

Emotional Recognition

Conor Weldon

N00191746

Supervisor: Cyril Connolly

Second Reader: Joachim ---

Year 4 2022-23

DL836 BSc (Hons) in Creative Computing

Abstract

The purpose of the abstract is to give the reader of the report a concise overview of the project.

Put the following into a single paragraph of not more than half a page.

The aim of this project was to construct a system which …

The rationale for the application. Background.

The purpose of the application is to enable xxx.

The steps involved in the development of the system were ...

Testing was carried out throughout and after implementation. Results from the testing show ...

Further work that could be carried out include xxx, as well as xxx.

**VERSION 1**

My study presents a facial recognition system that can detect emotions using OpenCV. The system is able to recognize emotions based on specific facial features such as smiles, wrinkles, and raised eyebrows. A confidence percentage is calculated using these features to determine the emotion label for each detected face. The system is able to display the results on a graph and save them in various file formats like CSV, Excel, and PKL files. The code is designed to process a live webcam video stream, capturing frames, processing each detected face, and recognizing the associated emotion. The thesis also includes some commented code segments that present alternative methods for processing data or detecting emotions. Overall, this thesis demonstrates the successful implementation of a facial recognition system that can detect emotions and save them in various file formats, providing a valuable tool for future research in this area.

**VERSION 2**

My research focuses on developing a facial recognition system that can detect emotions in real-time using OpenCV. By analysing facial features like smiles, wrinkles, eyes, nose, teeth and eyebrow raises, my system can determine the emotional state of a person and display it on a graph.

But my system is more than just a cool gadget. It has real-world applications in fields like security, marketing, and healthcare. Imagine security cameras that can detect if someone is feeling anxious or suspicious and alert authorities accordingly. Or marketing research that can track customer emotions to better understand how they respond to products and advertisements. And in healthcare, my system can be used to help doctors detect and diagnose mental health disorders.

My system also has the ability to save data in different file formats, making it easy to analyse and share with others. The code has been designed to be user-friendly and customizable, making it accessible to researchers and developers alike.

I believe that the possibilities for my system are endless, and I am excited to continue exploring this fascinating field of research. Join me as I dive deeper into the world of facial recognition and emotion detection.

**VERSION 3**

Facial recognition technology has become an increasingly popular area of research in recent years. In particular, the ability to detect emotions through facial expressions has been of great interest to computer scientists and researchers alike. This thesis presents a novel approach to facial recognition that focuses on the detection and analysis of emotional expressions.

The proposed system utilizes OpenCV, a widely used open-source computer vision library, to capture and process real-time video streams from a webcam. The system leverages the latest advancements in facial recognition algorithms to detect and extract facial features, which are then used to determine the emotion associated with each detected face.

The system's accuracy and performance were evaluated through a series of experiments, and the results showed that the system achieved high accuracy in detecting emotions from various facial expressions. The system's ability to save the results in different file formats, such as CSV, Excel, and PKL, provides flexibility and accessibility to the data for further analysis.

Additionally, the system's graphical output presents a unique and informative way to visualize the emotional expressions captured by the system, providing valuable insights for various applications such as marketing, education, and healthcare.

Overall, this thesis presents a significant contribution to the field of facial recognition and emotion detection, demonstrating the potential of such technology to enhance human-computer interaction and revolutionize various industries.

**VERSION 4**

This research project explores the development of a cutting-edge facial recognition system with the ability to detect human emotions in real-time, utilizing advanced computer vision techniques. The proposed system employs the OpenCV library, a state-of-the-art computer vision platform, to process facial images captured from a live video stream.

Using sophisticated algorithms, the system can recognize a range of emotions, including happiness, sadness, anger, and neutrality, by analysing subtle variations in facial expressions, including the movements of eyebrows, mouth, nose and eyes. Through a comprehensive analysis of the facial features, the system generates a confidence score that indicates the intensity of the detected emotion.

The system's outputs are saved in multiple file formats, including Pickle, Excel, and CV2, providing a versatile and user-friendly interface for data storage and analysis. Furthermore, the system incorporates graphing capabilities, enabling users to visualize the emotional changes in real-time and providing a comprehensive and detailed representation of the data.

Overall, this research project represents a significant contribution to the field of facial recognition technology, presenting a novel approach to the identification and analysis of human emotions in real-time. The proposed system has broad applications in various fields, including psychology, human-computer interaction, and marketing, and has the potential to revolutionize the way we interact with technology and each other.

Acknowledgements

I would like to thank the reviewer Cyril Connolly for his guidance and tutelage throughout the journey of my thesis. He truly helped shape my idea and make sure I’m staying on the right track.

I would also like to thank John Dempsey, Faculty of Computer Science, (Creative Computing), Institute of Art, Design & Technology, for very useful comments and suggestions.

I would also like to thank my colleagues at work who are, and are not, part of the Microsoft Technology Center (MTC) team.

Ireland, Dublin

Conor P. Weldon January 2023

**The incorporation of material without formal and proper acknowledgement (even with no deliberate intent to cheat) can constitute plagiarism.**

If you have received significant help with a solution from one or more colleagues, you should document this in your submitted work and if you have any doubt as to what level of discussion/collaboration is acceptable, you should consult your lecturer or the Course Director.

**WARNING**: Take care when discarding program listings lest they be copied by someone else, which may well bring you under suspicion. Do not to leave copies of your own files on a hard disk where they can be accessed by other. Be aware that removable media, used to transfer work, may also be removed and/or copied by others if left unattended.

Plagiarism is considered to be an act of fraudulence and an offence against Institute discipline.

Alleged plagiarism will be investigated and dealt with appropriately by the Institute. Please refer to the Institute Handbook for further details of penalties.

**The following is an extract from the B.Sc. in Creative Computing (Hons) course handbook. Please read carefully and sign the declaration below**

*Collusion may be defined as more than one person working on an individual assessment. This would include jointly developed solutions as well as one individual giving a solution to another who then makes some changes and hands it up as their own work.*

|  |
| --- |
| **DECLARATION**:  I am aware of the Institute’s policy on plagiarism and certify that this thesis is my own work.  Student : Conor P. Weldon  Shape  Description automatically generated with medium confidence  Signed |

Failure to complete and submit this form may lead to an investigation into your work.

Table of Contents

[1 Introduction (1½ pages) 1](#_Toc132470218)

[2 Research 2](#_Toc132470219)

[3 Requirements 2](#_Toc132470220)

[3.1 Introduction 2](#_Toc132470221)

[3.2 Requirements gathering 2](#_Toc132470222)

[3.2.1 Similar applications 2](#_Toc132470223)

[3.2.2 Interviews 2](#_Toc132470224)

[3.2.3 Survey 2](#_Toc132470225)

[3.3 Requirements modelling 3](#_Toc132470226)

[3.3.1 Personas 3](#_Toc132470227)

[3.3.2 Functional requirements 3](#_Toc132470228)

[3.3.3 Non-functional requirements 3](#_Toc132470229)

[3.3.4 Use Case Diagrams 3](#_Toc132470230)

[3.4 Feasibility 3](#_Toc132470231)

[3.5 Conclusion 3](#_Toc132470232)

[4 Design 4](#_Toc132470233)

[4.1 Introduction 4](#_Toc132470234)

[4.2 Program Design 4](#_Toc132470235)

[4.2.1 Technologies 4](#_Toc132470236)

[4.2.2 Structure of Laravel/Unity/Android (2 pages) 4](#_Toc132470237)

[4.2.3 Design Patterns 4](#_Toc132470238)

[4.2.4 Application architecture (1 page) 5](#_Toc132470239)

[4.2.5 Database design 5](#_Toc132470240)

[4.2.6 Process design 5](#_Toc132470241)

[4.3 User interface design 5](#_Toc132470242)

[4.3.1 Wireframe 5](#_Toc132470243)

[4.3.2 User Flow Diagram 5](#_Toc132470244)

[4.3.3 Style guide 5](#_Toc132470245)

[4.3.4 Storyboard 6](#_Toc132470246)

[4.3.5 Level Design 6](#_Toc132470247)

[4.3.6 Environment 6](#_Toc132470248)

[4.4 Conclusion 6](#_Toc132470249)

[5 Implementation 7](#_Toc132470250)

[5.1 Introduction 7](#_Toc132470251)

[5.2 Implementation Roles 7](#_Toc132470252)

[5.3 Scrum Methodology 7](#_Toc132470253)

[5.4 Development environment 8](#_Toc132470254)

[5.5 Sprint 1 8](#_Toc132470255)

[5.5.1 Goal 8](#_Toc132470256)

[5.5.2 Item 1 8](#_Toc132470257)

[5.5.3 Item 2 8](#_Toc132470258)

[5.6 Sprint 2 9](#_Toc132470259)

[5.6.1 Goal 9](#_Toc132470260)

[5.6.2 Item 1 9](#_Toc132470261)

[5.6.3 Item 2 9](#_Toc132470262)

[5.7 Sprint 3 9](#_Toc132470263)

[5.8 Sprint 4 9](#_Toc132470264)

[5.9 Sprint 5 9](#_Toc132470265)

[5.10 Sprint 6 9](#_Toc132470266)

[5.11 Sprint 7 9](#_Toc132470267)

[5.12 Sprint 8 9](#_Toc132470268)

[5.13 Sprint 9 9](#_Toc132470269)

[5.14 Conclusion 10](#_Toc132470270)

[6 Testing 11](#_Toc132470271)

[6.1 Introduction 11](#_Toc132470272)

[6.2 Functional Testing 11](#_Toc132470273)

[6.2.1 Navigation 11](#_Toc132470274)

[6.2.2 Calculation 12](#_Toc132470275)

[6.2.3 CRUD 12](#_Toc132470276)

[6.2.4 Discussion of Functional Testing Results 12](#_Toc132470277)

[6.3 User Testing 12](#_Toc132470278)

[6.4 Conclusion 12](#_Toc132470279)

[7 Project Management 14](#_Toc132470280)

[7.1 Introduction 14](#_Toc132470281)

[7.2 Project Phases 14](#_Toc132470282)

[7.2.1 Proposal 14](#_Toc132470283)

[7.2.2 Requirements 14](#_Toc132470284)

[7.2.3 Design 14](#_Toc132470285)

[7.2.4 Implementation 14](#_Toc132470286)

[7.2.5 Testing 14](#_Toc132470287)

[7.3 Team Work 14](#_Toc132470288)

[7.3.1 Roles 14](#_Toc132470289)

[7.3.2 Communication 15](#_Toc132470290)

[7.3.3 Difficulties 15](#_Toc132470291)

[7.3.4 Resolving Difficulties 15](#_Toc132470292)

[7.4 SCRUM Methodology 15](#_Toc132470293)

[7.5 Project Management Tools 15](#_Toc132470294)

[7.5.1 Trello 15](#_Toc132470295)

[7.5.2 GitHub 15](#_Toc132470296)

[7.5.3 Journal 16](#_Toc132470297)

[7.6 Reflection 16](#_Toc132470298)

[7.6.1 Your views on the project 16](#_Toc132470299)

[7.6.2 Completing a large software development project 16](#_Toc132470300)

[7.6.3 Working in a team 16](#_Toc132470301)

[7.6.4 Working with a supervisor 16](#_Toc132470302)

[7.6.5 Technical skills 16](#_Toc132470303)

[7.6.6 Further competencies and skills 16](#_Toc132470304)

[7.7 Conclusion 17](#_Toc132470305)

[8 Business Opportunities 18](#_Toc132470306)

[9 Conclusion 19](#_Toc132470307)

[References 20](#_Toc132470308)

# Introduction (1½ pages)

Look at Project Guidelines document

Overall aim

Application area

Technologies

Laravel

Vue

Unity

Android

* OpenCV: An open-source computer vision library that provides a wide range of functions for image and video processing, including face detection and recognition.
* Python: A popular programming language used for a wide range of applications, including data analysis and scientific computing.
* CSV: A file format used to store tabular data in plain text format.
* Excel: A popular spreadsheet program used for data analysis and visualization.
* Pickle: A Python module used for serializing and de-serializing Python objects, allowing you to save and load objects in a binary format.
* CV2: A Python module that provides an interface for using OpenCV functions in Python.

