# REAL-TIME FACE RECOGNITION SYSTEM USING RADIAL BASIS FUNCTION NEURAL NETWORKS

*(Keywords : Real-time, face recognition system, radial basis function, neural network, image processing)*

Face detection is the first step in face recognition system. The purpose is to localize and extract the face region from the background that will be fed into the face recognition system for identification. This project used general preprocessing approach for normalizing the image and Radial Basis Function (RBF) Neural Network will be used for face recognition. As for the detection process, new reduced set method for Support Vector Machines is used. The image will then be resized converted into grayscale format. The RBF network is trained using the user image and tested using several faces. Radial Basis Function (RBF) Neural Network was used to distinguish between the user face and imposter. RBF Neural Networks offer several advantages compared to other neural network architecture such as they can be trained using fast two stages training algorithm and the network possesses the property of best approximation. The performance of the RBFNN face recognition system will be based on the False Acceptance Rate (FAR) and the False Rejection Rate (FRR).

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# LIST OF ABBREVIATIONS

| | | |
|---|---|---|
| ANN | - | Artificial Neural Network |
| ATM | - | Automatic Teller Machine |
| CBCL | - | Center For Biological and Computation |
| CBIR | - | Content Based Image Retrieval |
| ED | - | Experiment Design |
| FA | - | Factor Analysis |
| FAR | - | False Acceptance Rate |
| FERET | - | Facial Recognition Technology |
| FRR | - | False Rejection Rate |
| FRT | - | Face Recognition Techniques |
| LDA | - | Linear Discriminant Analysis |
| OED | - | Optimum Experiment Design |
| ORL | - | Olivetti Research Laboratory |
| MD | - | Maximin distance |
| MIT | - | Massachusetts Institute of Technology |
| MLP | - | Multi-Layer Perceptrons |
| NN | - | Neural Networks |
| PCA | - | Principal Component Analysis |
| PDM | - | Point Distributed Models |
| RBF | - | Radial Basis Function |
| RBFNN | - | Radial Basis Function Neural Networks |
| RGB | - | Red-Green-Blue |
| SOFM | - | Self-Organizing Feature Maps |
| SVM | - | Support Vector Machine |
| XM2VTS | - | Extended Multi Modal Verification for Teleservices and Security applications database |

# LIST OF SYMBOLS

| | | |
|---|---|---|
| $A$ | - | Constant |
| $\hat{A}$ | - | Input space |
| $\Xi$ | - | Discrete design |
| $o_i$ | - | Neural Network input signal |
| $o_j$ | - | Neural Network output signal |
| $\sigma_i$ | - | Receptive field controller |
| $\varphi_j$ | - | Hidden unit |
| $p_i$ | - | Measurement weight |
| $w_i$, | - | Center |
| $x_i$ | - | Data sample |
| $X$ | - | Input set |
| $Y$ | - | k-dimensional space of the vectors |

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# CHAPTER 1

# INTRODUCTION

## 1.1. Background

Biometrics deals with the identification of individuals based on their biological or behavioral characteristics [13]. By using that trait to obtain a biometric enrollment, we can say that with a degree of certainty that someone is the same person in future biometric authentications based on their previous enrollment authentications [16]. The problem of resolving the identity of a person can be categorized into two fundamentally distinct types that are verification and recognition. Accurate identification of a person could deter crime and fraud, streamline business processes, and save critical resources [13]. Biometric identification has the potential to virtually eliminate there problems [15]. No single biometrics is expected to effectively satisfy the needs of all identification applications. A number of biometrics have been proposed, researched and evaluated for identification applications. Face is one of the most acceptable biometrics because it is one of the most common methods of identification which humans use in their interactions [13].

Face recognition from images is a sub-area of the general object recognition problem. A scene may or may not contain a set of faces, therefore if it does, their locations and sizes in the image must be estimated before recognition can take place by a system that can recognize only canonical faces. A face detection task is to report the location, and typically also the size, of all faces from a given image [13]. The process starts when an image that is obtained from sensors or cameras and the processing task will be done to the image according to the application. There are many areas that are related with image detection and recognition such as military and defense, security system, surveillance monitoring, biomedical engineering systems, health monitoring, surgery, intelligent transportation systems, manufacturing, robotics, entertainment, and security systems [3].

