Final Project Report

Secure Face Recognition App

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Content

Abstract

The concept of this project is to develop a face recognition application that can successfully recognise faces that are saved in the system and allow users to login using this feature. The reason for this login method is because it is more secure than the generic username and password systems which can be easily hacked into with the technology available today. What makes this application unique is the features the application has to offer for the users as it would have a password generator, password checker, image manipulation/identification features, notepad function, and face recognition system. This application would make use of many states of the art methods such as machine learning, AI, deep learning, and computer vision. I want this application to be used by individuals and hope that in the future the login face recognition feature could replace ID cards since it is a more secure and reliable method.

Keywords

Face recognition; Computer Vision; Deep Learning; AI; Machine Learning

Introduction

The general field I will be working in is computer vision and machine learning. Recently face recognition is being used more in different areas of the industry for example it is being used within airports to improve security; devices that people use daily such as mobile phones and laptops. My goal with this application is to make facial recognition technology more available to people to utilise whilst giving them a reason to use it which is by creating a secure environment where people can save files; write files; open files; and perform basic notepad functions, such as copy, paste, cut, undo and redo whilst being able to use keyboard shortcuts to perform these functions. This allows users to safely store sensitive information within the application and perform many other functions such as generate a random password or check the strength of a password of their choice or the password they generated. Additionally, since there are not many applications that provide such features for the users this would entice the user into using this application.

Finally, by using facial recognition technology as the login, it makes the application have a secure security system since a user's face is unique making it harder to breach into their account and get access to their sensitive information compared to password and username login systems which are easier to breach due to certain algorithms and methods available, for example brute force, phishing and many more causing it to be a system with a lot of vulnerabilities. An article published in May 2021 stated that 1 million passwords are stolen every week [1] and another article states that 80% of data breaches are due to poor password security and 50% of people use the same password for all their logins [2] making those people more vulnerable to being hacked and having their sensitive data stolen. Hence favouring facial recognition login systems since it is harder to hack as the user's face is unique. By users using this application it makes it more convenient for the user to generate secure passwords that they can use so they do not need to reuse the same password again and they can save those generated passwords within the application which is a secure environment that they would only have access to. This application would benefit the people with weak passwords and reused passwords preventing them from being vulnerable to

hacks within our system. Which is one of the reasons why I believe this application is worth developing.

Analysis

Features & Objectives

- **Face recognition system** (Detects faces and recognises all users that have been added to the system)
- **Face recognition login system** (Allows specific users to login to the application making the system more secure)
- **Password checker** (Checks the password the user inputted and returns the strength of the password)
- **Random password generator** (Generates and displays a random password using the parameters the user inputted)
- **General upload images** (Uploads images to the known folder. These users would not be able to login to the system, but the system would be able to recognise these individuals within the face recognition feature)
- **Login upload images** (Uploads images to the knownAdmin folder. These users would be able to login to the application as the login recognition feature can only recognise them)
- **Face match** (User uploads image, system checks if user in the image is in the system. If user is in the system, display a popup window with the user's name on it. If the user is not in the system, then display this user is not recognised)
- **Pull faces** (Takes a snapshot of the faces the system is able to recognise within the image uploaded. Display and save the images with a unique name to the pullfaceimages folder)
- **Identify faces** (User uploads image. System checks the people in the image and returns the image with the people's names it has recognised under their face; unrecognised people would be displayed as unknown then the image is displayed and saved to a folder called identifyfaceimages)
- **Find faces** (Finds number of faces within the image uploaded and displays it on a popup window)
- **Face app sign up** (If there are no admins within the system then it would allow you to sign up by making you chose an image of yourself to upload then it would open the login frame to allow the user to login to the system using their face)
- **Notepad**
- **Tkinter GUI** (This is the simple graphical user interface for users to navigate around the application and use specific functions available with ease)

Background

Identification

Looking at market growth and compound annual growth rate you can see that the face recognition market is rapidly growing compared to the password and username management market. Compound annual growth rate is the mean annual growth rate of an investment over a specified period of time. It is one of the most accurate ways to calculate the returns of an investment that can rise or fall in value over time [3], hence you can calculate the compound annual growth rate of the face recognition and password management market. The formula to calculate annual growth rate is below.

$$\mathrm{CAGR}(t_0, t_n) = \left(\frac{V(t_n)}{V(t_0)}\right)^{\frac{1}{t_n - t_0}} - 1$$

(Formula For Compound Annual Growth Rate)

In the formula above $V(t_0)$ is the initial value $V(t_n)$ is the final value and $t_n - t_0$ is the number of years.[4]

Data shows that there is a higher demand for facial recognition technology since it has an annual growth rate of 17.47% compared to the password management market which has an annual growth of 16.21% which is 1.26% lower. Furthermore, the facial recognition market was valued at $3.8 billion in 2020 [5] and the password management market was valued at $1.2469 billion [6] which is $2.5531 billion dollars less than the facial recognition market. Showing that the facial recognition market is valued more and will grow faster than the password management market, meaning that there is higher demand for this technology. Since this is the case, I've decided to develop an application that uses face recognition technology that can be used by anyone daily and aid them in keeping sensitive data safe whilst making use of many other functions and speeding up irritating tasks such as coming up with a secure password or using username and password to get access to a storage system which takes longer compared to facial recognition login.

Stakeholders

The main stakeholders for an application such as this would be anyone that can operate a computer and anyone that has sensitive information.

The application will undergo UI testing by a variety of individuals which cover a wide range of categories such as people from different age groups. Testing would be done a variety of people; this is because it can give me a better insight on what the majority of the people prefer or want, allowing me to tailor the application to fit the majorities preferences such as changing the colour to the colour most people from the user testing preferred or changing

certain features that most people criticised. This would allow me to adapt the application to the majorities likes enabling me to target the mass market of my application.

Another stakeholder for this application would be the investors. This is because the investors would want to monetise the application to get dividends for their investment and get their investment back. One way to monetise the application would be by doing sponsorship deals with different companies and advertise their company to users that are using the application. Another way would be by using programs that would allow me to run ads on the application to monetise the application, for example google AdSense which provides a way for publishers to earn money from their online content. It works by matching ads to your site based on your content and visitors [7]. By monetising my application, it would keep the investors happy as they would be getting dividends on their initial investment, and it enables me to pay any employee that is maintaining the application or further developing the application.

Research

There is a higher demand for systems that make use of facial recognition technology, and this can be seen in the technology available currently as most large brands have implemented facial recognition technology into their devices. For example, mobile phones and laptops have face recognition as their sign in feature and some devices use face recognition to allow payments to occur with that specific device. Some large brands that have implemented face recognition technology into their devices that consumers use daily are Apple, Samsung, One plus, HP, Windows and more.

The companies that are making use of this technology, allow the public to be able to have access and exposure to this technology, however these companies only use the technology to perform basic functions such as to unlock their device and the technology is rarely used within the device. However, my aim with this technology is to make an application that uses the technology constantly and allows users to perform many other functions such as using the notepad function to save files; write files; open files within the application. This allows the user to safely store the sensitive data in the files within the system. Also, if the user's device is unlocked a hacker will still be required to go past another security measure that my application has which can only be unlocked by the owner's face. Furthermore, the way these large brands have implemented the technology is only useful if the device is locked. If the device is unlocked and someone has remote access to the device, then they would be able to get all the sensitive data from that specific individual's device. However, if that user was utilising my application, then the hacker would have a harder time extracting the sensitive data from the device as it is securely stored within the application I developed.

An application that makes use of face recognition is true key this application allows users to protect and manage their password. The system is said to be able to work in almost all lighting conditions, including extremely low light situations. The application uses the users' devices biometric sign in methods that are already implemented in the device [9] for example if you were on an apple device it would make use of Apple's Face ID, suggesting that the application has not developed their own face recognition system. Therefore, there

is a chance that if the face recognition system on your device is bad then the application may perform poorly. Also, the application would not be able to work with older devices such any iPhone before the iPhone X since the predecessor of the iPhone X did not have face recognition technology. Hence the true key application may not fully work. However, with my system the face recognition application would work since the application does not require the user to have face recognition technology already implemented in their device since the face recognition technology is developed within the application hence allowing devices that do not have the technology preinstalled to be able to make use of it. This also allows more people to be exposed to this type of technology which may entice more users to want to use the application, potentially making my application more popular than competitors within the industry. Furthermore, in less developed countries people tend to have older devices that may not have facial recognition technology meaning that the true key system may not work as intended on those devices compared to my secure face recognition application which would in theory work as intended making my application better than some competitors that make use of this technology.

A company that uses face recognition successfully is MEGVII which is one of the largest companies that works with facial recognition technology. MEGVII uses deep learning for their face recognition technology. Their product Face++ can detect and analyse 106 data points on the face [10]. Compared to the technology I am using which uses 128 data points per face whilst using deep learning as well. Allowing my face recognition technology to have an 99.38% accuracy [11]. However, MEGVII's computer vision technology is more advanced than mine since it can perform more complex tasks such as gender and age recognition which has achieved a 99% age recognition accuracy with a maximum deviation of +/- 5 [12]. Compared to my application which performs poorly with children since the face recognition model is trained on adults meaning that it would struggle to do tasks such as age recognition with a maximum deviation of +/- 5.

However, my goal with face recognition is to have the system to be able to recognise people that are saved within the system successfully and allow certain people to login to the system to be able to perform the other features the application has to offer to the user. Therefore, having complex tasks would not be necessary in the short term. However, in the long-term developing complex tasks such as age recognition; gender recognition or face attribute recognition can be useful in different industries such as trying to find someone that has disguised themselves since you would have a better description of the person due to the complex task the facial recognition system can perform making it easier to identify them. To achieve this, since MEGVII's computer vision platform is open source, I can use the API's that MEGVII offers allowing me to implement their technology into my application allowing me to improve my application and the technology it has to offer even further. Furthermore, MEGVII does not have an application that the public can easily download and make use of the technology compared to mine which will be an application that is available to the public to make use of the technology allowing more people to have access to facial recognition technology whilst having the ability to perform other function or store sensitive information.

Methodology

Theory

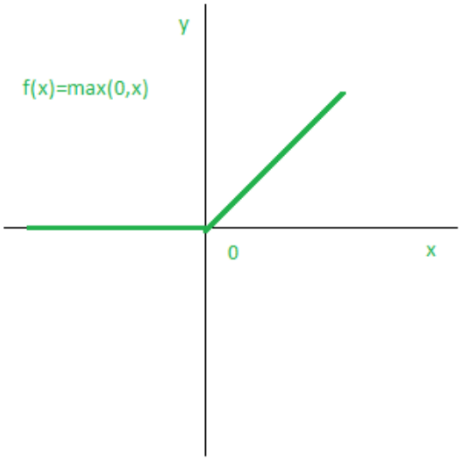
The library I am using is a model trained on adults. It has been trained using images. The system was built using Dlib's deep learning which is the state-of-the-art face recognition system [13]. The face recognition library encodes Dlib's face capture into 128 data points per face resulting in a unique parameter for the hash of each face across a variety of different photos. Causing the library to have a 99.38% accuracy on the university of Massachusetts' labelled face in the wild benchmark dataset [11]. The library's model of face encodings is from dlib metric learning.

The system uses a ResNet network with 29 convolutional layers where it applies a convolution operation to the input passing the result to the next layer [14]. A ResNet also known as residual neural network is an artificial neural network. ResNet utilises the skip connection or shortcuts to jump over some layers. Normally ResNet is implemented with double or triple layer skips that contain ReLu and batch normalisation [15]. Furthermore, ResNet is a way to manage the vanishing gradient problem in deep convolutional neural networks [16]. The vanishing gradient problem limits the development of DNN (deep neural networks) with activation functions [17]. Vanishing gradient is when more layers that use activation functions are added to the neural network which causes the gradient of the loss function to approach to zero making the network harder to train which can lead to the system to not reach its maximum potential [18].

Therefore, by using ResNet it would prevent vanishing gradient problem from occurring which would allow the development of DNN with activation functions. ReLu is a non-linear activation function that is used to perform on multi-layer neural networks [19]. ReLu is defined as follows:

$$f(x) = \max(0, x)$$

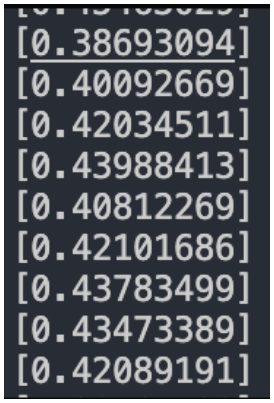
(How ReLu Works)



(ReLu Graph Using f(x)=max(0,x))

One of the main advantages of ReLu function over other activation functions is that ReLu does not activate all the neurons at the same time [19]. So, if the input is a negative it will convert it to zero and the neuron would not get activated and if the input is a positive then the neuron would get activated leading to a graph similar to the one above.

The system was trained from scratch on a dataset of approximately 3 million faces. Some of the datasets used to train the model were derived from the face scrub dataset (a dataset with over 100,00 face images of 530 people) and the VGG dataset (a dataset of 2.6 million face images of 2,622 people) [21,44].
The Deep learning algorithm will compare the measures of each face to known faces in a database by using the unique measurements of each face and then the match would be the closest face in the database [22]. To fix this I decided to add a threshold which finds the face distance of the face with the face that is the most similar and if it is below the threshold of 0.45 then the face is the same as the one in the known faces database. I did many tests to figure the most optimal threshold. I achieved the best results by printing the face distance values of an image of me compared to me in the webcam. This allowed me to find the optimal threshold for the system to perform at its maximum potential.