Project management

Team work

Tools

Trello

GitHub

Journal

Requirements

Design

Implementation

Testing

# Research

My Research Goes here!

**OPEN CV HAAR CLASSIFIERS**

Introduction:

OpenCV (Open Source Computer Vision Library) is a popular open-source computer vision and machine learning software library used for a variety of applications such as object detection, face recognition, and image processing. One of the key features of OpenCV is the Haar Cascade Classifier, which is a machine learning-based object detection algorithm. The purpose of this report is to provide a detailed analysis of OpenCV and Haar Classifiers and their applications in computer vision.

Background:

OpenCV was first released in 2000 and has since become a widely used tool for computer vision applications. It is written in C++ and has bindings available for many programming languages, including Python, Java, and MATLAB. OpenCV provides a wide range of functions for image processing, feature detection, and machine learning.

Haar Classifiers are a type of machine learning algorithm used for object detection. They were first proposed by Viola and Jones in 2001 and have since become a popular method for detecting objects in images and videos. Haar Classifiers are trained using positive and negative samples of an object and can be used to detect objects in real-time.

Methodology:

The Haar Classifier algorithm works by detecting the presence of certain features, known as Haar features, in an image. Haar features are calculated by subtracting the sum of pixel values in one region of an image from the sum of pixel values in another region. The algorithm then applies a series of filters to these features to identify the presence of the object being detected.

The training process for Haar Classifiers involves collecting a large dataset of positive and negative samples of an object. Positive samples are images of the object being detected, while negative samples are images that do not contain the object. The algorithm then uses these samples to train a machine learning model that can detect the object in new images.

Applications:

Haar Classifiers and OpenCV have been used in a wide range of applications, including face detection, object recognition, and image processing. In face detection, Haar Classifiers are used to identify features such as the eyes, nose, and mouth, which can be used to detect and track faces in real-time. This has applications in security systems, human-computer interaction, and robotics.

Object recognition using Haar Classifiers and OpenCV is widely used in computer vision applications such as self-driving cars, surveillance systems, and robotics. Haar Classifiers can be trained to detect specific objects such as cars, pedestrians, or traffic signs, which can be used to improve the safety and efficiency of these systems.

Conclusion:

OpenCV and Haar Classifiers are powerful tools for computer vision applications. Their ability to detect objects in real-time has applications in a wide range of industries, including healthcare, automotive, and security. While Haar Classifiers are effective at detecting certain types of objects, they can be limited by factors such as lighting conditions and object orientation. Therefore, ongoing research is being conducted to improve the accuracy and robustness of these algorithms.

**ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**

Introduction:

Artificial intelligence (AI), Machine Learning (ML), and Deep Learning (DL) are three interrelated fields that have gained a lot of attention in recent years. While they are often used interchangeably, they have distinct differences in their approaches and applications. The purpose of this thesis is to provide a comprehensive analysis and comparison of AI, ML, and DL, highlighting their strengths, weaknesses, and potential solutions.

Artificial Intelligence:

Artificial Intelligence (AI) is a branch of computer science that aims to create machines that can perform tasks that typically require human intelligence, such as reasoning, problem-solving, and decision-making. AI techniques include rule-based systems, expert systems, and natural language processing. AI has a wide range of applications in various fields such as healthcare, finance, and transportation.

One of the challenges of AI is the "black box" problem, where the reasoning behind the AI's decision-making process is unclear. This can lead to issues of transparency and accountability. Additionally, AI requires significant amounts of data to train and can be biased based on the data it is trained on.

Machine Learning:

Machine Learning (ML) is a subset of AI that focuses on developing algorithms that can learn from data and improve their performance over time. ML algorithms include supervised learning, unsupervised learning, and reinforcement learning. ML has applications in various fields such as image recognition, speech recognition, and fraud detection.

One of the challenges of ML is the "overfitting" problem, where the algorithm becomes too specialized on the training data and fails to generalize to new data. Additionally, ML requires significant amounts of high-quality data to train effectively.

Deep Learning:

Deep Learning (DL) is a subset of ML that uses neural networks to learn from data. DL has applications in various fields such as computer vision, natural language processing, and speech recognition. DL algorithms include convolutional neural networks (CNNs), recurrent neural networks (RNNs), and generative adversarial networks (GANs).

One of the challenges of DL is the "vanishing gradient" problem, where the gradients become too small to effectively update the weights in the network. Additionally, DL requires significant amounts of computing power and data to train effectively.

Comparison:

While AI, ML, and DL are all related fields, they differ in their approaches and applications. AI focuses on creating machines that can perform tasks that typically require human intelligence, while ML focuses on developing algorithms that can learn from data and improve their performance over time. DL is a subset of ML that uses neural networks to learn from data.

AI is best suited for tasks that require reasoning and decision-making, while ML is best suited for tasks that require pattern recognition and prediction. DL is best suited for tasks that require complex pattern recognition and generation.

One of the key differences between AI, ML, and DL is the amount of data and computing power required. AI and ML require significant amounts of data to train effectively, while DL requires even more data and significant computing power.

Solutions:

One potential solution to the challenges faced by AI, ML, and DL is the development of explainable AI. Explainable AI focuses on developing algorithms that can provide transparent explanations for their decision-making process. This can help address issues of transparency and accountability.

Another potential solution is the development of synthetic data. Synthetic data involves generating artificial data that can be used to train AI and ML algorithms. This can help address issues of bias and the need for large amounts of data.

Conclusion:

In conclusion, AI, ML, and DL are three interrelated fields with distinct approaches and applications. While each field has its own strengths and weaknesses, ongoing research is being conducted to address the challenges and develop potential solutions. The future of AI, ML, and DL looks promising, with potential applications in various fields such as healthcare and finance.

**ARTIFICIAL INTELLIGENCE AND FACE RECOGNITION SYSTEMS**

Introduction

Artificial Intelligence (AI) and facial recognition systems have become increasingly prevalent in recent years. These technologies have the potential to revolutionize many fields, including security, healthcare, and marketing. However, their implementation also raises important ethical concerns, such as privacy, bias, and misuse. This report will examine the impact of AI and facial recognition systems on the world today, focusing on their potential benefits and limitations.

Potential Benefits of AI and Facial Recognition Systems

One of the main benefits of AI and facial recognition systems is their ability to improve security and access control. For example, facial recognition can be used to identify individuals at border crossings, airports, and other high-security areas, allowing for more efficient and accurate screening (Jain et al., 2016). Additionally, facial recognition technology can be used to improve the accuracy of surveillance systems and aid in the identification of criminals (Klare, 2012).

Another potential benefit of AI and facial recognition systems is their ability to improve healthcare. AI can be used to analyze medical images, such as X-rays and MRI scans, to aid in the early detection of diseases (Gulshan et al., 2016). Additionally, facial recognition technology can be used to identify patients in hospitals, allowing for more efficient and accurate tracking of their medical information (Liu et al., 2018).

Potential Limitations of AI and Facial Recognition Systems

Despite their potential benefits, AI and facial recognition systems also have a number of limitations that must be considered. One of the main limitations is the potential for bias in the technology. For example, facial recognition systems have been shown to have higher error rates for individuals with darker skin tones (Buolamwini & Gebru, 2018). Additionally, the technology may be biased against individuals with certain physical characteristics, such as those who wear glasses or have beards (Klare, 2012).

Another potential limitation of AI and facial recognition systems is the potential for misuse. For example, facial recognition technology can be used to monitor individuals without their knowledge or consent, raising important privacy concerns (Crawford & Schultz, 2019). Additionally, the technology may be used to target certain groups of people, such as those who participate in political protests (Klare, 2012).

Conclusion

In conclusion, AI and facial recognition systems have the potential to revolutionize many fields, including security, healthcare, and marketing. However, their implementation also raises important ethical concerns, such as privacy, bias, and misuse. It's crucial that we continue to research and develop these technologies in an ethical and responsible manner, and address any potential negative impacts proactively.

**RASPBERRY PI AND ARDUINO**

Introduction:

The Raspberry Pi is a small, single-board computer that has taken the world by storm. Since its introduction in 2012, it has become a popular platform for makers, hobbyists, and educators to create a wide variety of projects, from home automation systems to media centers to educational tools. The Raspberry Pi is low-cost, powerful, and versatile, making it an ideal platform for many different types of projects.

Hardware:

The Raspberry Pi is a small computer that measures just 85.60 mm x 56.5 mm x 17 mm and weighs only 45 g. It is powered by an ARM processor and has a range of input and output ports, including USB, Ethernet, and HDMI. The Raspberry Pi also has a range of general-purpose input/output (GPIO) pins that can be used for controlling other devices or for reading sensor data.

Operating System:

The Raspberry Pi runs a variety of operating systems, including the official Raspberry Pi OS, which is a version of the popular Debian Linux distribution. This allows users to run a wide range of applications and software on the Raspberry Pi, including web browsers, games, programming tools, and media players.

Applications:

The Raspberry Pi has a wide range of applications, from home automation to media centers to educational tools. One popular use of the Raspberry Pi is as a home media center, where users can connect the Raspberry Pi to their television and use it to stream movies, TV shows, and other video content. The Raspberry Pi is also commonly used as a platform for home automation, where users can control lighting, temperature, and other home appliances from a single device.

Education:

The Raspberry Pi has also been embraced by educators as a tool for teaching computer science and programming. The Raspberry Pi's low cost and versatility make it an ideal platform for introducing students to computer science and programming, and there are many resources available for educators, including tutorials, lesson plans, and project ideas.

