**Chapter 1**

# Introduction

## 1.1 Introduction

Facial key points detection is a computer technology being used in a variety of applications that identifies human faces in digital images. Facial key points detection also refers to the psychological process by which humans locate and attend to faces in a visual scene. Face detection can be regarded as a specific case of object-class detection. In object-class detection, the task is to find the locations and sizes of all objects in an image that belong to a given class.[1]

## 1.2 Motivation

Detecting facial key points is a very challenging problem. Facial features vary greatly from one individual to another, and even for a single individual, there is a large amount of variation due to 3D pose, size, position, viewing angle, and illumination conditions. Computer vision research has come a long way in addressing these difficulties, but there remain many opportunities for improvement.[2]

## 1.3 Objective

The objective of this task is to predict key points positions on face images. This can be used as a building block in several applications, such as:

- Tracking faces in images and video
- Analyzing facial expressions
- Detecting dysmorphic facial signs for medical diagnosis
- Biometrics / face recognition
- Smart banking
- Forensic Investigation
- Security

## 1.4 Scope of the Work

Importance of Face Recognition System as a Security Solution Face is considered as the most important part of human body. Research shows that even face can speak and it has different words for different emotions. It plays a very crucial role for interacting with people in the society. It conveys people's identity, so it can be used as a key for security solutions in many organizations. Nowadays, face recognition system is getting increasing trend across the world for providing extremely safe and reliable security technology. It is gaining significant importance and attention by thousands of corporate and government organizations only because of its high level of security and reliability. Moreover, this system is providing vast benefits when compared to other biometric security solutions like palm print and finger print. As computation processing powers increases and large storage are available to store data, hence demand of it increases as it is used in several real-world applications.[3]

## 1.5 Outline of the Thesis

In “Introduction”, the 1st chapterof the book contains the information about project motivation, theobjective of the project and so on.

In “Literature Review”, the 2nd chapter of the book contains the information about Facial key points detection mechanism, Existing algorithms and its pros and cons, and a gentle overview of Machine learning, Deep learning and Convolutional Neural Network.

In “Existing system overview”, the 3rd chapter of the book contains the information about Existing system’s technical details and workflow, its pros and cons and features.

In “Proposed ML based facial key points detection system”, the 4th chapter of the book contains the information about Approach of proposed system, Diagram, Workflow and Merits.

In “Conclusion”, the 5th chapter of the book shows conclusion of this project.

## Chapter 2

# Literature Review

## 2.1 Introduction

Face detection is a computer technology that is being applied for many different applications that require the identification of human faces in digital images or video. It can be regarded as a specific case of object-class detection, where the task is to find the locations and sizes of all objects in an image that belong to a given class. The technology is able to detect frontal or near-frontal faces in a photo, regardless of orientation, lighting conditions or skin color.[1]

## 2.2 How Facial Key Points can be Detected?

Face detection applications use algorithms that decides whether an image is a positive image also called face image or negative image also called non-face image. This is called a classifier. To classify a new image correctly, it is trained on hundreds of thousands of face and non-face images. This feature answers the question “Where are the faces in this picture?”. For each face detected, you get a complete analysis of key points also called landmarks around the eyes, eye brows, jaw, nose and mouth.

## 2.3 Existing Key Points Detection Algorithms

OpenCV is a popular computer vision library started by Intel in 1999. The cross-platform library sets its focus on real-time image processing and includes patent-free implementations of the latest computer vision algorithms. OpenCV 2.3.1 now comes with a programming interface to C, C++, Python and Android. OpenCV 2.4 now comes with the very newFaceRecognizerclass for face recognition, so you can start experimenting with face recognition right away.[4] The currently available algorithms are:

- Eigenfaces
- Fisherfaces
- Local Binary Patterns Histograms

Among above mentioned available algorithms, Local Binary Patterns Histograms is the most widely used and most efficient algorithm.

