



Middle East Technical University Northern Cyprus Campus
Computer Engineering Program

CNG491 Computer Engineering Design I

Iris Analyzer

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Chapter 1

Introduction

1.1 Motivation

Iris recognition can be used for verifying owner identity (biometric data) and demographic data of the identified person (soft biometric data). Verification(1-to-1 comparison) is the process where the biometrics information of an individual is compared with biometrics on the record[4] while identification(1-to-many comparison) is used to discover the origin of certain biometrics to prove or disprove the association of that information with a certain person/individual. [4] Research and studies have been done on gender prediction[1], age prediction[2] and biometric technology[3] using iris analysis using image processing and machine learning techniques.

In biometrics, iris data cannot be same in two individuals and cannot wear out as seen in some people's fingerprints hence, iris recognition can be a secure way to identify and authenticate individuals. Our main motivation is to make iris recognition(in biometrics) more used option, by improving the output accuracy using deep learning algorithms rather than image processing. Deep learning

1.2 Aims and Objectives

The main aim of this project is to acquire identification and their demographic information by analyzing their eyes (iris). The objectives are:

1. Get eye data from a database.
2. Pre-processing where the eye image will be segmented using image processing techniques. This step will partition the eye image into image objects (iris and pupil) and this will be used to locate the objects and their boundaries(diameter and radius of pupil and iris). This will help us work on the image in the next stages.
3. Use deep learning to retrieve the identity and demographic data.

1.3 Research Methodology

The project will be done in two parts: image processing part and deep learning part. Image processing techniques shall be used to segment the eye images. This will define the iris and pupil objects(pixel values) and their boundaries(radius and diameters) which

will later be needed in deep learning process to work on specific objects i.e. the iris alone. The image processing part will be achieved using the following methods:

1. Images shall be acquired from the BioSecure Multimodal Database(BMDB). The BMDB is a database that contains eye images collected from a standard office environment using the LG Iris EOU3000 system. During acquisition, spectacles weren't allowed but contact lenses were allowed.
2. Pre-processing: The chosen eye image will be segmented using image processing segmentation algorithms. This process will localise the iris region and detect the sclera and pupil boundaries.

The deep learning part will use the method explained below:

1. The segmented eye images in the database shall be divided into training and testing sets.

The training set: is used to discover the predictive relationship by using a model. The model can learn the behavior and tweak itself. The model is built based on the data it discovers in the training dataset.

Testing set: Once the model is built, the test dataset is used to get the accuracy of the hypothesis.
2. The system shall use deep learning algorithms to train the input images using the training set, and to predict the output based on the model using the testing set.

Chapter 2

Related Work

// —————-In progress—————

The first successful and commercially available iris recognition system was in 1993, and was suggested by Daugman[5]. In the system, the inner and outer boundaries are detected using an integro-differential operator. Afterwards, the iris region template is transferred into normalised form using Daugman's rubber sheet method. This is followed by using a 2D Gabor filter to extract the iris features and the hamming distance for decision making.[6] The limitation to this method is that it requires a high resolution camera to capture the iris image and its accuracy significantly decreases under non-ideal imaging conditions due to sensitivity of the iris localization stage.

After decades of comparative research, many iris recognition methods have been introduced to enhance the reusability and reliability. In recent years, with the vigorous development of the annual ImageNet Large Scale Visual Recognition Challenge(ILSVRC)[8], deep learning networks, especially CNNs, have shown obvious improvement in the performance of computer vision tasks such as image classification, single object localization, and object detection.[7]

Chapter 3

Requirements

3.1 Stakeholders

1. System administrator : is responsible for updating and managing the iris analyser system.
2. Application users : every person that will use the iris analyser system to get an identity and demographic output i.e. students, teachers, workers.

3.2 Functional System Requirements

1. The system shall use an authentication for the system administrator.
 1. The system shall display an authentication message to the administrator.
 2. The system shall give the administrator access to the database if the pin is correct.
 3. The system display an error message if the pin entered is correct.
 4. The system shall display a add confirmation message to the system administrator.
2. The system administrator shall be able to add eye images in the database.
 1. The system shall authenticate the system administrator.
 2. The system shall send the added images to the database.
 3. The system shall display an added image successfully message to the system administrator.
3. The system administrator shall be able to delete eye images in the database.
 1. The system shall authenticate the system administrator.
 2. The system shall discard the selected image from the database.
 3. The system shall display a deleted image successful message to the system administrator.

4. The system administrator shall be able to create a model to be used in deep learning section.
 1. The system shall authenticate the system administrator.
 2. The system administrator shall divide the eye images in the database into 2 parts: training and testing set.
 3. The system shall save the 2 sets in the database.
 4. The system shall use the training set for modelling and the testing set for prediction using deep learning algorithms.
5. The user shall be able to choose eye images as inputs.
 1. The system shall display eye images as input to the screen.
 2. The system shall mark all the eyes images selected by the user as wanted input.
 3. The system shall move copies of the chosen eye inputs to the next stage (pre-processing stage).
6. The user shall be able to choose the expected output (identification and demographic output).
 1. The system shall read checkbox input of either or both identification and demographic data.
 2. The system shall display a confirmation message for the selected output.
 3. The system shall use the chosen input to process the data after the output confirmation from the user.

3.3 Non-functional System Requirements

1. The system shall be available to users 24hrs a day.
 1. The system shall check every 2hrs (system troubleshoot) that all parts are functioning properly.
 2. The system shall send a notification to the system administrator about any errors that occurred.
2. The system shall work on Windows, Linux and Mac operating system.
 1. The system shall run on all devices with Windows 7 and above, all Linux and Mac devices.
 2. The system shall display an error message if the device is incompatible.
 3. The system interface input response time should not be more than 1 second to users.
1. The system shall detect keyed and clicked inputs at a response time of 50ms.

3.4 Domain Requirements

1. The eye images in the database should be negatives (black and white) so as to used in the pre-processing and prediction part.
2. The system administrator should separate the training and testing datasets. This is to prevent the model seeing the test dataset and giving the exact results. (The model gives impartial results because it hasn't seen the test dataset)

3.5 Assumptions and Justifications

1. The eye images used are not captured in real time but are taken from a database. These is due to the following reasons:

1. It needs special cameras and scanners.
2. The eye is sensitive to flashes and they might be damaged.
3. Ethic and privacy concerns, because users may not be sure of their safety of their images.

