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# Face Recognition Using CV And CNN Algo.

**A PROJECT REPORT**

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***in partial fulfillment for the award of the degree of***

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# BONAFIDE CERTIFICATE

Certified that this project report **"USING CV FOR FACE RECOGNITION"** is the Bonafide work of "**KARAN DHINGRA, ADITYA RAJ, DEVANSH PUNJ, KHUSHI GUPTA, NIKITA RANA"** who carried out the project work under my/our supervision.

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# TABLE OF CONTENTS

# List Of Figures

# LIST OF TABLES

# LIST OF ABBREVIATIONS

| Sr. No. | Abbreviations | Full Forms |
|---|---|---|
| **1** | **CNN** | Convolution Neural Network |
| **2** | **LBP** | Local Binary Pattern |
| **3** | **LBPH** | Local Binary Patterns Histogram |

| | | |
|---|---|---|
| **4** | **LLE** | Local Linear Embedding |
| **5** | **MNPP** | Multi-Linear Neighborhood Preserving Projection |
| **6** | **DFD** | Data Flow Diagram |
| **7** | **FDDB** | Face Detection Dataset and Benchmark |
| **8** | **GPU** | Graphical Processing Unit |
| **9** | **TPU** | Tensor Processing Unit |
| **10** | **HOG** | Histogram of Oriented Gradients |
| **11** | **AI** | Artificial Intelligence |

# ABSTRACT

In an era dominated by visual information, the need for robust and efficient face detection systems has become increasingly paramount. Faces are not only the gateway to human identity but also pivotal in various applications, including security, surveillance, and human-computer interaction. This paper begins with an insightful analysis of the historical perspective, tracing the evolution from classical methods to the contemporary deep learning paradigms. We delve into the technical intricacies of convolutional neural networks (CNNs) and their pivotal role in achieving remarkable accuracy and speed. Additionally, we explore the impact of datasets, data augmentation, and transfer learning in enhancing detection performance. Furthermore, this paper investigates the ethical considerations surrounding face detection, focusing on privacy concerns,

bias mitigation, and responsible AI deployment. The fusion of cutting-edge technologies with ethical awareness is imperative in crafting equitable and secure systems. In this project, we have used CNN model because it has excellent recognition performance. CNN is a class of deep neural networks, most applied to analyze visual imagery. It uses a special technique called Convolution. If we take a kernel/ (3 X 3 Matrix) and apply it to the input image get convolved feature. At initial, neural network layers have some unwanted properties to filter and extract necessary data. We use filters that remove unnecessary features. The convolved feature passes to the next layer, every layer has its own properties, and so on. Also note that further research is needed to make the deep CNN model based on facial recognition more robust against image blur, noise, and occlusion. We also have used OpenCV because it talks about the emotion of the person only by looking at their expression. It can detect a large variety of emotions such as happiness, sadness, surprise, etc.

## ਸਾਰ

## (ਪੰਜਾਬੀ)

ਵਿਜ਼ੂਅਲ ਜਾਣਕਾਰੀ ਦੇ ਦਬਦਬੇ ਵਾਲੇ ਯੁੱਗ ਵਿੱਚ, ਮਜਬੂਤ ਅਤੇ ਕੁਸ਼ਲ ਚਿਹਰਾ ਖੋਜ ਪ੍ਰਣਾਲੀਆਂ ਦੀ ਲੋੜ ਵਧਦੀ ਜਾ ਰਹੀ ਹੈ। ਚਿਹਰੇ ਨਾ ਸਿਰਫ਼ ਮਨੁੱਖੀ ਪਛਾਣ ਦਾ ਗੇਟਵੇ ਹਨ, ਸਗੋਂ ਸੁਰੱਖਿਆ, ਨਿਗਰਾਨੀ, ਅਤੇ ਮਨੁੱਖੀ-ਕੰਪਿਊਟਰ ਆਪਸੀ ਤਾਲਮੇਲ ਸਮੇਤ ਵੱਖ-ਵੱਖ ਐਪਲੀਕੇਸ਼ਨਾਂ ਵਿੱਚ ਵੀ ਮਹੱਤਵਪੂਰਨ ਹਨ। ਇਹ ਪੇਪਰ ਇਤਿਹਾਸਕ ਦ੍ਰਿਸ਼ਟੀਕੋਣ ਦੇ ਇੱਕ ਸੂਝਵਾਨ ਵਿਸ਼ਲੇਸ਼ਣ ਨਾਲ ਸ਼ੁਰੂ ਹੁੰਦਾ ਹੈ, ਕਲਾਸੀਕਲ ਤਰੀਕਿਆਂ ਤੋਂ ਸਮਕਾਲੀ ਡੂੰਘੇ ਸਿੱਖਣ ਦੇ ਪੈਰਾਡਾਈਮ ਤੱਕ ਵਿਕਾਸ ਨੂੰ ਟਰੇਸ ਕਰਦਾ ਹੈ। ਅਸੀਂ ਕਨਵੋਲਿਊਸ਼ਨਲ ਨਿਊਰਲ ਨੈੱਟਵਰਕਾਂ (CNNs) ਦੀਆਂ ਤਕਨੀਕੀ ਪੇਚੀਦਗੀਆਂ ਅਤੇ ਕਮਾਲ ਦੀ ਸ਼ੁੱਧਤਾ ਅਤੇ ਗਤੀ ਨੂੰ ਪ੍ਰਾਪਤ ਕਰਨ ਵਿੱਚ ਉਹਨਾਂ ਦੀ ਮੁੱਖ ਭੂਮਿਕਾ ਦੀ ਖੋਜ ਕਰਦੇ ਹਾਂ। ਇਸ ਤੋਂ ਇਲਾਵਾ, ਅਸੀਂ ਖੋਜ

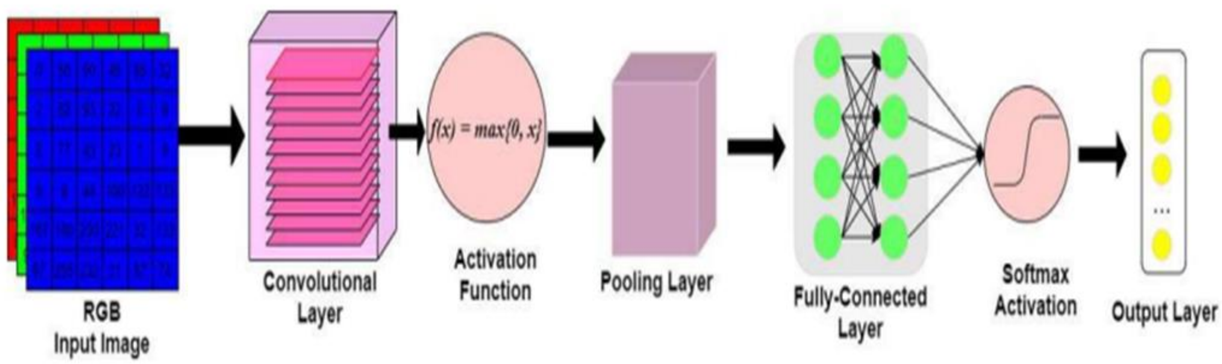
ਕਾਰਜਕੁਸ਼ਲਤਾ ਨੂੰ ਵਧਾਉਣ ਲਈ ਡੇਟਾਸੇਟਸ, ਡੇਟਾ ਵਧਾਉਣ, ਅਤੇ ਟ੍ਰਾਂਸਫਰ ਸਿਖਲਾਈ ਦੇ ਪ੍ਰਭਾਵ ਦੀ ਪੜਚੋਲ ਕਰਦੇ ਹਾਂ। ਇਸ ਤੋਂ ਇਲਾਵਾ, ਇਹ ਪੇਪਰ ਚਿਹਰੇ ਦੀ ਪਛਾਣ ਦੇ ਆਲੇ ਦੁਆਲੇ ਦੇ ਨੈਤਿਕ ਵਿਚਾਰਾਂ ਦੀ ਜਾਂਚ ਕਰਦਾ ਹੈ, ਗੋਪਨੀਯਤਾ ਦੀਆਂ ਚਿੰਤਾਵਾਂ, ਪੱਖਪਾਤ ਨੂੰ ਘਟਾਉਣ, ਅਤੇ ਜ਼ਿੰਮੇਵਾਰ AI ਤੈਨਾਤੀ 'ਤੇ ਕੇਂਦ੍ਰਤ ਕਰਦਾ ਹੈ। ਨੈਤਿਕ ਜਾਗਰੂਕਤਾ ਦੇ ਨਾਲ ਅਤਿ-ਆਧੁਨਿਕ ਤਕਨਾਲੋਜੀਆਂ ਦਾ ਸੰਯੋਜਨ ਬਰਾਬਰ ਅਤੇ ਸੁਰੱਖਿਅਤ ਪ੍ਰਣਾਲੀਆਂ ਨੂੰ ਬਣਾਉਣ ਲਈ ਜ਼ਰੂਰੀ ਹੈ। ਇਸ ਪ੍ਰੋਜੈਕਟ ਵਿੱਚ, ਅਸੀਂ CNN ਮਾਡਲ ਦੀ ਵਰਤੋਂ ਕੀਤੀ ਹੈ ਕਿਉਂਕਿ ਇਸ ਵਿੱਚ ਸ਼ਾਨਦਾਰ ਮਾਨਤਾ ਪ੍ਰਦਰਸ਼ਨ ਹੈ CNN ਡੂੰਘੇ ਤੰਤੂ ਨੈੱਟਵਰਕਾਂ ਦੀ ਇੱਕ ਸ਼੍ਰੇਣੀ ਹੈ, ਜੋ ਵਿਜ਼ੂਅਲ ਇਮੇਜਰੀ ਦੇ ਵਿਸ਼ਲੇਸ਼ਣ ਲਈ ਸਭ ਤੋਂ ਵੱਧ ਲਾਗੂ ਹੁੰਦੀ ਹੈ। ਇਹ ਕਨਵੋਲਿਊਸ਼ਨ ਨਾਮਕ ਇੱਕ ਵਿਸ਼ੇਸ਼ ਤਕਨੀਕ ਦੀ ਵਰਤੋਂ ਕਰਦਾ ਹੈ। ਜੇਕਰ ਅਸੀਂ ਇੱਕ □□□□/ (3 X 3 ਮੈਟ੍ਰਿਕਸ) ਲੈਂਦੇ ਹਾਂ ਅਤੇ ਇਸਨੂੰ ਇਨਪੁਟ ਇਮੇਜ 'ਤੇ ਲਾਗੂ ਕਰਦੇ ਹਾਂ ਤਾਂ ਸੰਮਿਲਿਤ ਵਿਸ਼ੇਸ਼ਤਾ ਪ੍ਰਾਪਤ ਕਰੋ। ਸ਼ੁਰੂਆਤੀ ਤੌਰ 'ਤੇ, ਨਿਊਰਲ ਨੈਟਵਰਕ ਲੇਅਰਾਂ ਵਿੱਚ ਜ਼ਰੂਰੀ ਡੇਟਾ ਨੂੰ ਫਿਲਟਰ ਕਰਨ ਅਤੇ ਐਕਸਟਰੈਕਟ ਕਰਨ ਲਈ ਕੁਝ ਅਣਚਾਹੇ ਗੁਣ ਹੁੰਦੇ ਹਨ। ਅਸੀਂ ਫਿਲਟਰਾਂ ਦੀ ਵਰਤੋਂ ਕਰਦੇ ਹਾਂ ਜੋ ਬੇਲੋੜੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਨੂੰ ਹਟਾਉਂਦੇ ਹਨ। ਸੰਮਿਲਿਤ ਵਿਸ਼ੇਸ਼ਤਾ ਅਗਲੀ ਲੇਅਰ ਵਿੱਚ ਜਾਂਦੀ ਹੈ, ਹਰ ਲੇਅਰ ਦੀਆਂ ਆਪਣੀਆਂ ਵਿਸ਼ੇਸ਼ਤਾਵਾਂ ਹੁੰਦੀਆਂ ਹਨ, ਅਤੇ ਇਸ ਤਰ੍ਹਾਂ ਹੀ। ਇਹ ਵੀ ਨੋਟ ਕਰੋ ਕਿ ਚਿਹਰੇ ਦੀ ਪਛਾਣ ਦੇ ਆਧਾਰ 'ਤੇ ਡੂੰਘੇ CNN ਮਾਡਲ ਨੂੰ ਚਿੱਤਰ ਬਲਰ, ਸ਼ੋਰ, ਅਤੇ ਰੁਕਾਵਟ ਦੇ ਵਿਰੁੱਧ ਹੋਰ ਮਜ਼ਬੂਤ ਬਣਾਉਣ ਲਈ ਹੋਰ ਖੋਜ ਦੀ ਲੋੜ ਹੈ। ਅਸੀਂ ਓਪਨਸੀਵੀ ਦੀ ਵਰਤੋਂ ਵੀ ਕੀਤੀ ਹੈ ਕਿਉਂਕਿ ਇਹ ਵਿਅਕਤੀ ਦੇ ਪ੍ਰਗਟਾਵੇ ਨੂੰ ਦੇਖ ਕੇ ਹੀ ਉਸ ਦੀਆਂ ਭਾਵਨਾਵਾਂ ਬਾਰੇ ਗੱਲ ਕਰਦਾ ਹੈ। ਇਹ ਬਹੁਤ ਸਾਰੀਆਂ ਭਾਵਨਾਵਾਂ ਜਿਵੇਂ ਕਿ ਖੁਸ਼ੀ, ਉਦਾਸੀ, ਹੈਰਾਨੀ, ਆਦਿ ਦਾ ਪਤਾ ਲਗਾ ਸਕਦਾ ਹੈ।