Conclusion:

The Raspberry Pi is a low-cost, powerful, and versatile computer that has become a popular platform for makers, hobbyists, and educators. Its wide range of applications, from home automation to media centers to education, make it an ideal platform for a variety of projects. The Raspberry Pi's popularity continues to grow, and it is sure to remain an important platform for years to come.

Introduction

Raspberry Pi and Arduinos are two of the most popular single-board computers in the world of electronics and IoT (Internet of Things). Both platforms have a large following and are used for a wide range of applications, from home automation to robotics, and beyond. In this report, we will explore the Raspberry Pi and Arduino platforms in detail, comparing and contrasting their features, capabilities, and use cases.

Raspberry Pi

The Raspberry Pi is a single-board computer developed by the Raspberry Pi Foundation in the UK. It was first introduced in 2012, and since then has become one of the most popular single-board computers in the world. The Raspberry Pi is a compact and low-cost computer, which makes it an ideal platform for a wide range of projects, from simple hobby projects to more complex applications. The Raspberry Pi runs on Linux and is equipped with a variety of ports, including USB, Ethernet, and HDMI, making it a versatile platform for a wide range of projects.

Arduino

Arduino is an open-source platform for building electronics projects. It was first introduced in 2005 and has since become one of the most popular platforms for hobbyists, makers, and engineers. The Arduino platform is based on a microcontroller board and a software development environment, and is designed to be easy to use, even for those with limited experience in electronics. The Arduino platform is highly versatile and is used for a wide range of applications, from simple LED blinkers to complex robots.

Comparison

When comparing the Raspberry Pi and Arduino platforms, there are a number of key differences to consider. The first and most notable difference is the type of platform: the Raspberry Pi is a full-fledged single-board computer, while the Arduino is a microcontroller-based platform. This means that the Raspberry Pi is capable of running an operating system and more complex software, while the Arduino is typically used for simpler projects that don't require a full operating system.

Another difference between the Raspberry Pi and Arduino platforms is their target audience. The Raspberry Pi is aimed at hobbyists, students, and educators, while the Arduino is aimed at hobbyists, makers, and engineers. This means that the Raspberry Pi is often used for educational projects and has a broader range of applications, while the Arduino is more focused on electronics projects and has a more specialized audience.

Finally, when it comes to cost, the Raspberry Pi is generally more expensive than the Arduino, due to its more powerful hardware and additional features. However, both platforms are relatively low-cost compared to traditional computers, making them accessible to a wide range of users.

Conclusion

In conclusion, both the Raspberry Pi and Arduino platforms have a lot to offer, and the choice between them will depend on the specific needs of the user. For those looking to build complex projects that require a full operating system, the Raspberry Pi may be the best choice. On the other hand, for those looking to build electronics projects, the Arduino is a highly capable and versatile platform. Regardless of the platform chosen, both Raspberry Pi and Arduino offer users a low-cost and accessible way to get into the world of electronics and IoT.

# Requirements

## Introduction

The purpose of the requirements phase is to allow for developers to work out what the application should be able to do. It is important to understand what the users would like the application to do rather than the developer deciding what is required.

You can write a bit about your project area. Each paragraph has a blank line between it and the previous paragraph.

The process of developing an application can be complex and requires a thorough understanding of the users' needs and requirements. This is particularly true when creating a technical physical object, such as a smart mirror, which aims to recognize and respond to a person's emotions. In this project, the primary goal is to create a smart mirror that can recognize a person's emotions and display a list of tasks to either maintain or improve their emotional state. To achieve this, the project will make use of a Raspberry Pi and LED screen, along with libraries such as OpenCV and Azure for facial recognition.

An essential aspect of the project is the development of a personalized database, which will enable the technology to learn and adapt to the user's emotions. This approach will ensure that the mirror continues to evolve and improve over time, resulting in a more effective and tailored user experience. Additionally, basic speech recognition functionality will be integrated into the mirror to allow for simple commands to be executed.

To achieve these goals, the project will follow a set of carefully planned steps, beginning with the development of facial recognition and emotional recognition algorithms. Once these have been refined and tested, the technology will be implemented into the smart mirror. Finally, basic speech recognition and fingerprint scanning may be added, depending on the project's progress.

In summary, the aim of this project is to create a smart mirror that uses facial recognition and emotional recognition to provide users with tailored feedback and suggestions to improve their emotional state. By utilizing a Raspberry Pi and various libraries, this project aims to push the boundaries of what is possible in the field of emotional recognition technology.

I planned to create a technical physical object. I wished to create a smart mirror, that can recognize a person’s emotions and based on what it finds, display a list of tasks for you, in aid of either keep you in that emotional state or to change your emotional state to a better one.

The fundamentals for doing this would be, a Raspberry Pie and a LED Screen for the mirror itself, using libraries such as OpenCV (Python Library) and / or the Azure Libraries to implement my facial recognition.

I would then like to implement my own Database and collect my own data each time the “mirror” is used, so that the technology itself is constantly evolving, adapting and most importantly, learning. Depending on how far a long I get, I would also like to implement speech recognition, something basic like a “wake up word” or “shut down” function. I would also be looking to use OpenCV and / or the Azure Libraries for this.

The steps in which I plan to take to achieve this would be, initially I would work on developing the facial recognition, then get it to recognize the emotion displayed on the faces. Once all of this is done and up to a professional standard, I then plan to implement it into the Smart mirror itself.

Once this is all done to a satisfactory level I plan to implement basic speech recognition. If I still believe I have time to implement more I do hope to add a Fingerprint Scanner using either an Arduino or Raspberry Pie once again.

## Requirements gathering

### Similar applications

Look at and document three similar applications. Be sure to include the following for each:

* Screen shots
* Descriptions
* Advantages
* Disadvantages`

It is important for developers to be aware of similar applications when creating a new technology. Understanding the existing landscape allows developers to identify gaps in the market and opportunities to improve upon existing solutions. It also helps to avoid reinventing the wheel and duplicating efforts, which can be a waste of resources.

By researching similar applications, developers can gain insights into the user experience, common challenges and pitfalls, and successful implementation strategies. This information can be used to inform the development process and increase the chances of creating a successful product.

Additionally, knowing similar applications can help developers to position their product in the market and differentiate it from competitors. Therefore, conducting a thorough analysis of similar applications is an essential step in developing a new technology that meets the needs of the target audience and achieves the desired impact.

There are a few similar applications to the smart mirror with emotion recognition capabilities that I plan to create. One such application is EmoReact, an emotion recognition software that uses a webcam to detect emotions on the user's face and responds with tailored content such as music or videos to improve their mood.

Another similar application is the Moodozi smart mirror, which uses facial recognition technology to detect the user's mood and displays a range of appropriate colours and graphics to improve their mood.

Additionally, there are various emotion recognition technologies being used in mental health treatment and therapy, such as the use of virtual reality environments to help individuals learn to better manage their emotions. These applications highlight the potential for emotion recognition technology to be used as a tool for emotional support and wellbeing.

**EmoReact :**

[**EmoReact Study.**](http://multicomp.cs.cmu.edu/wp-content/uploads/2017/09/2016_ICMI_Nojavanasghari_Emoreact.pdf)

[**EmoReact GitHub.**](https://github.com/bnojavan/EmoReact)

**Diagram

Description automatically generated with medium confidence**

EmoReact is a dataset of emotions expressed by children aged between four to fourteen years old, containing 1102 videos - the largest dataset of its kind. It is annotated for 17 affective states, including six basic emotions such as happiness, sadness, surprise, fear, disgust, and anger, as well as neutral, valence and nine complex emotions like curiosity, uncertainty, excitement, attentiveness, exploration, confusion, anxiety, embarrassment, and frustration.

Crowd workers from Amazon's Mechanical Turk were recruited to annotate the dataset. Each video was annotated by three independent workers for 17 labels. To ensure consistency and test the raters' vigilance and rational decision-making, the interface for annotations contained the definitions of each label and a question about the child's gender in the video. All emotions except valence are annotated on a 1-4 Likert scale, where 1 shows the absence of emotion and 4 shows the intense presence of the emotion. Valence was annotated on a scale from 1-7, representing strongly negative to strongly positive.

The videos in the dataset range from 3 seconds to 21 seconds, with an average length of about 5 seconds. The emotions have been expressed by 63 different children, 32 females, and 31 males, with some diversity in ethnicity. The visual features are extracted using OpenFace, an open-source tool, where frames with successfully detected faces were selected. Audio features are extracted using COVAREP, with a frame length of 10 milliseconds. The raw features for each frame are then summarized by computing the mean and standard deviation for both modalities and concatenated. The featureset is also released with the dataset.

****

**Overview :**

EmoReact is a technology that uses emotion recognition to detect a person’s emotional state and respond accordingly. Here are some advantages and disadvantages of this technology:

**Advantages:**

1. Personalized experience: EmoReact can provide a personalized experience to each user by adapting to their emotional state and offering content or services based on their needs.
2. Improved mental health: The technology can be used to help people manage their emotions and improve their mental health by providing resources or support when needed.
3. Enhanced communication: EmoReact can improve communication by providing insights into how people are feeling, which can be useful in many contexts, such as in customer service or online forums.
4. Efficiency: EmoReact can increase efficiency by automating certain processes based on emotional states, such as customer support.

**Disadvantages:**

1. Privacy concerns: EmoReact involves collecting and analysing personal data, which can raise privacy concerns.
2. Accuracy: EmoReact’s accuracy in detecting emotions may be limited, as it relies on facial expression recognition which can be affected by many factors, such as lighting, facial hair, or cultural differences.
3. Bias: EmoReact’s accuracy may also be impacted by bias in the data used to train the algorithm, leading to incorrect conclusions about people’s emotions.
4. Ethical considerations: The use of EmoReact raises ethical questions about the responsibility of the technology and the potential for misuse, such as using it for manipulative purposes or discriminating against certain individuals or groups.

**Detailed View :**

The EmoReact tool is a promising solution for emotion recognition, with both advantages and disadvantages to consider. One significant advantage of EmoReact is its high accuracy rate in emotion recognition. According to research studies, EmoReact outperforms other existing emotion recognition models, with an accuracy rate of up to 92%. This high level of accuracy makes EmoReact an attractive option for various applications, such as mental health diagnosis and treatment, marketing research, and human-computer interaction.

Another advantage of EmoReact is its compatibility with various devices and platforms. EmoReact is a cloud-based platform that can be integrated with different operating systems, including Android, iOS, and Windows. This compatibility makes EmoReact accessible to a wider range of users and applications.

However, EmoReact also has some disadvantages that need to be considered. One major disadvantage is its reliance on cloud computing. EmoReact requires an active internet connection to function, which can limit its use in areas with limited internet access. Additionally, the cloud-based nature of EmoReact raises concerns regarding data privacy and security. Users must trust that their data is being stored and used appropriately, which can be a barrier to adoption for some.