Chapter 4

System Modelling

4.1 Structured Use Case Diagram

The use case diagram shows how the relationship between the user and different use cases. The user can insert an image for the prediction but he has to set an output option first. Prediction model is then called to process the user input. The system administrator is entitled to manage the system. The system administrator can modify the processing model of the system later on. However, the user will be notified by the new modification.

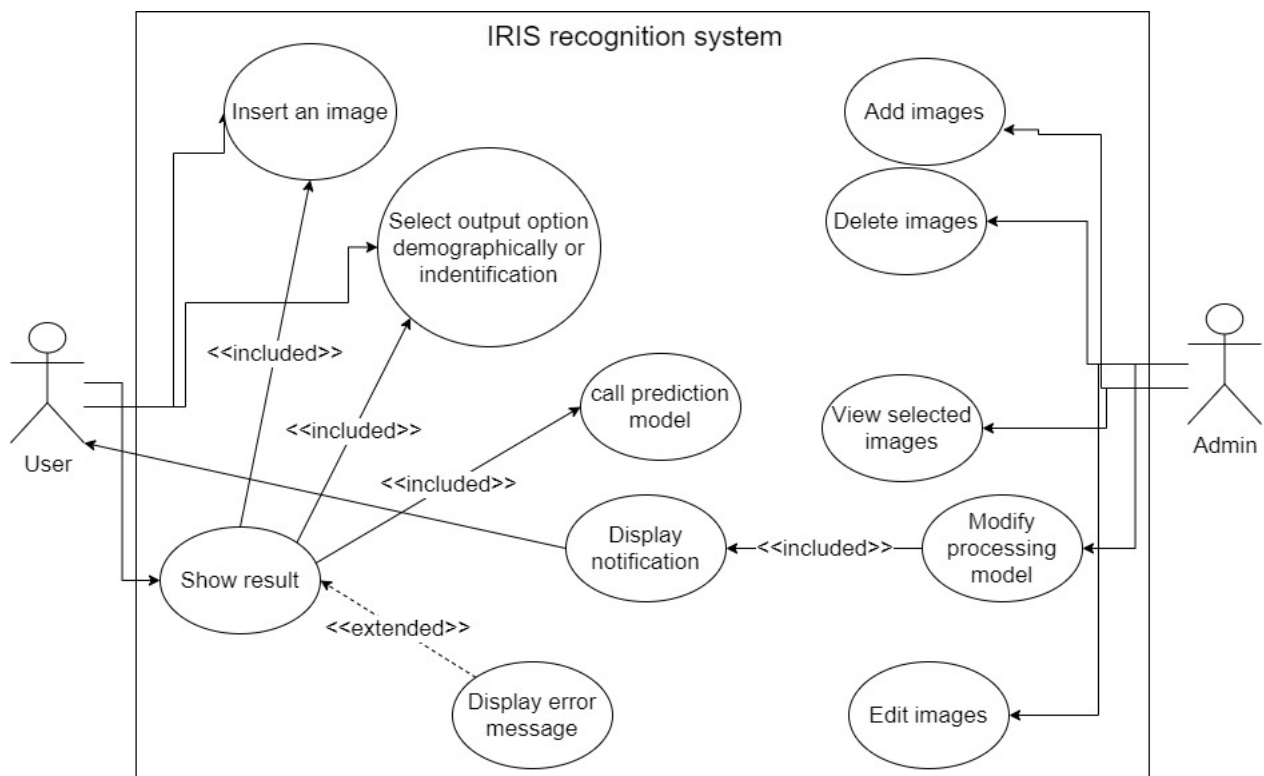


Figure 4.1: Structured Use Case Diagram for Iris Analyzer System

4.2 Sequence Diagram of Major User Cases

The system shall require authentication from the system administrator and give access to the system and Database. The System administrator shall choose training and testing sets from the images in the database. The sets will be used as a model to train the user inputs using deep learning algorithms and test them to get the output data.