### 2.3.1 Advantages

Some advantages of OpenCV face detection methods are:

- Computationally simple and fast
- Shorter training time
- Low false positive rate
- Better performance in offline learning system
- Vision based system
- Lower configuration PC required

### 2.3.2 Disadvantages

Some disadvantages of OpenCV face detection methods are:

- Not a knowledge-based system
- Cannot be used in online learning system
- Difficult to evolve

## 2.4 Machine Learning, Deep Learning and Convolutional Neural Network

### 2.4.1 Machine Learning

Machine learning is an application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience without being explicitly programmed. Machine learning focuses on the development of computer programs that can access data and use it learn for themselves.[5]

### 2.4.2 Deep Learning

Deep learning is a subset of machine learning in Artificial Intelligence (AI) that has networks capable of learning unsupervised from data that is unstructured or unlabeled. Also known as Deep Neural Learning or Deep Neural Network.[5]

### 2.4.3 Convolutional Neural Network

A convolutional neural network (CNN) is a type of artificial neural network used in image recognition and processing that is specifically designed to process pixel data.
CNNs are powerful image processing, artificial intelligence (AI) that use deep learning to perform both generative and descriptive tasks, often using computer vision that includes image and video recognition, along with recommender systems and natural language processing.[5]

## 2.5 Summary

In this chapter it is discussed where the system is being applied for. It is also shown that the system can be regarded as a specific case of object-class detection. Hundreds of thousands of face and non-face images data are fed to the system to classify new image correctly. OpenCV classifiers are existing solution to the system. Its pros and cons are also described in the chapter. Finally, a gentle overview to the Machine Learning, Deep Learning and Convolutional Neural Network is provided.

**Chapter 3**

# Existing System Overview

## 3.1 Introduction

OpenCV is a popular computer vision library started by Intel in 1999. The cross-platform library sets its focus on real-time image processing and includes patent-free implementations of the latest computer vision algorithms. OpenCV 2.3.1 now comes with a programming interface to C, C++, Python and Android. OpenCV 2.4 now comes with the very newFaceRecognizerclass for face recognition, so you can start experimenting with face recognition right away.[4] The currently available algorithms are:

- Eigenfaces
- Fisherfaces
- Local Binary Patterns Histograms

Among above mentioned available algorithms, Local Binary Patterns Histograms is the most widely used and most efficient algorithm.

## 3.2 OpenCV

Local Binary Patterns methodology is most widely used over the world for face detection. It is famous for its high accuracy. Hence it is used in this thesis for its high accuracy. Local Binary Patterns methodology has its roots in 2D texture analysis. The basic idea of Local Binary Patterns is to summarize the local structure in an image by comparing each pixel with its neighbourhood. Take a pixel as centre and threshold its neighbours against. If the intensity of the centre pixel is greater-equal its neighbour, then denote it with 1 and 0 if not. You'll end up with a binary number for each pixel, just like 11001111. So with 8 surrounding pixels, you'll end up with 2^8 possible combinations, called *Local Binary Patterns* or sometimes referred to as *LBP codes*. The first LBP operator described in literature actually used a fixed 3 x 3 neighbourhood just like this:

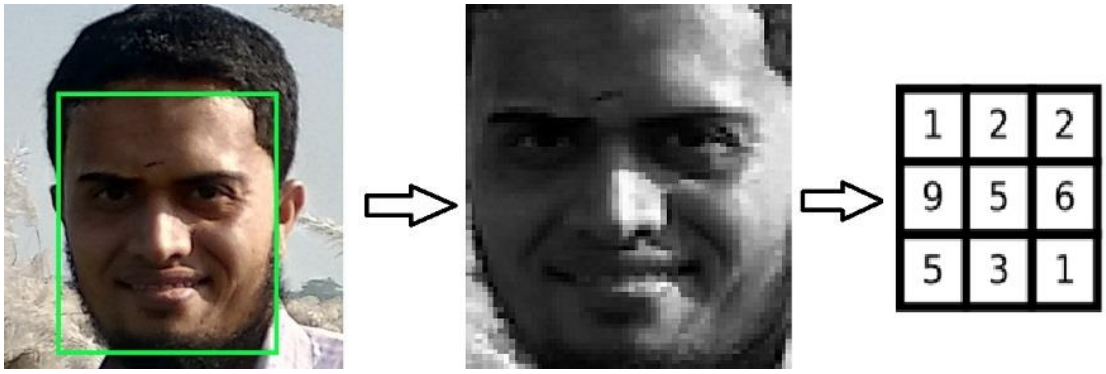


**Fig 3.1: Image conversion**

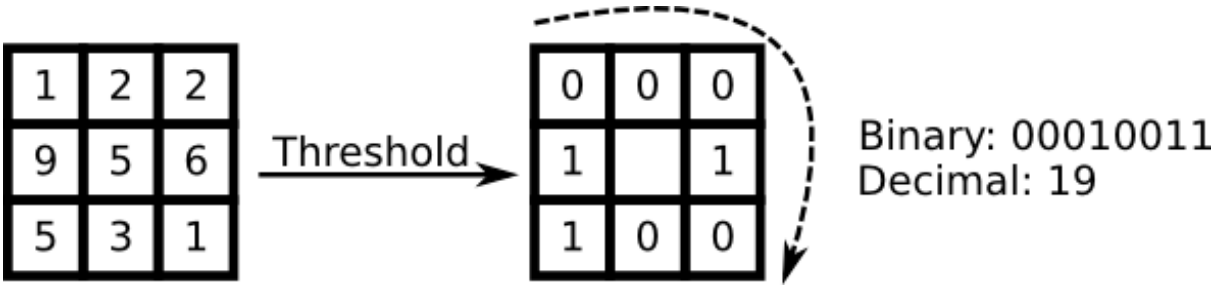


**Fig 3.2: LBP method**

A more formal description of the LBP operator can be given as:

$$LBP(x_c, y_c) = \sum_{p=0}^{P-1} 2^p s(i_p - i_c)$$

, with $(x_c, y_c)$ ascentral pixel with intensity $i_c$; and $i_n$ being the intensity of the neighbor pixel. $s$ is the sign function defined as:

$$s(x) = \begin{cases} 1 & \text{if } x \geq 0 \\ 0 & \text{else} \end{cases}$$

By definition, the LBP operator is robust against monotonic grey scale transformations. Dividing the LBP image into m local regions and extract a histogram from each. These histograms are called *Local Binary Patterns Histograms*.[4]

## 3.3 Workflow

Face Recognition process is about three steps:

- Prepare Training Data: Read training images for each person/subject along with their labels, detect faces from each image and assign each detected face an integer label of the person it belongs.
- Train Face Recognizer: Train OpenCV's LBPH recognizer by feeding it the data we prepared in step 1.
- Apply Test Data: Image data that will be tested against the model are applied to the model.
- Prediction: Introduce some test images to face recognizer and see if it predicts them correctly.[6]
- Result: Get the result after prediction and it is further processed in the next phase of the system.
- Analysis: After get the result of the system, it is analyzed with respect to some predefined threshold value.