# सारांश
# (हिंदी)

दृश्य सूचना के प्रभुत्व वाले युग में, मजबूत और कुशल चेहरा पहचान प्रणालियों की आवश्यकता तेजी से सर्वोपरि हो गई है। चेहरे न केवल मानव पहचान का प्रवेश द्वार हैं, बल्कि सुरक्षा, निगरानी और मानव-कंप्यूटर संपर्क सहित विभिन्न अनुप्रयोगों में भी महत्वपूर्ण हैं। यह पेपर ऐतिहासिक परिप्रेक्ष्य के एक व्यावहारिक विश्लेषण के साथ शुरू होता है, जिसमें शास्त्रीय तरीकों से लेकर समकालीन गहन शिक्षण प्रतिमानों तक के विकास का पता लगाया जाता है। हम कन्वेन्शनल न्यूरल नेटवर्क (सीएनएन) की तकनीकी पेचीदगियों और उल्लेखनीय सटीकता और गति प्राप्त करने में उनकी महत्वपूर्ण भूमिका के बारे में गहराई से जानते हैं। इसके अतिरिक्त, हम पता लगाने के प्रदर्शन को बढ़ाने में डेटासेट, डेटा संवर्द्धन और ट्रांसफर लर्निंग के प्रभाव का पता लगाते हैं। इसके अलावा, यह पेपर गोपनीयता चिंताओं, पूर्वाग्रह शमन और जिम्मेदार एआई तैनाती पर ध्यान केंद्रित करते हुए चेहरे की पहचान के आसपास के नैतिक विचारों की जांच करता है। न्यायसंगत और सुरक्षित प्रणाली तैयार करने के लिए नैतिक जागरूकता के साथ अत्याधुनिक प्रौद्योगिकियों का मिश्रण आवश्यक है। इस परियोजना में, हमने सीएनएन मॉडल का उपयोग किया है क्योंकि इसमें उत्कृष्ट पहचान प्रदर्शन है। सीएनएन गहरे तंत्रिका नेटवर्क का एक वर्ग है, जिसका उपयोग दृश्य इमेजरी का विश्लेषण करने के लिए किया जाता है। यह कन्वोल्यूशन नामक एक विशेष तकनीक का उपयोग करता है। यदि हम एक कर्नेल/(3 एक्स 3 मैट्रिक्स) लेते हैं और इसे इनपुट इमेज पर लागू करते हैं तो

कनवॉल्व्ड फीचर मिलता है। प्रारंभ में, तंत्रिका नेटवर्क परतों में आवश्यक डेटा को फ़िल्टर करने और निकालने के लिए कुछ अवांछित गुण होते हैं। हम ऐसे फ़िल्टर का उपयोग करते हैं जो अनावश्यक सुविधाओं को हटा देते हैं। जटिल विशेषता अगली परत पर जाती है, प्रत्येक परत की अपनी विशेषताएँ होती हैं, इत्यादि। यह भी ध्यान दें कि चेहरे की पहचान पर आधारित डीप सीएनएन मॉडल को छवि धुंधलापन, शोर और रोड़ा के खिलाफ अधिक मजबूत बनाने के लिए और अधिक शोध की आवश्यकता है। हमने OpenCV का भी उपयोग किया है क्योंकि यह व्यक्ति की अभिव्यक्ति को देखकर ही उसकी भावना के बारे में बात करता है। यह खुशी, उदासी, आश्चर्य आदि जैसी विभिन्न प्रकार की भावनाओं का पता लगा सकता है।

# GRAPHICAL ABSTRACT



# CHAPTER 1
# INTRODUCTION

## 1.1 Client Identification

Face recognition is a technology that can be used to identify or verify the identity of a person from a digital image or video frame. It is a powerful tool that can be used for a variety of purposes, including security, access control, and customer service. Face recognition is a powerful tool that can be used for client identification. However, it is important to use face recognition technology responsibly and in a way that respects individuals' privacy rights.

### 1.1.1 Client Identification Practices

Organizations that use face recognition technology should follow best practices to ensure that the technology is used ethically and responsibly. There are several best practices that organizations can follow when using face recognition[1] for client identification. These best practices include:

- **Transparency**: Organizations should be transparent about their use of face recognition technology. They should inform individuals about how their face data is being collected, used, and stored.
- **Consent**: Organizations should obtain informed consent from individuals before collecting their face data.
- **Data minimization:** Organizations should only collect the face data that is necessary for the intended purpose.
- **Data security:** Organizations should implement appropriate security measures to protect face data from unauthorized access, use, disclosure, alteration, or destruction.
- **Accuracy:** Organizations should use face recognition technology that is accurate and reliable.
- **Non-discrimination:** Organizations should use face recognition technology in a way

that does not discriminate against individuals based on race, ethnicity, or other protected characteristics.

### 1.1.2 Client Identification Methods:

There are two main methods of client identification for face recognition:

- **Verification:** This method compares a captured image of a person's face to a stored image of that person's face. If the two images match, then the person is identified.
- **Search:** This method compares a captured image of a person's face to a database of images of known individuals. If the captured image matches[2] an image in the database, then the person is identified.

### 1.1.3 Client Identification Challenges:

There are several challenges associated with using face recognition for client identification. These challenges include:

- **Privacy concerns:** Face recognition technology raises privacy concerns because it can be used to track and monitor individuals without their knowledge or consent.
- **Bias:** Face recognition technology can be biased, meaning that it may be less accurate when identifying individuals from certain racial or ethnic groups.
- **Liveness detection:** Face recognition technology can be fooled by images or videos of people. Liveness detection technology[3] can be used to mitigate this risk by ensuring that the person being identified is alive and present.

## 1.2 Identification of Problem

It is important to carefully consider these problems before deploying face recognition technology. Organizations should have clear policies in place to address data privacy, bias, accuracy, and ethical concerns. They should also be transparent about their use of the technology and engage with stakeholders to ensure that it is used responsibly.

### 1.2.1 Data Collection and Privacy Concerns:

- **Data collection and storage**: The collection of large amounts of facial data[4] raises privacy concerns, as individuals may not be aware of or consent to their facial data being collected and stored.
- **Data bias:** Face recognition algorithms may be biased, potentially leading to inaccurate or discriminatory outcomes, particularly for individuals from certain racial or ethnic groups.
- **Data misuse:** Facial data could be misused for unauthorized purposes, such as surveillance or tracking individuals without their knowledge or consent.

### 1.2.2 Technical Limitations:

- **Image quality and lighting:** Face recognition systems may struggle to accurately identify individuals in low-quality or poorly lit images.
- **Pose variations:** Face recognition systems may not perform well when individuals are not facing the camera directly or their face is obscured by facial expressions or accessories.
- **Occlusions:** Face recognition systems may not accurately identify individuals when their face is partially obscured by objects such as sunglasses, hats, or masks.

### 1.2.3 Accuracy and Reliability:

- **False positives and false negatives:** Face recognition systems can produce false positives, where the system identifies an unauthorized person as an authorized person, or false negatives, where the system fails to identify an authorized person.
- **Liveness detection:** Face recognition systems may be fooled by images or videos of people. Liveness detection technology[5] can be used to mitigate this risk by ensuring that the person being identified is alive and present.
- **Performance over time:** Face recognition systems may degrade in performance over time due to factors such as changes in facial appearance[6] or the introduction of new faces into the database.

### 1.2.4 Social and Ethical Considerations:

- **Individual privacy:** Face recognition technology can be used to invade individuals' privacy by tracking and monitoring their movements without their knowledge or consent.
- **Misuse of power:** Face recognition technology could be misused by governments or organizations to suppress dissent or control individuals' movements.
- **Lack of transparency and accountability:** The development and deployment of face recognition systems often lack transparency and accountability, making it difficult to assess the potential risks and impacts of the technology.

## 1.3 Background and Significance

### 1.3.1 Background

The concept of face recognition has existed for centuries, with early attempts at automating the process dating back to the 1960s[7]. However, it was not until the development of powerful computers and advanced algorithms in the 1980s and 1990s that face recognition technology began to become viable.

Over the past two decades, face recognition technology has made significant strides in terms of accuracy and speed. Today, face recognition systems can identify individuals with high accuracy[8], even in challenging conditions such as low light or poor image quality. This progress has led to the widespread adoption of face recognition technology in a variety of applications, including:

- **Security and access control:** Face recognition is used to control access to physical spaces, such as buildings and offices, as well as digital resources, such as computers and networks.
- **Law enforcement:** Face recognition is used to identify suspects in criminal investigations and to locate missing persons.
- **Consumer applications:** Face recognition is used to unlock smartphones, authenticate online payments, and enable personalized customer experiences.

### 1.3.2 Significance

Face recognition technology is a powerful tool with the potential to revolutionize a wide range of industries and applications. However, it is important to recognize that face recognition also raises significant privacy and ethical concerns.

The collection and storage of large amounts of facial data raise concerns about individual privacy. Face recognition systems can be used to track and monitor individuals movements without their knowledge or consent. Additionally, there is a risk that facial data could be misused for unauthorized purposes[9], such as identity theft or discrimination.

Face recognition technology is still in its early stages of development. As the technology continues to evolve, it is important to carefully consider the potential impacts on individuals and society. Public discourse and debate are essential to ensure that face recognition technology is developed and used in a responsible and ethical manner.

## 1.4 Timeline

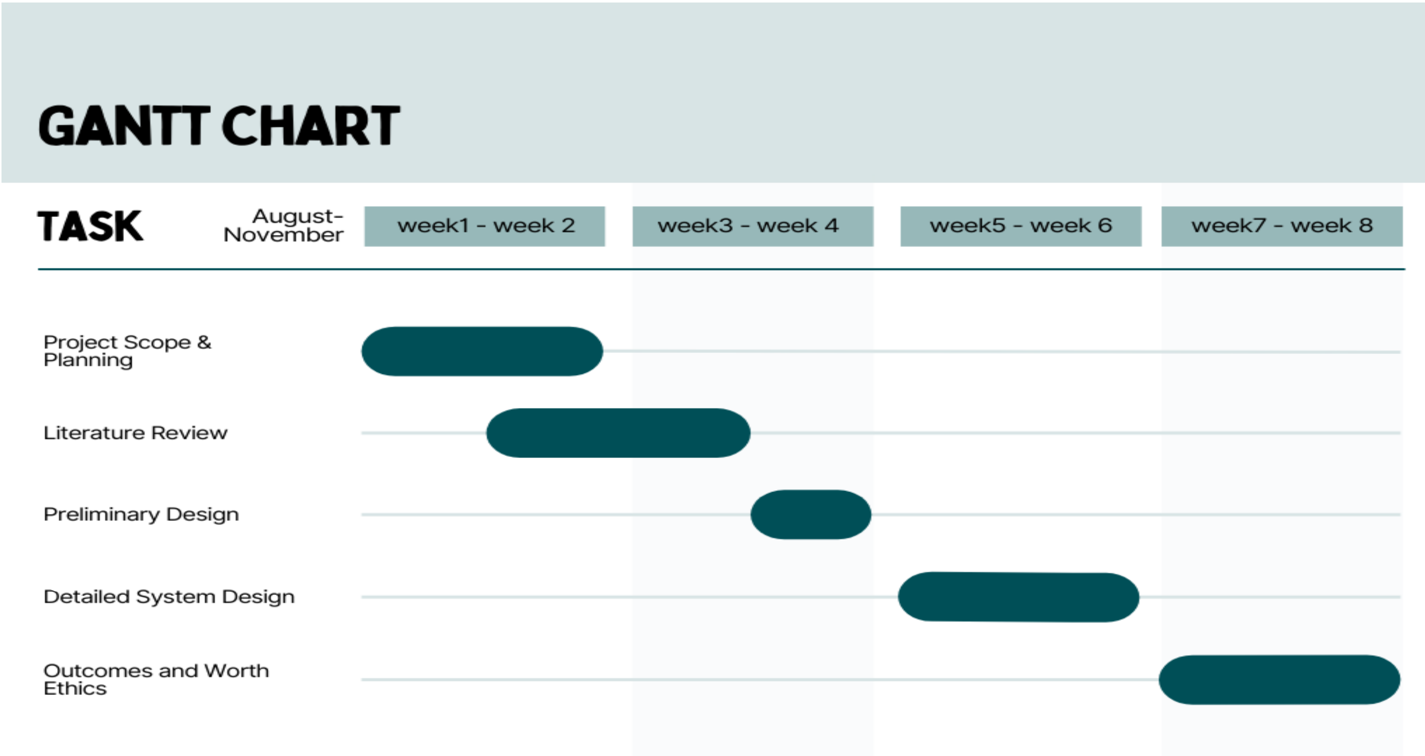



*Fig 1.1: Gantt Chart*

# CHAPTER 2

# LITERATURE REVIEW / BACKGROUND STUDY

## 2.1 Timeline of the Reported Problem

Here is a timeline of the development and reported problems of using computer vision (CV) for face recognition [10]:

Early Developments (1960s-1970s)

- 1968: The first automated face recognition system is developed by Goldstein, Harmon, and Munson at the New York Institute of Technology[11].