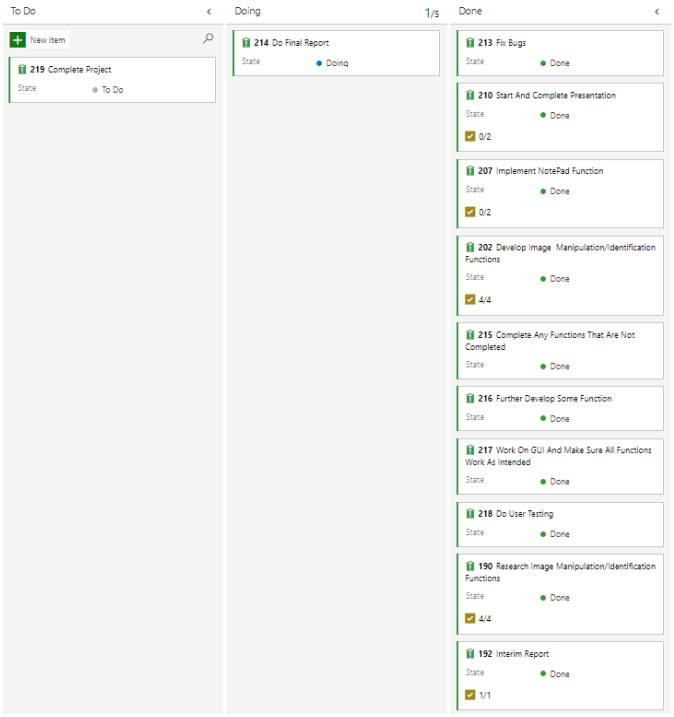
(Face Distance Values In Console)

Within the image above you can see that the highest value is 0.44(2dp) so I decided to use 0.45 as the threshold. This is because the system would get the image with the closest match to the face in the webcam and recognise that person as the closest match but by checking if the face distance is less than 0.45 it allows the system to be able to accurately recognise people within the system and not within the system. Hence the threshold of 0.45 allowed the system to provide the most accurate results at recognising between different individuals and was able to successfully distinguish if someone is not within the system.

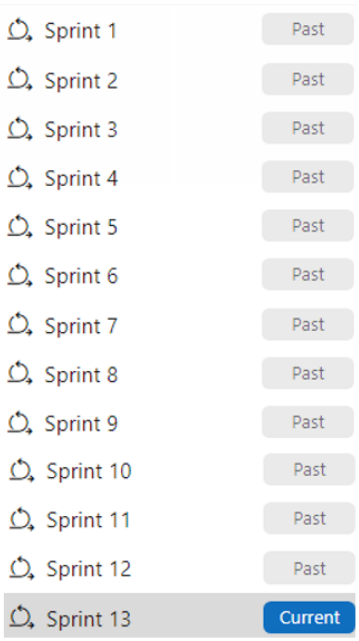
Implementation

Whilst developing this application I'd make use of third-party software to assist me in keeping track of my progress. One of the methods that I used is Kanban which enables me to keep track of the tasks that have been done and ones that need to be done. This will give me a good idea of what needs to be done next and would allow me to work more efficiently as I've a clear goal to achieve, which is the task that I am currently working on. Furthermore, I'd make use of sprints to manage my time for each feature I am developing for the

application, so I don't spend too long on certain features causing me to fall behind in development and have a half-done application. To help me create sprints I will use Gantt charts. This will influence how my sprints are set up and it would give me a good indication of what I've to do during a certain sprint. These methods would enable me to manage my time efficiently and effectively enabling me to keep track of my progress therefore aiding me in developing this application.

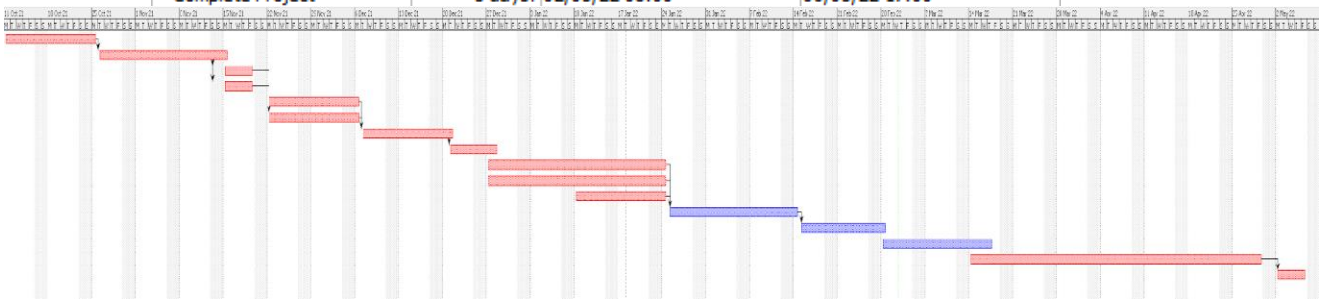


(Image Of Kanban)



(Image Of Sprints)

Name	Duration	Start	Finish
Project Spec	11 days?	11/10/21 08:00	25/10/21 17:00
Research & Implement Face	15 days?	25/10/21 08:00	12/11/21 17:00
Submit Prototype	5 days?	13/11/21 08:00	19/11/21 17:00
Research & Implement GUI	5 days?	13/11/21 08:00	19/11/21 17:00
Research & Implement Face	11 days?	22/11/21 08:00	06/12/21 17:00
Early User Testing	11 days?	22/11/21 08:00	06/12/21 17:00
Research & Implement Passv	11 days?	06/12/21 08:00	20/12/21 17:00
Research & Implement Uploa	6 days?	20/12/21 08:00	27/12/21 17:00
Further Develop Certain Fea	21 days?	27/12/21 08:00	24/01/22 17:00
Research Image Manipulatior	21 days?	27/12/21 08:00	24/01/22 17:00
Interim Report	11 days?	10/01/22 08:00	24/01/22 17:00
Develop Image Manipulation,	15 days?	25/01/22 08:00	14/02/22 17:00
Research & Implement Notep	10 days?	15/02/22 08:00	28/02/22 17:00
Presentation	14 days?	28/02/22 08:00	17/03/22 17:00
Refer To Sprint 12 On Sprints	35 days?	14/03/22 08:00	29/04/22 17:00
Complete Project	5 days?	02/05/22 08:00	06/05/22 17:00



(Gantt Chart)

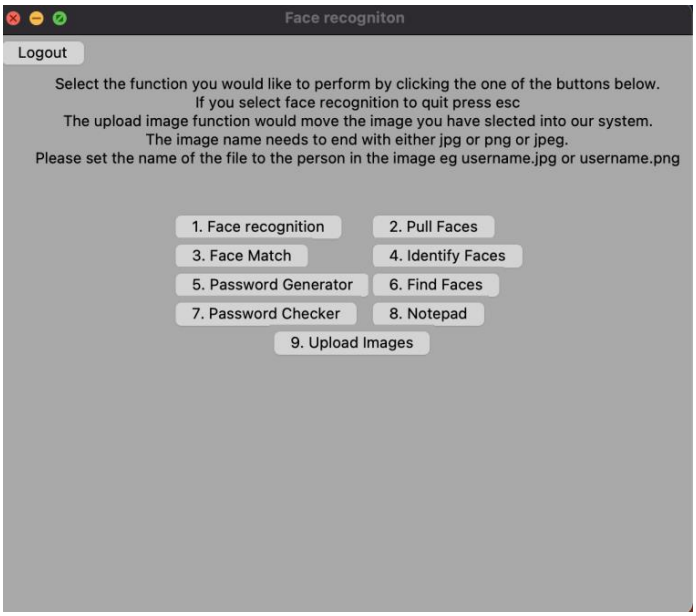
I have made use of the libraries that are available to me which were very useful when developing this application. The main libraries that I made use of were OpenCV [45], NumPy [46], Face recognition [13], OS [47], Tkinter [24], Shutil [48], PIL [49] and pip [20]. The IDE that I have used whilst developing this application is visual studio code. This is because I have prior knowledge and experience with this particular IDE from doing a group project in year 2 which gave me the necessary knowledge to be able to work with this IDE and develop my application successfully. The main language I have used for my application is python the reason for this is because python is a very flexible language and has a vast number of frameworks and libraries that are well developed for machine learning, AI and deep learning which are some of the key components required for developing a face recognition/detection application. Python also has the ability to do a set of complex machine learning tasks which can help build prototypes quickly allowing testing to occur more often which can be useful when developing complex applications such as face recognition systems. My methodology will be based on the waterfall model which is a sequential development style which would allow me to focus on each part of the development fully before moving on to testing.

Iteration 1 (Sprint 1)

I first started to research around face recognition and find what features I would like to implement into my application. Once I had the set of features I would like to implement, I decided to then think of how to design the application. I did this by creating low fidelity and high-fidelity wireframes. Which can be found within the appendix of this report.

Iteration 2 (Sprint 2 – 3 & 6)

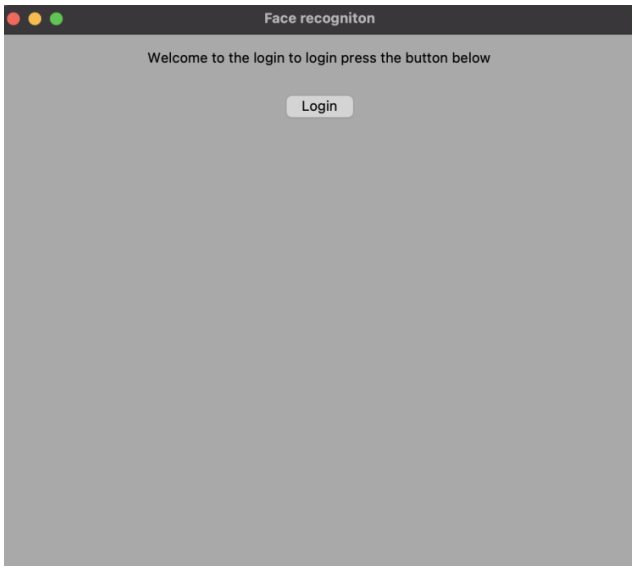
During this iteration I started the development of the application by researching how to develop a face recognition application. Then I came across a library that was supported by pip. The library was pre-trained allowing me to easily use the system they had and further develop their system to make it work better than it was. They also provided examples on how I could potentially use the library to make the face recognition system work [23]. This allowed me to develop the main part of my system which was the face recognition system. Then I implemented a basic UI using my designs and the Tkinter library so I could put all the features the application is offering in one place. I achieved this by utilising the tkinter library documentation [24] and some examples on how to implement a tkinter GUI [25]. After that was implemented, I decided to implement the upload images function as it would make the in-house testing in the earlier stages easier as I could upload new images for the system to recognise faces faster without wasting time. I implemented the upload image's function by mainly using the shutil library [48].



(First Version Of The Application With Only Face Recognition And Upload Images Working)

Iteration 3 (Sprint 4)

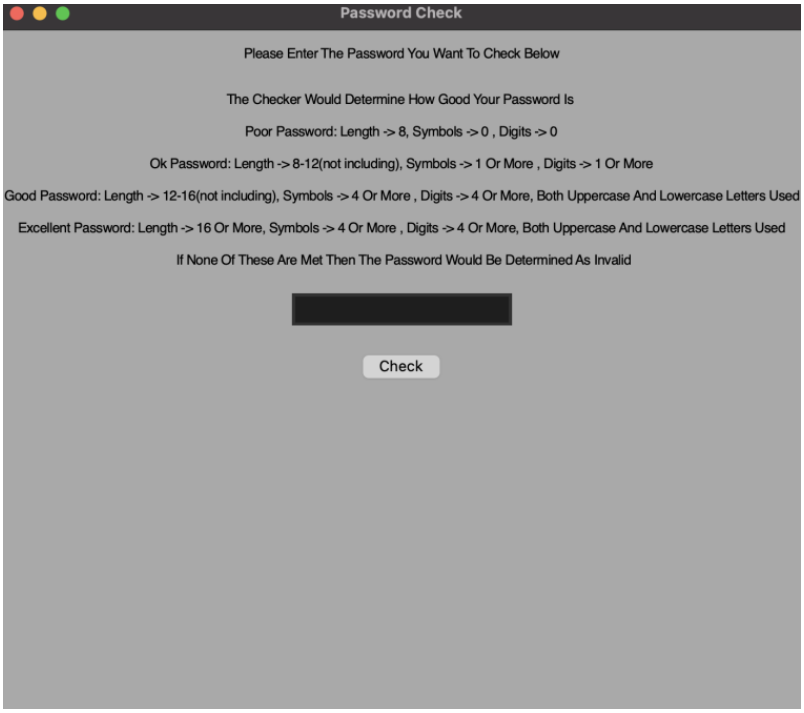
During Iteration 3 I decided to start research on allowing users to login to the system using the face recognition feature. I implemented a new frame which would be the initial frame to open when a user launches the application and they would be required to press a button to be able to login once they pressed the button then the face recognition system would launch and if the system is able to recognise the user, then the frame that contains all the features the application offers will launch meaning that the login was successful. However, if the user is not recognised then the login face recognition system would run until someone that it can recognise is looking at the webcam. After this I had some errors that would come up in the console, so I also managed those errors during this iteration.



(Login Frame And Face Recognition Login Feature Implemented)

Iteration 4 (Sprint 5)

During this iteration I started to research potential ways I could implement a password generator and checker and decided to use a similar method used in my year 2 java module where we were required to implement a password checker and generator. If I had more time, I would have further developed the password checker feature by using dictionaries to check how common a certain password is which would help determine the strength of the password. I could have also checked if the password that the user has inputted has common words used in English which could also help determine the strength of the password. However, currently for my password checker I created some parameters to determine the strength of the inputted password. In the image below you can see the password checker UI and the parameters it is using to determine the strength of the password.



(Password Checker Frame)

Then I implemented a password generator which would use letters, numbers and symbols found on a generic keyboard to randomly generate a password using the users inputted parameters then the user can copy the password generated to their clipboard. This function had some errors as people could input anything for example users can input letters whilst digits are required or input a higher value for digits and symbols than length of password which would stop the password checker from running as intended to. I am going to fix this in a later iteration.