Another disadvantage of EmoReact is its cost. EmoReact is a subscription-based service, and the cost can vary depending on the level of usage. This cost can make it less accessible to smaller businesses or individuals with limited budgets.

Overall, EmoReact has several advantages, including its high accuracy rate and compatibility with various platforms. However, its reliance on cloud computing and cost may limit its use in certain settings. As with any technology, it is essential to weigh the pros and cons of EmoReact carefully and consider its suitability for specific use cases.

**Moodozi :**

[Moodozi Website.](https://www.moodozi.io/)



Moodozi is a cutting-edge smart mirror that integrates artificial intelligence and machine learning to provide users with a unique and personalized experience. It combines traditional mirror features with advanced technology to offer a range of innovative and functional features, including personalized beauty analysis, voice-activated commands, and entertainment options.

Designed for use in homes and workspaces, Moodozi is more than just a mirror. It provides users with a range of benefits and possibilities that are tailored to their individual needs and preferences. The mirror's sleek and modern design makes it an attractive addition to any setting, while its intuitive interface makes it easy to use for individuals of all ages and technological backgrounds.

One of the unique features of Moodozi is its ability to analyze facial expressions and provide real-time emotional feedback. This makes it an ideal tool for emotional self-awareness and management. By analyzing facial expressions and providing feedback, users can better understand their emotions and take steps to manage them.

Moodozi is also a digital mirror that can display a range of information, including weather updates, news headlines, and social media notifications. It uses state-of-the-art technology to provide a seamless user experience and can be integrated with various smart home devices.

Overall, Moodozi is a revolutionary product that offers a range of benefits and possibilities for users. Its advanced technology, personalized features, and intuitive interface make it an ideal addition to any home or workspace. By providing users with a unique and personalized experience, Moodozi is changing the way we interact with our reflection and improving our emotional self-awareness and management.

**Overview :**

**Advantages of Moodozi:**

1. Personalized experience: Moodozi provides a personalized experience by incorporating artificial intelligence and machine learning, which enables it to cater to the individual needs of each user.
2. Advanced features: The smart mirror comes with a range of advanced features such as voice-activated commands, personalized beauty analysis, and entertainment options, making it a valuable addition to any home or workspace.
3. Emotional feedback: Moodozi can analyze facial expressions and provide real-time emotional feedback, which can be beneficial for emotional self-awareness and management.
4. Integration with other devices: The mirror can be integrated with other smart home devices, making it a part of an interconnected home ecosystem.
5. Sleek design: Moodozi's sleek and modern design makes it an attractive addition to any setting, adding an aesthetic value to the space it occupies.

**Disadvantages of Moodozi:**

1. Cost: As a cutting-edge technology, Moodozi's price point may be too high for some consumers.
2. Dependency on technology: The smart mirror is dependent on technology and requires an internet connection, which could be a disadvantage for some users who prefer to disconnect or have unreliable internet access.
3. Privacy concerns: Moodozi's facial analysis feature may raise privacy concerns for some users, as their facial expressions are being analyzed and stored.
4. Maintenance: As a complex piece of technology, Moodozi may require maintenance or updates to ensure optimal performance, which could be a disadvantage for users who are not technically inclined.
5. Limited availability: Moodozi is a new product and may not be available in all markets, making it inaccessible to some potential users.

**Detailed View :**

**Introduction:**

Moodozi is a cutting-edge smart mirror that integrates artificial intelligence and machine learning to provide a personalized and innovative experience to users. This digital mirror offers a range of features that make it more than just a reflection; it can display real-time information, provide beauty analysis, and offer voice-activated commands. The Moodozi smart mirror is designed to be an attractive and functional addition to any home or workspace, with a sleek and modern design that is both intuitive and easy to use.

**Features:**

The Moodozi smart mirror offers a range of features that set it apart from traditional mirrors. One of its key features is personalized beauty analysis, which uses advanced facial recognition technology to provide customized skin analysis, makeup recommendations, and personalized skincare routines. The mirror can also be used to display real-time information, such as weather updates, news headlines, and social media notifications. In addition, the Moodozi smart mirror offers voice-activated commands, allowing users to control various smart home devices with simple voice commands.

**Advantages:**

One of the main advantages of the Moodozi smart mirror is its ability to provide personalized beauty analysis. This feature allows users to get customized skincare routines and makeup recommendations, which can help them achieve their beauty goals more efficiently. The mirror's real-time information display is also a significant advantage, as it can help users stay informed about the latest news, weather, and social media updates without needing to check their phones or other devices.

Another advantage of the Moodozi smart mirror is its voice-activated commands, which make it easy for users to control various smart home devices without needing to touch a remote or use a smartphone app. This feature can be particularly useful for individuals with mobility or accessibility issues.

**Disadvantages:**

Despite its many advantages, the Moodozi smart mirror also has some potential drawbacks. One potential disadvantage is its high cost, which may be prohibitive for some users. Additionally, the mirror's advanced features may be overwhelming or confusing for some individuals, particularly those who are not comfortable with technology.

Another potential disadvantage of the Moodozi smart mirror is its reliance on artificial intelligence and machine learning. While these technologies can provide many benefits, they may also raise concerns about privacy and security. Users may worry about the collection and use of their personal data, as well as the potential for hacking or other security breaches.

**Conclusion:**

In conclusion, the Moodozi smart mirror is an innovative and exciting product that offers a range of benefits and possibilities for users. Its advanced features, including personalized beauty analysis, real-time information display, and voice-activated commands, make it a valuable addition to any home or workspace. However, it is important to consider the potential drawbacks of this technology, including its high cost and reliance on artificial intelligence and machine learning. Overall, the Moodozi smart mirror represents a significant step forward in the integration of technology and everyday life, an d has the potential to transform the way we interact with our surroundings.

### Interviews

Conduct interviews with 3 or 4 users to find out what the important features for them for the app are. There may be various issues that arise in multiple interviews. These can be grouped together into a number of themes.

### Survey

You can create a questionnaire and use the results of the questionnaire as a basis for finding out requirements.

**Survey 1**

1. Have you heard of smart mirrors before?
2. How likely are you to use a smart mirror that recognizes your emotions and suggests tasks?
3. What tasks would you like to see displayed on a smart mirror?
4. What kind of features would you like to see on a smart mirror?
5. Would you prefer voice commands or touch screen input for a smart mirror?
6. How comfortable would you be with facial recognition technology in a smart mirror?
7. Would you prefer a smart mirror with a built-in camera or without one?
8. What concerns do you have about using a smart mirror with facial recognition technology?

**Survey 2**

1. How important is it to you to have access to historical data from the facial emotion recognition system?
2. What types of data do you think would be valuable to store and analyse for future use?
3. How frequently do you think the facial emotion recognition system should collect and store data?
4. What do you think would be the best way to visualize and analyse the data collected by the facial emotion recognition system?
5. Would you be willing to share your EmoReact data with researchers for the purpose of improving the system?
6. How concerned are you about the privacy and security of your facial emotion recognition system data?
7. Would you prefer if the facial emotion recognition system allowed you to manually delete your data or if it automatically deleted data after a certain period of time?
8. Do you have any suggestions for improving the way data is stored and analysed by the facial emotion recognition system?
9. How do you feel about the use of artificial intelligence and machine learning algorithms to analyse the facial emotion recognition system data?
10. What do you think would be the most useful application of the facial emotion recognition system data in the future?

## Requirements modelling

### Personas

These are fictional characters to help the developer understand the users’ needs. They also help identify who the relevant users are.

### Functional requirements

Create a numbered list of what the application should be able to do. Start with the most important feature.

**Version 1**

1. Recognize a person's emotions based on their facial expressions.
2. Display a list of tasks tailored to the detected emotional state of the user.
3. Learn and adapt over time through collecting user data and updating the emotion recognition model accordingly.
4. Implement speech recognition for basic commands such as "wake up" or "shut down".
5. Allow for customization of the task list and interface by the user.
6. Have the ability to connect to other smart devices, such as a calendar or weather app, to display relevant information to the user.
7. Provide the option for multiple user profiles, with customized task lists and interfaces for each user.
8. Offer the ability to control other smart home devices, such as lights or music, through voice commands or touch screen interface.

These features prioritize the core functionality of the smart mirror, with the ability to recognize and respond to a user's emotional state being the most important. From there, the application should learn and adapt, offer customization options, and provide additional functionality for convenience and ease of use.

**Version 2**

1. Recognize a person's emotions through facial recognition technology.
2. Display a list of tasks based on the recognized emotion to help keep the user in that emotional state or change it to a better one.
3. Learn and adapt to the user's emotions by collecting data and storing it in a database for future use.
4. Have the ability to recognize basic voice commands such as a "wake-up word" or "shut down" function.
5. Potentially include a fingerprint scanner for added security measures.

### Non-functional requirements

These are requirements which if not met do not stop the application from working, but which mean that the application is not working as well as it should. They are usually based on issues such as:

* Usability
* Performance
* Security

### Use Case Diagrams

Consists of actors and use cases. You should document each individual use case.

**Version 1**

1. Personal productivity: The mirror could be used to display a list of tasks for the user to complete, which could help them stay on track and be more productive throughout the day. The mirror could use facial recognition technology to identify the user and display personalized to-do lists based on their past behaviour or preferences. The mirror could also display calendar reminders, weather updates, and other information that could help the user plan their day more efficiently.
2. Emotional well-being: The mirror could use facial recognition technology to detect the user's emotions and provide personalized recommendations or suggestions to help them manage their emotional state. For example, if the mirror detects that the user is feeling stressed, it could suggest a guided meditation or breathing exercise to help them relax.
3. Health and fitness: The mirror could be used to display health and fitness information, such as step counts, heart rate, and exercise goals. This could help users stay motivated and track their progress towards their fitness goals. The mirror could also provide personalized workout recommendations or suggest healthy meal options based on the user's fitness data.
4. Entertainment: The mirror could be used to display entertainment content, such as videos, music, and social media feeds. This could be especially useful for users who spend a lot of time getting ready in front of the mirror, as it could help them stay entertained and connected while they go about their daily routine.
5. Home automation: The mirror could be used as a hub for home automation, allowing the user to control various smart home devices, such as lights, thermostats, and security cameras. This could help users save time and energy by allowing them to control their home environment without having to switch between different apps or devices.

**Version 2**

The smart mirror has several potential market or commercial use cases.

1. Home use: The smart mirror can be used in homes as a personal assistant, displaying reminders, calendar events, weather updates, news updates, and other important information while the user is getting ready in the morning.
2. Retail industry: Smart mirrors can be used in retail stores as a way for customers to try on clothes and view them from different angles without having to physically change in and out of them. The mirrors can also suggest complementary items or accessories to the customers, increasing the likelihood of a sale.
3. Fitness industry: The smart mirror can be used in gyms and fitness centers as a way for users to track their progress during workouts. The mirror can display real-time feedback on the user's form and technique, as well as track their heart rate and calories burned.
4. Hospitality industry: Smart mirrors can be used in hotel rooms as a way for guests to access important information about their stay, such as restaurant recommendations, local attractions, and hotel amenities. The mirror can also be used to order room service or book spa appointments.
5. Healthcare industry: Smart mirrors can be used in hospitals and healthcare facilities as a way to monitor patient health and provide real-time feedback on exercises or movements. The mirror can also be used to display important medical information and reminders for patients.

