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A Hybrid Approach to Human Face Detection

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ABSTRACT

Face detection is the problem of determining whether a sub-window of an image contains a face or not.The rapidly expanding research in face processing is based on the premise that information about a user's identity, state, and intent can be extracted from images, and that computers can then react accordingly.

This hybrid face detection system is combination of two methods i.e. Feature Extraction method and Neural Networks method. This method works in two stages. The **first stage** involves extraction of **pertinent features** from the localized facial image using **Gabor filters**. **Second stage** requires classification of facial images based on the derived feature vector obtained in the previous stage. And so a **Neural Network Based** classifier is used which examines an incremental small window of an image to decide if there is a face contained in each window. The neural network is trained to choose between two classes **'faces'** and **'non-faces'** images. To decrease the amount of time needed for detection and to enhance image's quality, processing the image before training the neural network on these two classes enhances the algorithm. Training a neural network for the face detection task is a challenging job due to the difficulty in characterizing **'non-face'** images. It is easy to get a representative sample of images that contain faces but it is much harder to get a representative sample of those images that do not contain faces.

INTRODUCTION

A first step of any face processing system is detecting the locations in images where faces are present. However, face detection from a single image is a challenging task because of variability in scale, location, orientation (up-right, rotated), and pose (frontal, profile). Facial expression, occlusion, and lighting conditions also change the overall appearance of faces.

Numerous methods have been proposed to detect faces in an image. **Image detection methods** can be classified into **four categories:**

1. Knowledge-based methods: These rule-based methods encode human knowledge of what constitutes a typical face. Usually, the rules capture the relationships between facial features. These methods are designed mainly for face localization. **Yang and Huang [1]** used a hierarchical knowledge-based method to detect faces.

2. Feature invariant approaches: These algorithms aim to find structural features that exist even when the pose, viewpoint, or lighting conditions vary, and then use these to locate faces. These methods are designed mainly for face localization. Edge representation was applied to early face detection system by Sakai et al**. [2].**

3. Template matching methods: Several standard patterns of a face are stored to describe the face as a whole or the facial features separately. The correlations between an input image and the stored patterns are computed for detection. These methods have been used for both face localization and detection. An early attempt to detect frontal faces in photographs is reported by **Sakai et al. [3].** They used several sub templates for the eyes, nose, mouth, and face contour to model a face.

4. Appearance-based methods: In contrast to template matching, the models (or templates) are learned from a set of training images, which should capture the representative variability of facial appearance. These learned models are then used for detection. These methods are designed mainly for face detection. Among all the face detection methods that used neural networks, the **most significant** work is done by Henry A. Rowley, Shumeet Baluja, and Takeo Kanade **[4] [5] [6].**

2. IMPLEMENTATION OF METHODOLOGY USED

1) Introduction to Gabor Filters

Gabor filters are believed to function similarly to the visual neurons of the human visual system. From an information-theoretic viewpoint, Okajima **[7]** derived Gabor functions as solutions for a certain mutual-information maximization problem. It shows that the Gabor receptive field can extract the maximum information from local image regions. For face recognition applications, the number of Gabor filters used to convolve face images varies with applications, but usually **40 filters** (**5 scales and 8 orientations**) are used.

2) Introduction to Neural Networks

Neural Nets are networks of simple neural processors, arranged and interconnected in parallel. Neural Nets can be used to construct systems that are able to classify data into a given set or class, in the case of **face detection**, a set of images containing one or more faces, and a set of images that contain no faces.

3. IMPLEMENTATION DETAILS

The operation of the face detection system can be broken down into 4 main areas:

a) Creation of database (Detection of facial features by Gabor filters)

b) Initialization of network (Design and creation of a Neural Network)

c) Training (Choice of training data, parameters, and training)

d) Classification (Scanning images to locate faces)

1) Creation of Database

A set of two classes namely **"non-face"** and **"face"** images of size 27X18 are provided to the system with preprocessing techniques applied on them. And including original faces, their mirror images and their left-right mirror images enlarges face database. Similarly including non-faces images, their mirror images and up-down mirror images enlarges non-face database. Here **Gabor filters** are also used to extract the **facial features** from the images. Then a database of "face" and non-face" images are ready.

2) Initialization of Neural Network

A custom network is created, and its properties are set as desired.

net = network // Creates a custom neural network.

The various properties of the network are set. These properties determine the number of network sub objects (which include inputs, layers, outputs, targets, biases, and weights), and how they are connected.

3) Training the Neural Network

The two classes both "non-faces" and "faces" are ready to train the neural network on them. But random images are taken from training set and fed into the system. Training occurs according to the trainscg's training parameters shown here with their default values:

net.trainParam.epochs // Maximum number of epochs to train

net.trainParam.show // Epochs between showing progress

net.trainParam.goal // Performance goal

"trainscg" that is **Scaled conjugate gradient backpropagation**, is a network training function that updates weight and bias values according to the scaled conjugate gradient method. Training stops when any of these conditions occur:

a) Maximum number of epochs (repetitions) is reached.

b) Maximum amount of time has been exceeded.

c) Performance has been minimized to the goal.

4) Classification

Here the trained network that has been trained is used to test a particular image to find out whether it contains any face or not. Any image to be tested is first converted into gray scale. When a new image is presented to the network, the image divided into windows that are individually presented to the network for classification. Windows thought to contain a face are outlined with a cyan bounding box of size 27X18 and on completion a copy of the image is displayed.