- 1973: Kirby and Sirovich introduce the eigenface method[12], a significant advancement in face recognition technology.

Maturation and Commercialization (1980s-1990s)

- 1986: Pentland, Picard, and Sclaroff introduce elastic matching, a technique that accounts for facial deformations due to expressions[13].
- 1997: Face recognition technology is commercialized by Identix, paving the way for its adoption in various applications.

Increased Adoption and Concerns (2000s-2010s)

- 2001: Face recognition is used for the first time at the Super Bowl to identify potential criminals.
- 2010: Facebook introduces face tagging, raising concerns about privacy and data usage.
- 2014: Google launches Google Glass, which includes face recognition capabilities, sparking further privacy debates.

Advancements, Challenges, and Ethical Considerations (2020s-Present)

- 2020: Deep learning algorithms revolutionize face recognition, achieving unprecedented accuracy.
- 2021: NIST's National Institute of Standards and Technology (NIST) Face Recognition Vendor Test (FRVT)[14] reveals significant biases in commercial face recognition algorithms[15], particularly against people of color.
- 2023: The European Union strengthens its General Data Protection Regulation (GDPR)[16] to limit the use of face recognition in public spaces.

## 2.2 Proposed Solution

### 2.2.1 Feature Extraction and Classification

Our report focuses on facial recognition using images. We want to know if there is a person inside a photograph shot with a digital camera, where their face is located, and who they are. To achieve this, we often divide the face recognition process into three stages: Face Recognition, Face Detection, and Feature Extraction. [17]

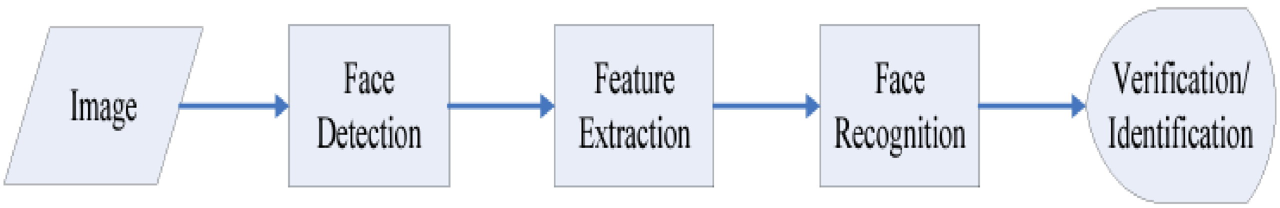



***Fig 2.1: General face recognition process.***

**Face Recognition:** It is a visual pattern recognition problem in which the goal is to identify a face based on acquired images. The face is addressed as a three-layered object that is liable to shifting enlightenment, present, and different elements. Therefore, the task of determining whether a face that has already been detected is known or unknown, and in more complex cases, determining precisely whose face it is, is known as face recognition.

**Face Detection:** This step's primary goals are to check whether human faces are present or not in a particular image and the location of those faces. The output of this is the patches of every face in the input image. Face alignment is carried out to support the scales and orientations of these patches to further improve the robustness and design simplicity of face recognition systems. Face recognition could be utilized for district-of-interest location, retargeting, video, picture grouping, and so on as well asimage classification[18], etc. in addition to being the pre-handling for face recognition.[19]

**Feature extraction:** It is the process of extracting human-face patches from images. The first drawback of directly utilizing these patches for face recognition is that they typically contain more than 1000 pixels, which is too many to construct a reliable recognition system. Secondly, face patches could be captured from various camera angles, with distinct facial expressions and lighting conditions, Feature extractions are used for information packing, dimension reduction, salience extraction, and noise cleaning to get around these problems. Following this stage, a face patch is typically converted into a vector with a fixed dimension.

### 2.2.2 Digital Image Processing:

The process of processing digital photos with a digital computer is known as digital image processing. Digital image processing techniques [20] are mainly motivated by improvement of visual information for human understanding.

The following fundamental tasks are involved in digital image processing:

- **Image Acquisition:** The ability to digitize the signal generated by an imaging sensor.
- **Preprocessing:** improves the quality of the image by filtering, enhancing contrast, etc.
- **Segmentation:** Divides an input image into the individual object components.
- **Description/Feature Selection:** This process gathers information about image objects that can be processed further by a computer.
- **Identification and Interpretation:** Labelling the object according to the details given by its descriptor. Through interpretation, a group of labeled objects is given meaning.

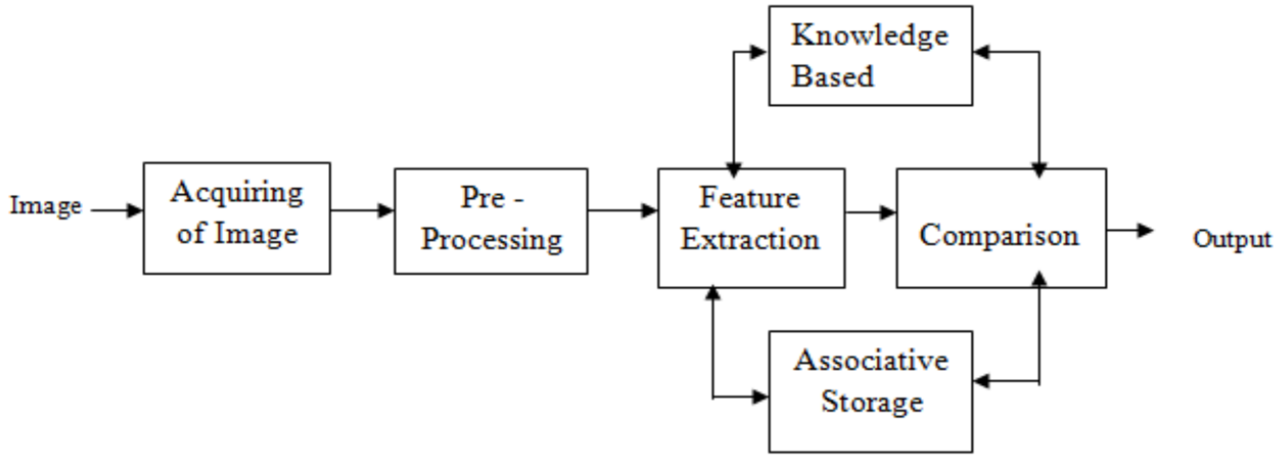



*Fig 2.2: Image Processing*

### 2.2.3 Local Binary Pattern Histogram

The Local Binary Pattern (LBP)[21] texture operator is a straightforward yet highly effective technique that assigns a binary number to each pixel in an image by thresholding its surrounding pixels. Since its initial description in 1994 (LBP), it has been discovered to be an effective feature for texture classification. Furthermore, on some datasets, it has been found that combining LBP with the histograms of oriented gradients (HOG)[22] descriptor significantly improves the detection performance. We can use a straightforward data vector to represent the face images by combining the LBP with histograms. LBPH algorithm states:

**1. The LBPH employs four parameters:**

- **Radius:** the radius denotes the area surrounding the central pixel and is utilized to construct the circular local binary pattern. Usually, it is set to 1.

- **Neighbors:** the quantity of sample points needed to construct the local binary circular pattern. Remember that the computational cost increases with the number of sample points you include. Normally, it is set to 8.

- **Grid X:** the quantity of cells arranged horizontally. The resulting feature vector has a higher dimensionality the finer the grid and the more cells it contains. Normally, it is set to 8.

- **Grid Y:** the number of cells arranged vertically. The resulting feature vector has a higher dimensionality the finer the grid and the more cells it contains.

**2. Algorithm Training:**

The algorithm must first be trained. To accomplish this, we must utilize a dataset containing the faces of the individuals we wish to identify. To enable the algorithm to identify an input image and provide you with an output, we also need to set an ID (which could be a number or the person's name) for each image. The same ID must appear in all images of the same person. Now that the training set has been created, let's examine the LBPH computational procedures.[23]

**3. Using the LBP operation:**

The first computational stage of the LBPH is to produce an intermediate image that, by emphasizing the facial features, more accurately describes the original image. The algorithm does this by using the idea of a sliding window, which is dependent on the neighbors and radius parameters.

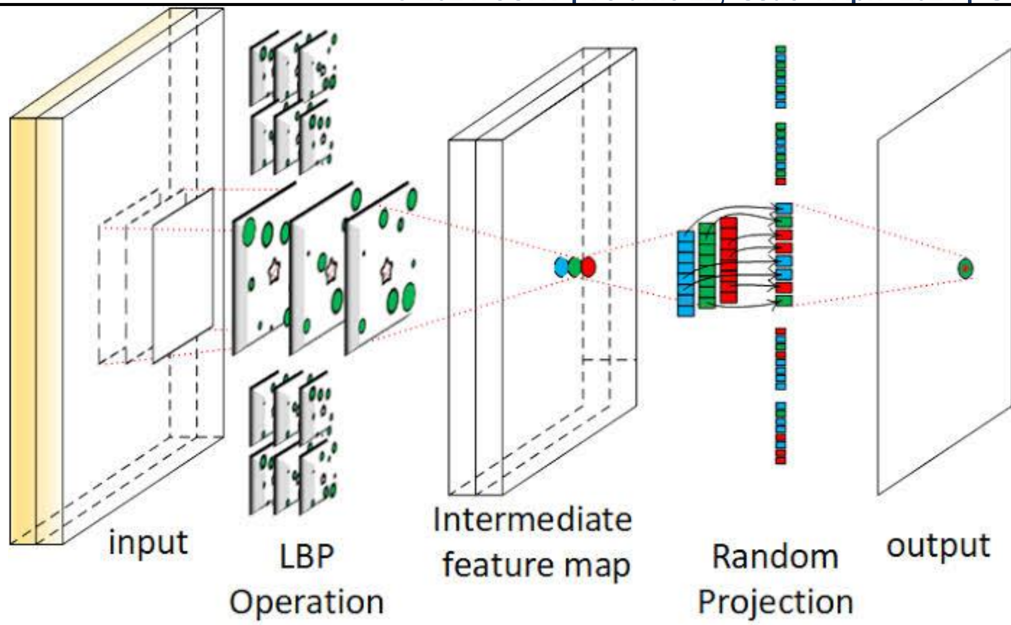



*Fig 2.3: LBP Operation*

## 2.3 Bibliometric Analysis

To further understand the research of Face recognition using OpenCV was conducted. The analysis was performed using the machine learning model where database of images[24] of people was taken.

The analysis showed that the number of publications on this topic has been steadily increasing over the past decade. The majority of the publications were in the fields of computer science, engineering, and medicine. The top countries in terms of publications were the United States, China, and India

The analysis also showed that the most common keywords used in the publications were "machine learning"[25], "surveillance", "prediction", "feature", "detection" and "extraction"[26]. This indicates that these are the key areas of focus in the research on face recognition using OpenCV and machine learning algorithms[27].

## 2.4 Review Summary

The application of facial recognition technology is growing more widespread. Businesses of all sizes, including Microsoft, Facebook, and Google, have adopted face recognition technology extensively. Face recognition technology has a lot to offer the police, security, medical, and marketing sectors.