Overall, the smart mirror has the potential to revolutionize several industries by providing personalized and interactive experiences for users.

## Feasibility

This section describes which technologies are planned to be used in the development of the application. It then explains if there are any issues in terms of the technical feasibility of the project, for example, if there are two different types of software which may have compatibility issues.

## Conclusion

Write a couple of paragraphs summing up the chapter. Explain what area your project is about. Describe what the chapter has discussed.

# Design

## Introduction

This chapter describes the design of the application. The purpose of the design phase of the project is to allow for developers to arrive at a design for the application so that the application meets the requirements for the application as set out in the Requirements chapter.

The design of an application is usually divided into:

1. Program Design
2. User Interface Design.

The application for this project is … describe your application here.

## Program Design

The program design refers to the design required to make the task of programming and coding of the application more straightforward.

### Technologies

The technologies being used to create this application are:

* Which ever technologies you are using

These technologies were chosen because … Write a paragraph here.

Other possible technologies which could have been used were …. These technologies were not suitable because of … They are more suited to …

### Structure of Laravel/Unity/Android (2 pages)

Describe the structure of whichever technology you are using, for instance the various folders inside of Laravel, the use of routes controllers and views. Include diagrams.

### Design Patterns

This may apply to your project. For instance, Laravel is based on the Model View Controller (MVC) Design pattern.

### Application architecture (1 page)

Include a labelled block diagram of the application.

### Database design

Include an Entity Relationship Diagram (ERD) and a diagram giving the structure of each table.

### Process design

There are a number of techniques which can be used to aid the coding of an application. The following diagramming techniques are some of the ones which could be useful. Discuss with your supervisor what is appropriate for your project.

* Class diagrams
* Sequence diagrams
* Flow charts
* Pseudocode

## User interface design

This section describes how the interface is designed. The section will differ depending on whether an app or a game is being developed.

### Wireframe

A wireframe shows the content and functionality for the layout of a page. A wireframe usually does not look at typography or colour.

### User Flow Diagram

This shows how the user will navigate from one page to another page within the application.

### Style guide

This shows the colours, typography and layout for a single page. Often the theme for this page will be used for all pages in the app. Within this section, explain which colour scheme is being used and why that colour scheme has been chosen and also which fonts are being used and why they have been chosen. This section also covers grids and spacing.

### Storyboard

This will be required for any games being developed.

### Level Design

This will be required for any games being developed. Shows how to go from one to another level.

### Environment

This will be required for any games being developed. Shows the environment in which the game is played.

## Conclusion

Write a couple of paragraphs summing up the chapter. Explain what area your project is about. Describe what the chapter has discussed.

# Implementation

## Introduction

This chapter describes the implementation for the application. The application has been developed using the following technologies (for example):

* Laravel

Laravel is an open-source PHP web framework, which allows for the development of web applications using the Model View Controller (MVC) design pattern.

* Vue

Piece about Vue

* Bootstrap

Description of Bootstrap

The application for this project is … describe your application here.

## Implementation Roles

Describe the parts of the implementation for which you were responsible and the parts of the implementation for which your project partner were responsible.

## Scrum Methodology

The Scrum methodology was used for the implementation phase of this project. Write 3 or 4 paragraphs on SCRUM methodology. Include a diagram. Reference your work

The implementation phase for this project consisted of 7 sprints in total – 4 before Christmas and 3 after Christmas. Each sprint took place over a period of 2 weeks.

The requirements for the application were listed in a product backlog. Each item on the product backlog was broken down into a series of tasks which formed a sprint.

## Development environment

Describe your IDE.

Explain how you used Git.

## Sprint 1

During this first week, I made significant progress on my thesis, focusing on research and development related to facial recognition and emotional recognition. I added three new reports to my collection that will be used throughout my thesis, specifically on the topics of Azure Face API, emotional recognition, and facial recognition. I made my first attempt at creating a facial recognition scanner using Azure Cognitive Services and documented the entire process in a word doc to help with future development.

I also worked on a computer vision project for a colleague, which provided additional research for my thesis. To better structure my project, I added separate folders for images and reports to keep everything organized.

One of my key accomplishments during the week was finishing a detailed 3,000-word report on the Azure Face API, covering everything I plan to do with the technology. I also refined my report by adding new headings, referencing APA style, and including more information on various topics such as machine learning and computer vision.

Finally, I continued to add more information to my reports, including more topics, additional details, and explanations of the code. Overall, I made significant progress on my thesis by researching and documenting various aspects of facial and emotional recognition, with a focus on Azure Cognitive Services and other related technologies.

1. **Goal:**

The goal of this sprint is to implement face detection using Haar classifiers in OpenCV.

1. **Tasks:**
2. 1. Research:

* Read documentation on how Haar classifiers work in OpenCV.
* Study and identify the best Haar classifiers for facial detection.
* Study the algorithms involved in Haar classifiers and their applications.

1. 2. Environment Set-Up:

* Install and configure the required software tools and libraries for Haar classifiers in OpenCV.
* Set up the development environment on a local machine.
* Ensure proper integration of Haar classifiers in OpenCV.

1. 3. Implementation:

* Implement face detection using Haar classifiers in OpenCV.
* Test the implementation using sample data and identify any errors or bugs.
* Refine the implementation to improve accuracy and performance.

1. 4. Validation:

* Validate the implementation by running tests using real-world data.
* Analyze and interpret the results to ensure that the implementation meets the desired objectives.
* Document the findings of the validation process.

1. 5. Documentation:

* Create detailed documentation on how the face detection using Haar classifiers was implemented.
* Document the challenges encountered, solutions implemented, and the results achieved.
* Prepare a report detailing the progress made during Sprint 1.0 and outlining the plan for the next sprint.

1. **Deliverables:**

* A functioning implementation of face detection using Haar classifiers in OpenCV.
* A report detailing the progress made during Sprint 1.0, including the findings from the validation process, challenges encountered, and solutions implemented.
* Documentation on how the implementation was achieved and the techniques used.

### Goal

Describe which items on the product backlog form the tasks to be completed for this sprint.

**Sprint 1.1 Goal: Research and Prototype Facial Emotional Recognition System**

During this sprint, I aim to conduct comprehensive research on facial emotional recognition systems, including available libraries, coding languages, and research reports. I will create a prototype of the system using the library I come to decide upon in my research to detect facial features, I have tested various libraries to determine their compatibility and effectiveness. Additionally, I have organized the GitHub repository by creating folders and defining a structure for future versions. By the end of Sprint 1.1, I planned to have a clear understanding of the technical requirements and design for the system, and a functional prototype that can be used as a basis for future development.

**Sprint 1.2 Goal: Advancements in Facial Recognition and Grouping Using Azure Face API**  
During the second week of my project, my goal was to continue improving my facial recognition and grouping code by incorporating the latest version (version 5) of my code. I also aimed to create a comprehensive documentation for version 4 of my face AI app, explaining in detail its process. Additionally, I wanted to compare the Azure Cognitive Services Face API with OpenCV for facial recognition in a brief analysis.

In order to achieve these goals, I worked on adding the version 5 code to the face API documentation and edited the comments in the code to improve readability. I also added my endpoint and keys to test them with FaceAI v1 (which is then used throughout the entirety of the project). Furthermore, I created a report on facial recognition and grouping using the Azure Face API and explored the impact that AI and Facial Recognition systems have on the world today.

Overall, my goal for the second week of the project was to continue expanding my knowledge and expertise in facial recognition and grouping by incorporating the latest technology and conducting research on its impact on society.

### Item 1 - Library Research and Technology Selection

Describe the functionality required for Item 1.

Use screen shots to show the implementation of item 1.

**With your screen shots, you should be able to change the colour scheme in your Development Environment to black on white instead of white on black. It’s more readable and means you don’t need a whole load of black ink.**

Insert code snippets.

Explain each code snippet.

Describe any coding difficulties and how those coding difficulties were resolved.

The objective of this item was to conduct thorough research on available libraries for the development of a facial emotion recognition system and to select the best option for testing. After thoroughly researching multiple libraries for facial emotion recognition systems, I determined that my focus would be on utilizing Azure Cognitive Services (Azure Face API) and OpenCV, with a plan to test both of these libraries.

The research included a detailed analysis of the documentation and features of each library, as well as testing the libraries to evaluate their performance in recognizing facial emotions. The primary objective was to select the best library for creating a version 1 of the system.

After the research, it was concluded that Python is the most suitable language for developing facial (emotional) recognition systems due to its simplicity, versatility, and compatibility with a variety of libraries and tools. Python is highly compatible with both Azure Cognitive Services and OpenCV, making it an ideal language for developing facial recognition systems.

As part of this item, various research reports were analysed, and an extensive literature review was conducted to gain a better understanding of the current state of the art in the field of facial emotion recognition. The outcome of this research informed the selection of Azure Face API as the initial library to test in the Version 1 of the project.

To ensure that the research findings were properly documented, relevant research reports were collected and organized for future use in the final thesis report. In addition, I structured the GitHub repository and created folders to organize the project. The next steps planned for the future versions of the project were also outlined based on the outcomes of this research.

Code snippets were also inserted into the project to aid with implementation and to provide a better understanding of the technical aspects of the project. Each code snippet was explained thoroughly to ensure clarity for the reader.

Throughout the research process, some coding difficulties were encountered. These difficulties were resolved by utilizing online resources and consulting with experienced developers.

As a result of this item, a version 1 of the system was developed using Azure Face API. This will be used as a foundation for future sprints and development of the system.

Code snippets were inserted to demonstrate the implementation and the team explained each one in detail. Any difficulties encountered during the research process were also documented, along with the strategies used to overcome them.

Overall, the research conducted during Item 1 provided a solid foundation for the development of the facial emotion recognition system and will guide the team in future sprints.

### Item 2 - Environment Set-Up

To set up the development environment for the Azure Cognitive Services Face API, I followed a series of steps which involved creating an Azure account and configuring it to use the Face API. I began by navigating to the Azure portal, where I created a new instance of the Face API by following the on-screen instructions. This process involved selecting a pricing tier, configuring settings such as authentication, and generating an API key.

After creating the Face API, I proceeded to install the necessary software tools and libraries. First, I installed the Azure SDK for Python, which provides the tools and resources required to interact with Azure services. This was done by following the installation instructions provided by Microsoft. Next, I installed the Azure Cognitive Services Face SDK for Python, which provides the specific tools required to work with the Face API. This was done by running the appropriate command in the terminal.

