CHAPTER I

Introduction

1.1 Background and Motivation

With the ubiquity of new information and media, more effective and friendly methods for human computer interaction (HCI) are being developed which do not rely on traditional devices such as keyboards, mice, and displays. Furthermore, the ever decreasing price/performance ratio of computing, coupled with recent decreases in video image acquisition cost, implies that computer vision systems can be deployed in desktop and embedded systems [1–3]. The rapidly expanding research in face processing is based on the premise that information about a user's identity and intent can be extracted from the face images, and that computers can then react accordingly. In the last five years, face and facial expression recognition have attracted much attention though they have been studied for more than 20 years by psychophysicists, neuroscientists, and engineers. Many research demonstrations and commercial applications have been developed from these efforts. The first essential step of face processing is detecting the locations of face and facial features such as eyes, nose, mouth, etc. The identification of face and facial features also plays an important role in many other face applications such as video surveillance, face tracking, and face recognition. From this reason, the detection method should be able to handle various practical and artificial problems. A definition of face detection is defined as follows: given an image, the target is to determine whether or not there are any faces in the image and, if any, return the face location. In the case

of facial feature detection, the goal is to detect the presence and location of features after the locations of faces are extracted using existing face detection methods. The challenges associated with face and facial feature detection can be attributed to the following factors [4]:

- **Intensity.** There are three types of intensity: color, gray, and binary.
- **Pose.** The face images vary due to the relative camera-face pose (frontal, 45 degree, profile), and some facial features such as an eye may become partially or wholly occluded.
- **Structural components.** Facial features such as beards, mustaches, and glasses may or may not be presented and there is a great deal of variability among these components including shape, color, and size.
- **Facial expression.** The appearance of faces depends on a person's facial expression.
- **Occlusion.** Faces may be partially occluded by other objects such as hand, scarf, etc.
- **Image rotation.** Face images directly vary for different rotations.
- **Image conditions.** Factors such as lighting effects and camera characteristics affect the appearance of a face when the image is formed.
- **Poor quality.** Image intensity in poor-quality images, for instance, blurry images, distorted images, and images with noise, becomes unusual.
- **Unnatural intensity.** Cartoon faces (color cartoon and sketchy cartoon) and rendered faces from 3D model have unnatural intensity.

Existing techniques aim to accurately detect facial features. However, they are not applicable to all images with any of the above factors or combinations. In addition, those techniques are based on the usage of intensity information as input. Thus, the accuracy of the algorithms depend upon intensity information. To overcome this limitation for extending to any face images, the input should be obtained from the position and shape information. In this dissertation, face and facial feature detection algorithms are developed to handle a wide range of variations in face images with above attributes, based on neural network and image processing techniques without intensity information. The proposed approach can be used as the first step of any face processing systems. Individual detected faces and facial features are adequate to be applied for face recognition. Moreover, the detected features can be separately reconstructed in three-dimensional face reconstruction applications.

1.2 Objective

This dissertation proposes algorithms for locating facial features (eyes, nose, and mouth) without considering the appearance of image context by using neural networks and image processing techniques. It is expected that the approach from the dissertation can be applied to accurately extract the features in any face images.

1.3 Scope of Work

In this dissertation, the proposed algorithms are based on multilayer perceptron network, mathematical morphology, and the Radon transform. Among the various facial features, eyes, nose and mouth are the most prominent features for face processing system. Rectangular boundaries of the features are stored regardless of texture or intensity. One constraint is that there is only one face in the image under consideration with black

background and fixed size (128 × 128 pixels). The inputs are numeric data obtained from position and face shape information. The data are trained to attain the predefined outputs. The performance of the proposed algorithms are measured by testing the algorithms with some existing benchmarks such as ESSEX-face database [5], AR-face database [6], and MIT-CMU database [69].

1.4 Contributions

The proposed face and facial feature detection algorithms that are able to handle a wide range of variations in face images, whereby contribute to facial image processing as follows:

(1) Extract the edge of an image from the original image using Canny edge detection since the edge is rather independent of the intensity information;

(2) Generate mean face template from average intensity of faces at same size in the databases [5–7];

(3) Detect a face region from the region having the number of pixels corresponding to mean face template and high matching value;

(4) Apply neural visual model (NVM) to recognize and extract all possibilities of facial feature locations. Input parameters are obtained from the face characteristics and the locations of facial features which are independent of the intensity information;

(5) Enhance the results using image dilation for removing some irrelevant regions;

(6) Extend to rotated face image using Radon transform; and

(7) Analyze the proposed method by comparing detected faces and facial features, detection rate, and the number of false positives with other existing techniques.

1.5 Dissertation Organization

The remainder of the dissertation is organized as follows. Chapter 2 presents existing related works. Chapter 3 describes the face detection algorithm. Chapter 4 presents facial feature detection algorithms. Experimental results are shown in Chapter 5. Chapter 6 concludes the dissertation.