The application of image detection and recognition had been increased slowly in the past due to the constraint in the technology, processing power and also because of the high cost of developing the system [5]. Due to the advances in technology, the research had increased and solve many problem related to image processing. As a part of image detection and recognition, face detection is also a crucial and important. Face detection is the early process before the face recognition process. The output of the face detection system will be the input to the face recognition system. Same as the application of image detection, face detection is used widely in security system.

With the development of biometric fusion system, the face detection and recognition had been fused with other biometric such as fingerprint, iris, signature, voice and etc. The design of biometric system to recognize a person based on information acquired from multiple biometric sources offers several advantages over traditional biometric system such as reduces the False Acceptance Rate (FAR) and False Rejection Rate (FRR) [14].

## 1.2. Project Objectives

The main objective of this project is to develop a real-time face recognition system using radial basis function (RBF) neural network. The algorithm and graphical user interface are developed using MATLAB.

Next, the project objective is to compare the result of using fixed and variance spread values of RBF for face detection. The system will focus on appearance based approach. In this part, both sets of sample face and non-face data are trained to form an interconnection of artificial neurons and processes information. The system will then classified all the inputs as face or non-face.

Finally the system's performance will be measured according to the rate of detection of the real user and imposter.

# CHAPTER 2

# BACKGROUND

## 2.1 Introduction of Face Detection

Face can be defined as the front part of head from the forehead to the chin [11]. Face detection is a difficult computer vision problem. There are many variation factors affecting detection accuracy. In order to simplify the task, many researchers focus only on developing detection algorithms for frontally view faces. For application such as ATM access control, one can assume that rightful users will show their faces to the camera in an upright position. The face detector needs to carefully comb through arbitrary scenes to screen out false facial patterns while remain responsive to the true face patches [15]. In object-class detection, the main task is to find the sizes and locations of all objects in an image that belong to a given class. In other word we are to determine whether there is face or not in the image. Face detection can be regarded as a more general case of face localization. In face localization, the task is to find the locations and sizes of a known number of faces [6].

## 2.2. Methods for Face Detection in a Single Image

Numerous techniques have been developed to detect faces in a single image. The methods can be classified into two main categories that are feature based approach and image based approach [5]. Researchers normally will choose either one of these categories even though some had tried to combine these techniques [17]. All of these categories will be explained briefly in this section. Figure 2.1 shows the face detection categories.