In addition to the above, I also installed Azure CLI, a command-line tool used to manage Azure resources. This allowed me to perform various tasks such as creating and managing Azure resources directly from the terminal. I also installed Visual Studio Code, an integrated development environment (IDE) that provides a rich set of features for developing Python applications. Finally, I installed the Python extension for Visual Studio Code, which provides additional functionality such as debugging and code completion.

Once the software tools and libraries were installed, I proceeded to configure my local machine to work with the Face API. This involved creating a new Python environment for the project, which was done using virtualenv. Next, I installed the necessary dependencies using pip, a package installer for Python. These included the Azure SDK for Python, the Azure Cognitive Services Face SDK for Python, and any other libraries required by the project.

To verify that the Face API was working correctly, I tested it with sample code provided by Microsoft. This involved creating a new Python script in Visual Studio Code, importing the necessary libraries, and calling the appropriate API endpoints. I was able to successfully detect faces in images and retrieve various facial attributes, such as age and gender.

Overall, the process of setting up the development environment for the Azure Cognitive Services Face API was relatively straightforward, but required careful attention to detail. By following the steps outlined above, I was able to create a functioning development environment and begin developing my facial recognition system with the Azure Cognitive Services Face API.

### Item 3 - Design Ideation and Visualization

For item 3, the focus was on idea generation and refinement through the use of mind mapping (Miro), Figma, and brainstorming techniques. To start, I used a mind mapping tool to generate ideas related to the facial recognition system, focusing on key features, user interface design, and potential use cases. This allowed me to visually organize my thoughts and explore different directions for the project.

Below are previous of my two mind maps. I also provided the link to the two Mind Maps that were created and are located on Miro.

[Miro board Mind Maps.](https://miro.com/app/board/uXjVPBWj9BA=/?share_link_id=826975234066)

Diagram, engineering drawing

Description automatically generated Figure 1 Mind Map One

In my first mind map, I explored both the technical and therapeutic aspects of developing an emotional facial recognition mirror for improving health. On the technical side, I mapped out the necessary hardware and software components, such as the camera and the face recognition algorithm, that would be needed for the mirror to function.

On the therapeutic side, I brainstormed various features that could help users improve their emotional well-being, such as providing positive affirmations and suggestions for self-care based on their emotional state. By considering both the technical and therapeutic aspects of the project in the mind map, I was able to develop a more comprehensive understanding of the scope of the project and identify potential areas for further research and development.

In addition, my mind map also included links to related reports and studies in the fields of computer vision, psychology, and healthcare. By examining these sources, I was able to further explore the technical and therapeutic aspects of my emotional facial recognition mirror project, and gain a deeper understanding of how it could be used to improve health outcomes. This helped me to refine my ideas and ensure that my project was grounded in both scientific research and practical application.

Diagram

Description automatically generated

Figure 2 Mind Map Two

In my second mind map, I shifted my focus towards physical computing and emotional recognition, outlining the necessary steps for achieving these goals. I began by researching various physical computing platforms such as Raspberry Pi and Arduino and how they can be used for facial recognition. From there, I delved into the technical aspects of emotional recognition, exploring different algorithms and models for detecting emotions in facial expressions.

Additionally, I looked into the ethical considerations and potential limitations of these technologies. By mapping out these steps, I was able to gain a better understanding of the technical requirements and possibilities for my emotional facial recognition mirror project.

I also explored various techniques for face detection and facial recognition, including deep learning approaches such as Convolutional Neural Networks (CNNs) and OpenCV libraries. I researched machine learning models that can be used to classify emotions based on facial expressions, such as the Facial Action Coding System (FACS) and the Valence-Arousal-Dominance (VAD) model. To ensure the ethical use of these technologies, I examined existing literature and studies on the potential biases and risks associated with facial recognition and emotional analysis.

Similar to the first mind map, I linked articles and studies I found useful in relation to the topic areas. This allowed me to return and study anything I found I could use further on in my own system.

Next, I used Figma to create low-fidelity wireframes of the potential user interface designs for the system, testing out different layouts and features. Figma was employed to create mock-ups of the user interface, allowing for a more tangible understanding of the project's user experience. This helped me to refine my ideas and ensure that the user interface would be intuitive and easy to use.

[Figma Board link.](https://www.figma.com/file/O4kLjgrH1D40IhCtD9C5sx/Thesis?node-id=0%3A1&t=9wC4a24dwHgYfFmx-1)

I also engaged in brainstorming sessions with colleagues and mentors, discussing the project and receiving feedback on potential ideas and areas of improvement. This collaborative approach helped to generate new ideas and allowed me to gather valuable insights from others in the field. Brainstorming sessions were conducted to explore potential implementation strategies and identify potential issues that may arise. These activities allowed for a more comprehensive understanding of the project and aided in creating a clear plan for development moving forward.

Overall, the mind mapping, Figma, and brainstorming techniques were effective in generating and refining ideas for the facial recognition system, ensuring that the project would meet the needs of its users and be successful in its implementation.

**Week 2**

Over the course of the second week, several commits were made to a facial recognition project. The first two commits were the addition of versions 3 and 4 of the face AI app, respectively. These updates likely included improvements and new features to enhance the functionality of the app.

The next commit added a document that provided a detailed explanation of the process involved in version 4 of the app. This document likely serves as a useful resource for developers who may need to modify or update the app in the future.

Another update included the addition of version 5 code explanation to the face API docs, which further enhances the documentation of the project. Version 5 of the face AI code was also added, indicating that significant changes or improvements were made to the code.

Face grouping, a technique that recognizes and groups together faces, was also implemented into the project. The addition of code for face grouping further enhances the functionality of the app, making it more accurate and efficient.

Several updates to the documentation were also made, including the addition of a brief report on facial recognition and grouping using Azure Face API. This report likely provides an overview of the project and its capabilities. Another report was added to discuss the impact of AI and facial recognition systems on the world today, highlighting the relevance and significance of this project.

Lastly, a brief analysis of Azure Cognitive Services Face API vs OpenCV for facial recognition was added. This analysis provides insight into the different technologies available for facial recognition and their respective advantages and disadvantages.

Overall, the commits made to this facial recognition project demonstrate a significant effort to improve and enhance its functionality, accuracy, and documentation. The se updates and improvements make the project more robust and useful for developers and end-users alike.

### Item 1 – Environment Set-Up:

* Adding endpoint and keys for Azure Cognitive Services Face API and testing them with FaceAI v1.

### Item 2 – Implementation:

* Adding versions 3, 4, and 5 of the FaceAI app with corresponding code and documentation.
* Adding face grouping functionality to the app.
* Adding a brief report on facial recognition and grouping using Azure Face API, as well as a report on the impact of AI and facial recognition systems on the world today.
* Conducting a brief analysis of Azure Cognitive Services Face API vs OpenCV for facial recognition.

### Item 3 – Documentation:

* Adding a document that provides a detailed explanation of the process involved in version 4 of the app.
* Adding version 5 code explanation to the face API docs.
* Editing comments in the code for better documentation.

### Item 4 – Deliverables:

* A more robust and functional version of the FaceAI app with improved documentation and additional features like face grouping.
* Reports on facial recognition and grouping, as well as the impact of AI and facial recognition systems on the world today.
* An analysis of Azure Cognitive Services Face API vs OpenCV for facial recognition.

## Sprint 2

During the second week of my project, I made significant progress towards testing and improving my facial recognition application. In particular, I focused on the following tasks:

Firstly, I conducted a series of tests to evaluate the performance of my code compared to Microsoft's version of a simplified face API. This allowed me to identify areas where my code needed improvement and to gain a deeper understanding of the functionality of the face API.

Next, I tested all of the versions of my code and updated the documentation for Version 4. I also tested my error with Json Dump, which helped me to present the errors in a more readable manner.

Another important aspect of my work during the week was testing errors with my subscription key. I also updated the endpoint, which involved investigating the cause of errors that kept appearing.

To further evaluate the performance of my code, I tested it with a new image of a woman. This helped me to identify any limitations of my code and to ensure that it was accurate and efficient.

In terms of documentation, I produced several brief reports that delved deeper into the technical aspects of the project. Firstly, I provided an authentication report that explained subscription keys and endpoints, their role in the project, and included an example with Azure Cognitive Services. I also wrote a report on an overview of Azure Cognitive Services, highlighting its capabilities and uses.

In addition, I produced two more reports that discussed the potential issues surrounding facial recognition technology. The first report focused on ways in which we can combat the problems involving facial systems today, while the second report highlighted the damaging effects facial systems can have on the world without proper safety measures.

Overall, my work during the second week of the sprint was highly focused on testing and evaluating my code, as well as documenting the technical aspects of the project. By conducting thorough tests and producing detailed reports, I was able to gain a deeper understanding of the functionality of the face API and to identify areas where my code needed improvement. This work was essential in ensuring the accuracy and efficiency of the facial recognition application, as well as identifying potential issues and solutions.

### Goal

Describe which items on the product backlog form the tasks to be completed for this sprint.

**Sprint 2.1 Goal: Advancing Facial Recognition: Testing, Documentation, and Analysis**

During the second week of Sprint 2, I conducted extensive testing and documentation to improve the functionality and reliability of my facial recognition project. My goal for this week was to conduct in-depth testing of the project, including my own code and Microsoft's simplified face API, as well as testing various versions and error-handling techniques.

Additionally, I aimed to update the documentation for Version 4 of the project and create a brief report on subscription keys and endpoints, as well as an overview of Azure Cognitive Services and its capabilities. I also created two reports on the potential harms and resolutions for facial recognition systems, highlighting the importance of ethical considerations in the development of these technologies.

Through my testing and documentation efforts, I was able to identify and resolve several errors, including an issue with the JSON dump that was successfully addressed. I also explored ways to combat the problems associated with facial recognition systems, both in terms of technical challenges and ethical considerations

Overall, my goal for Sprint 2, Week 1 was to improve the functionality and documentation of my facial recognition project while maintaining a strong focus on ethical considerations and responsible development practices.

### Item 1 - Improving Facial Recognition System Accuracy and Documentation

Describe the functionality required for Item 1.

Use screen shots to show the implementation of item 1.

Insert code snippets

Explain each code snippet.

Describe any coding difficulties and how those coding difficulties were resolved.

During the second week of the sprint, I made several commits to improve the functionality, accuracy, and documentation of a facial recognition project

### Item 2 - Research

The same as Item 1.

Keep going for as many Items as you have for Sprint 1.

As part of my research, I tested out my own code alongside Microsoft's version of a simplified face API and tested all my versions. I also tested my code with a new image of a woman and updated the documentation for version 4.

### Item 3 – Environment Set-Up

I changed the endpoint and looked into why it kept giving me errors. I also tested my errors with my subscription key and worked on fixing them.

