracker-in-two-nights/, 09.01.2018

[35] CamRanger PT Hub and MP-360 Pan/Tilt Head https://www.bhphotovideo.com/c/product/1040115-REG/camranger_1006_camranger_pt_hub_and.html, 09.01.2018

[36] Vidpro Motorized Pan & Tilt Gimbal Head, https://www.bhphotovideo.com/c/product/1271009-REG/vidpro_mh_430_professional_motorized_pan.html, 09.01.2018

[37] Star Tracker Using 28BYJ-48 Stepper Motor, Arduino and LCD Display to Vary Speed http://www.instructables.com/id/Star-Tracker-Using-28BYJ-48-Stepper-Motor-and-LCD-/

[38] 1 Beyond AutoTracker™, http://1beyond.com/autotracker, 09.01.2018, 09.01.2018

[39] PTZ Remote Camera SRG-360SHE, https://www.sony.com.tr/pro/product/network-camera-systems-visual-imaging-cameras/srg-360she/overview/, 09.01.2018

[40] Avires Research Laboratory, https://avires.dimi.uniud.it/research-areas/, 09.01.2018

[41] Webcam Effects, Software, http://webcameffects.net/, 09.01.2018

[42] Chou, H., Wang, J., Fuh, C., Lin, S., and Chen S., Automated Lecture Recording System , 2010 International Conference on System Science and Engineering