(Password Generator Frame)

After I had this implemented, I did some user testing with the face recognition system so I could talk about how my system is performing within my interim report.

Iteration 5 (Sprint 7 & 9)

During this iteration I began by checking some of the features that have been implemented and checked if they worked as intended or if there were bugs within the features that were currently implemented. If so, I'd then proceed to fixing the bugs within those features.

Once I was done with that, I started researching potential ways to implement image manipulation/identification features. I came across a tutorial [26] on how to implement the features that I was intending to implement based on the face recognition library that I was making use of. The tutorial was very basic and most of the features were hard coded and were not dynamic, but it gave me a good understanding of how I could potentially implement the features into my application. By using the tutorial and some of the code provided within the tutorial I was able to adapt the code to work with my dynamic application allowing it to work in different scenarios and return various messages depending on the user inputs. I also made it so the features allow users to upload specific images they would like to use on the feature by using tkinter filedialog which further enhanced the image manipulation/identification features. Finally, the main libraries I used during this iteration were face recognition [13], pil [49], os [47], Numpy [46] and tkinter [24] which allowed me to successfully implement pull faces, identify faces, face match, and find faces function.

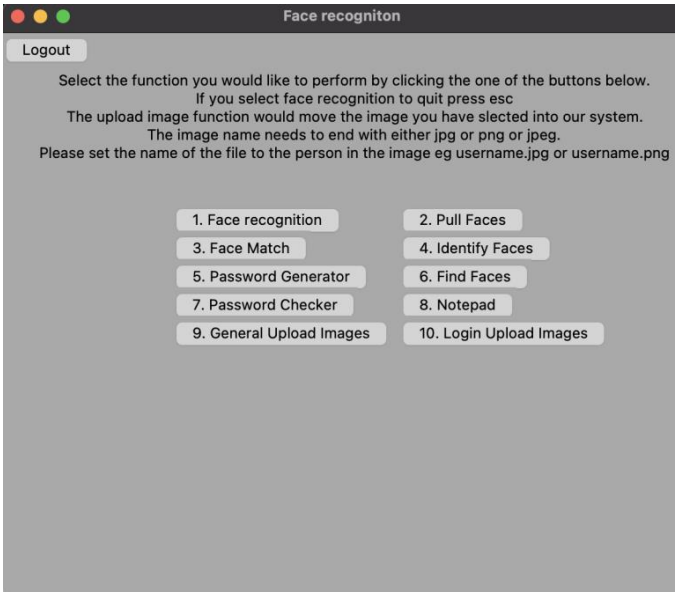
After I had implemented this, I decided to further develop the login feature as right now anyone saved within the system has the ability to login. I did this by splitting the users that can login and cannot login by creating two new folders to store images of people, one for admin users and another for normal users. Then within the login face recognition feature I only made it so it would use the admin images folder, so it could only recognise admins and not normal users this allowed the application to only allow admins to login. Then within the normal face recognition feature I made it so the system would use both the normal user folder and admin user folder and recognise anyone from either folder. Then I decided to implement another upload images button, but this one was for login users only which would be admin users, so that the images of admins are uploaded to the admin images folder if the login upload images button is pressed. This is implemented using a similar method to the general upload images feature.

```
#finds the files with all the images of the admins. The names of the admins are in the file name
path,dirs,files = next(os.walk('./img/knownAdmin'))
#get the number of files within the knownAdmin folder
Admin_file_count = len(files)

#empty array/list
KnownFaceEncodings = []
KnownFaceNames = []

#set i to 0
i = 0
#goes through the number of files
while i is not Admin_file_count:
    #get the name of each file one by one and saves it to name
    name = files[i]
    #skips the file name .DS_Store which is found on macs.
    if(name != ".DS_Store"):
        #loads the specific file it is on and adds the files face encodings to the KnownFaceEncodings array/list
        KnownFaceEncodings.append(face_recognition.face_encodings(face_recognition.load_image_file("./img/knownAdmin/" + name))[0])


        #splits the filename to only get the name of the admin in the file and saves that to the KnownFaceNames array/list
        split_string = name.split(".", 1)
        name = split_string[0]
        KnownFaceNames.append(name)


    #increment i to move to the next file
    i += 1
```

(Code In Login Face Recognition That Would Only Allow System To Recognise Admin Users)

```
#finds the files with all the images of the admins. The names of the admins are in the file name
path,dirs,files = next(os.walk('./img/knownAdmin'))
#get the number of files within the knownAdmin folder
Admin_file_count = len(files)

#empty array/list
KnownFaceEncodings = []
KnownFaceNames = []

#set i to 0
i = 0
#goes through the number of files
while i is not Admin_file_count:
    #get the name of each file one by one and saves it to name
    name = files[i]
    #skips the file name .DS_Store which is found on macs.
    if(name != ".DS_Store"):
        #loads the specific file it is on and adds the files face encodings to the KnownFaceEncodings array/list
        KnownFaceEncodings.append(face_recognition.face_encodings(face_recognition.load_image_file("./img/knownAdmin/" + name))[0])


        #splits the filename to only get the name of the admin in the file and saves that to the KnownFaceNames array/list
        split_string = name.split(".", 1)
        name = split_string[0]
        KnownFaceNames.append(name)


    #increment i to move to the next file
    i += 1
#finds the files with all the images of the known users. The names of the known users are in the file name
path,dirs,files = next(os.walk('./img/known'))
#get the number of files within the known folder
known_file_count = len(files)

#set i to 0
i = 0
while i is not known_file_count:
    #get the name of each file one by one and saves it to name
    name = files[i]
    #skips the file name .DS_Store which is found on macs.
    if(name != ".DS_Store"):
        #loads the specific file it is on and adds the files face encodings to the KnownFaceEncodings array/list
        KnownFaceEncodings.append(face_recognition.face_encodings(face_recognition.load_image_file("./img/known/" + name))[0])


        #splits the filename to only get the name of the person in the file and saves that to the KnownFaceNames array/list
        split_string = name.split(".", 1)
        name = split_string[0]
        KnownFaceNames.append(name)


    #increment i to move to the next file
    i += 1
```

(Code In Face Recognition That Would Allow System To Recognise Both Admin Users And Normal Users)



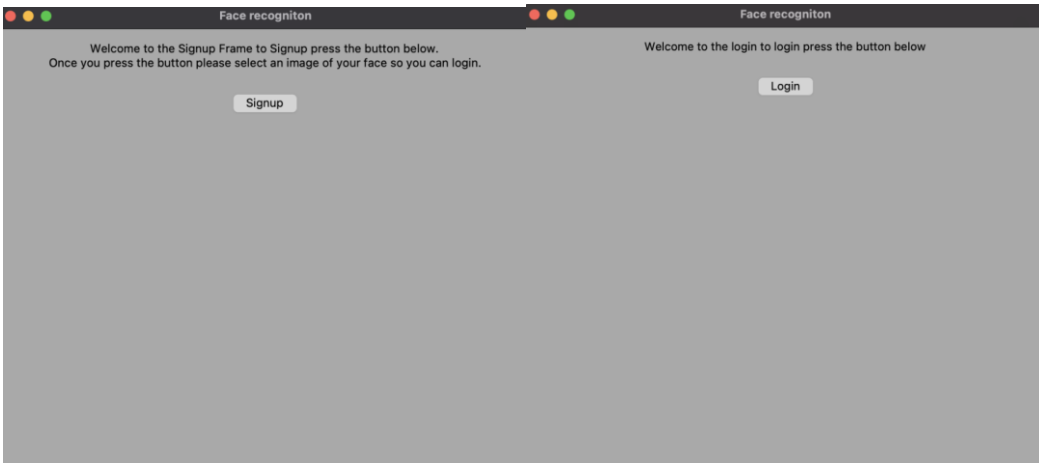
(Main UI Frame)

Finally, I decided to develop a sign-up feature. I done this by working on my login feature. Within the file where I implemented the login window, I changed it so it would check if admin users exist within the application by counting the number of files within the knownAdmin folder whilst excluding the ds_store file.

```
#finds the files with all the images of the admins. The names of the admins are in the file name
path,dirs,files = next(os.walk('./img/knownAdmin'))
#get the number of files within the knownAdmin folder
Admin_file_count = len(files)

#initialise i as 0
i = 0
while i is not Admin_file_count:
    #get the name of each file one by one and saves it to name
    name = files[i]
    #skips the file name .DS_Store which is found on macs.
    if(name == ".DS_Store" and Admin_file_count > 0):
        #subtract one from Admin file count as .DS_STORE is a file that is found on macs
        Admin_file_count -= 1
        #checks if Admin_file_count is equal to 0 if it is then it would stop the while loop from running
        if(Admin_file_count == 0):
            break
    i+=1
```

(Code That Checks If Admin User Exists)

If there were an admin in the system, it would require you to login by displaying the login window text. However, if an admin did not exist in the system, it would require you to sign up to the application with the signup window text being displayed on the frame. If the user pressed the signup button, it would require the user to upload an image of themselves which would be uploaded to the knownAdmin folder and then the login/signup window would reopen with the login prompt this time, as an admin exists within the system.

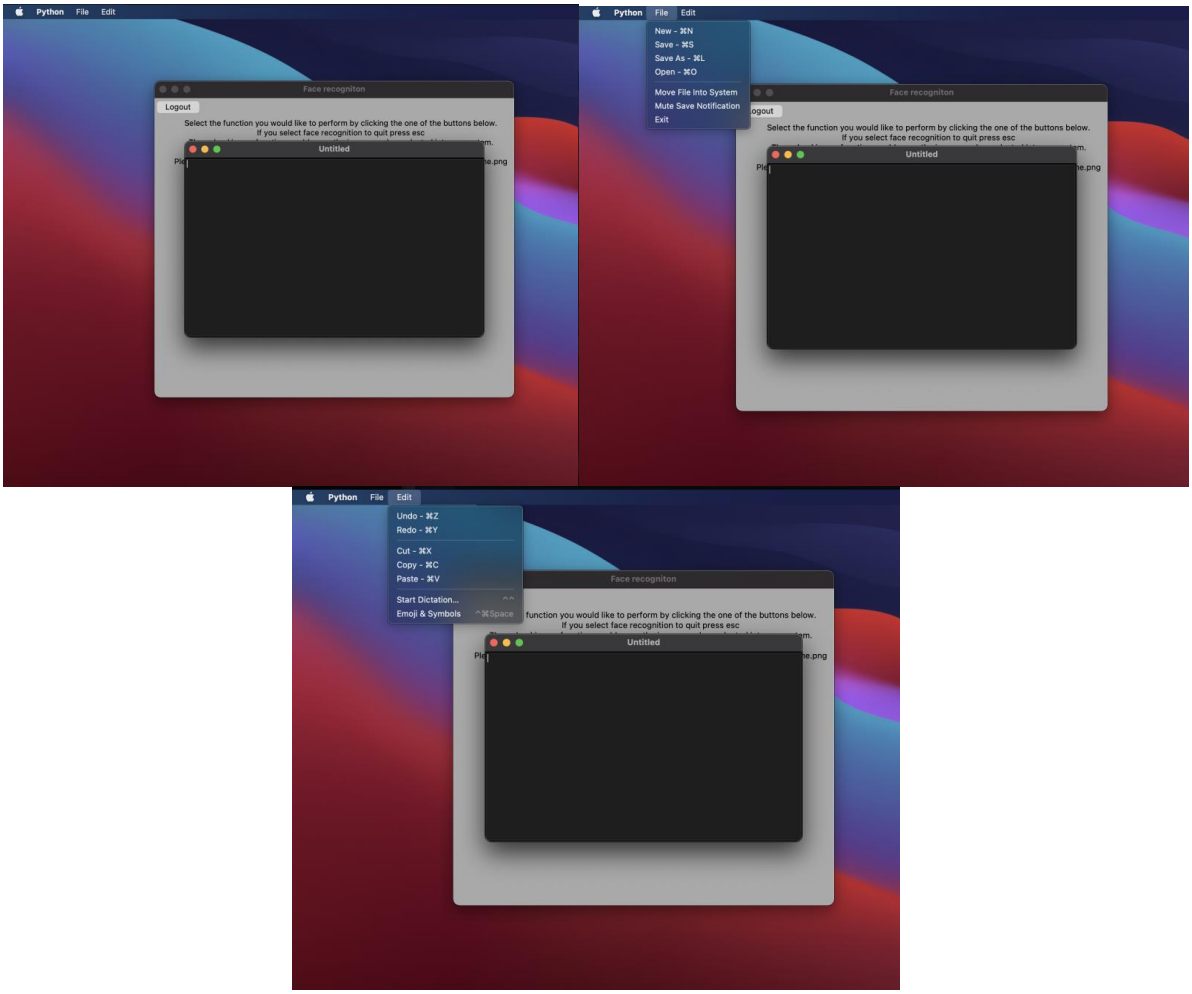


(Sign-Up And Login UI)

Iteration 6 (Sprint 10)

During this iteration I started research on the final feature on the application which was the notepad function. From my research I found out that I could use tkinter to develop the notepad function. Tkinter is what I've been using to develop my GUI. After utilising multiple websites which offered tutorials on how I could implement the notepad function using tkinter I was able to develop the feature to a good standard where it was able to perform all the necessary functions that a notepad function was required to perform. For example, save, save as, open (which can open files of specific type which are txt, py, java, cs), new file, paste, copy, cut, undo and redo. I further developed the feature by adding notifications so every time a file is being saved there would be a pop up stating that the file has been saved with the time and date it has been saved. However, if a user is constantly saving files this may get annoying so I decided to implement a new feature that is found within the menu bar which can be used to mute the save notifications if pressed and if it is pressed again, it would unmute the save notifications. The default is, notifications are not muted. I also implemented another feature that could be found within the menu bar which is move files this would allow users to select a file of certain type (txt, docx, doc, rft, tex, wpd, py, java, cs) and move that file into the specific folder within the system where all the files are securely stored. Once the file is moved a pop-up frame would appear stating that the file has been successfully moved into the system. If the user selects a file that is not the correct type, then a pop up would appear stating that the file is the incorrect type.