Google's implementation of face recognition technology on Google Pixel 4 smartphones, which employ facial recognition techniques to access the system on the device, is a security measure. The 2002 Face Recognition Vendor can differentiate the faces that are identical twins. Face recognition technology is also utilized by law enforcement, where it is employed to identify offenders so that, even in cases where they are lying, the authorities can ascertain their identity and criminal history. Law enforcement also makes use of face recognition technology to identify criminals so that, even in situations where they are lying, the authorities can determine who they are and what their criminal history follows.

The effects of technology on our life are both advantageous and detrimental. While facial recognition technology was initially developed to help people, it also has drawbacks. Racism hurts Google's face recognition algorithm, which makes it more accurate for white faces only and less accurate for black faces. The algorithm employed by these big corporations causes some users of Google face recognition technology uneasy. There is concern that the widespread use of databases for face recognition could violate people's right to privacy, as is the case in the UK. This is because more and more face recognition cameras are being installed in public spaces like shopping malls and theaters, giving authorities more access to monitor people's daily activities. Every person who is applying for a passport or driver's license faces the possibility that their face recognition data is added to a new, national network that the government is attempting to establish. In the past 20 years, face recognition technology has advanced significantly. These days, devices can automatically confirm identity information for safe transactions, security, and surveillance duties, building access control, etc. These kinds of applications mostly operate in controlled settings and high accuracy which recognition algorithms can achieve. However, next-generation face recognition systems will be widely used in smart environments where computers and other machinery resemble helpful assistants.

The computer's ability to accurately identify people in the vicinity in a way that blends in with typical human interactions is necessary to accomplish this goal. They must be compatible with human intuition regarding the likelihood of recognition and not require any special interactions. According to this, artificial intelligence (AI)[28] systems of the future ought to operate with human modalities and constraints. These objectives now seem attainable, but much research is still needed to ensure that person recognition technologies operate consistently under a wide range of circumstances, utilizing data from one or more modalities.

## 2.5 Problem Definition

Face recognition is the ability of a computer system to identify or verify an individual based on their facial characteristics. It is a powerful technology with a wide range of potential applications, including security, surveillance, and access control. However, face recognition systems are not without their challenges. These challenges include:

**Accuracy:** Face recognition systems are not always 100% accurate. They can be fooled by changes in lighting, pose, and facial expressions.

**Privacy:** Face recognition systems raise privacy concerns, as they can be used to track and monitor individuals without their knowledge or consent.

**Bias:** Face recognition systems can be biased, as they may be less accurate at recognizing people from certain demographic groups.

Objective:

The objective of this report is to investigate the use of computer vision (CV) for face recognition. The report will discuss the challenges of face recognition and explore how CV can be used to address these challenges.

## 2.6 Goals/Objectives

- The primary objective of this project is to develop an innovative and efficient system for the early recognition and identification of faces using advanced OpenCV, namely Local

Binary Pattern Histogram[29]. The project aims to create a robust and user-friendly system.

- Real-time Processing: Enable real-time processing of medical images for quick diagnosis, minimizing the time required for medical professionals to interpret results.
- User-Friendly Interface: Create an intuitive and user-friendly web-based interface accessible to all using it, allowing them to identify people.
- Scalability and Future Integration: Design the system with scalability in mind, allowing for future integration with security systems.

# CHAPTER 3
# DESIGN FLOW/PROCESS

## 3.1 Evaluation & Selection of Specifications/Features

Optimizing face detection performance using OpenCV and TensorFlow [30] necessitates a meticulous evaluation of various factors, ensuring seamless integration with the specific application requirements and achieving the desired level of accuracy, speed, and efficiency.

**Accuracy**: The cornerstone of reliable face detection lies in unwavering precision, measured by the proportion of correctly identified faces, and recall, which determines the percentage of actual faces that are detected. Carefully comparing the accuracy of different model architectures and training configurations allows for identifying the most suitable model that strikes a balance between precision and other considerations.

**Speed**: In the realm of real-time applications, inference speed reigns supreme, demanding lightning-fast processing of images or frames. Assessing the model's ability to handle input data efficiently is paramount, considering the need for immediate feedback and responsiveness. Optimizing the model architecture and implementation can significantly reduce inference time, rendering face detection virtually instantaneous. Leveraging hardware acceleration, such as GPUs or TPUs, further elevates performance, enabling real-time face detection[31] even in resource-constrained environments.

**Latency**: The time delay between capturing an image or frame and displaying the processed output with detected faces, known as latency, directly impacts user experience. Minimizing latency is crucial for seamless and responsive interactions. Streamlining the overall workflow, including data pre-processing, model inference, and post-processing, can significantly reduce latency. Additionally, employing techniques like asynchronous processing and pipelining further optimizes this aspect, ensuring that the pipeline remains responsive even under heavy workloads.

**Resource Requirements**: Face detection models often exhibit varied memory and computational demands, necessitating a thorough assessment of the target platform's capabilities. Quantization, the process of reducing model size and memory footprint, can be highly beneficial in resource-constrained environments. Optimizing the model architecture and implementation to minimize computational complexity further enhances efficiency, maximizing performance while minimizing resource consumption.

**Desired Application:** The specific requirements of the application steer the selection of specifications and features. Real-time applications demand a balance between speed and latency, prioritizing both aspects to ensure seamless interactions. For high-precision tasks, accuracy takes precedence, demanding models that can accurately detect faces across diverse scenarios. In resource-constrained environments, model size and computational efficiency become paramount, necessitating lightweight models that can operate efficiently on limited resources.

**Evaluation Methodology:** A comprehensive and rigorous evaluation methodology is paramount for objectively assessing the model's performance. Standard evaluation datasets, such as FDDB [32] and Pascal VOC, provide a controlled benchmark for comparison. Metrics like precision, recall, mean average precision (mAP), and frames per second (FPS) should be employed to evaluate accuracy and speed across diverse conditions, including varying lighting, poses, and occlusions. This rigorous evaluation process ensures that the selected model is well-suited for the intended application and can consistently deliver accurate and efficient face detection.

**Selection Process:** Identifying the most critical requirements for the specific application is crucial. Carefully analyzing the evaluation results and evaluating trade-offs between different specifications and features allows for selecting the optimal combination that best meets the overall objectives. Continuous evaluation and refinement of the selection are essential as the application evolves and requirements change, ensuring that the face detection capabilities remain optimized for the current context.

**Face Tracking:** Seamlessly track the movement of detected faces across video sequences, maintaining consistent identification throughout the footage. Employ algorithms like Kalman filtering or optical flow to anticipate the position of faces in subsequent frames, ensuring smooth and accurate tracking. Utilize adaptive search regions to optimize tracking performance under challenging conditions, such as rapid movements, occlusions, or varying lighting.

**Facial Landmark Detection:** Pinpoint and localize key facial landmarks, such as the eyes, nose, mouth, and eyebrows, providing a comprehensive representation of facial features. Leverage algorithms like SIFT (Scale-Invariant Feature Transform) [33] or deep learning models to extract facial landmarks with high accuracy and robustness. Employ facial landmark detection for applications like facial expression recognition, facial animation, or facial morphing.

**Facial Attribute Recognition:** Automatically classify facial attributes, such as gender, age, ethnicity, and emotion, providing valuable insights into individual characteristics. Utilize deep learning models trained on large datasets of labeled facial images to achieve high-performance attribute recognition. Employ facial attribute recognition for applications like demographic analysis, personalized marketing, or user experience personalization.

**Face Morphing:** Craft seamless transitions between the features of two or more faces, producing morphing effects that are visually appealing and realistic. Utilize techniques like triangulation and warping to blend facial features effectively, preserving the overall facial structure and maintaining a natural appearance. Apply face morphing for entertainment purposes, creating personalized avatars, or generating visual effects.

**Face Occlusion Handling:** Effectively detect and handle occlusions, such as sunglasses, hats, or masks, that partially obscure the face, ensuring robust face detection performance under challenging conditions. Utilize algorithms like occlusion detection and inpainting to recover obscured facial regions, restoring missing information and improving recognition accuracy. Employ face occlusion handling for applications like facial recognition under challenging conditions, such as surveillance or access control.

**Face Matching:** Compare and match faces to determine whether they belong to the same individual, enabling identity verification and person recognition. Utilize algorithms like face embedding extraction and similarity measures to compare facial features effectively, considering facial variations and individual characteristics. Employ face matching for applications like identity verification, access control, or security systems.

**Face Privacy:** Implement privacy-preserving techniques to safeguard sensitive facial data and adhere to data privacy regulations. Utilize anonymization methods, such as blurring or pixelation, to conceal facial features and prevent unauthorized identification. Employ federated learning or differential privacy to protect data privacy while still enabling training and evaluation of face detection models without compromising individual privacy.

By incorporating these advanced features, face detection systems can transcend mere identification and become powerful tools for a wide range of applications, from enhancing user experiences to bolstering security measures. The combination of OpenCV and TensorFlow provides a robust foundation for building these sophisticated systems, paving the way for advancements in computer vision and artificial intelligence [34].

### 3.1.1 Design of Face Recognition:

Face detection is a crucial component of computer vision applications, enabling the identification and tracking of individuals within images and videos. The synergy between OpenCV, a versatile open-source computer vision library, and TensorFlow, a powerful machine learning framework, empowers developers to create robust and scalable face detection systems.

1. **Data Acquisition and Preparation:**

The foundation of successful face detection lies in the quality and diversity of the training data.

- **Dataset Assembly:** Gather a comprehensive dataset of images containing diverse facial representations. Ensure the dataset includes images with varying lighting conditions, poses, occlusions, ethnicities, and age groups to foster a robust model.

- **Image Annotation:** Annotate the collected images with meticulously labeled bounding boxes around the faces. This meticulous labeling provides accurate ground truth data for the model to learn from.

- **Dataset Partitioning:** Divide the annotated dataset into training, validation, and testing sets. The training set is used to train the model, the validation set is used to fine-tune hyperparameters, and the testing set is used to evaluate the model's performance on unseen data.

**2. Face Detection Model Development:**

The choice of model architecture and its training methodology significantly impacts face detection accuracy and efficiency.

- **Model Architecture Selection:** Choose an appropriate face detection model architecture. Popular choices include MTCNN (Multi-Task Cascaded Convolutional Neural Networks) [35] and SSD (Single Shot MultiBox Detector) [[36]. Consider factors such as desired accuracy, speed, and resource constraints when selecting the architecture.

- **Model Implementation:** Implement the selected model architecture using TensorFlow, leveraging its deep learning capabilities to extract and analyze facial features effectively. Pay attention to efficient data representation and memory management to optimize performance.

- **Model Training:** Train the implemented model on the training dataset. Optimize the model's parameters using techniques like gradient descent and backpropagation to minimize the loss function and maximize detection accuracy.

- **Hyperparameter Tuning:** Employ hyperparameter tuning techniques to fine-tune the model's training configuration. Balance accuracy, speed, and resource utilization by adjusting hyperparameters such as learning rate, batch size, and optimizer settings.

**3. Face Detection and Visualization:**

Integrating the trained model into the application involves image or video capture, preprocessing, face detection inference, and result visualization.

- **Image or Video Acquisition:** Capture images or video frames using OpenCV's image and video capture functionalities [37]. Ensure the capture device is properly configured and aligned to capture high-quality images or videos.

- **Image Preprocessing:** Preprocess the captured images or video frames to prepare them for model input. This may include resizing, converting to RGB format, and normalizing pixel values to ensure consistent input representation.

- **Face Detection Inference:** Feed the preprocessed data to the loaded TensorFlow model, triggering the face detection inference process. The model extracts facial features and applies its learned patterns to identify and localize faces within the input data.

- **Detection Results Analysis:** Extract the detection results from the model's output. This typically includes bounding box coordinates, confidence scores, and class labels (e.g., face). Analyze the confidence scores to filter out false positives and enhance detection accuracy.

- **Face Visualization:** Utilize OpenCV's drawing functions to visualize the detected faces. Draw bounding boxes around the detected faces on the original images or video frames. Customize the appearance of the bounding boxes, such as color, thickness, and transparency, to enhance visual clarity.

- **Visualization Output:** Display the processed images or video frames with the detected faces and bounding boxes, providing real-time visualization of the face detection process. Ensure the visualization output is synchronized with the input data and provides a smooth user experience.

**4. Evaluation, Optimization, and Deployment:**

Continuous evaluation, optimization, and deployment are crucial for maintaining a high-performing face detection system.

- **Model Evaluation:** Evaluate the model's performance on the testing dataset. Measure its precision, recall, mean average precision (mAP)[38], and frames per second (FPS) to assess accuracy and speed. Analyze the results to identify areas for improvement.

- **Performance Analysis:** Analyze the model's performance under diverse conditions, including varying lighting, poses, occlusions, and ethnicities. Evaluate its robustness and generalizability to ensure it can handle real-world scenarios effectively.