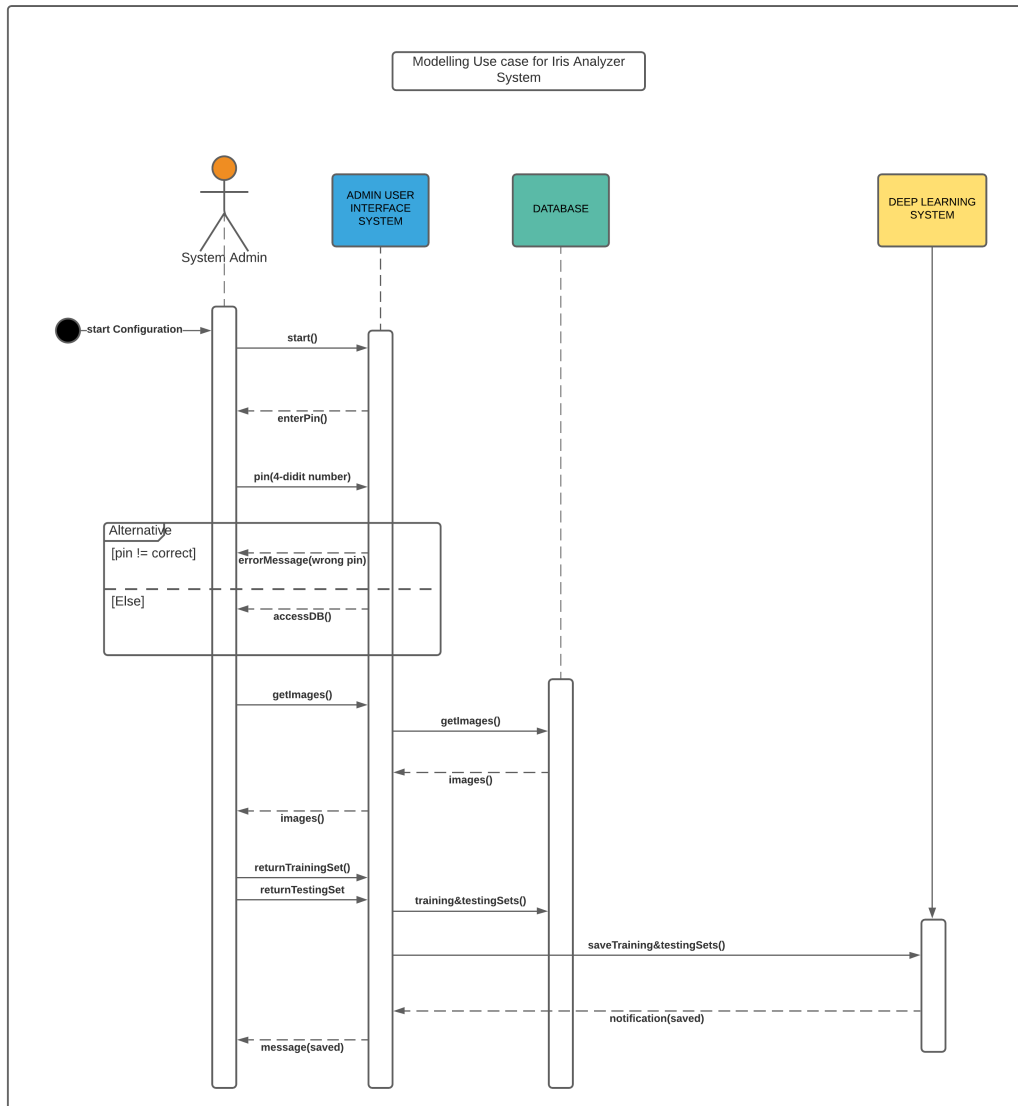


Figure 4.2: Modelling Image Use Case Sequence Diagram

4.3 Context Model

The context model shows the external and actors on the applications environment which are the Users, system administrator and Database.

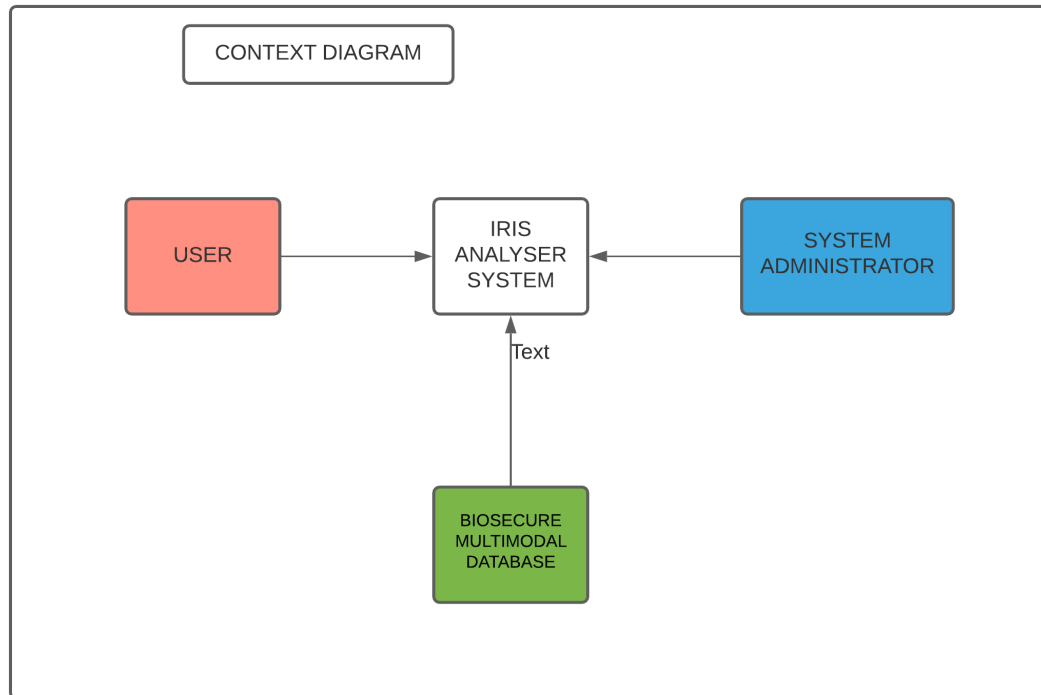


Figure 4.3: Context Model for the Iris Analyzer System

4.4 Architectural Model

This is a pipe and filter architecture diagram since the flow of the diagram is very straight forward. We have a data-set in which some parts of it get segmented, to build the model. After that, the user can insert an image or set of images. These pictures will be first filtered by modelling and segmented, then passed to the prediction for the final result.

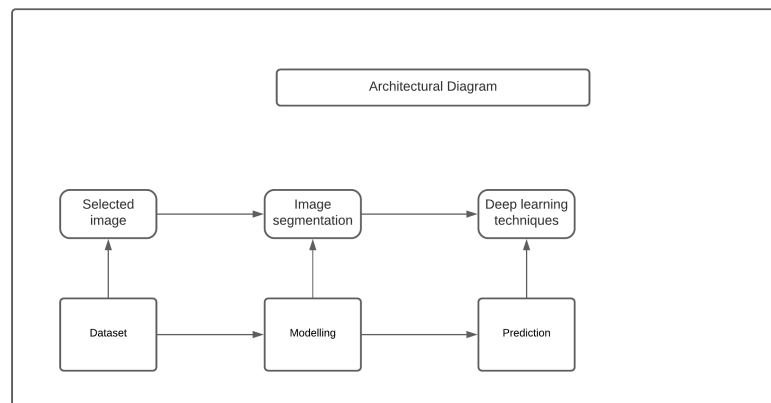


Figure 4.4: Architectural Model for the Iris Analyzer System

4.5 Process Model

The process model diagram shows the procedure to get the output from the inputted data. The user shall choose an image and the expected output wanted. The image shall be segmented and prediction done using deep learning methods to display the output.