Finally, I implemented shortcuts/key bindings for the functions that are found within the menu bar and displayed the specific functions shortcuts within the menu bar, so users know the shortcuts for all the functions in the menu bar. I decided to implement shortcuts because it makes it easier for users to use the application and it allows users to waste less time whilst performing functions as they would not need to constantly open the menu bar and click on the specific function they would like to utilise.



(Notepad Function UI)

The main sites used whilst developing this function can be found within the bibliography at indices [27-42].

Iteration 7 (Sprint 11)

During this Iteration I decided to go over the functions that I have implemented and looked for any bugs within my code and fixed any bugs that came up. I fixed the bugs by making use of the console and the print tool within python to debug the code and find what is causing the bug. This allowed me to successfully fix the bugs within my application.

After this was done, I looked at my system and thought of ways that I could improve some features. I decided to improve my password generator and checker function.

I improved the password generator function by adding constraints to what users can input into the boxes as they were allowed to input anything but for the function to work as intended to, they are required to input numbers so I made it so the boxes only accept numbers and if anything, other than a number is inputted a pop-up frame would come up telling the user to input digits within the boxes. Then I decided to change the boxes to spin boxes so users can easily adjust their input within the spin box. The max and min number for the spin box is 0 to 100. Then the final improvement for this function was that before you

could enter a length for the password and enter a higher value for digits and symbols than length this would prevent the function from running as intended to. To fix this I added some code that would check if any of the values are greater than the length the user inputted or the values for symbols and digits combined is greater than the length the user inputted. If any of these were true a pop up would come up telling the user what the problem is with the inputs. This allowed the feature to function as intended to. Below you could see the main code for this.

```
#get user input and save them according to their variable
input_length=pop_entryLength.get()
symbol = pop_entrySymbols.get()
digits = pop_entryDigits.get()
RequirementPassword  = ''
#checks if the sum of digits length and symbols length is greater than password length
if((int(digits) + int(symbol)) > int(input_length)):
    #checks if length of digits is greater than password length
    if(int(digits)>int(input_length)):
        #change the output of msg
        msg = 'Inputted number for digits is too large make sure it is less than input number for length.'"\n"' Please change your
        digits input'
    #checks if length of symbol is greater than password length
    elif(int(symbol) > int(input_length)):
        #change the output of msg
        msg = 'Inputted number for symbols is too large make sure it is less than input number for length.'"\n" 'Please change your
        symbols input'
    #if nither are true then runs code in else statement
    else:
        #change the output of msg
        msg = 'The sum of the numbers inputted for digits and symbols are larger than the input number for length.' "\n" 'Please
        change your inputted values'
```

(Code That Checks Which Input Is Causing Error And Sets Message For That Specific Error)

Then I Improved my password checker function as it was not working as intended to as it would give invalid password entered frequently. To fix this bug within the system I changed the parameters used to measure whether a password is Horrible, Poor, Ok, Good and Excellent this allowed the function to work as intended to. The code for the new parameters can be found below.

```
#compare the results to the systems criteria and update the output variable so it returns the criteria the password met
if(len(input_length) >= 16 and symbolCount >= 4 and digitCount >= 4 and UpperCaseFound == True and LowerCaseFound == True):
    Output = "Your Password Is Excellent And Your password is " + input_length
elif(len(input_length) >= 12 and symbolCount >= 3 and digitCount >= 3 and UpperCaseFound == True and LowerCaseFound == True):
    Output = "Your Password Is Good and Your password is " + input_length
elif(len(input_length) >=8 and symbolCount >=2 and digitCount >=2):
    Output = "Your Password Is Ok and Your password is " + input_length
elif(len(input_length) >= 4 and symbolCount >= 1 and digitCount >= 1):
    Output = "Your Password Is Poor and Your password is " + input_length
elif(len(input_length) > 0 and symbolCount == 0 and digitCount == 0):
    Output = "Your Password Is Horrible and Your password is " + input_length
else:
    Output = "Your Password Does Not Meet Any Of Our Requirements. Hence Your Password Is Invalid"
```

(Code That Determines How Good The Password The User Inputted Is)

Iteration 8

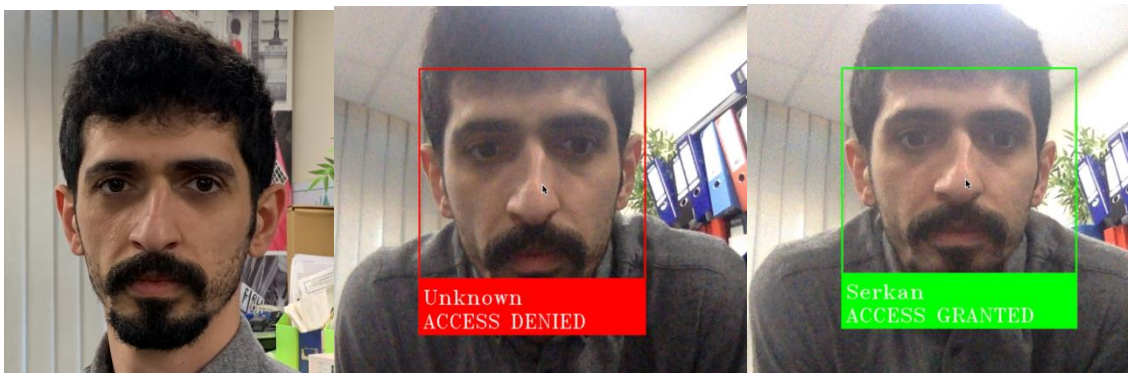
In my final iteration I have done my final user testing where I would test the face recognition feature with people in normal conditions and extreme conditions such as poor lighting conditions to see the systems performance. I have also tested my UI and the features within the application and had the test group give feedback via a survey based on the application I developed on google forums.

Results

Face recognition testing in normal conditions

First, I started to do some user testing where I had four individuals to test my application's face recognition system. The individuals had similar features making them a good test set as it would show how well the system performs with people that have similar facial features as it makes it harder to distinguish between the individuals. I had these individuals test the face recognition system under normal lighting conditions. Each individual tested the system twice. The first time the individual would test the face recognition system they would not be saved within the face recognition system this was to see if the face recognition system would give the correct output and detect a face within the webcam. The first test was successful with all four individuals, with the system giving no errors or incorrect outputs. The second time the user tested the face recognition system they would be saved within the system meaning that the system can now recognise the person in the webcam as they are saved within the system. The outputs for test 2 were also successful. The images below are the results from the testing.

(Results From Individual 1 Testing With The Image Of Them In The System)



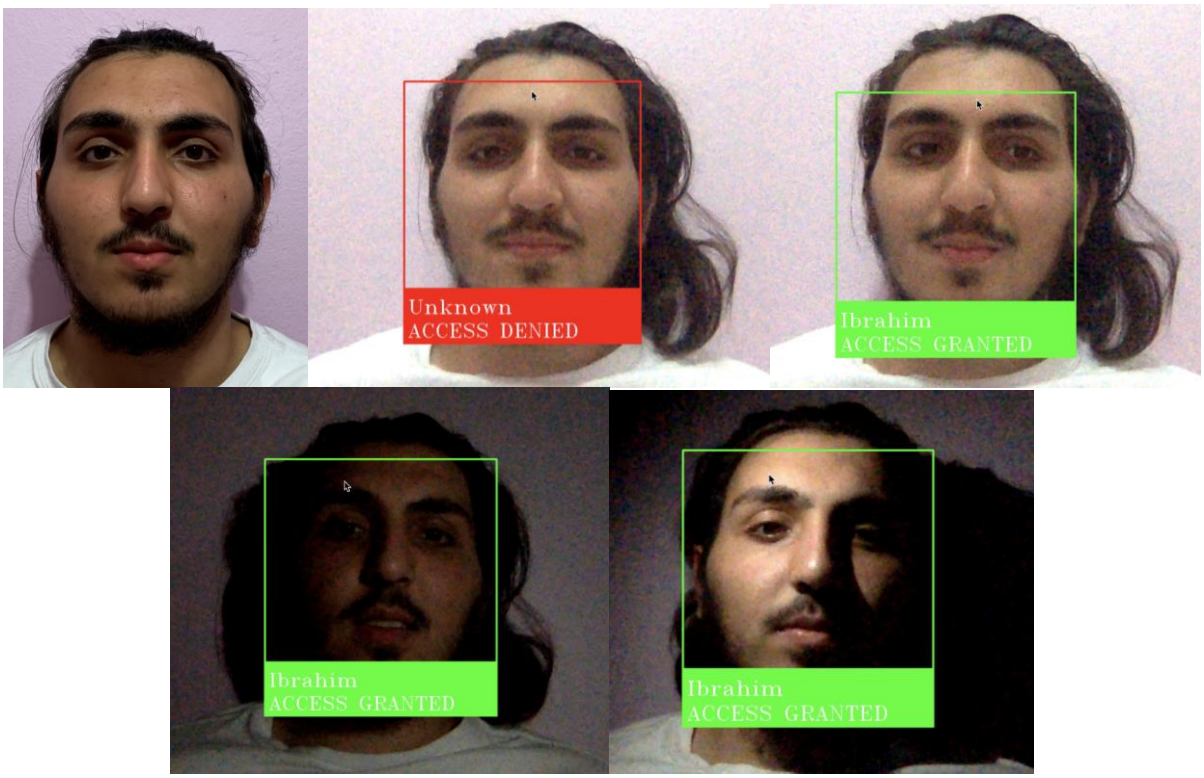
(Results From Individual 2 Testing With The Image Of Them In The System)

(Results From Individual 3 Testing With The Image Of Them In The System)

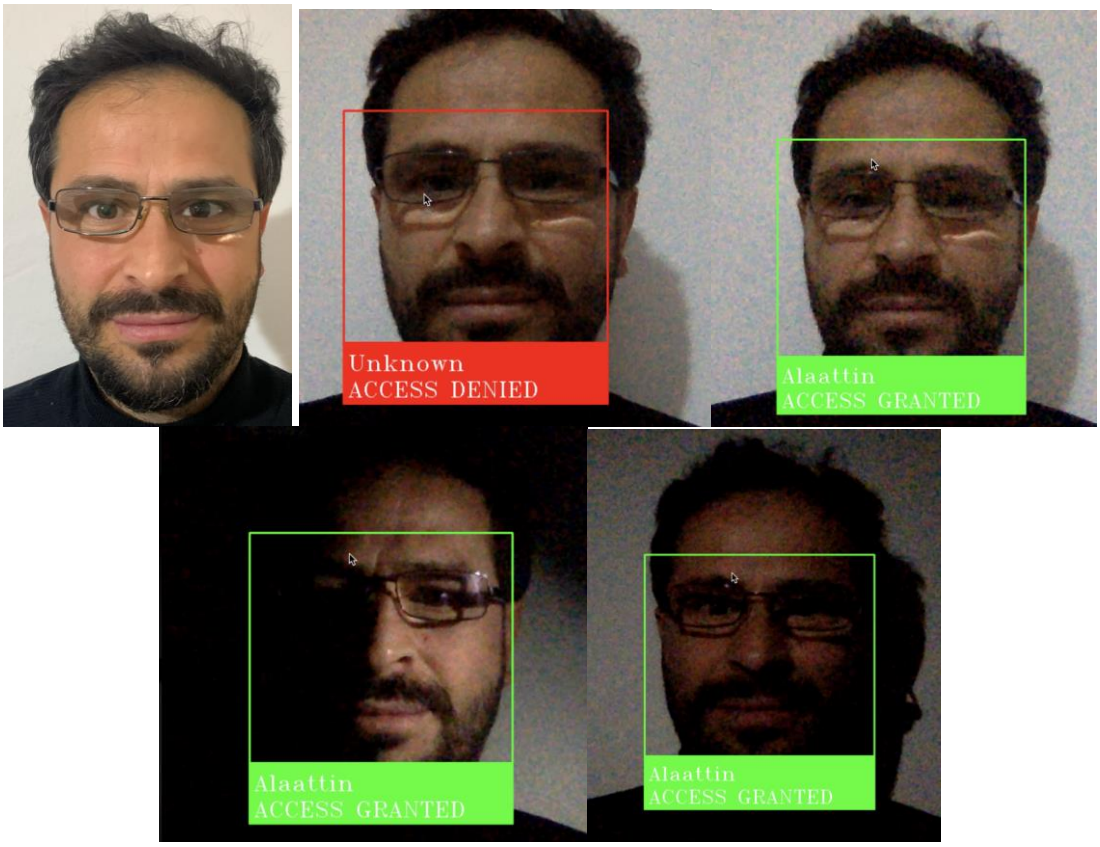
(Results From Individual 4 Testing With The Image Of Them In The System)

Face recognition testing in extreme conditions

After I had completed the face recognition testing under normal lighting conditions, I decided to get a separate set of users and test the system under poor lighting conditions. I used three individuals for this, I initially had them do testing under normal lighting conditions similar to the testing above. However, the only difference was that the testing was done during the evening so the light in the room had to be switched on. This is because the testing under normal lighting conditions was done during the day where daylight was available. After the first test was done, I switched off the light in the room and shined light on their face using the flashlight found on my phone at different angles and distances. This allowed me to fully test the face recognition system under poor lighting conditions allowing me to see how well the system actually performs. The images below are the results from testing the system with the three individuals in extreme lighting conditions.