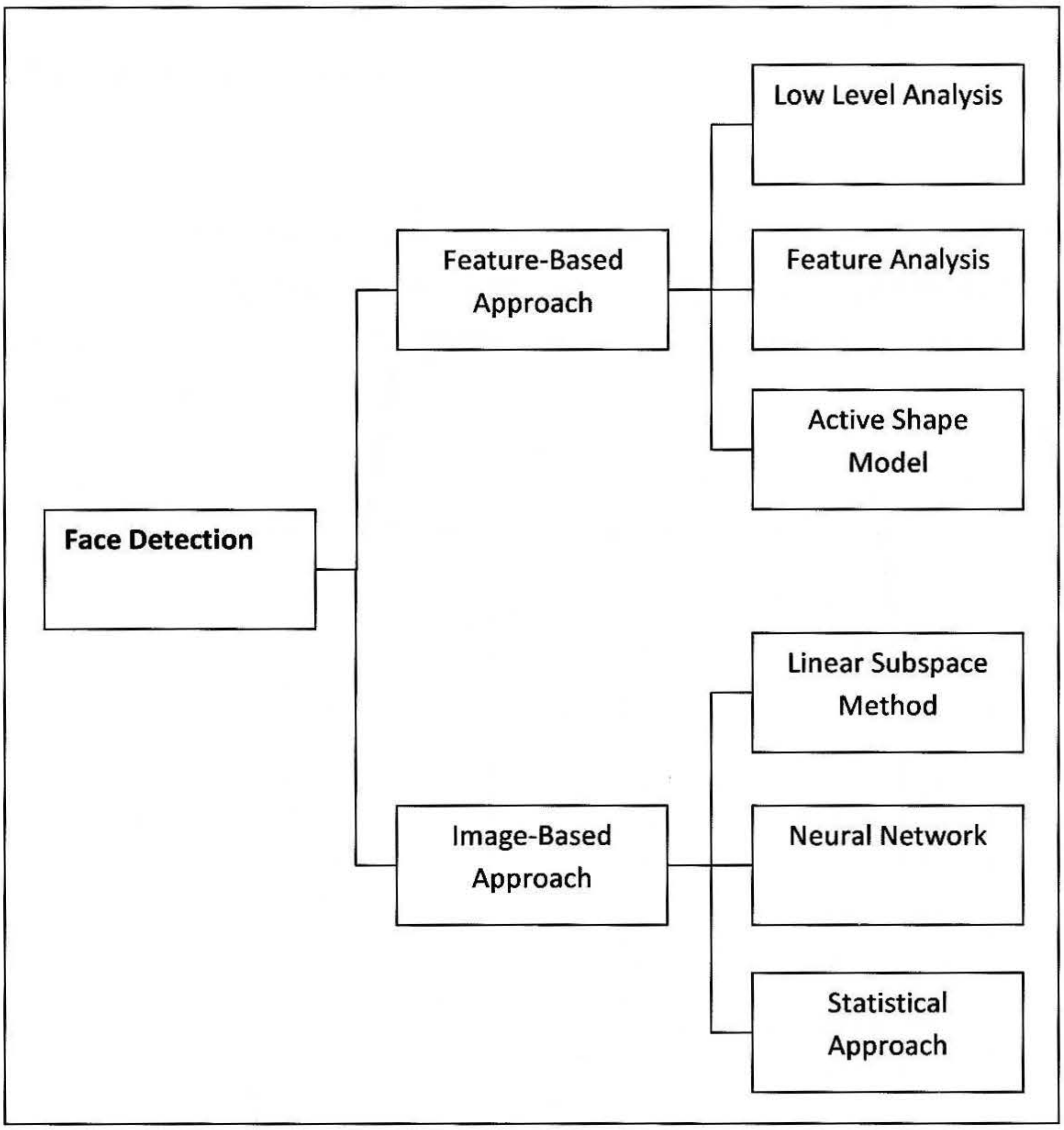



Figure 2.1 Face Detection Methods in a single image

### 2.2.1. Feature-Based Approach

Feature-based approach can be divided into three areas that are Low Level Analysis, Feature Analysis and Active Shape Model. Feature-based approach make explicit use of face knowledge and follow the classical detection methodology where the low level features are derived prior before goes to the knowledge-based analysis [5][24]. The apparent properties of the face such as skin color, face geometry, and all other visual features are manipulated at different system levels. This technique was termed feature-based approach as feature is the main component [5].

#### 2.2.1.1 Low Level Analysis

For an image containing faces with a cluttered scene, low-level analysis first deals with the segmentation of visual features using pixel properties such as grayscale and color. Low level analysis can be divided into five components as shown in Figure 2.2.