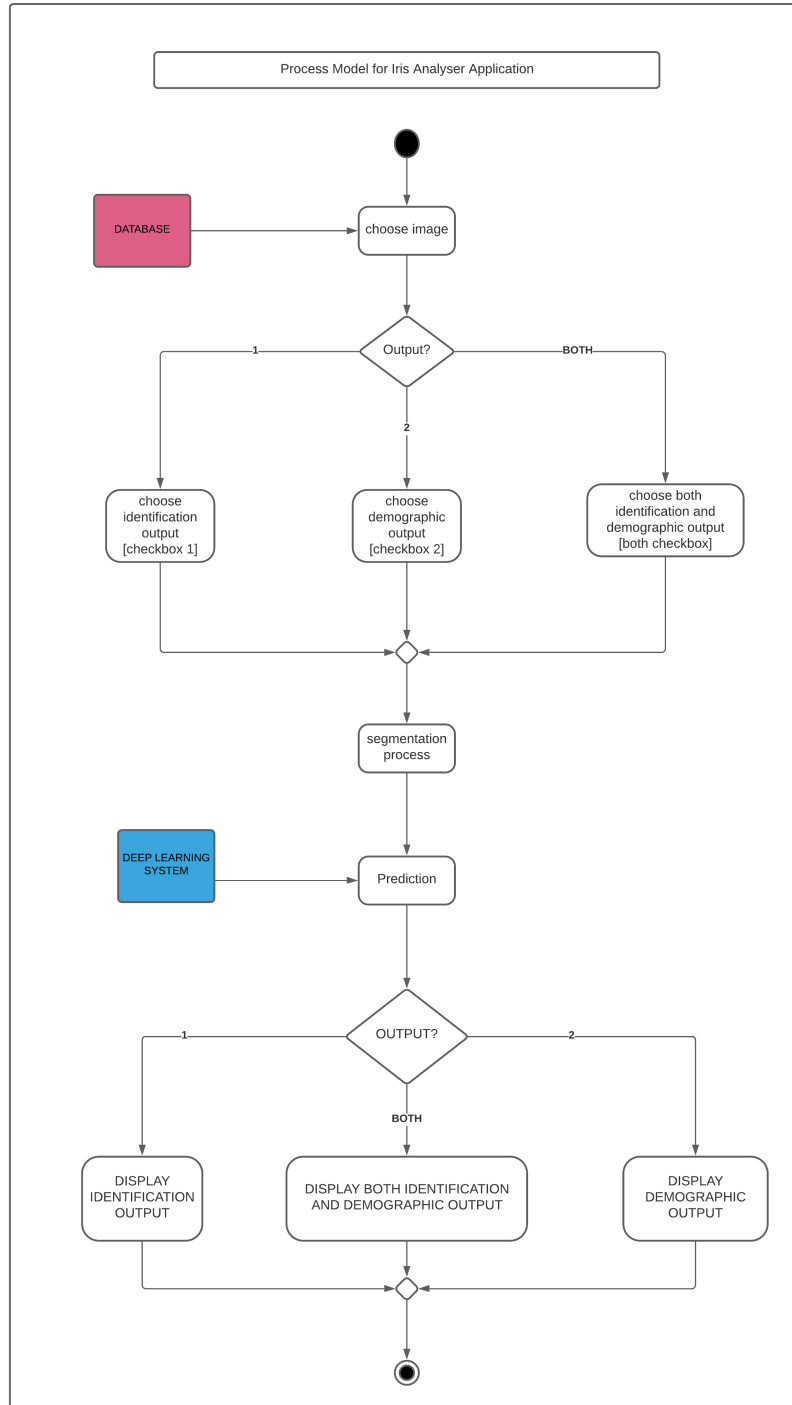


Figure 4.5: Process Model for the Iris Analyzer System

Chapter 5

Graphical User Interface

Below is a very early iteration of how the graphical user interface of the Iris Analyser application will look like. The interface is in early stages of design and is subject to many changes across the upcoming sprints.

5.1 Main Page GUI

The user will be given an option either to open the system administrator section or User section.

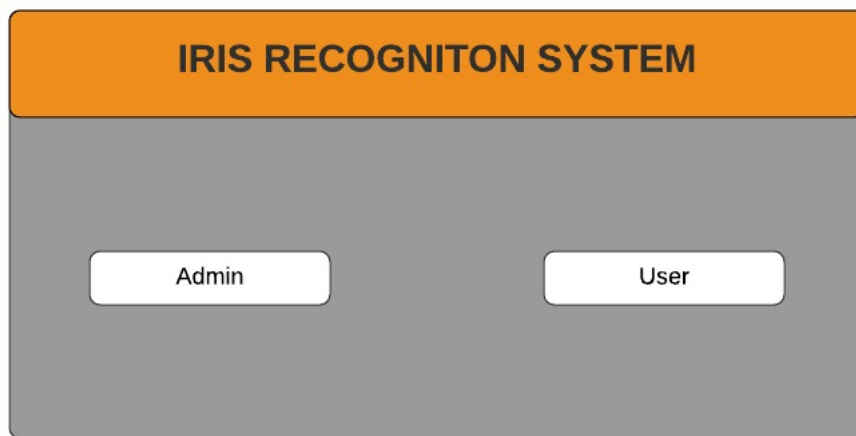


Figure 5.1: Graphical User Interface Main page view

5.2 User GUI

The User Interface works as follows; After the appearance of the interface below, the user must first click on "Choose eye image" in order to choose an eye image of their choice from the Iris Analyzer eye image database. If the user presses any other option before doing so an appropriate error message will be prompted. The user shall choose either the identification or demographic output or both. After having chosen an eye image, output and confirming, the user must press the "Start Configuration" button

and will be immediately presented with the identification and demographic result in the "Identification output" and "Demographic output" boxes respectively.

The image shows a graphical user interface for an "IRIS RECOGNITION SYSTEM". The interface has a grey background with an orange header bar at the top containing the text "IRIS RECOGNITION SYSTEM" in bold black font. Below the header, there are three main sections. On the left, there is a vertical stack of controls: a white button labeled "Choose eye image", two checkboxes (the first is checked), and two dark grey buttons labeled "Identification" and "Demographic" corresponding to the checkboxes. Below these is a white button labeled "Start Configuration". On the right, there are two large white rectangular boxes, one labeled "Identification output" and the other labeled "Demographic output", both with dark grey headers.