(Results From Individual 1 Extreme Testing With The Image Of Them In The System)

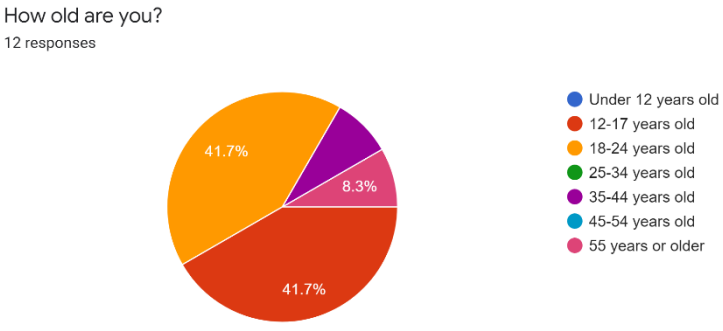


(Results From Individual 2 Extreme Testing With The Image Of Them In The System)

(Results From Individual 3 Extreme Testing With The Image Of Them In The System)

Application UI Testing

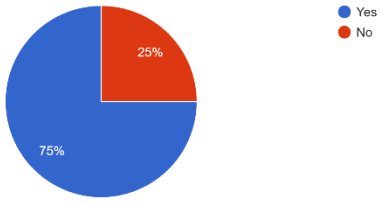
The final test I conducted was UI testing. This was done by showing a few individuals how the system ran and how the functions within the system ran by screen sharing the system running to the individuals. Then these individuals would anonymously answer questions about the system on google forums. I decided to conduct UI testing over the internet due to covid and having a lot of people in a room to test an application could be a risk of spreading the virus. However, in the future, if there was more time available, I would like to do another test with the improved UI after using the suggestions and feedback from the previous UI testing. The results from the UI testing can be found below.



(Question 1 Results)

Did you like the user interface that you saw when testing the application

12 responses



Could you please explain your answer to the question above? (Optional)

7 responses

Yes, it was a clean and neat user interface. I do think that it isn't perfect, though it is clear to see all the possible features, the user interface doesn't help or guide a user through the system thoroughly. i.e. the instructions are in dark text above the buttons, and don't stand out to show how to fully use the software.

increases user interaction

Basic UI, could improve further.

Very simplistic, could be modernised

its simple and easy to use

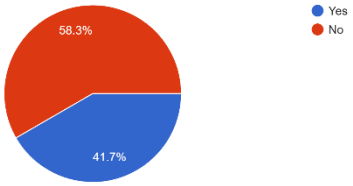
You could make it more modern as it is very basic

You could have made a better looking UI by using swift or PyQt

(Question 2 Results)

Did you like the colour scheme that was presented to you when you were testing the application?

12 responses



Could you please explain your answer to the question above? (Optional)

8 responses

Colours are dull, could be better.

The colour scheme is good, the different shades of grey make the buttons stand-out. Though the instructions are not clear and the darker shades of text make it harder to see. The lack of differing colours, only greyscale, would be more useful to have the user interface have more meaning to guide the user. i.e. separating the password checker and generator with matching colours to signify that they are used together.

I like the grey and black colour scheme.

the colours are dull

Looks dark.

Somewhat dull, but it does the job

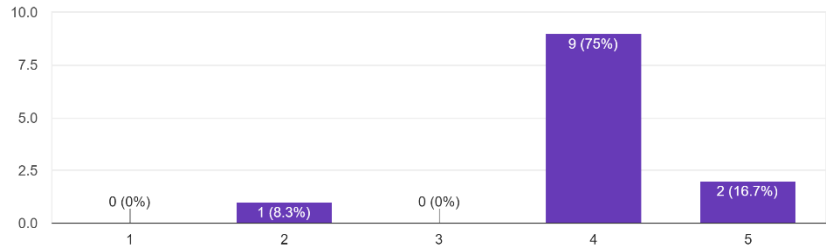
colours are to dull

black on grey is hard to read

(Question 3 Results)

On a scale of 1-5 what would you rate the Signup Frame UI? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

5 responses

The sign up is nice, simple and readable. The button could be bigger and clearer welcome, though this isn't necessary.

simple sign up with required fields

it is simple to navigate

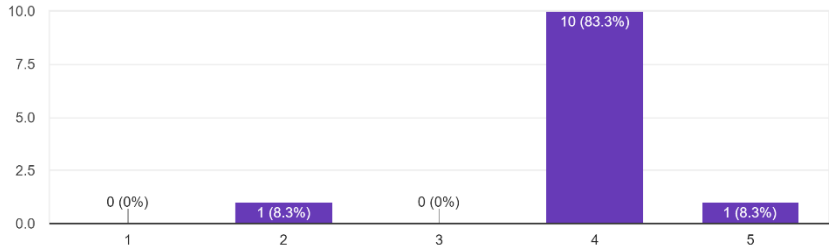
Instructions are clear

90% dead space

(Question 4 Results)

On a scale of 1-5 what would you rate the Login Frame UI? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

6 responses

The login is nice, simple and readable. Though similar improvements could be made to the signup.

It is simple and it is straight forward.

value for time

simple login with required fields

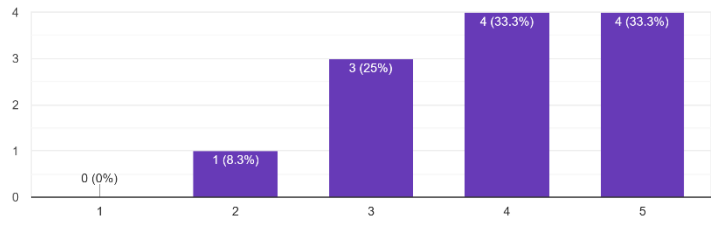
it is simple to navigate

lots of wasted space, a bit plain

(Question 5 Results)

On a scale of 1-5 what would you rate the main frames UI? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

6 responses

I think that the main frames UI is the worst offender of too much text, that is potentially the most useful to a new user. While the layout is nice and visibly pleasing to the eye, the numbers on the buttons are confusing and don't correspond to anything. I think that separating the buttons to their related functions would help.

Buttons could be larger.

it's unique

all options clear and visable but ui too simple

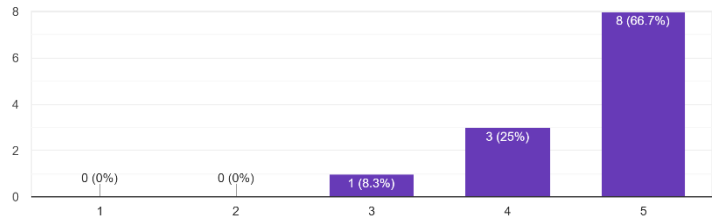
Straight forward

Numbered left to right, top to bottom. Is this even necessary? margins inconsistent

(Question 6 Results)

On a scale of 1-5 what would you rate the Password generator? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

6 responses

It is an effective password maker, with a clear easy use.

it gives you a more unique password and it's a quicker way to find a password

The implementation of the arrows to the right of the box is convenient.

seems like a secure password generator

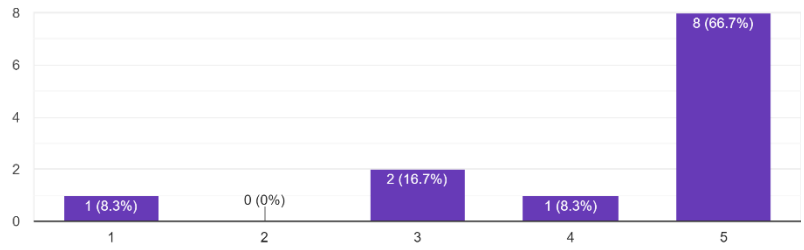
Well done and easy to use

Functional. No default values or suggested values

(Question 7 Results)

On a scale of 1-5 what would you rate the Password Checker? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

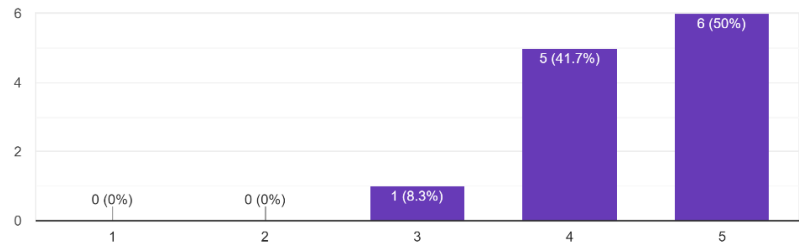
6 responses

- While it functions appropriately, the text is overwhelming and extremely hard to read.
- Explains how the password checker works.
- it gives you the knowledge to make a more secure password
- Very cool, but the interface looks very clunky
- Gives a rundown of how the system works which is quite useful as it can give me a good idea of what makes a good password.
- A huge mess, too specific.

(Question 8 Results)

On a scale of 1-5 what would you rate the Notepad Function? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

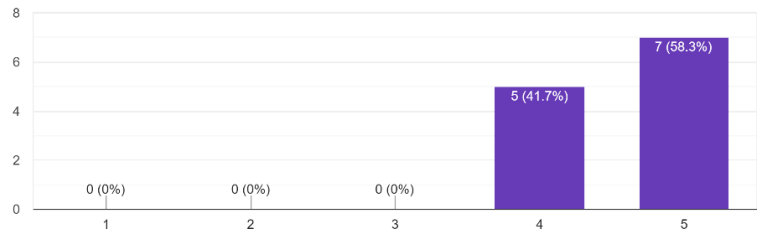
5 responses

- It works as a notepad.
- You can secure your notes
- useful feature to take notes
- Can perform basic functions and has shortcuts implemented
- Functional. Interface different from rest of the application

(Question 9 Results)

On a scale of 1-5 how did you find the face manipulation/identification functions (eg face match)? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

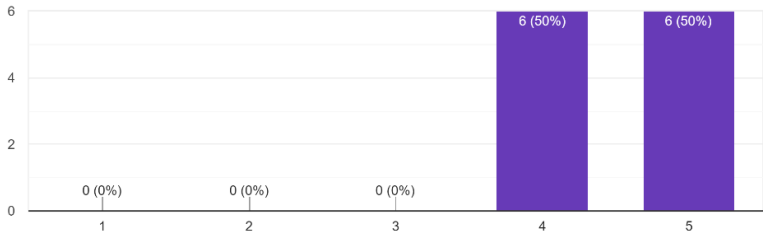
7 responses

- Watching the demonstrations, it worked fast, cleanly and was very effective at recognising faces.
- Could be faster, loads slow.
- It's a very secure way of keeping your files and those kind of stuff protected
- It was slow to run.
- does as intended
- It could be optimised as it loads slowly
- Works as intended

(Question 10 Results)

On a scale of 1-5 how useful did you find the admin upload images and general upload images functions? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

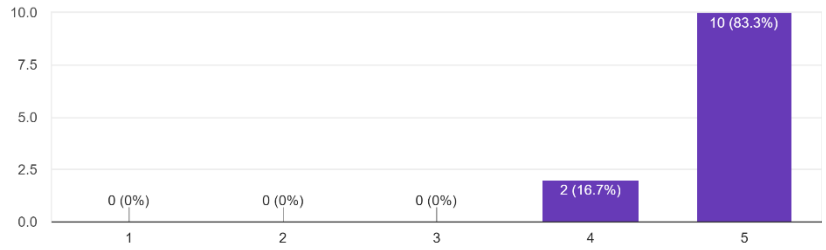
4 responses

- Worked fine, the demonstration showed easy file management.
- does as intended
- Makes using the system easier as you are able to upload images to the system whilsts its running
- Works as intended

(Question 11 Results)

On a scale of 1-5 how did you find the face recognition function? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

5 responses

Extremely useful and worked at a high standard.

Accurate results.

does as intended

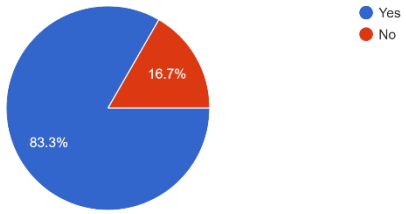
Was accurate in detecting and recognising faces

Works as intended

(Question 12 Results)

Was it easy to navigate the application and perform the functions available to you?

12 responses



Could you please explain your answer to the question above? (Optional)

3 responses

The buttons are obvious and following as a user who is clearly used to the UI is fine. I do not think that it would be too easy to navigate for a new user who isn't used to computers or a user demographic who doesn't use much modern technology.

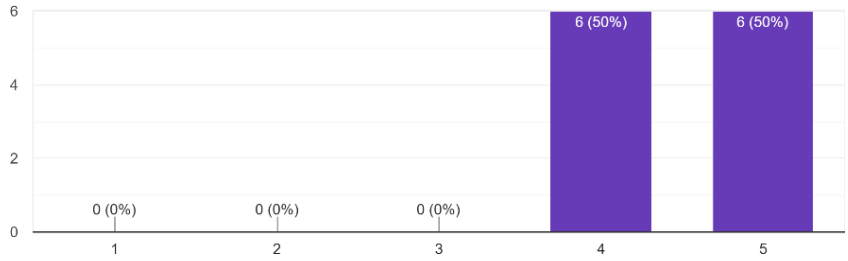
the options could do with a brief explaination when hovered over

Functions as expected

(Question 13 Results)

How satisfied are you with the features the application has to offer? (1 being the worst, 5 being the best)

12 responses



Could you please explain your answer to the question above? (Optional)

4 responses

It has several features that are useful and all work well. I think that as an application it has lots to offer that can be used.

I am very satisfied because I'll get to keep all my files, notes and etc in one place with them being protected

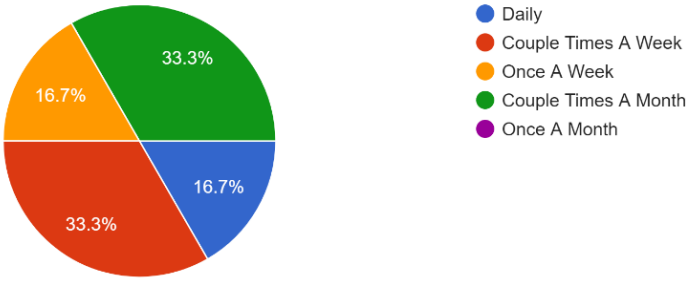
all useful features

Goes beyond what is necessary.