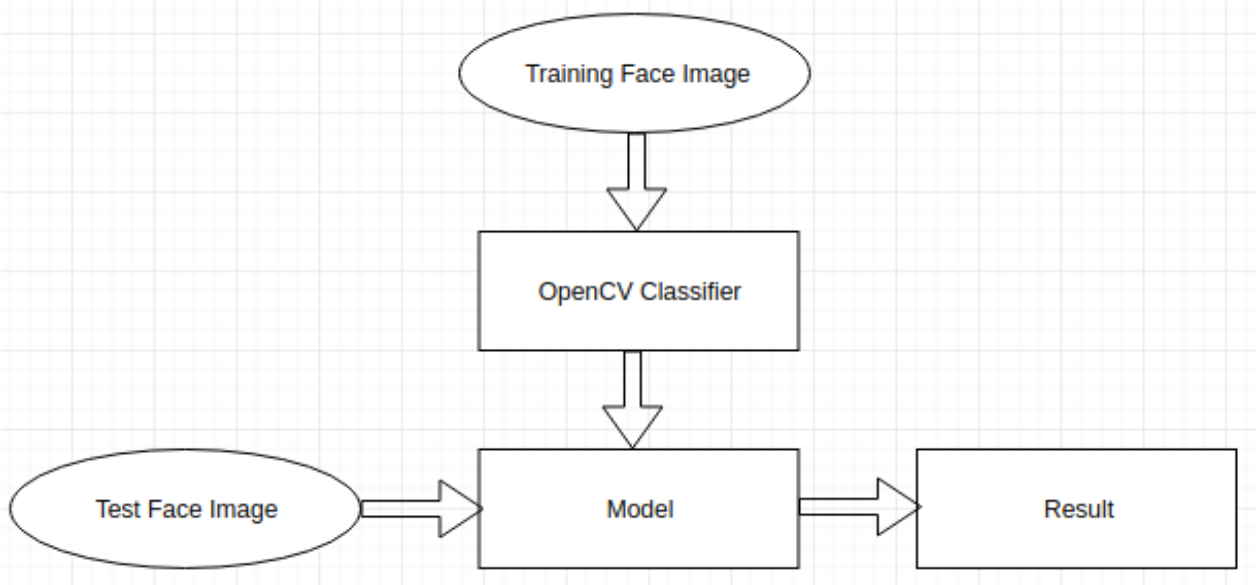


**Fig 3.3: Workflow of existing system**

## 3.4 Advantages and Disadvantages

### 3.4.1 Advantages

Some advantages of OpenCV face detection methods are:

- Computationally simple and fast
- Shorter training time
- Low false positive rate
- Better performance in offline learning system

### 3.4.2 Disadvantages

Some disadvantages of OpenCV face detection methods are:

- Not a knowledge-based system
- Cannot be used in online learning system
- Difficult to evolve

## 3.5 Summary

In this chapter it is discussed what OpenCV is. It is also shown that what methods of face detection are offered by OpenCV and how to use that methods. OpenCV's technical details, to be specific how Local Binary Pattern method works are discussed here. It also depicts workflow of OpenCV face detection and its pros and cons are also described in the chapter.

**Chapter 4**

# Proposed Machine Learning Based Facial Key Points Detection System

## 4.1 Introduction

In this proposed system, the combined knowledge of computer vision techniques and deep learning architectures will be applied to build a facial key points detection system. Facial key points include points around the eyes, nose, and mouth on a face and are used in many applications. This system has several applications including facial tracking, facial pose recognition, facial filters, and emotion recognition. The final system should be able to look at any image, detect faces, and predict the locations of facial key points on each face.[7]