- **Model Optimization:** Optimize the model architecture, training hyperparameters, and post-processing techniques to improve accuracy, speed, and resource utilization. Consider techniques like model pruning, quantization, and transfer learning to enhance efficiency.

- **Application Integration:** Integrate the optimized face detection model into the target application or system. Ensure seamless integration with existing functionality and maintain compatibility with the target platform.

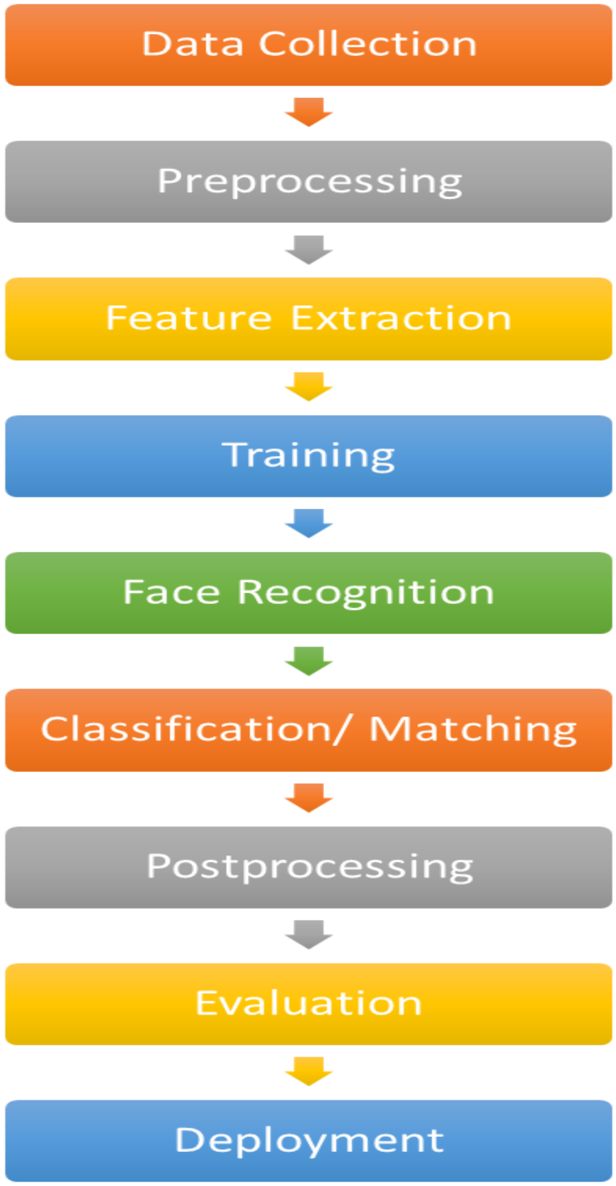



*Fig 3.1: Methodology*

### 3.1.2 Description of the platform:

Our Facial Recognition System is a creative AI-driven product intended to upgrade user experience in different applications. This framework uses deep-learning models[39], including TensorFlow for the neural network, Flask for web application improvement, and OpenCV for real-time image processing. By joining these innovations, we mean to make a flexible prediction equipped for facial expressions in pictures or video streams.

***Technology:***

- **TensorFlow:** It is a popular deep learning framework, to build and train neural networks for facial expression recognition, gender detection, and mask detection. TensorFlow provides a scalable and efficient platform for model development and deployment.
- **Keras:** In open-source high-level neural network Programming interface written in Python that sudden spikes in demand for top of other DL frameworks, for example, TensorFlow. Keras[40] permits you to make brain networks by joining different structure blocks like layers, analyzers, and misfortune capabilities.
- **Flask:** It is employed to create an interactive web application that allows users to interact with the system. The web interface provides a seamless experience for uploading images or accessing real-time video streams for analysis.
- **OpenCV:** It is an open-source computer vision library which plays a crucial role in image processing, face detection, and real-time video analysis. It is used to capture, process, and display images and video streams.
- **Haar Cascade:** The Haar Cascade method [41] is an AI method that can be utilized to identify objects. It gains from a series of images that have positive and negative qualities. The Haar cascade strategy can be utilized to see objects in various frames.

## 3.2 Design Flow:

There are various diagrams that are used to visualize how the information flows within the application. It visualizes how the data enters, leaves, or changes within the application.

Some of these diagrams are-

**1. DFD**- It graphically visualizes the flow of data within the application

**2. ER Diagram-** It is a flow chart that tells how different entities relate to eachother within the system.

**3. Block diagram-** It is a high-level flow chart in which major components are represented by blocks with the line between them which shows the relationship between different blocks.

### 3.2.1 DFD

Data Flow Diagram is a way of representing how data flows through system or processes.

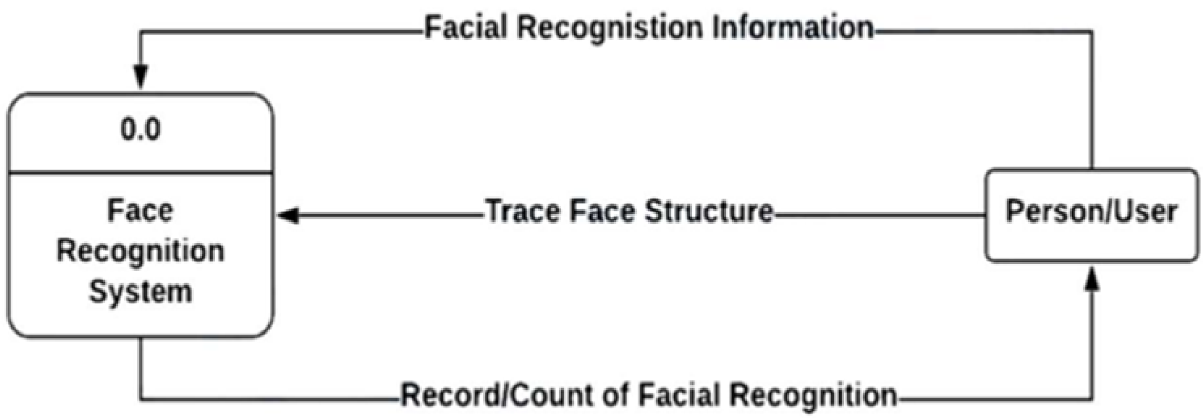



*Fig 3.2: Level 0 Diagram*

The above diagram is the level 0 DFD which shows the abstract view. It only represents the main functions of the FER.

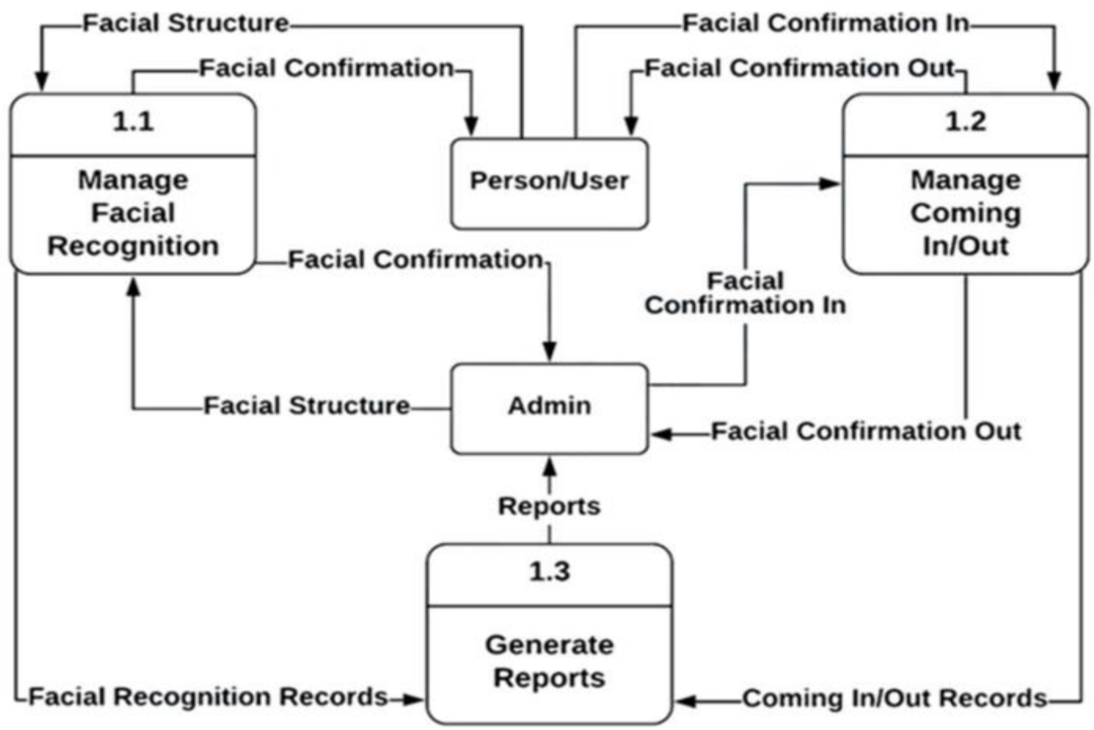



*Fig 3.3: Level 1 Diagram*

Level 1 DFD is more specific than Level 0 DFD. It tells about the basic process and the flow of data between basic modules.

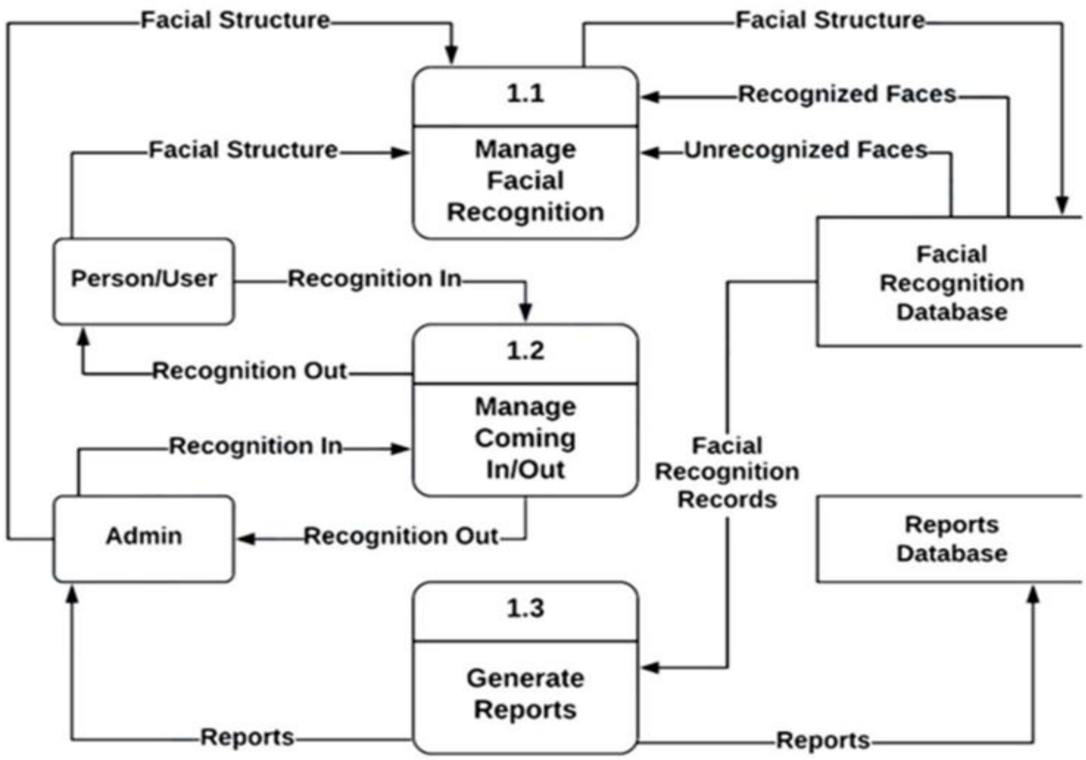



*Fig 3.4: Level 2 Diagram*

It is more specific than both of those. It exactly tells how the data is flowing between different modules.