(Question 14 Results)

How often would you use this application to store files and perform the functions it offers?

12 responses



(Question 15 Results)

Discussion

The results from the face recognition testing under normal lighting conditions show that my face recognition system can successfully distinguish between different people that have similar attributes for example the four individuals I tested had beards and the system was still able to distinguish between all four correctly without giving incorrect results suggesting that my system is robust and works at a good level.

Furthermore, looking at the results from the face recognition testing under extreme lighting conditions such as low lighting, the data shows that the system is able to recognise and distinguish people accurately and successfully which suggests that the system is well developed and robust as it can successfully detect and recognise people in extreme conditions. However, if the majority of the face is not visible within the webcam, then the system is unable to recognise the face as it's unable to detect the face. An example of this problem is in the image below.

(Example Of Face Recognition/Detection Not Working When Majority Of Face Is Not Visible)

Additionally, whilst testing the application I found out that if there are multiple people within the webcam the face recognition system struggles to recognise the faces within the webcam, however it is able to detect the multiple faces within the webcam. Having the system to recognise multiple people at once could be a long-term goal and if successfully implemented it can make my system stand out more within the industry which can potentially attract more potential users within the target market to start using the application.

Furthermore, comparing my face recognition system to face recognition systems within the field the performance compared is close if not the same as my testing shows that my face recognition system can distinguish between different people that have similar features in normal and extreme conditions. However, since my system was mainly built using adult faces it would not perform as well with children compared to the well-established companies face recognition systems within the field such as MEGVII's face recognition system, which most likely preforms better when trying to recognise different children's faces since it can perform a lot of complex tasks such as age recognition and etc.

I've tested the application with a variety of age groups and looking at my UI and system testing results I can see that majority of the people tested liked the UI Layout, Signup UI, Login UI, Main Frame UI, Password generator feature, Password checker feature, Notepad function, Image manipulation/identification features and Admin/General user upload features. I came to this conclusion because the majority of the people rated the features 4 or above out of 5 which suggests that they liked the features or UI presented to them. This data suggests that the system is tailored to the majority's preferences.

However, the majority did not like the colour scheme on the application as 58% of the people tested answered no and majority of them explained that the colours are dull and that black on grey is hard to read. This is something that I could focus on changing and improving as the majority disliked the colours as they were too dark and dull. Furthermore, one person suggested that I could separate certain functions by changing their button colour to signify that the features can be used together which can enhance the user experience, this is something else I might want to try and test and get opinions on. Additionally, some stated that the UI was basic and can be more modernised by using better frameworks for developing GUIs such as PyQt5.

Another issue that was bought to my attention was that there is too much text on the main frame which was overwhelming for people as the instructions are not going to be necessary for people that have used the system multiple times, a suggestion for this was I could potentially have the specific instruction on how to use each feature show up if the user hovers their mouse cursor over a feature making the main frame less cluttered. Finally, by looking at my results I can see that the majority of the people said they would either use the application a couple times a week or a couple times a month. This suggests that the features and technology offered within the application is beneficial to people as they could see themselves making use of the application and the features it has to offer.

You can find my applications GitLab repository, where I have committed my final applications code in the following link - https://gitlab.doc.gold.ac.uk/oguve001/faceapp

Progress Of Project, Limitations And Future Works

With my project I have implemented all the features I wanted to implement to a good standard where they function as intended to with no system breaking bugs allowing the system to be released in closed beta/alpha for people to utilise. This would allow me to gain more data on the application allowing me to have a better understanding on what is working well and what is not working well which I could work on improving in the short term. This can also help me discover bugs that have not been discovered within the system allowing me to fix the bugs before the system is officially released to the public. Furthermore, in the short term I'd like to make it so users cannot access any of the folders directly within the application. This would allow the system to be more secure as hackers would not be able to see the sensitive data within the folders or find exploits within the system and breach the users account and steal their sensitive data. Which would essentially make the system more secure. Additionally, having the application to be able to run via an executable file is another short-term goal of mine.

Finally, by looking at the feedback from my UI and system testing my main short-term plans with this application is to further develop the UI by potentially changing the framework to PyQt5 as it offers more in terms of widgets and looks [43]. This can potentially help make my application look more modern. Furthermore, I would like to change the colour scheme on the application so it's not dull and allows users to have an easier time to read the text on the screen. Additionally looking at my feedback, on the main frame people suggested that the numbers next to the buttons are not necessary which is something I could remove. Also, during my testing some users said that the buttons in the main frame are small and making them larger could be another plan.

Furthermore, removing dead space around certain frames could be another plan as it could potentially make the application look better. My penultimate short-term plan could be to make the main frame less cluttered by removing unnecessary text on how to use certain features and have it so the instructions for certain features show up if the user hovers over the button using their mouse cursor for that specific feature. My final short-term plan with this application is to have the application responsive, making the application more accessible on different devices and different screen sizes as right now it is optimised for a 13-inch mac screen.

A limitation with this project was the testing as I would have liked to get more people to test the UI and the system including the face recognition system but due to the circumstances caused by the virus it made testing the application harder. A limitation with the system was if the majority of the face is not visible, which may be caused by the lighting, then the system is unable to detect the face in the webcam causing it to be unable to recognise the person as well. Also, if multiple individuals are present in the webcam the system has a hard time distinguishing between the faces and recognising the people in the webcam. These are some of the main limitations with this system. Finally, more testing could have occurred in extreme lighting conditions by utilising algorithms to change the colour spaces to see how the system would perform in those environments. So, the lighting the system was tested under was another limitation and having more testing in different lighting conditions can show how well the face recognition system actually performs.

Tasks	Completed?
Research Libraries & Background Information	Completed
Research & Implement Face Recognition	Completed
Research GUI Library Design & Implement GUI	Completed
Research & Implement Login	Completed
Research & Implement Password Generator	Completed
Research & Implement Upload Images	Completed
Research Image Identification Functions	Completed
Develop Image Identification Functions	Completed
Research & Implement Notepad Function	Completed
Complete Project.	Completed

(Progress Of Project)

My long-term plan with this project is to develop the app further and make the app usable on different operating systems and devices since right now it can only be run on macOS. My goal is to let it run on devices that use windows, android and IOS. This is so the application is readily accessible since more devices and operating systems can run it. Another long-term plan I've with this project is to have the face recognition login technology used in places of work that use Identification cards. This is because ID cards are easy to be forged or stolen allowing people to access areas that they should not be allowed to access causing there to be a higher level of threat within the workplace, making it an unsafe environment. However, with this technology it is harder to add yourself to the system since it is harder to hack into the system as it uses face recognition as its login. Additionally, by using this technology it can also monitor the people going in and out of a building allowing there to be a safer and more secure environment as it can detect and prevent people that are not in the system from accessing the building. This technology can be implemented in buildings to replace ID cards, in a similar way to the image below. Where the machine gives you access to the building and the security cameras can keep track of who is where in the building and detect intruders.

(Example Of Face Recognition Technology In Buildings - https://www.wired.com/story/opt-out-of-facial-recognition-at-the-airport/)

In the future to make my face recognition system better I would implement the API MEGVII is offering since their system is open sourced which would allow me to further enhance my system. This would allow my system to perform better than my competitors systems and by offering the system as an application it would make it easier for people to make use of the application, unlike MEGVII who does not have an application. Also, everyone does not have the necessary skill set and time to develop such applications to make use of. Which could also entice more people to want to utilise my application.

Conclusion

Overall, my results and research suggest that my application and face recognition system is robust and can distinguish between different people successfully whether it is under normal lighting conditions or under poor lighting conditions as the system was able to give accurate results in both tests. However, my system struggles to recognise multiple people at once. This is something I would like to focus on and develop so the system is able to recognise multiple people at once as I believe this would allow my application to stand out more within the industry. During my research I have gained a better understanding of the field I'm within, for example I have gained a better understanding of the differences between my system and high-end face recognition systems as a high-end face recognition system can perform more complex tasks, such as gender and age recognition where the age recognition system can achieve a 99% accuracy with a maximum deviation of +/- 5 [12]. Furthermore, I discovered that in the future to develop my face recognition system even further I can make use of the API some of the well-established companies within the industry have to offer allowing me to further develop my application and potentially have it perform better than some of the high-end face recognition systems within the industry.

During my UI/system testing, if I was able to get a larger sample of people to test my system (around 50-100) and give feedback on the system and the UI I believe that I would have managed to get better feedback on the mass markets preferences. This is because the larger the sample the more likely that the mass market would have a similar thought process, which would give me a better view on the mass markets preferences and likes as the same answers would come up frequently to questions. This would show the mass markets preferences allowing me to adapt the UI and certain features to fit the majority of the target markets preferences. For example, looking at my results from the 12 individuals I tested my system, and UI with I can see that most of them disliked the colour scheme and would like a better colour scheme as the current one is very dull and makes it hard to read the instructions and text on the frame, which makes using the system harder and less convenient. Also, most stated that the UI was basic and some stated that it could be a more modern UI. But the majority of the people did not dislike the current UI layout. The results I have gathered show the mass markets likes as it is the majority's answer. However, if I were to use a larger sample of individuals to test the system and UI the majority's answer may change which would allow me to get more reliable results into the mass markets preferences. Hence, I would've liked to test my UI and system with a larger sample of people.

Furthermore, most companies that work within the face recognition market do not have applications that the public can use and perform different functions with such as generating secure passwords or saving files within the system. My main goal with this application was to offer a system that uses face recognition to the public to use whilst allowing them to store sensitive information or perform a variety of functions that they would not usually be able to perform using one application, which I was able to successfully implement. Finally, I have implemented the face recognition system; face recognition login system; password checker; random password generator; general upload images; login upload images; face match; pull faces; identify faces; find faces; face app sign-up and the tkinter GUI successfully where the features function as intended to with no bugs that cause the application to crash.

However, I believe I could have implemented a better password checker function or have developed mine even further by checking if the password the user entered contains words from dictionaries and depending on the result it would have an effect on the strength of the password for example if the user used common words from a dictionary, then the strength of the password would be lowered.

In conclusion I believe I have developed a robust application that runs as intended to. However, I also believe that the application has room for improvement for example further developing existing features within the application such as making the UI more modern as it is currently very basic; or further developing the password checker where it would make use of dictionaries to determine the strength of the password inputted instead of the custom parameters; or I could optimise the image manipulation/identification functions so they run faster.

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Appendix

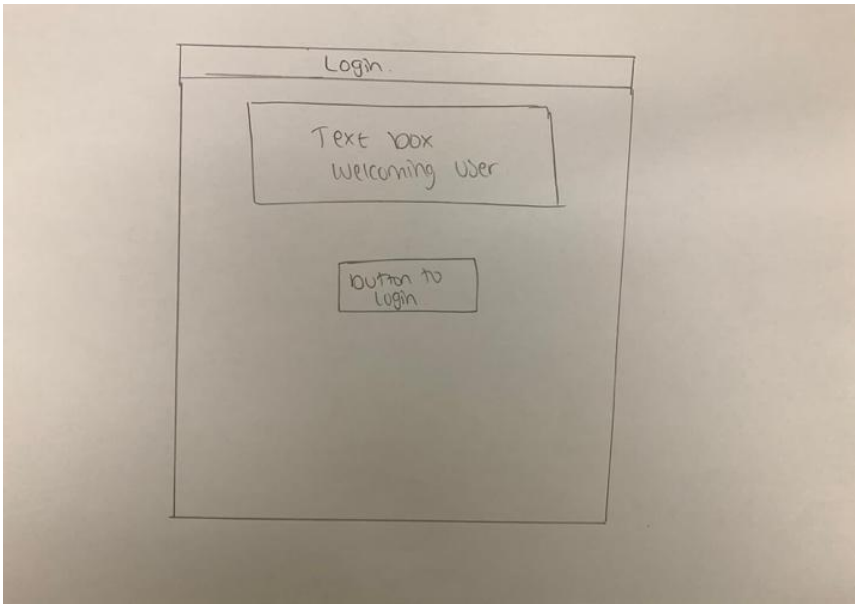
High fidelity wireframe

Below is the link to the High-fidelity wireframe I designed using Adobe XD

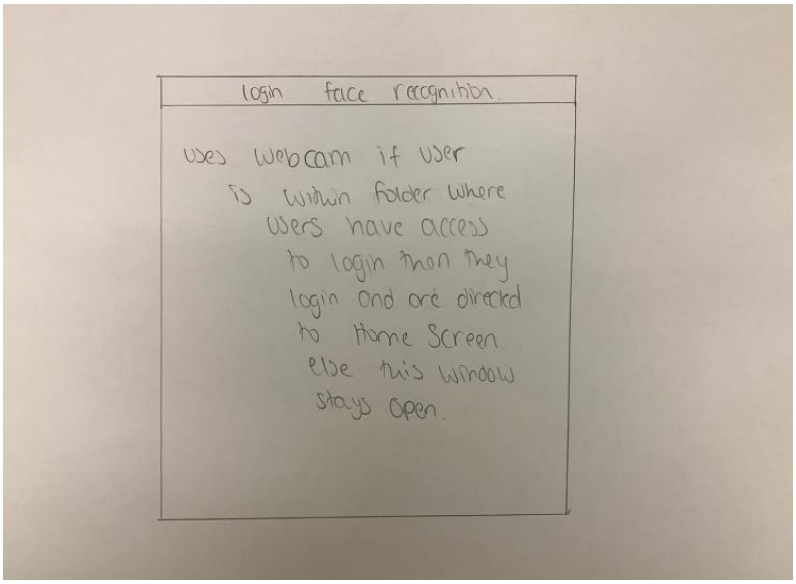
- https://xd.adobe.com/view/aeda60de-ac8d-4b3c-8fc5-e41f149cc1ea-fb89/