Figure 5.2: Graphical User Interface User view

5.3 System Administrator GUI

The system administrator interface works as follows; After the appearance of the interface below, the system admin shall be prompted to enter a 4-digit pin. The system shall move on to the next interface if pin is correct and if its wrong display an error message. In the next interface the system admin can add and delete images from the database.

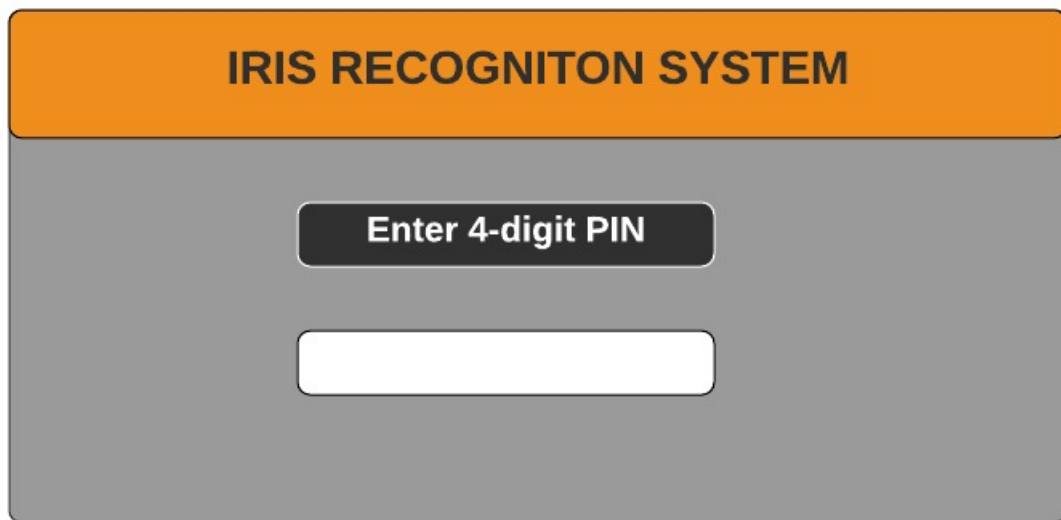


Figure 5.3: Graphical User Interface Authentication view

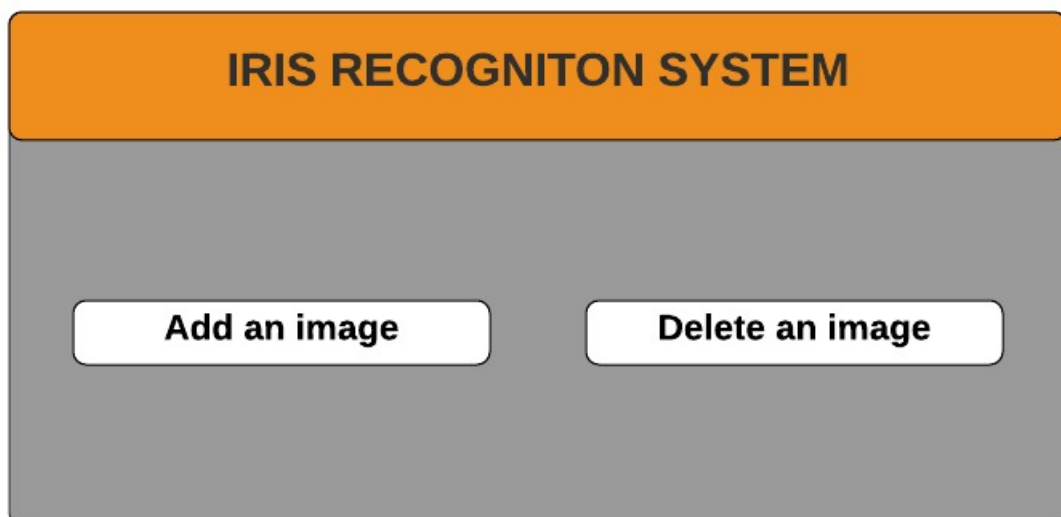


Figure 5.4: Graphical User Interface User database add/delete image view

Chapter 6

Agile Development with Scrum

6.1 Sprint Backlog

Table 6.1 shows the list of tasks completed so far and the time spent on each one. It also includes the priority level for each task. During the first sprint since we did not have many tasks to complete, the group was not divided in any particular way, and we shortly after decided on dividing the task of writing up a literature review corresponding to the two parts, we were completing research on at the time. After a consensus decision, Aref and Evans completed the first literature review while Sameh and Baraa took charge of the deep learning literature review that followed. However, for the research part itself, all 4 members worked on the Research for both Image processing techniques as well as Deep learning basics. During the second sprint, the tasks became more defined and we were able to distribute them more efficiently. As shown in the sprint backlog, each individual was responsible for a certain task from that point forwards, with the exception of the project report and deep learning research which was done as a group effort. We met for the research part once a week, but for the higher priority tasks we met twice a week to ensure all members were kept informed and up to date. At the end of this sprint, we now have our images segmented and ready to feed to the deep learning model.

Table 6.1: Sprint Backlog table

	Sprint Backlog Tasks	Priority (High, Med or Low)	Responsible By	Time Spent (Hours)	Sprint
1	Research (Image Processing techniques)	L	All	6	1
2	Write a Literature Review (on Image Processing)	L	Aref, Evans	3	1
3	Research (Deep Learning basics)	L	All	7	1
4	Write a Literature Review (on Deep learning basics)	L	Baraa, Sameh	3	1
5	Write a Project Report (1)	M	All	10	1
<i>Sprint 1 (12.10.20 - 29.11.20) Gather enough information regarding deep learning in Iris Recognition studies</i>					
6	Research (Deep Learning Algorithms)	L	All	7	2
7	Research (Image Segmentation Techniques)	M	Aref, Sameh	5	2
8	Research (Convolutional Neural Networks)	M	Baraa, Evans	7	2
9	Segmentation of Iris in Eye Images	H	Aref, Sameh	12	2
10	Preparation of Data Test and Training Sets	H	Baraa , Evans	2 (ongoing)	2
11	Write a Project Report (2)	M	All	10	2
<i>Sprint 2(30.11.20 - 27.12.20) Segment Iris from eye images + work on data set preparation + continued research</i>					

6.2 Sprint Burndown Chart

Table 6.2 shows the remaining time of the tasks of the first sprint over the first 7 weeks period. The sprint is shown against a general sprint guideline in red.