### 3.2.2 BLOCK DIAGRAM

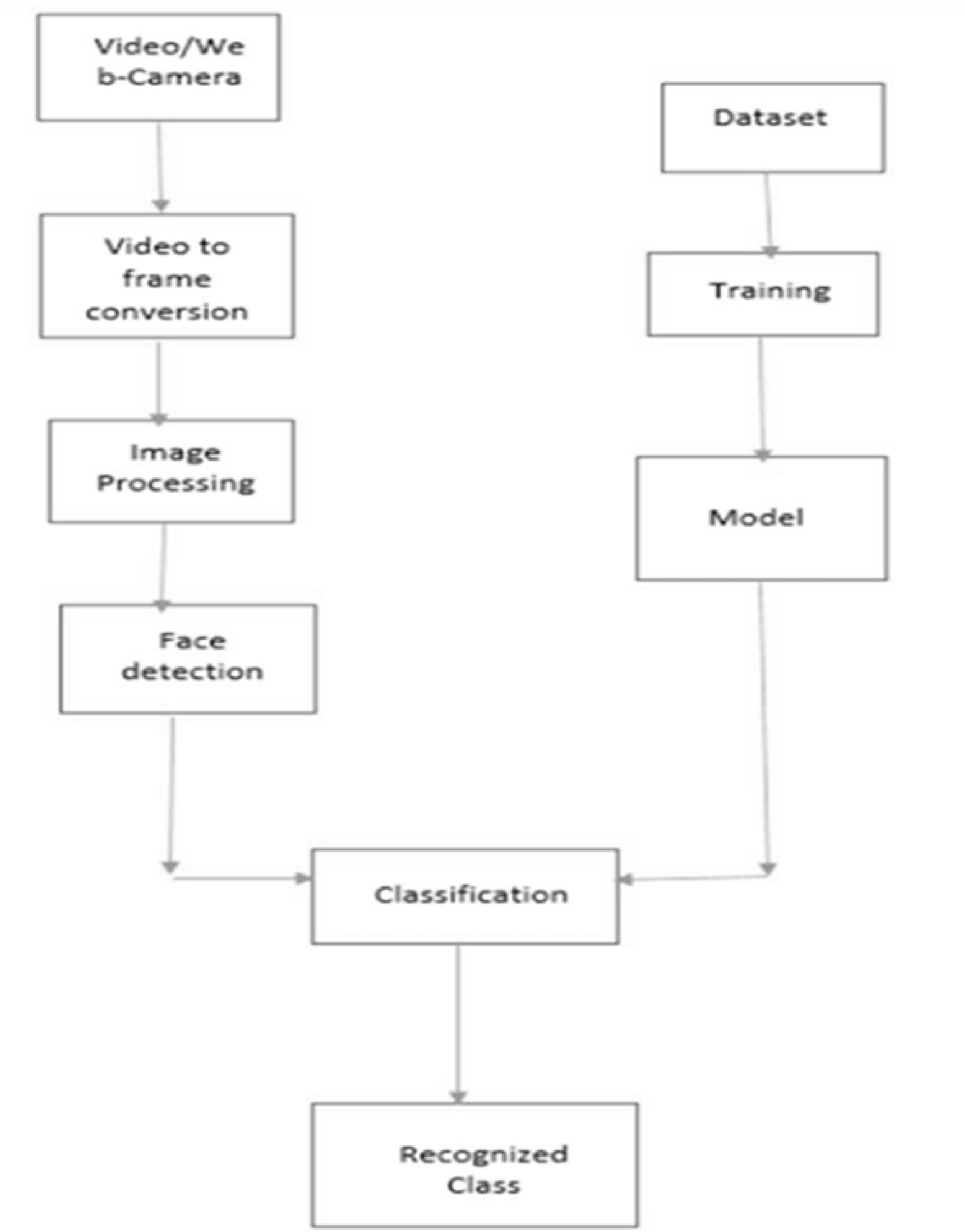



*Fig 3.5: Block Diagram*

### 3.2.3 ER DIAGRAM

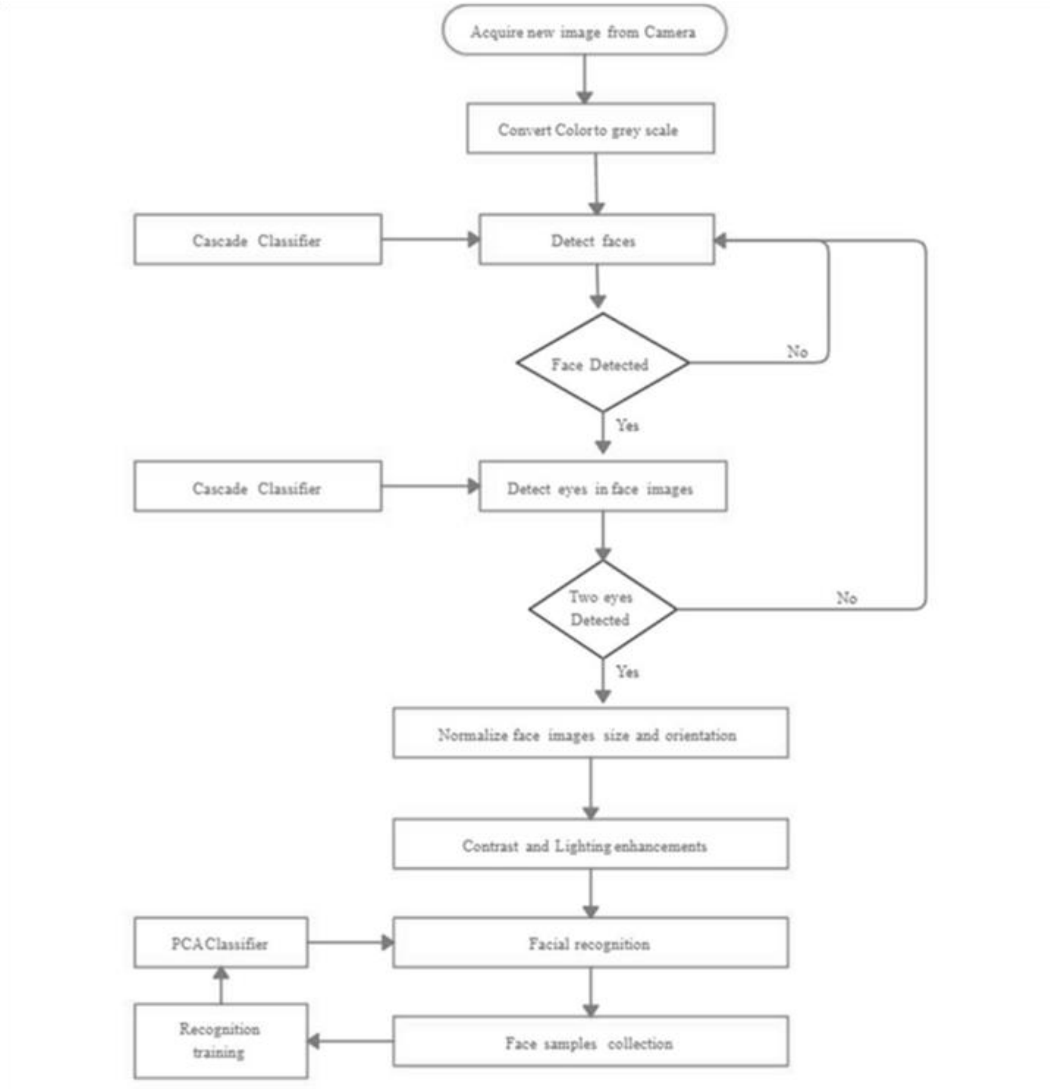



*Fig 3.6: ER Diagram*

## 3.3 Design Execution:

- Importing Libraries

```python
import tkinter as tk
from tkinter import *
import cv2
from PIL import Image, ImageTk
import os
import numpy as np
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Dropout, Flatten
from tensorflow.keras.layers import Conv2D
from tensorflow.keras.optimizers import Adam
from tensorflow.keras.layers import MaxPooling2D
from tensorflow.keras.preprocessing.image import ImageDataGenerator
import threading
```

➢ Neural Network Modeling

```python
emotion_model = Sequential()
emotion_model.add(Conv2D(32, kernel_size=(
    3, 3), activation='relu', input_shape=(48, 48, 1)))
emotion_model.add(Conv2D(64, kernel_size=(3, 3), activation='relu'))
emotion_model.add(MaxPooling2D(pool_size=(2, 2)))
emotion_model.add(Dropout(0.25))
emotion_model.add(Conv2D(32, kernel_size=(3, 3), activation='relu'))
emotion_model.add(MaxPooling2D(pool_size=(2, 2)))
emotion_model.add(Dropout(0.25))
emotion_model.add(Flatten())
emotion_model.add(Dense(1024, activation='relu'))
emotion_model.add(Dropout(0.5))
emotion_model.add(Dense(7, activation='softmax'))
emotion_model.load_weights('model.h5')
cv2.ocl.setUseOpenCL(False)

```

➢ Web Application Development

```python
from flask import Flask, render_template, Response
from camera import Video
import cv2
app = Flask(__name__)
camera = cv2.VideoCapture(0)


def gen(camera):
    while True:
        frame = camera.getframe()
        yield()


def gen_frames():
    while True:
        success, frame = camera.read()  # read the camera frame
        print(success)
        if not success:
            break
        else:
            detector = cv2.CascadeClassifier(
                'Haarcascades/haarcascade_frontalface_default.xml')
            eye_cascade = cv2.CascadeClassifier(
                'Haarcascades/haarcascade_eye.xml')
            faces = detector.detectMultiScale(frame, 1.1, 7)
            gray = cv2.cvtColor(frame, cv2.COLOR_BGR2GRAY)
            # Draw the rectangle around each face
            print(faces)
            for (x, y, w, h) in faces:
                cv2.rectangle(frame, (x, y), (x+w, y+h), (255, 0, 0), 2)
                roi_gray = gray[y:y+h, x:x+w]
                roi_color = frame[y:y+h, x:x+w]
                eyes = eye_cascade.detectMultiScale(roi_gray, 1.1, 3)
                for (ex, ey, ew, eh) in eyes:
                    cv2.rectangle(roi_color, (ex, ey),
                                  (ex+ew, ey+eh), (0, 255, 0), 2)

            ret, buffer = cv2.imencode('.jpg', frame)
            frame = buffer.tobytes()
            yield (b'--frame\r\n'b'Content-Type: image/jpeg\r\n\r\n' + frame + b'\r\n')


@app.route('/')
def index():
    return render_template('base.html')


@app.route('/emotion/')
def emotion():
    return render_template('index.html')

```

```
# @app.route('/video_feed')
# def video_feed():
#     return Response(gen_frames(), mimetype='multipart/x-mixed-replace; boundary=frame')

@app.route('/video_feed')
def video_feed():
    return Response(gen(Video()),
                    mimetype='multipart/x-mixed-replace; boundary=frame')


if __name__ == '__main__':
    app.run(debug=True)
```

# CHAPTER 4

# RESULTS ANALYSIS AND VALIDATION

## 4.1 Implementation of design using Modern tools

Real valued and binary parameters were extracted from the facial pictures[42] from ninety-seven subjects (467 images). Table 1 shows the typical proportion deviations from the corresponding neutral values, for all the eight real valued parameters. the typical proportion presence of the seven binary parameters for all the seven expressions.

| ***Real valued parameter*** | **Average percentage deviation from neutral value** | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Neutral* | *Angry* | *Disgust* | *Fear* | *Happy* | *Sad* | *Surprised* |
| *Eyebrow raise distance* | 0.00 | -28.04 | -36.86 | 1.43 | 1.54 | 5.29 | 49.67 |
| *Upper eyelid-eyebrow distance* | 0.00 | -31.18 | -26.47 | 4.15 | 11.91 | 15.03 | 106.12 |
| *Inter eyebrow distance* | 0.00 | -22.36 | -9.45 | -16.09 | -0.50 | -6.43 | 5.62 |
| *Upper eyelid-lower eyelid distance* | 0.00 | -34.60 | -49.52 | -18.69 | -20.07 | -13.04 | 25.13 |
| *Top lip thickness* | 0.00 | -49.99 | -10.20 | -17.46 | -11.04 | -23.31 | 1.27 |
| *Bottom lip thickness* | 0.00 | -51.77 | -6.83 | -23.55 | -10.92 | -8.80 | 23.65 |
| *Mouth width* | 0.00 | -8.19 | -7.48 | 9.90 | 33.35 | -4.04 | -14.62 |
| *Mouth opening* | 0.00 | -7.74 | 95.37 | 738.30 | 785.81 | 2.55 | 2489.00 |