Low fidelity wireframe

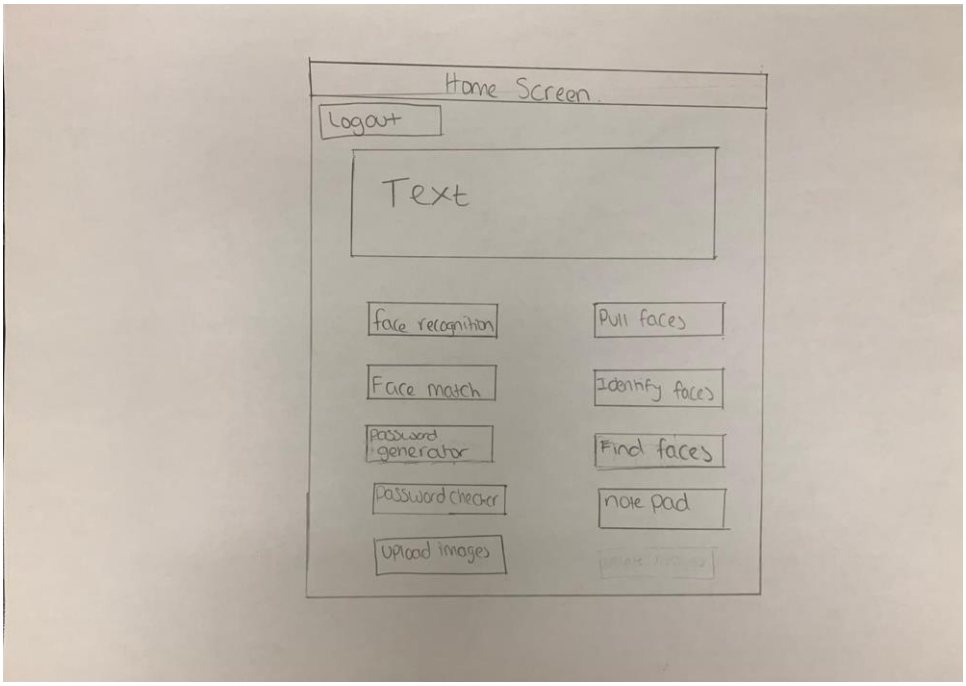
Below are the images of the Low fidelity wireframe I designed



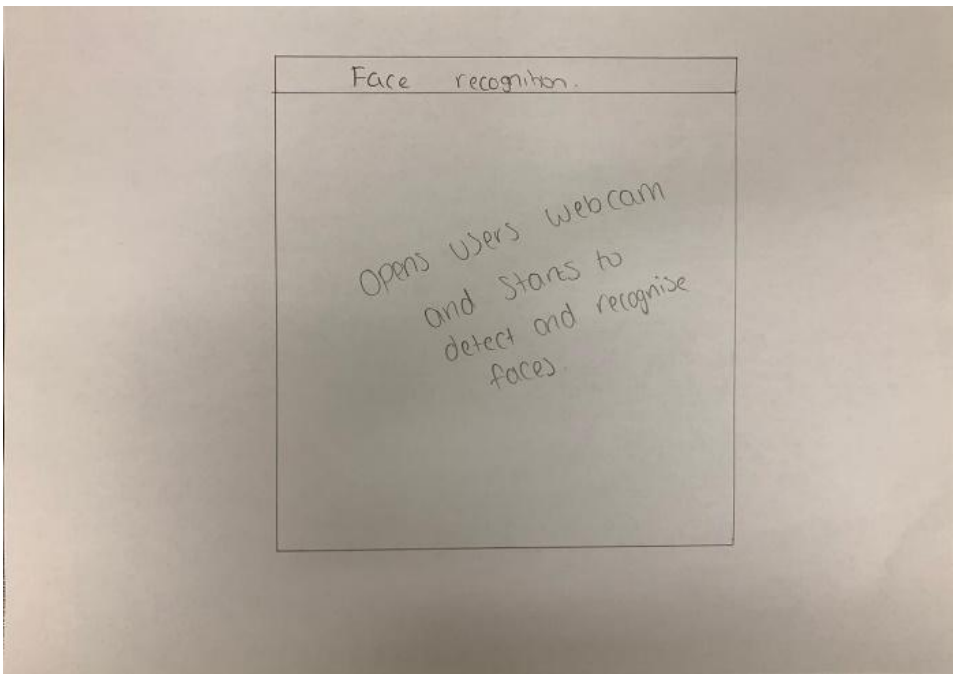
(Login Window)



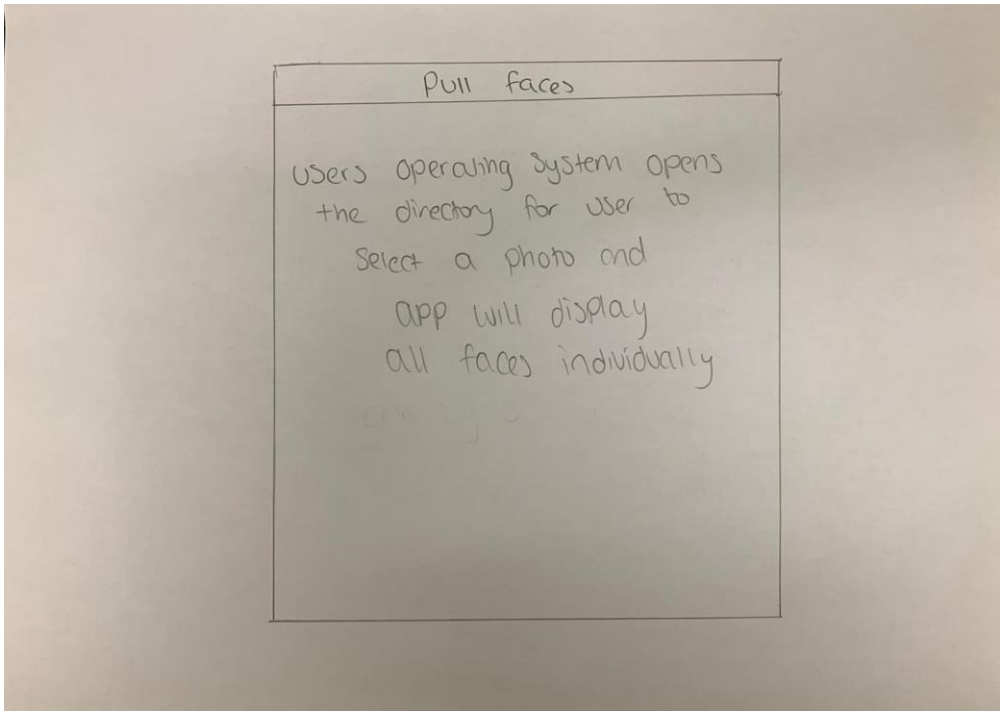
(Login Face Recognition Window)



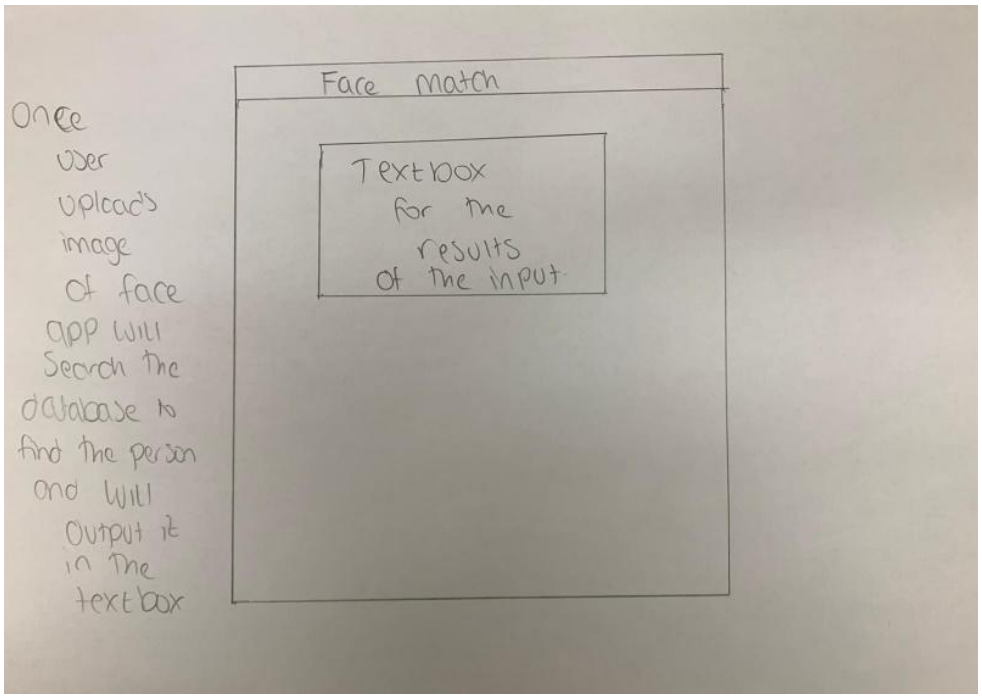
(Home Screen Window)



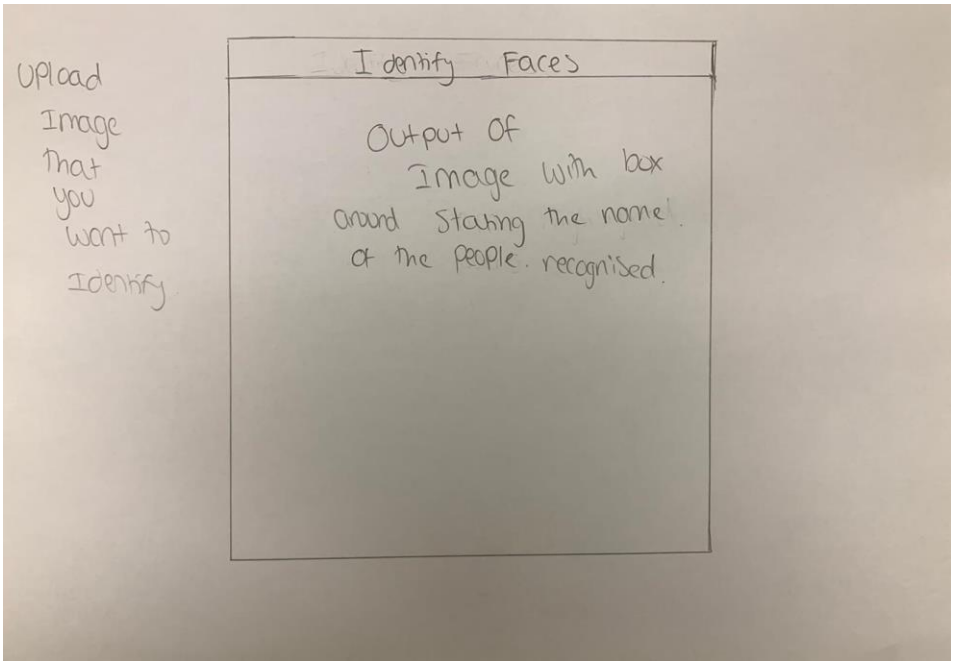
(Normal Face Recognition Window)



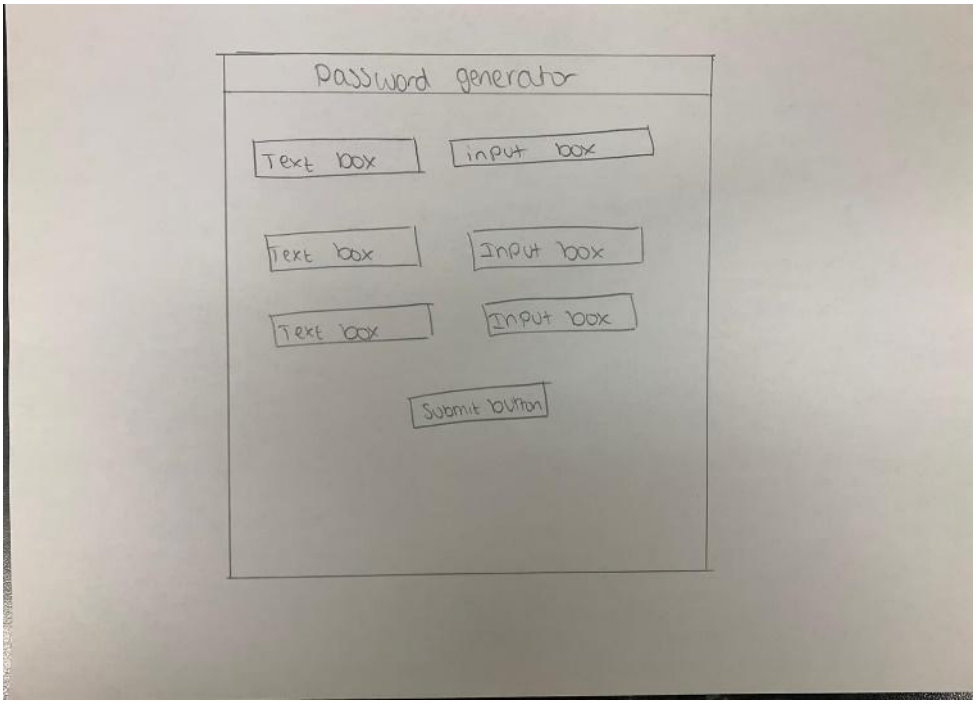
(Pull Faces Window)