Table 6.2: Sprint 1 Burndown table

Task #	Sprint Backlog Tasks	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	<i>Sprint 1 Ends</i>
	Guideline	29	25	20	15	10	5	0	
	Remaining Values	29	23	15	13	10	7	0	
1	Research (Image Processing techniques)	6	0	0	0	0	0	0	
2	Write a Literature Review (on Image Processing)	3	3	0	0	0	0	0	
3	Research (Deep Learning Basics)	7	7	2	0	0	0	0	
4	Write a Literature Review (on Deep Learning Basics)	3	3	3	3	0	0	0	
5	Write a Project Report (1)	10	10	10	10	10	7	0	

Figure 6.1 shows the graphical format of the above Sprint 1 Burndown chart with the red line indicating the guideline to follow, and the green line representing the group progress on the hours spent and remaining on the tasks.

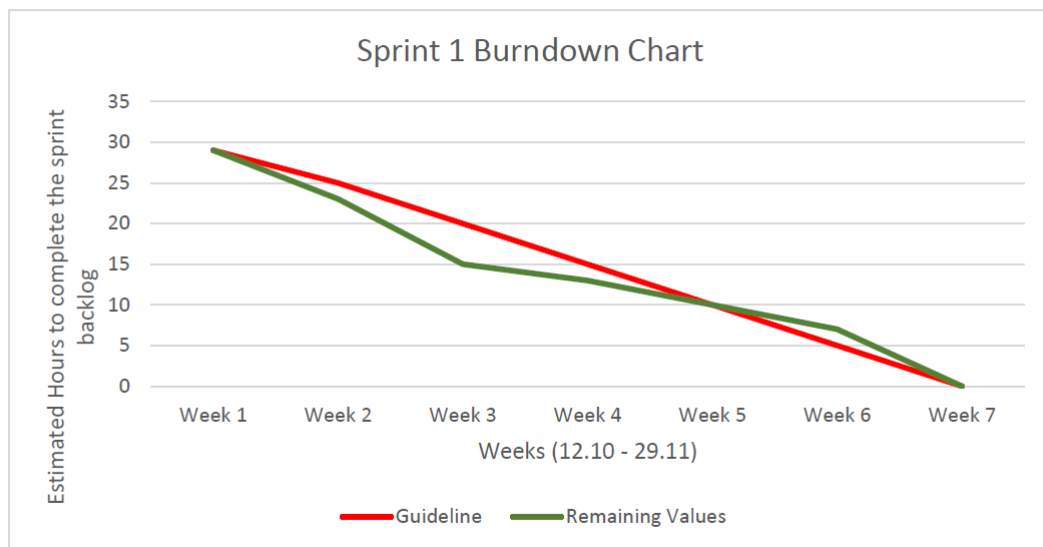


Figure 6.1: Sprint Backlog graph

Table 6.3 shows the remaining time of the tasks of the second sprint over the following 4 weeks, it is shown against a general sprint guideline

Table 6.3: Sprint 2 Burndown table

Task #	Sprint Backlog Tasks	Week 8	Week 9	Week 10	Week 11	Sprint 2 Ends
	Guideline	46	30	15	0	
	Remaining Values	46	32	15	7	
1	Research (Deep Learning Algorithms)	5	0	0	0	
2	Research (Image Segmentation Techniques)	4	0	0	0	
3	Research (Convolutional Neural Networks)	5	0	0	0	
4	Segmentaion of Iris in Eye Images	12	12	0	0	
5	Preparation of Data Test and Training Sets	10	10	10	7	
6	Write a Project Report (2)	10	10	5	0	

Figure 6.2 shows the graphical format of the above Sprint 2 Burndown chart with the red line indicating the guideline to follow, and the green line representing the group progress on the hours spent and remaining on the tasks.

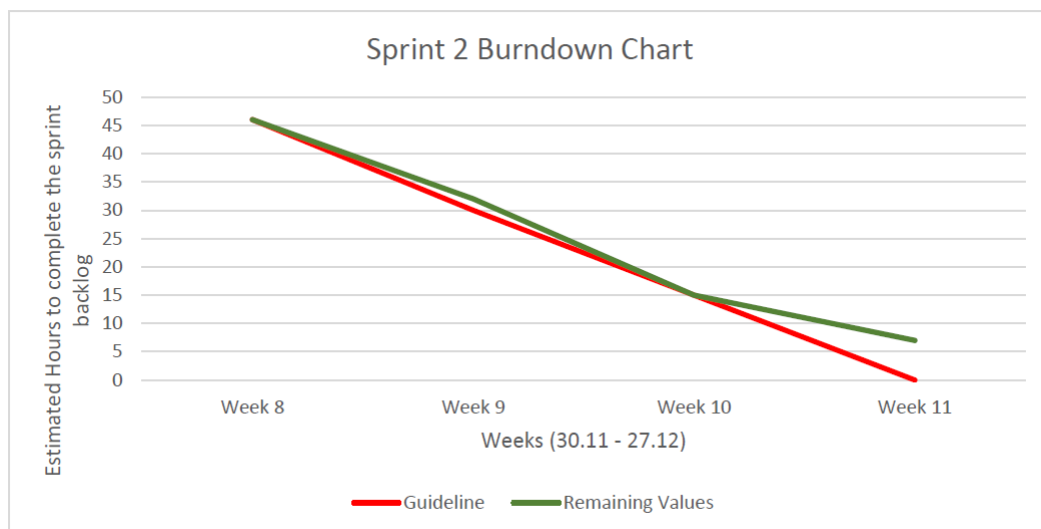


Figure 6.2: Sprint 2 Backlog graph

6.3 Sprint Review

Once we had completed the first sprint, which lasted for 6-7 weeks, we gathered strong knowledge regarding the very foundation and fundamentals of the image processing and deep learning basics we were planning to use in the second sprint further on, which is reflected in the first phase of the product backlog figure. This research-intensive work we completed revolved mostly around finding specific research papers which included many image segmentation processes as well as information on neural networks in general which were found through online means as well as being provided by our supervisor. The first sprint helped us transition easily to the next sprint which although had its fair share of research as well, this sprint was more focused on the application of the knowledge we have gathered up to this point. This helped us in completing the segmentation of the iris from the eye images and preparing the images in the correct format needed for the deep learning model we want to use. The research portion of the sprint could have been completed and managed better as it halted us from completing the division of the data test and training sets. We will keep in mind to complete research more efficiently for the upcoming future in order to match our sprint guideline.