## 4.2 Approach of the Proposed System

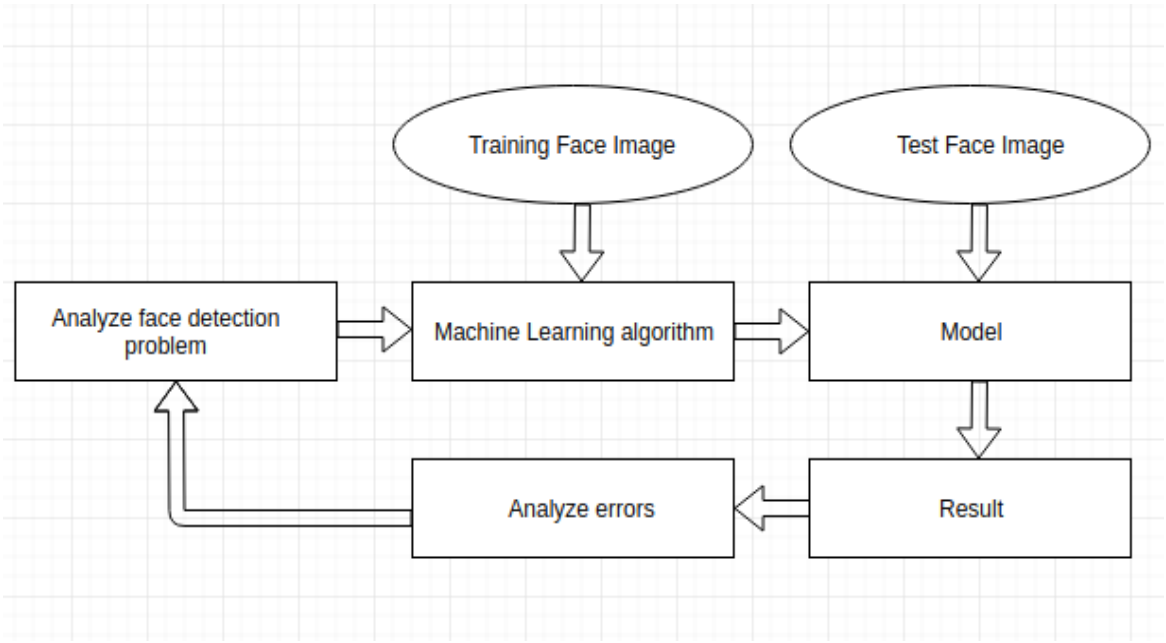


**Fig 4.1: Proposed ML based system**

In the proposed system, analysis of the face detection problem is performed at first. It includes data cleaning, data visualization and features extraction. If this phase is completed successfully then the next phase of the system is performed which is applying Machine Learning algorithm. An appropriate Machine Learning algorithm is applied on training data such as Logistic regression, Deep Learning, Convolutional Neural Network etc. After applying the Machine Learning algorithm, a model can be obtained and test data are applied on that model. Result are obtained after scientific computation of the particular algorithms. And then error analysis of the model is performed. If error rate is greater than a threshold value then changes to model are required else the model is deployed. Otherwise, the problem is analyzed again in similar fashion. This process is repetitive.[8]

## 4.3 Workflow of the Proposed System

### 4.3.1 User Perspective

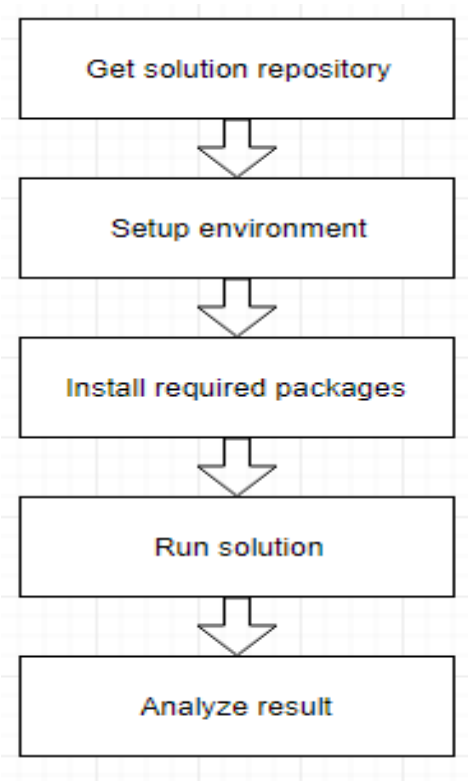


**Fig 4.2: User perspective workflow**

User needs to get the solution repository either from git or from other sources. Then he should install Python 3.5, Tensorflow latest version, Keras Latest version and install other packages through pip package manager. These packages are required to perform scientific computation, visualization etc. Then it is required to run the solution along with data. Finally, it needs to collect result and analyze it.

## 4.4 Features

Some features of the proposed system are:

- This system is a knowledge-based system
- It can be used in online learning system
- It is easy to evolve the model
- It is possible to automate the learning system

## 4.5 Merits of the System

Some merits of the proposed system are:

- Detect facial key points with high accuracy
- Easy to use in time series problem
- Low false positive rate
- Improved computing performance with short training time

## 4.6 Required Tools

### 4.6.1 Hardware Tools

Required hardware tools for the proposed system are:

- CPU: Core i7 at least 3.0 GHz and quad core
- RAM: 16 GB
- GPU: Nvidia graphics at least 3 GB
- Auxiliary Storage: 512 GB SSD with 1 TB HDD

### 4.6.2 Software Tools

Required software tools for the proposed system are:

- Python 3.5
- IDE
- Numpy
- Matplotlib
- Pandas
- Seaborn
- Tensorflow
- Keras

## 4.7 Summary

In this chapter proposed system is discussed in details. A diagram is also provided that depicts how the proposed system will work and its description provided as well. A user view workflow, features and merits of the proposed system is also given. Finally, required tools for the proposed system is also mentioned.

**Chapter 5**

# Conclusion

## 5.1 Conclusion

Detecting facial keypoints is a very challenging problem. Facial features vary greatly from one individual to another due to position, viewing angle, and illumination conditions. Computer vision research has come a long way in addressing these difficulties, but there remain many opportunities for improvement. This proposed system will provide high accuracy performance to detect facial key points using latest trending technologies.

## 5.2 Future Work

Future work of this thesis is to build more accurate machine learning model so that it will be able to determine facial key points better. Suitable, advanced and new machine learning methods will be applied to enhance the system. The portable binary version of the mini project will be made and package will also be available so that other developers can include it easily.

# REFERENCES

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[8] Aurelien Geron, 13 March 2017, Hands-On Machine Learning with Scikit-Learn and TensorFlow