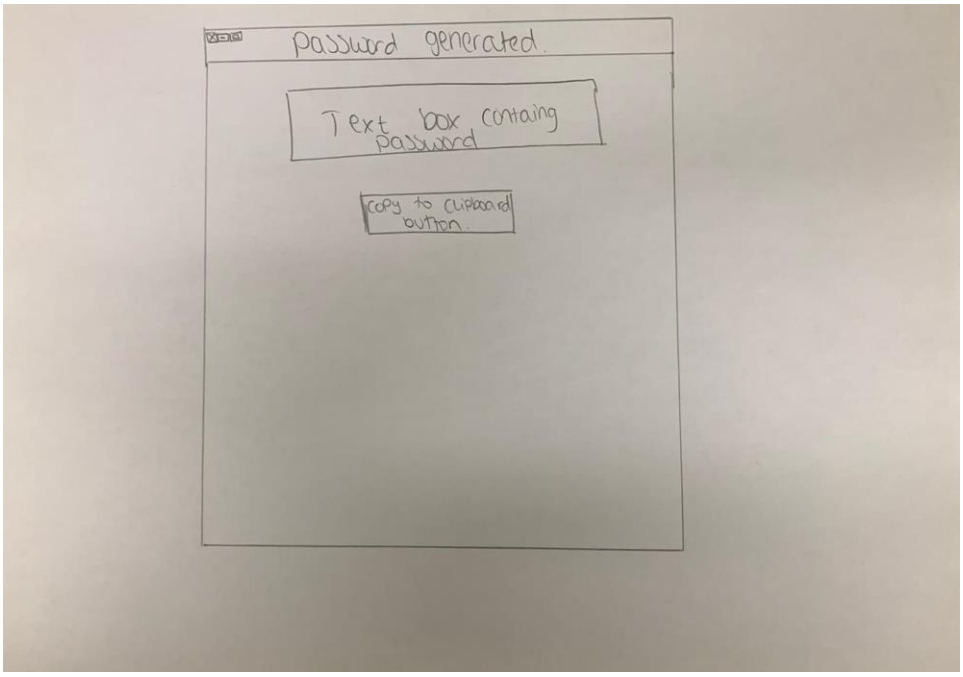
(Face Match Window)



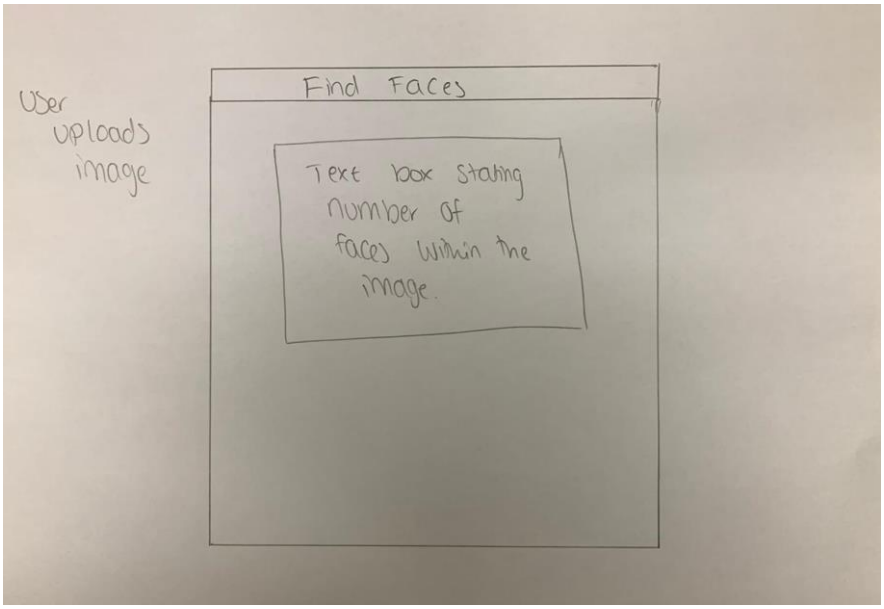
(Identify Faces Window)



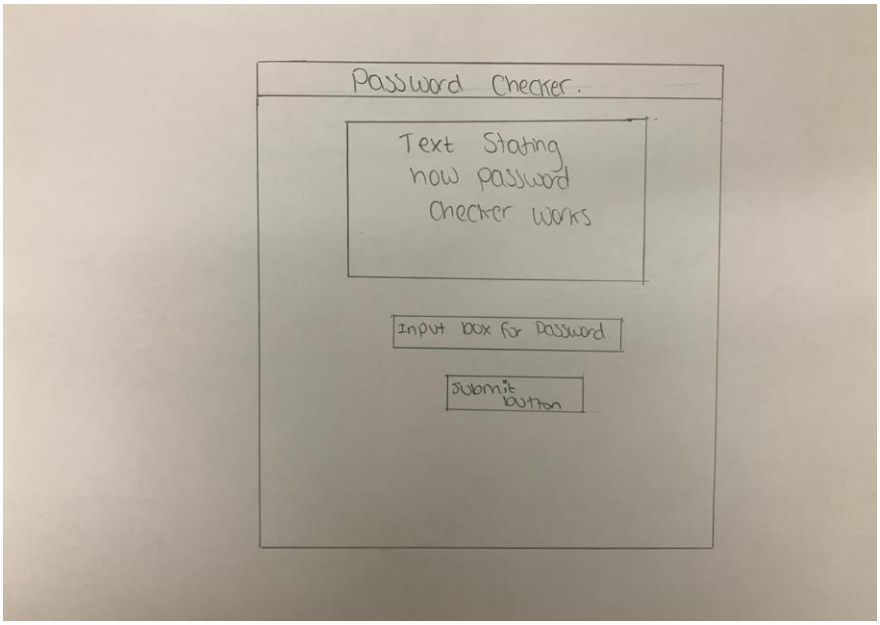
(Password Generator Window)



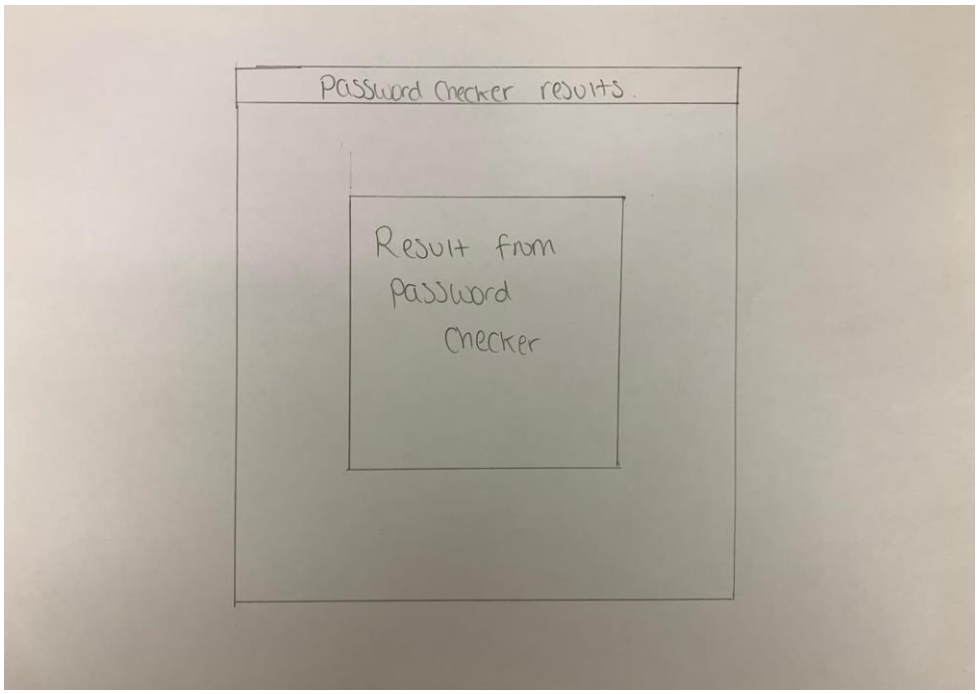
(Password Generated Window)



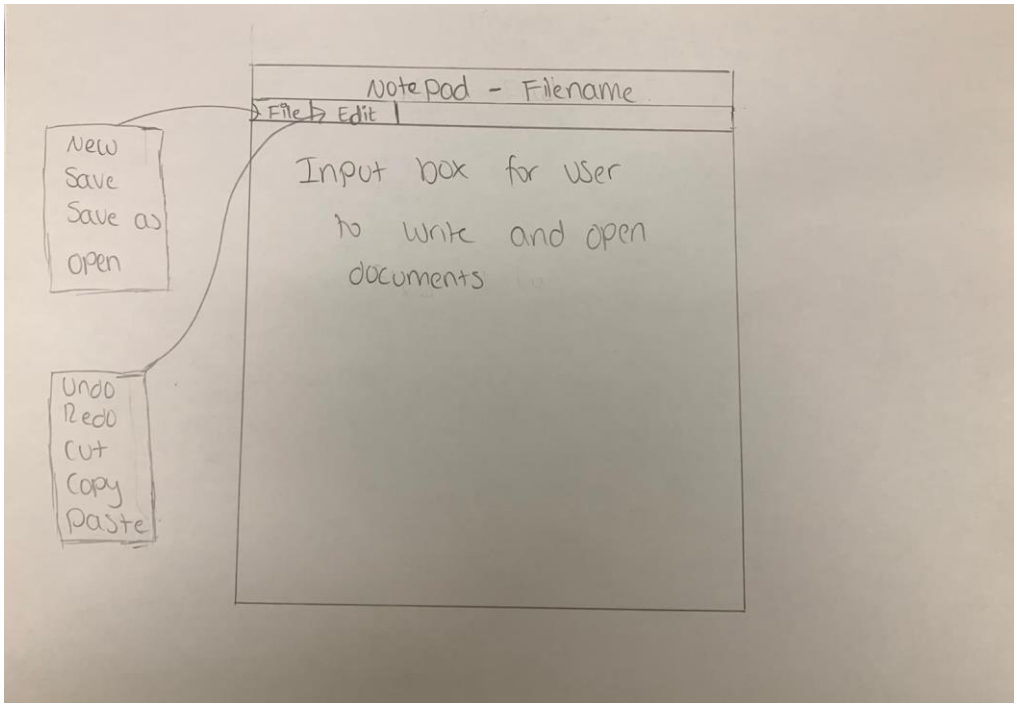
(Find Faces Window)



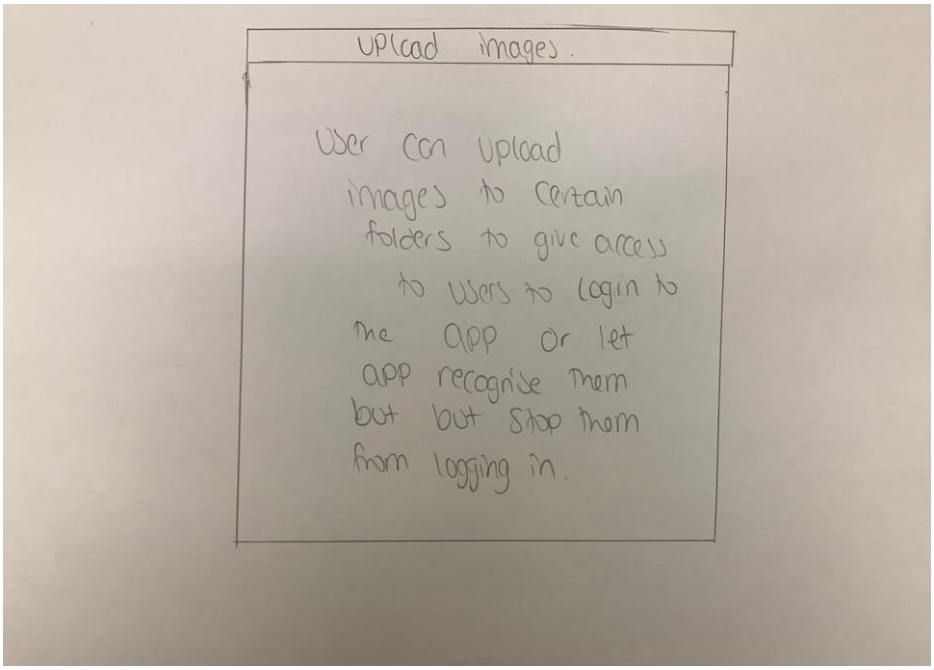
(Password Checker Window)



(Password Checker Results Window)



(Notepad Window)

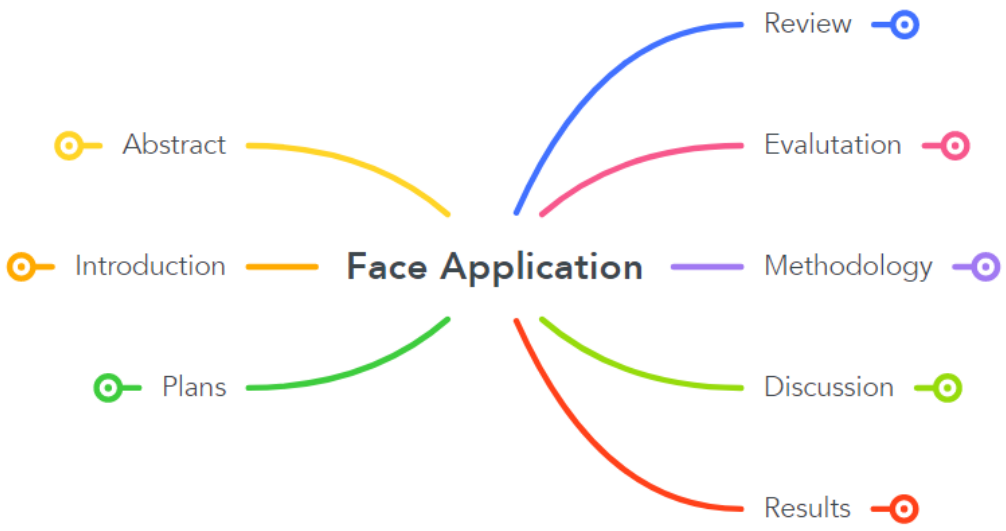


(Upload Images Window)

Apple FaceID Implementation

Apple's Face ID is based on True Depth Camera which captures face data by projecting and analysing thousands of invisible dots to create a depth map of the face then it captures an infrared image of the face. Then the chip within the device transforms the depth map and infrared image into mathematical representation and compares that to the enrolled face data [8].

Mind Map



(Mind Map Link (Work In Progress) - https://mm.tt/map/2089858024?t=A1VSXEuWcF)