6.4 Sprint Retrospective

At the beginning of the project, it was difficult to look at the shape of the sprint, although it looked like we were on track, there were very few and limited tasks to complete as well as the fact that most of the tasks revolved around individual research by each group member rather than strongly defined tasks which made the sprint chart obsolete. This caused us to encounter our first problem which was communication; although we met with our supervisor, the weekly meetings left many topics and questions regarding the project itself unanswered and unclear as we did not have a strong basis to work upon. This also resulted in miscommunication regarding a major aspect of the project as a whole: whether we were doing an application or research-based project. However, during the second sprint which occurred after the 7th week of the project development process, we learned to become more collaborative and work better together as a team. The first step was to make ourselves more experienced with the Trello Board and learn to use it in a correct manner. This immediately had a positive impact on the shape of the group, as we started to become more expressive in our opinions. On the other hand, we did not have to change everything, for example, our method of communication from start to present is done through Google Meets as we found it to be the easiest, fastest and most clear way of staying in touch within the group and with the supervisor as well. We also kept in touch with our supervisor more often through Messenger which was initially only used to set up and approve meeting dates and timings, however, on week 7 and on-wards we started to share more ideas and ask more questions through the Messenger medium as well where we were able to receive almost immediate answers. In summary;

What went well so far:

- Thorough research was made during the research-oriented weeks.
- Gathered many related works due to strong research.

- Were able to clearly grasp the end goal by the end of the project deadline.

What went wrong:

- Misunderstanding about the nature of the project (Research-based).
- Work done at the start and towards the end of the sprint more often, instead of being spread throughout the duration (caused fatigue).
- We were not able to complete the preparation of the data sets (training and test sets)
- Some tasks took longer than expected, mostly due to the 2nd sprint being much shorter (sprint 1 was 7 weeks, sprint 2 was only 4 weeks)

What was improved:

- Improved expressiveness during meetings and chats.
- Better use of communication software such as Trello, Messenger.
- Incorporate supervisor more strongly in development process.

What can still be improved:

- Manage time more efficiently in order to complete more demanding tasks on time whilst still doing research on the side.
- Look even further ahead in order to plan better and more accordingly.

Chapter 7

Estimation

7.1 Input

Each input in GUI is 1 functional point in which some are complex, simple and average.

Measurement Parameter	Count (value ≥ 0)	Weighting Factor
Number of User Input	7	Average
Number of User Outputs	2	Complex
Number of User Inquiries	1	Complex
Number of Files	2	Complex
Number of External Interfaces	0	Simple

7.2 Complexity Adjustment Table

Item	Complexity Adjustment Questions	Scale
1	Does the system require reliable backup and recovery?	5
2	Are data communications required?	5
3	Are there distributed processing functions?	1
4	Is performance critical?	5
5	Will the system run in an existing, heavily utilized operational environment?	5
6	Does the system require on-line data entry?	2
7	Does the on-line data entry require the input transaction to be built over multiple screens or operations?	1
8	Are the master files updated on-line?	1
9	Are the inputs, outputs, files or inquiries complex?	5
10	Is the internal processing complex?	5
11	Is the code to be designed reusable?	4
12	Are conversion and installation included in the design?	4
13	Is the system designed for multiple installations in different organizations?	3
14	Is the application designed to facilitate change and ease of use by the user?	4

Result	
Project Function Points	89.6999999

7.3 Line of Code

To calculate the number of code lines we chose Python as the language to use and had a unit size of 67 which we multiplied by ATFP. This is the average unit size for both.

Python 100

$$\text{Loc} = 67 * 89.7 = 6009.9$$

7.4 Estimate the Efforts

7.4.1 Constructive Cost Model COCOMO Basic

Development mode: organic.

$$a=2.4, b=1.05, c=0.38$$

Number of thousand delivered source instructions= (KDSI) = ATFP* Language unit size/1000 = 6009.9/1000=6.0090

Effort in staff months =effort in man-months=MM=a*KDSI^b = 2.4*(6.0090^{1.05}) = 15.77

The development time=TDEV=2.5*MM^c = 2.5(15.77^{0.38}) = 6.99 *approx.7months*

7.4.2 jones's first -order effort estimation methods

We are building a shrink-wrap kind of software in an average organization.

Rough schedule estimation = ATFP^e_{xp} = 90.042 = 6.61 *7months*.

7.4.3 Schedule rule of thumb

Schedule in months = 4.76 *5 months*

Chapter 8

Project Management

8.1 Milestones and Tasks

Table 8.1 shows all tasks to be completed by the end of the academic semester (January 2020) as well as the duration of each task, in addition to an estimate for the tasks in the upcoming weeks. The dependencies show which tasks depend on other tasks to be completed before they can be started. The group members responsible for the corresponding tasks are also mentioned. The colors indicate different sprint duration's (Blue = Sprint 1, Purple = Sprint 2, Green = Sprint 3).