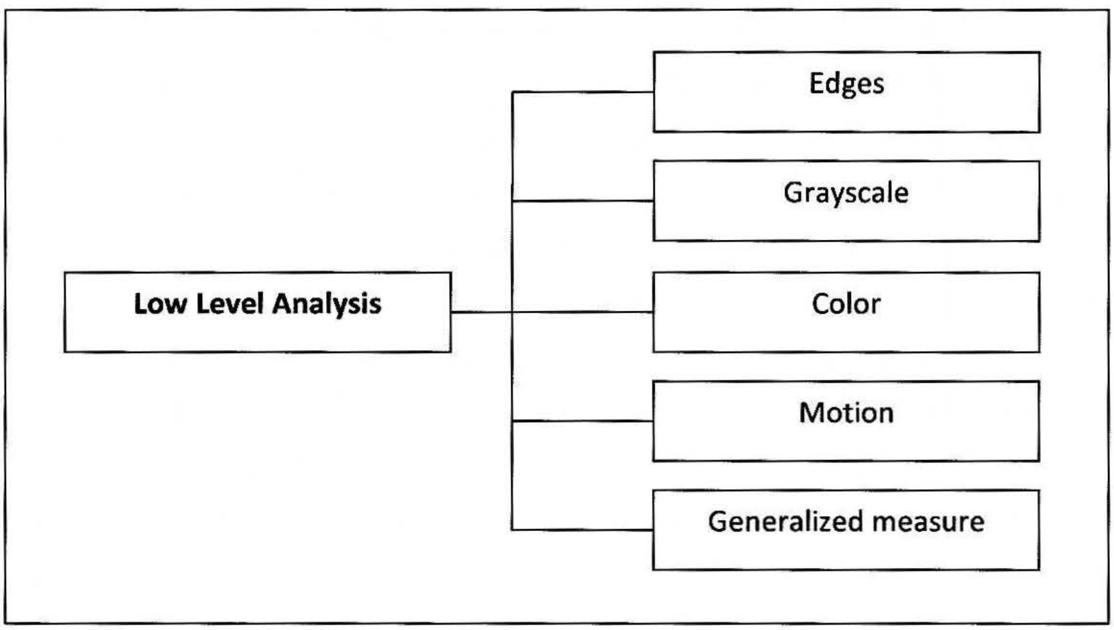



Figure 2.2: Low level analysis approach

Edge representation is the most primitive feature in computer vision applications. It was applied in the earliest face detection work by Sakai *et al.* The work was based on analyzing line drawings of the faces from photographs, aiming to locate facial features. In order to derive edge representation in edge detection, many different types of edge operators have been applied. The Sobel operator was the most common filter that had been used. In an edge-detection-based approach to face detection, edges need to be labeled and matched to a face model in order to verify correct detections [5].

In Grayscale representation, the gray information within a face can also be used as features. Facial features such as eyebrows, pupils, and lips appear generally darker than their surrounding facial regions. This property can be exploited to differentiate various facial parts. Several facial feature extraction algorithms used to search for local gray minima within segmented facial regions. In these algorithms, the input images are first enhanced by contrast-stretching and gray-scale morphological routines to improve the quality of local dark patches and thereby make detection easier. The extraction of dark patches is achieved by low-level gray-scale thresholding [5].

As gray information provides the basic representation for image features, color is a more powerful means of representing the object appearance. Due to the extra dimensions that color has, two shapes of similar gray information might appear very differently in a color space. It was found that different human skin color gives rise to a tight cluster in color spaces even when faces of difference races are considered. One of the most widely used color models is RGB representation in which different colors are defined by combinations of red, green, and blue primary color components. Besides RGB color models, there are several other alternative models currently being used in the face detection research that is HSI color representation. These models are used to extract facial features such as lips, eyes, and eyebrows [5].

Motion information is a convenient means of locating moving objects in a video sequence. Frame difference analysis is a way to achieve motion segmentation. This approach is able to recognize a moving foreground efficiently regardless of the background content. Another way of measuring visual motion is through the estimation of moving image contours. Compared to frame difference, results generated from moving contours are always more reliable, especially when the motion is insignificant. Besides the methods described above, there are also methods rely on the accurate estimation of the apparent brightness velocities called optical flow. Because the estimation is based on short-range moving patterns, it is sensitive to fine motion [5].

Reisfeld *et al.* [45] proposed that machine vision systems should begin with pre-attentive low-level computation of generalized image properties. Since facial features are symmetrical in nature, the operator which does not rely on higher level a priori knowledge of the face effectively produces a representation that gives high responses to facial feature locations. The symmetry measure assigns a magnitude at every pixel location in an image based on the contribution of surrounding pixels [5].

#### 2.2.1.2 Feature Analysis

In feature analysis, visual features are organized into a more global concept of face and facial features using information of face geometry. Although feature generated from this analysis are ambiguous because of the low-level nature, visual features are organized into more global concept of face and features using information of face geometry. The feature ambiguities are reduced and the locations of the face and facial features are determined. Figure 2.3 shows the two approaches in the application of face geometry.