***Table 4.1: Percentage deviation of eight valued params***

| ***Binary parameter*** | **Average percentage presence of parameter** | | | | | | |
|---|---|---|---|---|---|---|---|
| | *Neutral* | *Angry* | *Disgust* | *Fear* | *Happy* | *Sad* | *Surprised* |
| *Upper teeth visible* | 0.00 | 0.00 | 13.33 | 93.10 | 83.91 | 0.00 | 57.89 |
| *Lower teeth visible* | 0.00 | 0.00 | 6.67 | 77.59 | 37.93 | 0.00 | 47.37 |
| *Forehead lines* | 0.00 | 0.00 | 2.22 | 29.31 | 0.00 | 14.52 | 69.74 |
| *Eyebrow lines* | 0.00 | 73.81 | 86.67 | 50.00 | 0.00 | 20.97 | 30.26 |
| *Nose lines* | 0.00 | 61.90 | 88.89 | 31.03 | 0.00 | 4.84 | 0.00 |
| *Chin lines* | 0.00 | 80.95 | 22.22 | 10.34 | 0.00 | 85.48 | 0.00 |
| *Nasolabial lines* | 0.00 | 16.67 | 84.44 | 56.90 | 97.70 | 9.68 | 9.21 |

***Table 4.2: Percentage presence of seven binary params***

| ***Expressions presented*** | ***System Classification*** | | | | | | | | | | | ***Total*** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **A** | **D** | **F** | **H** | **S** | **Su** | **Z** | **AD** | **DF** | **FH** | |
| **Neutral (N)** | 62 | | | | | | | | | | | 62 |
| **Angry ( A)** | | 15 | 1 | | | 3 | | 1 | | | | 20 |
| **Disgust ( D )** | | 2 | 17 | 2 | | 1 | | 2 | 2 | | | 26 |
| **Fear ( F )** | | | 1 | 26 | 7 | | | | | 2 | | 36 |
| **Happy ( H )** | | | | | 54 | | | | | | 1 | 55 |
| **Sad ( S )** | | 1 | | | | 34 | | 1 | | | | 36 |
| **Surprised (Su)** | | | | | | | 47 | | | | | 47 |
| **Total** | 62 | 18 | 19 | 28 | 61 | 38 | 47 | 4 | 2 | 2 | 1 | 282 |

***Table 4.3: The Confusion Matrix***

| **Neural Networks** | **Designated expression correctly identified out of 282 expressions presented.** |
|---|---|
| NN-1 | 198 |
| NN-2 | 182 |
| NN-3 | 194 |
| NN-4 | 191 |
| NN-5 | 204 |
| NN-6 | 206 |
| NN-7 | 204 |
| NN-8 | 213 |
| NN-9 | 204 |
| NN-10 | 217 |
| NN-11 | 203 |
| **Integrated Committee Results** | **255** |

***Table 4.4: Number of correct classifications by individual networks and by the committee***

The integrated committee system properly known 255 out of 282 totally different completely different expressions from 62 different subjects. there have been twenty-seven incorrect classifications. the inaccurate classifications were either misclassifications, ambiguous classification, or no-classification cases. A misclassification occurred once associate degree expression was not accurately categorized. associate degree ambiguous classification occurred once 2 or additional expressions were known for a classification output. A no-classification occurred once there was associate degree all zero output, and no expression was classified. There were eighteen misclassification cases, four no classification cases, and 5 ambiguous classification cases amongst the 282 expressions evaluated. the confusion matrix. The matrix shows the system classification versus the expression bestowed. for example, once fifty-five happy expressions were bestowed, the integrated committee classified fifty-four expressions as happy and classified one expression as a mixture of happy and worry. once thirty-six worry expressions were bestowed, the committee properly classified twenty-six cases as worry. It classified one expression as disgust, seven expressions as happy and 2 expressions as a mixture of worry and disgust. shows a comparative graphical outline of the integrated committee neural network system performance. provides a plot of expression-wise performance of the integrated committee neural network system. The angry, disgust and worry expressions showed low classification accuracy (in the vary of sixty fifth to 75%) whereas the happy, unhappy, and stunned expressions showed high classification accuracy (more than 90%). presents the number of correct classifications by the individual networks and therefore the committee network.

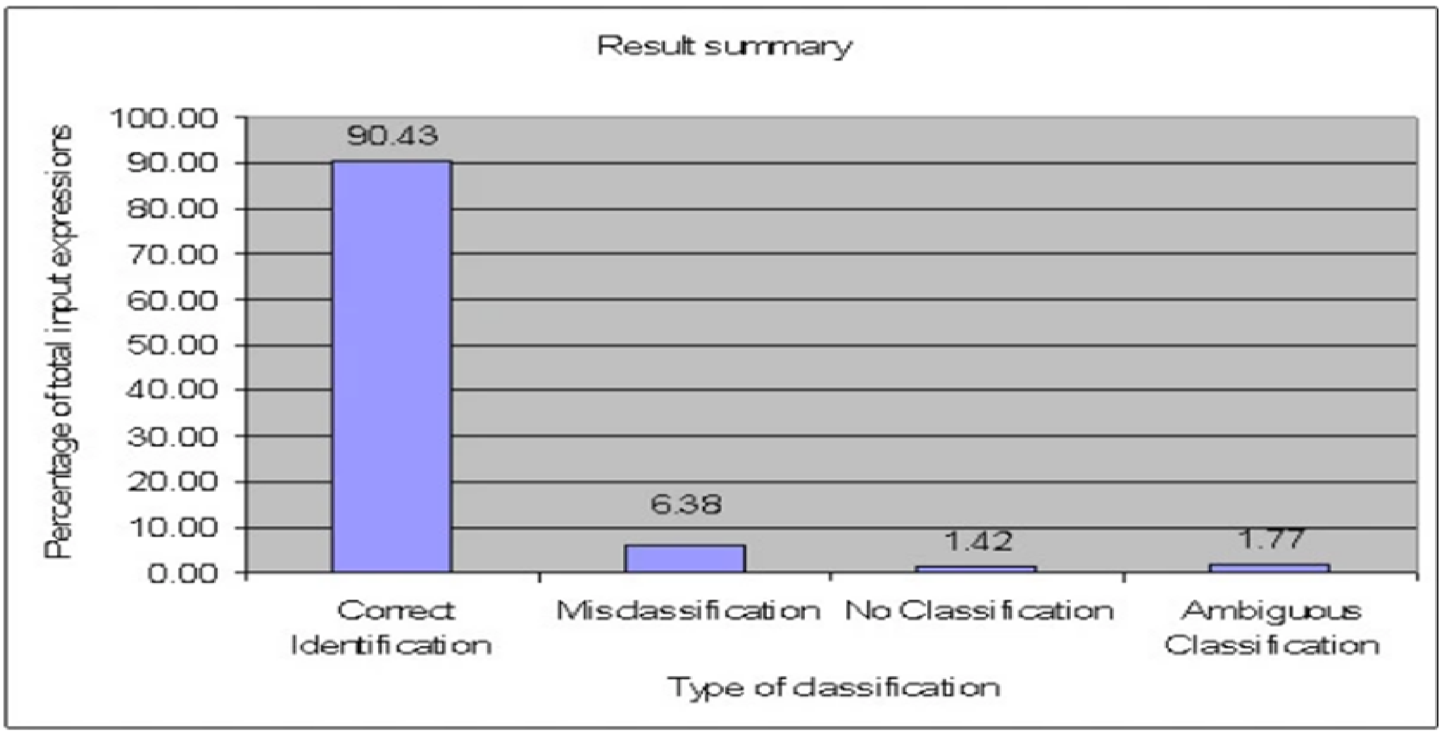



***Fig 4.1: Plot of percentage of total input expressions versus type of classification.***

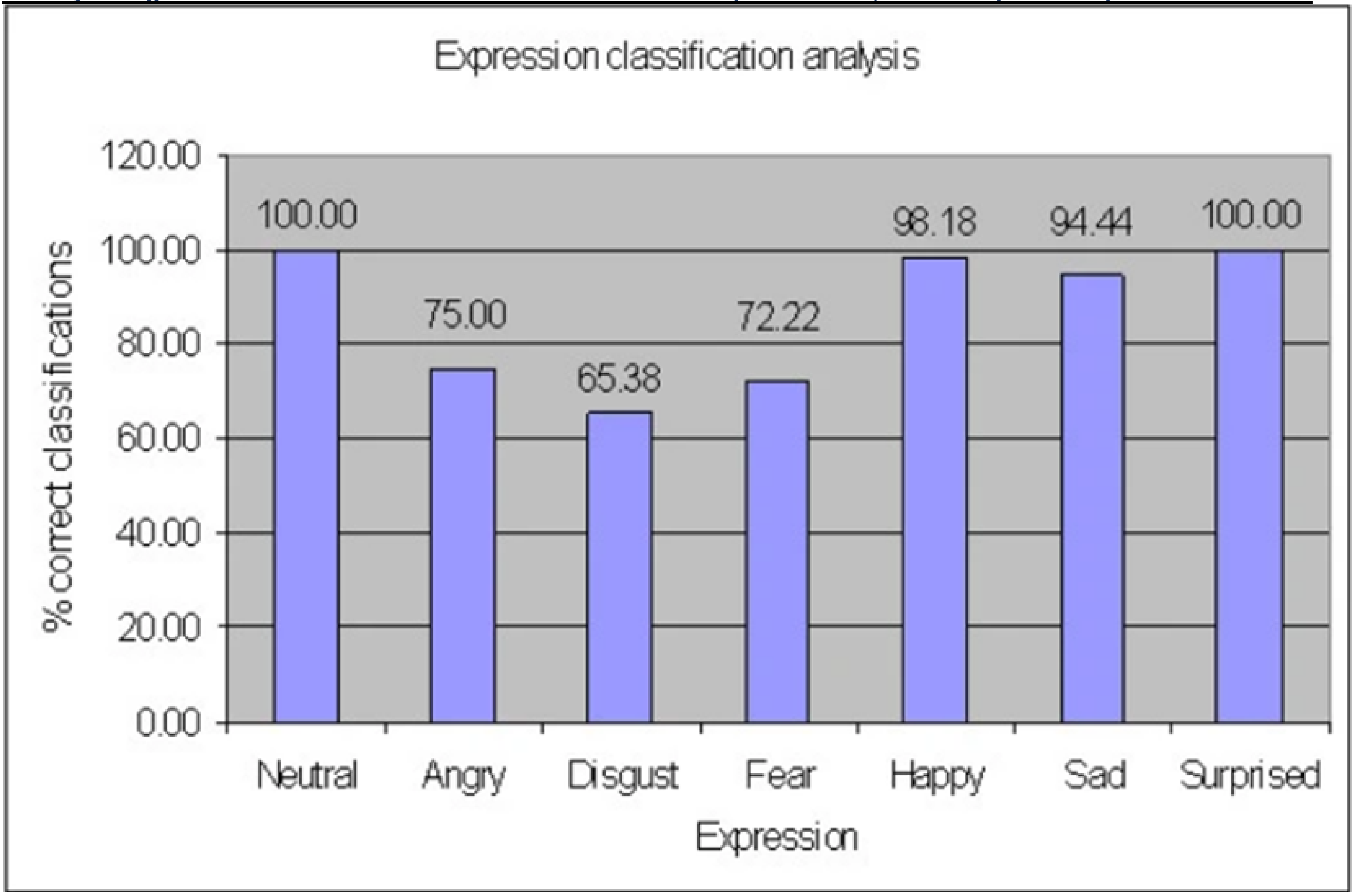



*Fig 4.2: Plot of percentage correct classifications for different expressions.*

# CHAPTER 5

# CONCLUSION AND FUTURE WORK

## 5.1 Conclusion

The purpose of this study is to develop a model that can accurately identify the significance of utilizing OpenCV for face recognition, a pivotal field in today's era of visual information dominance. OpenCV's versatile tools and algorithms have been instrumental in addressing the challenges of face detection and recognition. The paper emphasizes OpenCV's evolution[43], from classical methods to contemporary deep learning approaches, highlighting its adaptability to changing technological landscapes. While OpenCV provides powerful solutions, it is essential to acknowledge its limitations, such as sensitivity to lighting conditions, pose variations, and privacy concerns.

In sum, OpenCV remains a cornerstone in the realm of face recognition, offering a gateway to advanced applications while prompting thoughtful deliberation on the ethical implications of this technology. To further improve the general accuracy of this model, further datasets will be incorporated in the future.

## 5.2 Future Work

- Improving the accuracy and robustness of the model: Although the current model has achieved a high detection accuracy rate, there is still room for improvement in terms of reducing false positives and false negatives, handling different types of facial structures, and generalizing to new datasets.
- Dataset Diversity: Create and utilize diverse and comprehensive face datasets that include a wide range of ages, ethnicities, and gender identities. This will help in reducing bias and ensuring that face recognition systems work accurately for all individuals.
- Scaling up the model to larger datasets and populations: Although the current model has been trained and tested on a relatively small dataset and population, there is a need to scale

up the model to larger datasets and populations to ensure its validity and generalizability. Future work could explore various approaches such as cloud computing to handle the large-scale data and computation requirements of[44] the model.