### Item 4 – Implementation

I implemented several changes to improve the accuracy of the facial recognition system, including the addition of face grouping to the project. I added code for face grouping and updated the documentation with a brief report on facial recognition and grouping using Azure Face API. I also added a brief analysis of Azure Cognitive Services Face API vs OpenCV for facial recognition to provide insight into different technologies available for facial recognition and their respective advantages and disadvantages.

### Item 5 – Validation

To validate the accuracy of the facial recognition system, I tested my code with a new image of a woman and tested my errors with my subscription key.

### Item 6 – Documentation

As part of my documentation efforts, I added a document that provided a detailed explanation of the process involved in version 4 of the app. This document serves as a useful resource for developers who may need to modify or update the app in the future. Additionally, I added a brief report on subscription keys and endpoints, what they do, why we need them, and an example with Azure Cognitive Services. I also created a brief report on an overview of Azure Cognitive Services, its capabilities and uses, as well as two reports discussing ways to combat the problems involving facial recognition systems today and the damaging effects facial systems can have on the world without proper safety measures.

### Item 7 – Deliverables

The commits made to this facial recognition project demonstrate a significant effort to improve and enhance its functionality, accuracy, and documentation. These updates and improvements make the project more robust and useful for developers and end-users alike.

## Sprint 3

## Sprint 4

## Sprint 5

## Sprint 6

## Sprint 7

## Sprint 8

## Sprint 9

## Conclusion

Write a couple of paragraphs summing up the chapter. Explain what area your project is about. Describe what the chapter has discussed.

# Testing

## Introduction

This chapter describes the testing that has been undertaken for the application. This chapter is presented in two sections:

1. Functional Testing
2. User Testing

Functional testing is a type of software testing whereby the system is tested against the functional requirements. The app is tested by looking to see if the actual output for a given input corresponds with the expected output. The tests should be based on the requirements for the app. The results of functional testing can indicate if a piece of software is functional and working, but not if the software is easy to use.

User testing looks to see if a piece of software is easy and intuitive for the user.

## Functional Testing

This section describes the functional tests which were carried out on the app. These functional tests can be categorised as: (whatever is relevant to your app)

* Navigation
* Calculation
* CRUD

Functional testing generally uses a Black Box Testing technique which means that the internal logic of the system being tested is not of interest to the tester. The tester is only interested in whether the actual output agrees with the expected output.

### Navigation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test No | Description of test case | Input | Expected Output | Actual Output | Comment |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

### Calculation

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test No | Description of test case | Input | Expected Output | Actual Output | Comment |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

### CRUD

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Test No | Description of test case | Input | Expected Output | Actual Output | Comment |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

### Discussion of Functional Testing Results

## User Testing

Use the report which you have written for Interaction Design.

## Conclusion

Write a couple of paragraphs summing up the chapter. Explain what area your project is about. Describe what the chapter has discussed.

# Project Management

## Introduction

This chapter describes how the project was managed and how well the group worked together as a team. It shows the phases of the project, going from the project idea through the requirements gathering, the specification for the project, the design, implementation and testing phases for the project. It also discusses Trello, GitHub and project member’s journals as tools which assist in project management.

## Project Phases

In this section, describe each of the following project phases. Explain any issues which arose for each of the phases.

### Proposal

### Requirements

### Design

### Implementation

### Testing

## Team Work

### Roles

### Communication

### Difficulties

### Resolving Difficulties

## SCRUM Methodology

Look at Project Guidelines

Sprints

How well did the 7 sprints work?

Requirements

Project Backlog

## Project Management Tools

### Trello

Description

Include diagrams

How it worked in practice

### GitHub

Description

How it is used

How it worked in practice

### Journal

Description

How it was used

How useful it was in practice

## Reflection

### Your views on the project

Describe how you feel the project went from your perspective and from the team’s perspective.

### Completing a large software development project

Describe what you have learnt from the project, from the point of view of completing a large software development project.

### Working in a team

Describe what you have learnt from the project, from the point of view of working in a team.

### Working with a supervisor

Describe how you feel the project went from the point of view of working with a supervisor.

### Technical skills

Describe what you have learnt from the project, from a technical skills viewpoint.

### Further competencies and skills

Describe any extra competencies and skills that would help you with your development in the work place.

## Conclusion

Write a couple of paragraphs summing up the chapter. Explain what area your project is about. Describe what the chapter has discussed.

# Business Opportunities

This is from your module with Tim McNicholls

# Conclusion

One paragraph on the background, the overall aim and the goals of the project.

One paragraph on the technologies used in the project.

Research

Design

Implementation

Testing

Overall result

Project management

What was learnt

How the project could be further developed

# References

The Department of Technology and Psychology in IADT uses APA referencing style.

Use alphabetical order for your references.

This site gives details about how to cite websites using APA:

https://www.wikihow.com/Cite-a-Website-in-APA

The following is a useful site for creating citations for APA for websites.

<http://www.citationmachine.net/apa/cite-a-website>

You can also use the Referencing tab within Microsoft Word to enter reference information manually. Word then creates an APA style reference.

Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. Proceedings of Machine Learning Research, 81, 1-15.

Crawford, K., & Schultz, J. (2019). The use and misuse of facial recognition technology. Communications of the ACM, 62(6), 34-40.

Gulshan, V., Peng, L., Coram, M., Stumpe, M. C., Wu, D., Narayanaswamy, A., … & Kim, R. (2016). Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. JAMA, 316(22), 2402-2410.

Jain, A. K., Ross, A., Nandakumar, K., & Ngo, C. W. (2016). Introduction to biometrics. Springer.

Microsoft Azure Face API documentation: <https://azure.microsoft.com/en-us/services/cognitive-services/face/>

Microsoft Azure Face API blog: <https://azure.microsoft.com/en-us/blog/category/cognitive-services/face/>

Microsoft Azure Face API pricing: <https://azure.microsoft.com/en-us/pricing/details/cognitive-services/face-api/>

Microsoft Azure Face API sample code: <https://github.com/Azure/azure-sdk-for-python/tree/main/azure-cognitiveservices-vision-face>

Microsoft Azure. (n.d.). Azure Cognitive Services overview. Retrieved from <https://azure.com/cognitive-services>

Microsoft Azure. (n.d.). What are Azure Cognitive Services? Retrieved from <https://docs.microsoft.com/en-us/azure/cognitive-services/cognitive-services-apis-overview>

Chollet, F. (2018). Deep Learning with Python. Shelter Island, NY: Manning Publications.

Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. Cambridge, MA: MIT Press.

Russel, S. J., & Norvig, P. (2010). Artificial Intelligence:

**Microsoft Azure Face API documentation:**

<https://azure.microsoft.com/en-us/services/cognitive-services/face/>

**OpenCV documentation:**

<https://docs.opencv.org/>

**"Facial Recognition with OpenCV" by Adrian Rosebrock** https://www.pyimagesearch.com/2018/09/24/opencv-face-recognition/

Barr, C. (2017). How to build your own smart mirror. Retrieved from https://www.digitaltrends.com/home/how-to-build-your-own-smart-mirror/

Bowers, J. (2017). The DIY smart mirror: a simple introduction. Retrieved from https://www.makeuseof.com/tag/diy-smart-mirror-simple-introduction/

Heath, T. (2018). Smart mirror guide: the ultimate guide to building your own smart mirror. Retrieved from https://www.smartmirrorguide.com/

Lin, K. (2017). Building a magic mirror with Raspberry Pi. Retrieved from https://www.instructables.com/id/Building-a-Magic-Mirror-With-Raspberry-Pi/

Schneider, K. (2017). The future of mirrors: an overview of smart mirrors and their benefits. Retrieved from https://www.electronicproducts.com/Sensors/Sensors\_Display\_Technologies/The\_future\_of\_mirrors\_an\_overview\_of\_smart\_mirrors\_and\_their\_benefits.aspx

Craciun, G. (2018, August 10). How to Build a Smart Mirror with Raspberry Pi. Retrieved January 08, 2023, from https://www.makeuseof.com/tag/build-smart-mirror-raspberry-pi/

Kitajima, Y. (2018, October 17). Smart Mirror with Raspberry Pi and Magic Mirror Software. Retrieved from https://www.instructables.com/Smart-Mirror-With-Raspberry-Pi-and-Magic-Mirror-Software/

"Emotion Recognition using Facial Landmarks, Python, DLib and OpenCV" by Rishi Bhatnagar <https://www.learnopencv.com/facial-landmark-detection/>

"Emotion recognition from speech signals" by E. Mower <https://www.sciencedirect.com/science/article/pii/S2405452620300333>

"Emotion recognition in physiological signals" by D. D. Reinoso et al. <https://www.sciencedirect.com/>

Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. Conference on Fairness, Accountability, and Transparency, 72–81. <https://doi.org/10.1145/3287560.3287591>

Garvie, C., & Luther, K. (2019). The Perpetual Line-Up: Unregulated Police Face Recognition in America. Center on Privacy & Technology at Georgetown Law. <https://www.perpetuallineup.org/>

Diaz, C. (2019). The ethics of facial recognition technology. Forbes. <https://www.forbes.com/sites/cognitiveworld/2019/07/15/the-ethics-of-facial-recognition-technology/?sh=52a0164e19fe>

"Facial recognition technology" by National Institute of Standards and Technology (NIST) <https://www.nist.gov/programs-projects/face-recognition-technology>

"Facial recognition technology and its potential impact on privacy" by American Civil Liberties Union (ACLU) <https://www.aclu.org/issues/privacy-technology/surveillance-technologies/facial-recognition-technology>

"The State of Facial Recognition: 2019" by the Center on Privacy & Technology at Georgetown Law <https://www.law.georgetown.edu/center-privacy-technology/wp-content/uploads/2019/10/The-State-of-Facial-Recognition-2019.pdf>

"Facial Recognition: A Closer Look at the Technology and Its Impact on Society" by the MIT Technology Review <https://www.technologyreview.com/s/613429/facial-recognition-a-closer-look-at-the-technology-and-its-impact>

Azure Face API documentation: <https://docs.microsoft.com/en-us/azure/cognitive-services/face/overview>

Microsoft Azure Blog: <https://azure.microsoft.com/en-us/blog/introducing-facial-grouping-in-the-face-api/>

TechCrunch article: <https://techcrunch.com/2018/05/07/microsofts-azure-cognitive-services-adds-facial-recognition-api/>

Alcantara, J. (2017). The Internet of Things: A review of the state-of-the-art and future perspectives. Future Internet, 9(4), 77. <https://doi.org/10.3390/fi904077>

Kshetri, N. (2017). Internet of Things (IoT) security: An overview. International Journal of Information Management, 36(3), 295-298. <https://doi.org/10.1016/j.ijinfomgt.2017.06.001>

Smart Homes Market. (2020). In Statista. <https://www.statista.com/topics/1936/smart-homes-market/>

Wang, Q., Chen, W., & Wang, X. (2016). Internet of things: A survey. Information Systems Frontiers, 18(2), 223-249. <https://doi.org/10.1007/s10796-015-9604-y>

Dyche, J. (2010). The definitive guide to the Internet of Things. Apress.

Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. Future Generation Computer Systems, 29(7), 1645-1660.

Kortuem, G., Klemke, R., Wulf, V., & Baker, T. (2010). Smart objects as building blocks for the Internet of Things. Internet of Things, 1-15.

*Facial recognition: Microsoft Azure*. Facial Recognition | Microsoft Azure. (n.d.). Retrieved January 15, 2023, from <https://azure.microsoft.com/en-us/services/cognitive-services/face/>

Pablo Castro Distinguished Engineer, Priyanka Rawat Senior Product Marketing Manager, Andy Beatman Sr. Product Marketing Manager, Kate Browne Program Manager, Sarah Bird Principal Group Product Manager, Ali Dalloul Vice President Strategy and Commercialization, & Tom Keane Corporate Vice President. (n.d.). *Cognitive services: Azure blog and updates: Microsoft Azure*. Azure Blog and Updates | Microsoft Azure. Retrieved January 15, 2023, from <https://azure.microsoft.com/en-us/blog/topics/cognitive-services/>

*Facial recognition: Microsoft Azure*. Facial Recognition | Microsoft Azure. (n.d.). Retrieved January 15, 2023, from <https://azure.microsoft.com/en-us/products/cognitive-services/face/>

*Pricing - face API: Microsoft Azure*. Pricing - Face API | Microsoft Azure. (n.d.). Retrieved January 15, 2023, from <https://azure.microsoft.com/en-us/pricing/details/cognitive-services/face-api/>

Azure. (n.d.). *Azure/azure-SDK-for-python: This repository is for active development of the Azure SDK for python. for consumers of the SDK we recommend visiting our public developer docs at https://docs.microsoft.com/python/azure/ or our versioned developer docs at https://azure.github.io/azure-sdk-for-python.* GitHub. Retrieved January 15, 2023, from <https://github.com/Azure/azure-sdk-for-python>

Chappell, D. (2019) Understanding Azure API Management. O’Reilly Media, Inc.

Microsoft Azure. (n.d.). Azure API Management overview. Retrieved from <https://docs.microsoft.com/en-us/azure/api-management/api-management-overview>

Microsoft Azure. (n.d.). Azure Cognitive Services overview. Retrieved from <https://azure.com/cognitive-services>

Tiwari, S. (2019). Hands-On API Management. Packt Publishing Ltd.

Python Software Foundation. (n.d.). The History of Python. Retrieved from <https://docs.python.org/3/library/history.html>

Wes McKinney. (2017). Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython (2nd ed.). O'Reilly Media, Inc.

GeeksforGeeks. (2021, June 4). Introduction to Python Programming. Retrieved from <https://www.geeksforgeeks.org/introduction-to-python-programming/>

Eben Upton, G. D. (2012). The Raspberry Pi: A computer for everyone. Raspberry Pi Foundation.

Gibson, J. (2015). Raspberry Pi User Guide (3rd ed.). John Wiley & Sons.

Lacey, J. (2017). Raspberry Pi: The complete manual (7th ed.). Imagine Publishing Ltd.

Nash, S. (2015). Raspberry Pi Projects for the Evil Genius. McGraw-Hill Education.

Wright, C. (2015). Raspberry Pi For Dummies (2nd ed.). John Wiley & Sons.

Raspberry Pi Foundation. (2021). Raspberry Pi. Retrieved January 8, 2023, from <https://www.raspberrypi.org/>

Arduino. (2021). Arduino. Retrieved January 8, 2023, from <https://www.arduino.cc/>

Sainsbury, R. (2019). Raspberry Pi vs Arduino: Which is the Mini Computer for You? MakeUseOf. Retrieved January 8, 2023, from <https://www.makeuseof.com/tag/arduino-vs-raspberry-pi-which-is-the-mini-computer-for-you/>

Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. Proceedings of Machine Learning Research, 81, 1-15.

Garvie, C., & Luther, K. (2019). The Perpetual Line-Up: Unregulated Police Face Recognition in America. Georgetown Law Center on Privacy & Technology.

Diaz, D. (2019). The Ethics of Artificial Intelligence. Cambridge University Press.

Garside, J. (2019, November 12). Smart mirrors are the future of home technology. Wired. <https://www.wired.com/story/smart-mirrors-are-the-future-of-home-technology/>

Rich, K. (2019, December 23). What is a smart mirror, and why would I want one? The Ambient. <https://www.theambient.com/guides/what-is-a-smart-mirror>

Smart Mirrors. (n.d.). ABI Research. <https://www.abiresearch.com/market-research/product/>

Royce, W. W. (1970). Managing the development of large software systems: concepts and techniques. Proceedings of IEEE WESCON, Los Angeles, CA, 1-9.

Myers, G. J. (1979). The Art of Software Testing. John Wiley & Sons.

Kitajima, Y. (2018, October 17). Smart Mirror with Raspberry Pi and Magic Mirror Software. Retrieved from <https://www.instructables.com/Smart-Mirror-With-Raspberry-Pi-and-Magic-Mirror-Software/>

Nielsen, J. (1993). Usability Engineering. Academic Press Professional, Inc.

Rubin, J. (1994). Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests. John Wiley & Sons.

Kim, D. (2015, November 30). The Importance of Wireframing in Web Design. Retrieved from <https://uxdesign.cc/the-importance-of-wireframing-in-web-design-a83fad5cf8b1>

Nielsen, J. (1994, October). Usability Engineering. San Francisco, CA: Morgan Kaufmann Publishers Inc.

The UX Review. (2017, June 21). Low-Fi vs High-Fi Wireframes: When to Use Each. Retrieved from <https://www.justinmind.com/wireframe/low-fidelity-vs-high-fidelity-wireframing-is-paper-dead>

Balsamiq. (n.d.). Balsamiq Wireframes. Retrieved January 08, 2023, from <https://balsamiq.com/wireframes/>

Nielsen, J. (1995). Multimedia and Hypertext: The Internet and Beyond. Academic Press.

Nielsen, J. (2000). Designing Web Usability: The Practice of Simplicity. New Riders Press.

Sneppen, T. (2018). The wireframing process in user-centered design. User Experience Magazine, 17(3), 22-30.

Tog. (n.d.). Tog on interface design. Retrieved January 08, 2023, from <http://www.tog.com/>

Wodtke, C. (2011). Information Architecture: Blueprints for the Web. New Riders Press.

Balsamiq. (n.d.). Balsamiq Wireframes. Retrieved January 08, 2023, from <https://balsamiq.com/wireframes/>

Kim, D. (2015, November 30). The Importance of Wireframing in Web Design. Retrieved from <https://uxdesign.cc/the-importance-of-wireframing-in-web-design-a83fad5cf8b1>

Nielsen, J. (1994). Usability Engineering. San Francisco, CA: Morgan Kaufmann Publishers Inc.

Nielsen, J. (1995). Multimedia and Hypertext: The Internet and Beyond. Academic Press.

Nielsen, J. (2000). Designing Web Usability: The Practice of Simplicity. New Riders Press.

Sneppen, T. (2018). The wireframing process in user-centered design. User Experience Magazine, 17(3), 22-30.

Tog. (n.d.). Tog on interface design. Retrieved January 08, 2023, from <http://www.tog.com/>

Wodtke, C. (2011). Information Architecture: Blueprints for the Web. New Riders Press.

Viola, P., & Jones, M. (2001). Rapid object detection using a boosted cascade of simple features. Proceedings of the 2001 IEEE Computer Society Conference on Computer Vision and Pattern Recognition. CVPR 2001, 1, I-I. https://doi.org/10.1109/cvpr.2001.990517

Bradski, G. (2000). The OpenCV Library. Dr. Dobb's Journal of Software Tools, 25(11), 120-126.

Kaehler, A., & Bradski, G. (2017). Learning OpenCV 3: computer vision in C++ with the OpenCV library. O'Reilly Media, Inc

Artificial Intelligence:

• Bostrom, N., & Yudkowsky, E. (2014). The Ethics of Artificial Intelligence. In The Cambridge Handbook of Artificial Intelligence (pp. 316-334). Cambridge University Press. doi: 10.1017/9781316214032.016

• Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

• Jordan, M. I., & Mitchell, T. M. (2015). Machine learning: Trends, perspectives, and prospects. Science, 349(6245), 255-260. doi: 10.1126/science.aaa8415

Machine Learning:

• Bishop, C. M. (2006). Pattern Recognition and Machine Learning. Springer.

• Domingos, P. (2015). The Master Algorithm: How the Quest for the Ultimate Learning Machine Will Remake Our World. Basic Books.

• Hastie, T., Tibshirani, R., & Friedman, J. (2009). The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Springer.

Deep Learning:

• Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep Learning. MIT Press.

• LeCun, Y., Bengio, Y., & Hinton, G. (2015). Deep learning. Nature, 521(7553), 436-444. doi: 10.1038/nature14539

• Schmidhuber, J. (2015). Deep learning in neural networks: An overview. Neural Networks, 61, 85-117. doi: 10.1016/j.neunet.2014.09.003

Buolamwini, J., & Gebru, T. (2018). Gender shades: Intersectional accuracy disparities in commercial gender classification. Proceedings of Machine Learning Research, 81, 1-15.

Crawford, K., & Schultz, J. (2019). The use and misuse of facial recognition technology. Communications of the ACM, 62(6), 34-40.

Gulshan, V., Peng, L., Coram, M., Stumpe, M. C., Wu, D., Narayanaswamy, A., … & Kim, R. (2016). Development and validation of a deep learning algorithm for detection of diabetic retinopathy in retinal fundus photographs. JAMA, 316(22), 2402-2410.

Jain, A. K., Ross, A., Nandakumar, K., & Ngo, C. W. (2016). Introduction to biometrics. Springer.

Klare, H. R. (2012).

Eben Upton, G. D. (2012). The Raspberry Pi: A computer for everyone. Raspberry Pi Foundation.

Gibson, J. (2015). Raspberry Pi User Guide (3rd ed.). John Wiley & Sons.

Lacey, J. (2017). Raspberry Pi: The complete manual (7th ed.). Imagine Publishing Ltd.

Nash, S. (2015). Raspberry Pi Projects for the Evil Genius. McGraw-Hill Education.

Wright, C. (2015). Raspberry Pi For Dummies (2nd ed.). John Wiley & Sons.

Raspberry Pi Foundation. (2021). Raspberry Pi. Retrieved January 8, 2023, from https://www.raspberrypi.org/

Arduino. (2021). Arduino. Retrieved January 8, 2023, from https://www.arduino.cc/

Sainsbury, R. (2019). Raspberry Pi vs Arduino: Which is the Mini Computer for You? MakeUseOf. Retrieved January 8, 2023, from https://www.makeuseof.com/tag/arduino-vs-raspberry-pi-which-is-the-mini-computer-for-you/