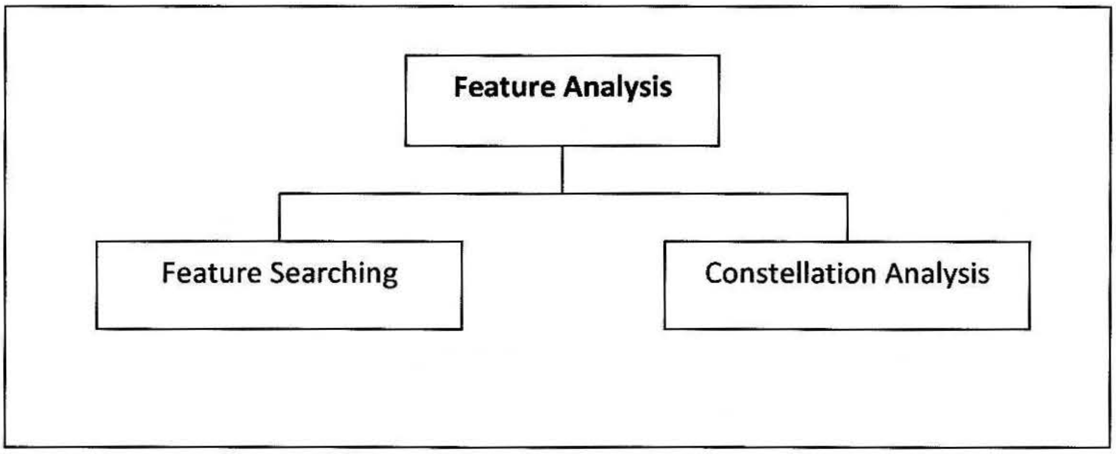


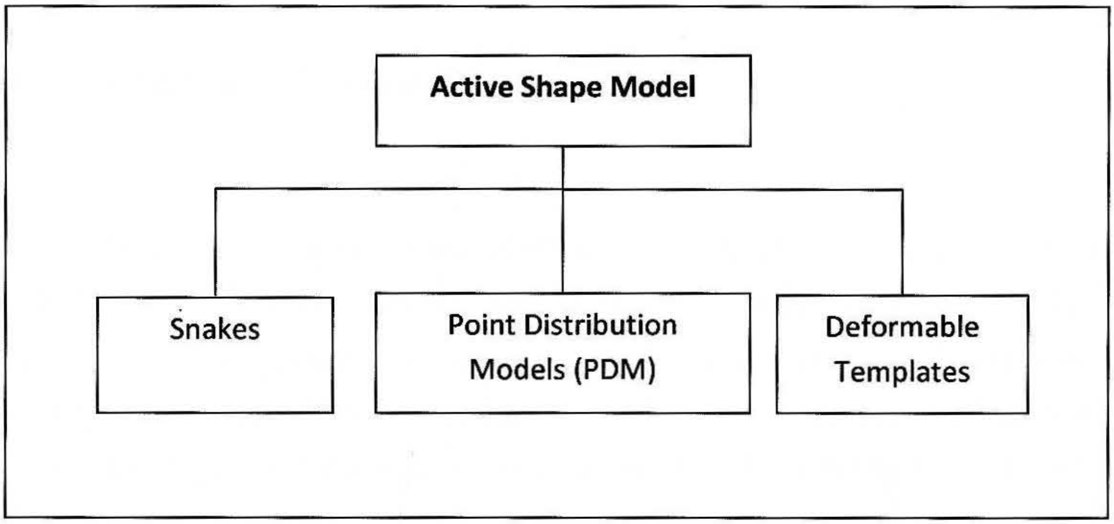

Figure 2.3: Feature Analysis approach

Feature searching techniques begin with the determination of prominent facial features. The detection of the prominent features then allows for the existence of other less prominent features to be hypothesized using anthropometric measurements of face geometry [5].

In constellation analysis, facial features in face-like constellations are group using more robust modeling methods such as statistical analysis. A probabilistic model for the spatial arrangement of facial features enables higher detection flexibility. The algorithm is able to handle missing features and problems due to translation, rotation, and scale to a certain extent. In face recognition systems, one of the most widely used techniques is graph matching. Graphs store local feature information in feature vectors at their nodes and geometrical information in their edges [5].

### 2.2.1.3 Active Shape Model

The next group involves the use of active shape models. These models ranging from snakes, proposed in the late 1980s, to the more recent point distributed models (PDM) have been developed for the purpose of complex and non-rigid feature extraction such as eye pupil and lip tracking. Figure 2.4 shows the active shape approach components.




2.4: Active Shape Model Approach

Active contours, or snakes, are commonly used to locate a head boundary. In order to achieve the task, a snake is first initialized at the proximity around a head boundary. It then locks onto nearby edges and subsequently assumes the shape of the head. Two main considerations in implementing a snake are the selection of the appropriate energy terms and the energy minimization technique. Elastic energy is used commonly as internal energy. It is proportional to the distance between the control points on the snake and therefore gives the contour an elastic-band characteristic that causes it to shrink or expand. The external energy consideration is dependent on the type of image features considered [5].