- Collaborating with other researchers and stakeholders: Although the current model has been developed by a single team, there is a need to collaborate with other researchers and stakeholders to ensure the relevance and impact of the model. Future work could explore various opportunities, such as open science, open data, or open source, to share the model, the data, and the code with the wider community and to foster innovation and collaboration.
- Privacy and Security: Address privacy and security concerns associated with face recognition technology. Develop methods to protect user data and prevent unauthorized access to facial recognition systems, adhering to legal and ethical guidelines.

# User Manual

**Step1**: Click on Services

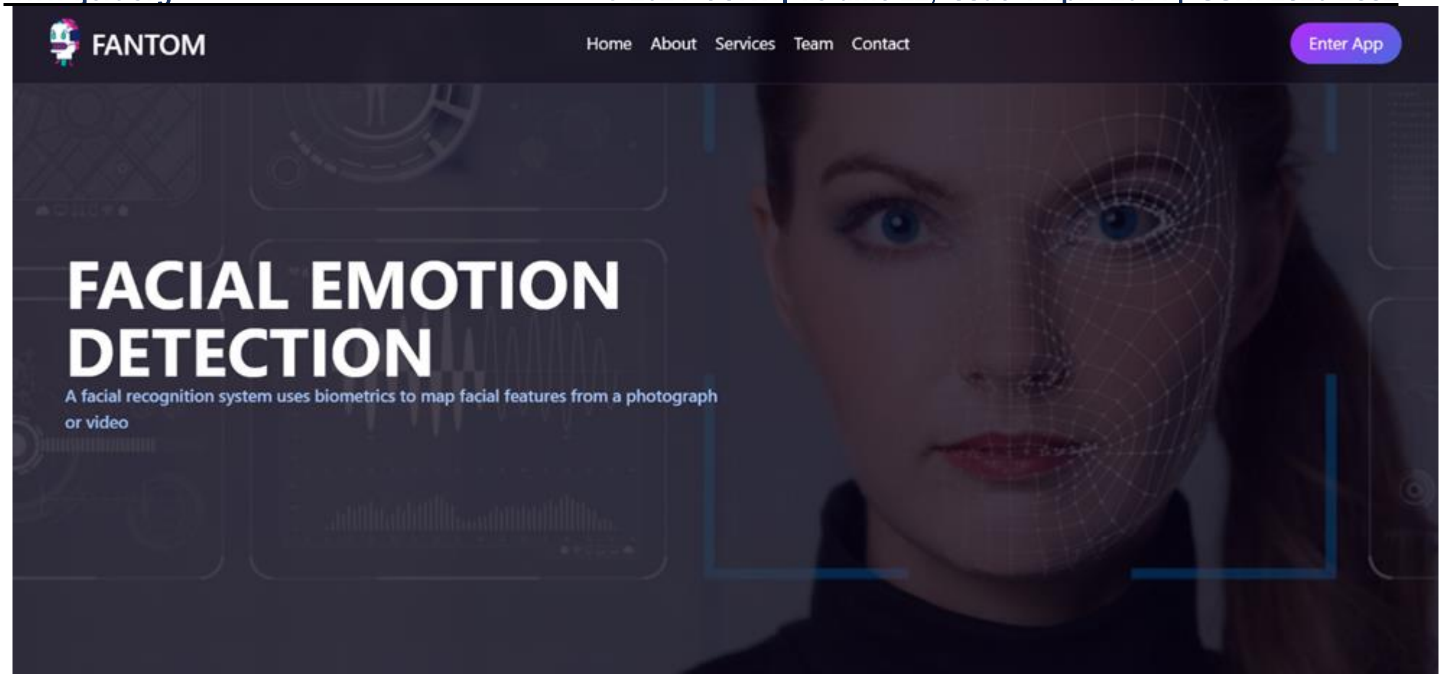



*Fig 6.1: Step1*

**Step2**: Choose Service which you want to go with

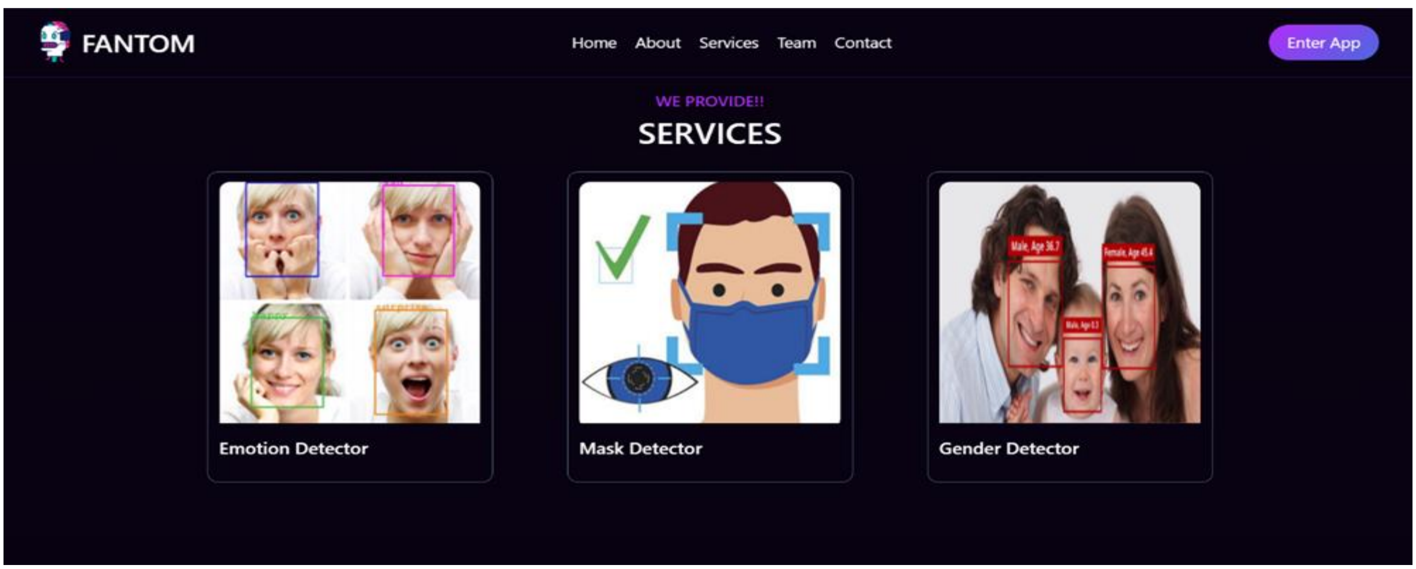



*Fig 6.2: Step2*

**Step3**: Click on any Service, for Emotion Detector, you will get following as output.


*Fig 6.3: Output1*

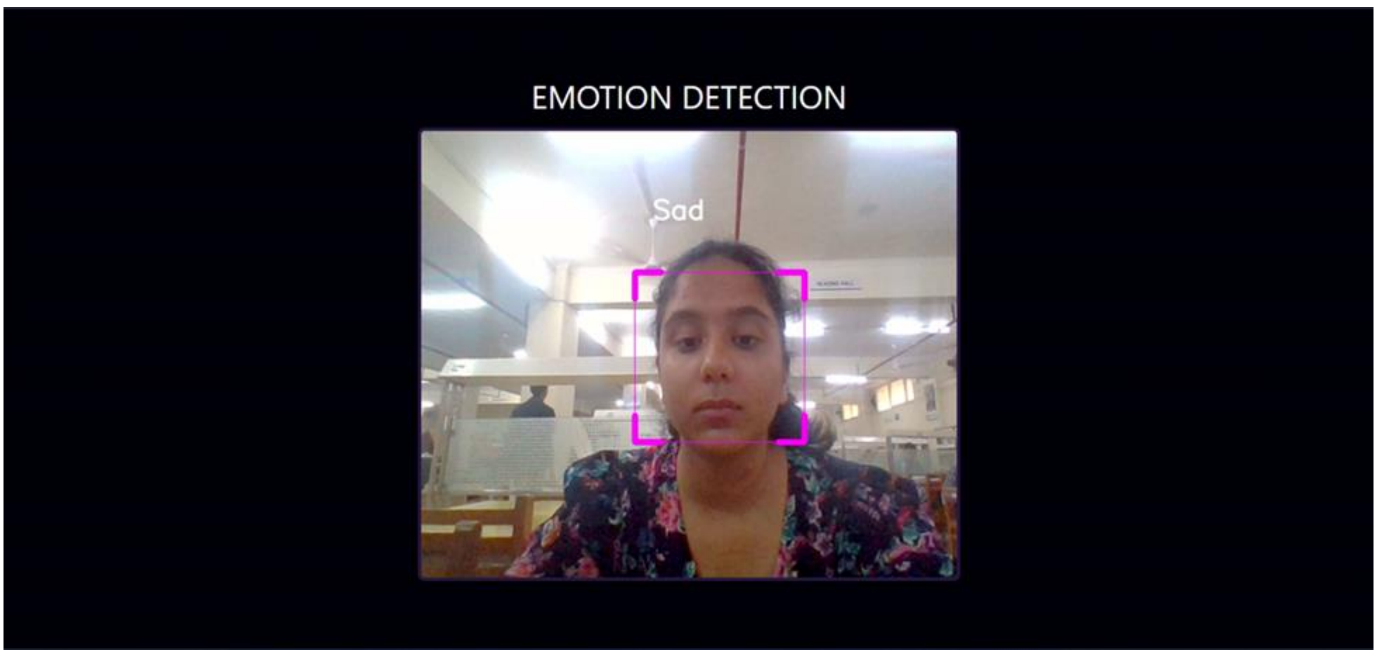



*Fig 6.4: Output2*

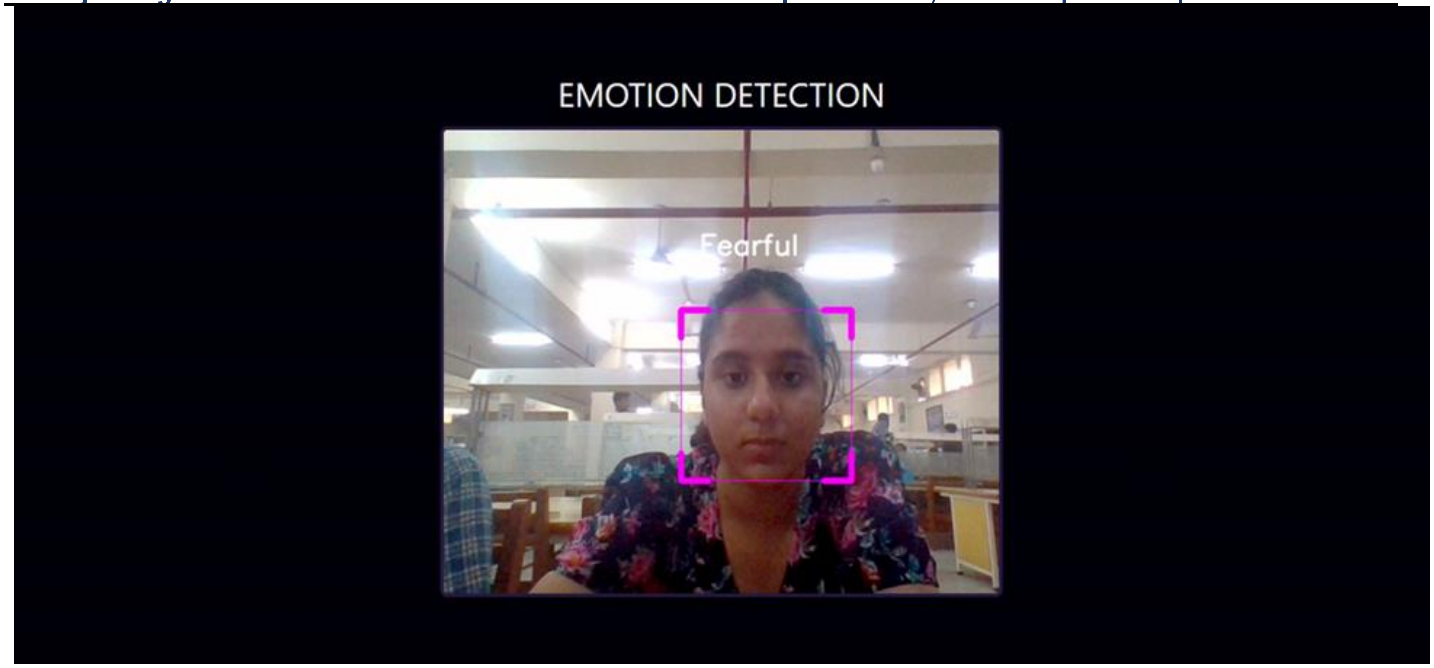



*Fig 6.5: Output*

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