Table 8.1: Tasks for the semester

Task #	Task	Duration (weeks)	Dependencies	Responsible By
T1	Research (Image Proc Techniques) + Literature Review	2		All
T2	Research (Deep learning Basics) + Literature Review	2		All
T3	Write a Project Report (1)	2	T1,T2	All
T4	Research (Deep Learning Algorithms)	2		All
T5	Research (Image Segmentation Techniques)	2		Aref, Sameh
T6	Research (Convolutional Neural Networks)	2		Baraa, Evans
T7	Segmentation of Iris region from Eye Images	1	T5 (M2)	Aref, Sameh
T8	Crop and Prepare Segmented Images	1	T7	Baraa, Evans
T9	Divide Images into Training and Test set	1	T8	Baraa, Evans
T10	Write a Project Report (2)	2		All
T11	Convolutional Neural Network (Code)	1		Baraa, Evans
T12	Train Deep Learning Model	1	T7,T8,T11(M3)	All
T13	Gather Outcome (Accuracy) Information	1	T12	Baraa, Evans
T14	Analyze Deep Learning Model Results	1	T13	Aref , Sameh
T15	Compare Deep Learning Outcome vs Traditional Methods	1	T13	Aref, Sameh
T16	Design and Code the GUI	2		Aref, Sameh
T17	Integrate GUI with Model and Database	1	T16, T12 (M4)	All
T18	Write a Project Report (3/Final)	2		All

Table 8.2 shows the milestones occurring throughout the academic semester. Milestones represent any significant goal or activity in the project cycle.

Table 8.2: Milestones for the semester

Milestone #	Milestone
M1	Project Fundamentals Understood
M2	Sufficient Fundamental Research for Deep Learning Model
M3	Images are Segmented and Ready (Finalized Format)
M4	Deep Learning Model Complete
M5	Results Analysis and Comparison Report Ready
M6	Finalized Working GUI
M7	Final Working Prototype (FINISH)

8.2 Gantt Chart

Figure 8.1 shows the visual representation of tasks that are scheduled throughout a time period (one semester's length). The tasks mentioned in table 8.1 are shown on the left of the chart and the corresponding scheduled dates are followed. The progress of each task and completion status of each milestone is shown with a percentage. In the case of this project cycle, the tasks are between 1 to 2 weeks and are represented with the bars shown on the timeline. Each milestone from table 8.2 is indicated with an orange diamond and each color corresponds to a different sprint duration (Blue = Sprint 1, Purple = Sprint 2, Green = Sprint 3).

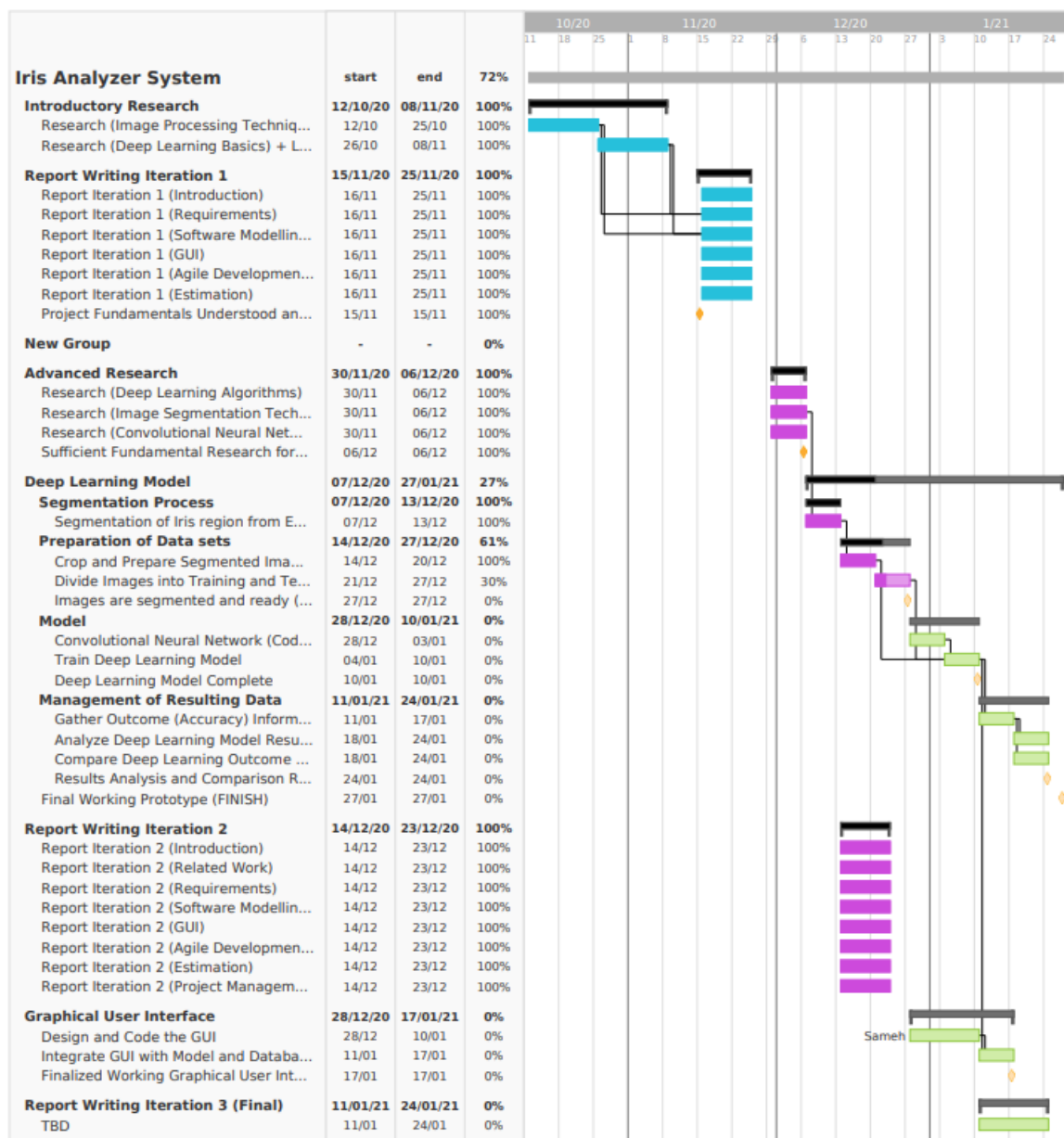


Figure 8.1: Gantt Chart

Chapter 9

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