4. RESULTS AND DISCUSSIONS

An insight into the true performance of the system can only be achieved through the use of an independent test set of "unseen" images. The test set should contain images of various resolutions, with both face and scenery examples present. The appropriate choice of an image database for training is extremely important in order to fulfill the goals set for training. With these considerations in mind, the human face database chosen for training was the Yale face database **[8]** that contains 10 frontal images per person, each with different facial expressions, with and without glasses, and under different lighting conditions. The strengths include the large number of different subjects; the dataset has good diversity across age, race, and gender.

The training dataset was restricted only to frontal view images and it contains 148 training examples, 93 face and 55 non-face images. The images in the dataset are of 27x18 pixels; each image is a Grayscale image in TIFF format. Some samples of images of faces and non-faces from database are shown in figure 1 and figure 2.

Figure 1: Samples of Faces from Database used in the Face Detection System

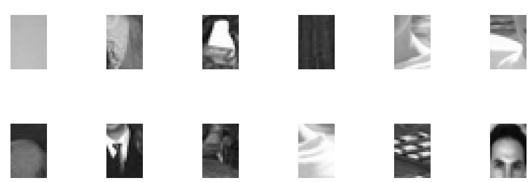

Figure 2: Samples of Non-Faces from Database used in the Face Detection System

This face detection system was run on a 3.00 GHz Intel Pentium (R) D processor system with 1 GB of memory running Windows XP.It took 2 minutes to create the database of **1120 images.**

Gabor Mask Used in the Face Detection System

Interesting feature points in the face image are located by Gabor filters. The feature points are typically located at positions with high information content (such as facial features), and at each of these positions we extract a feature vector consisting of Gabor coefficients

Testing of Images and Results

The Hybrid face detection system was tested on **35** images having different number of faces.

Results:

Total number of faces present in test images = 77

Number of faces detected correctly = 65

Number of false positives = 35

Number of false negatives = 12

Accuracy of the system is **84.4 %**.

Some Results of Hybrid Approach to Face Detection from Test Data Set

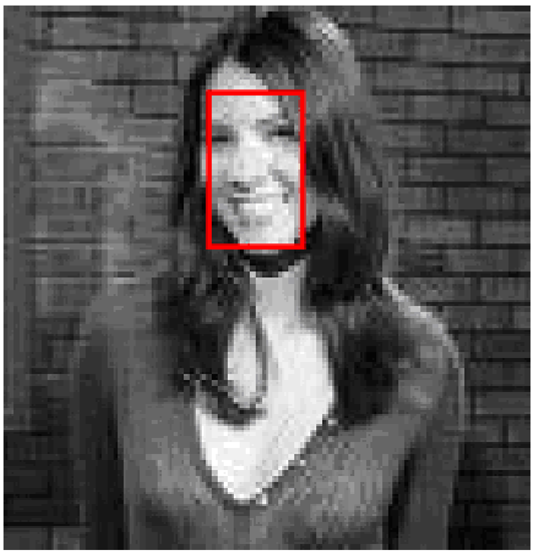

Figure 3

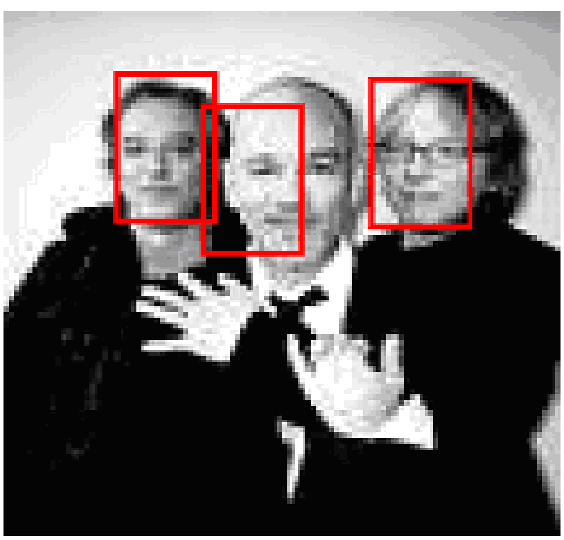

Figure 4

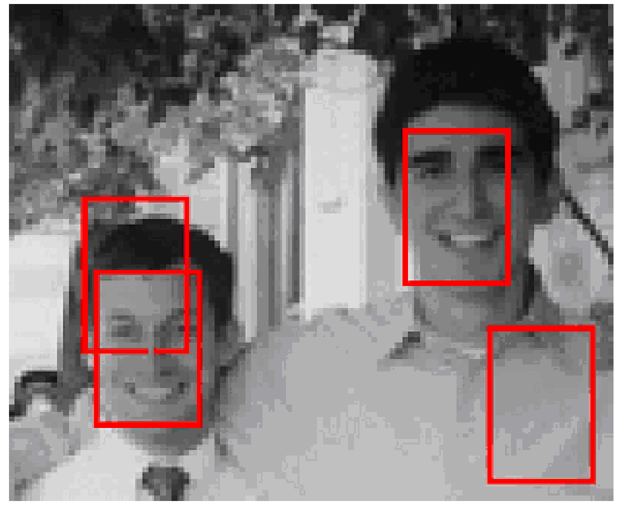

Figure 5

Conclusions and Future Work

In this Thesis work **"FACE DETECTION SYSTEM BY USING FACIAL FEATURES AND NEURAL NETWORKS"** is developed.

The main **limitation** of the implemented system is that it only detects **upright frontal faces** and the variation like rotated faces and side views are restricted **.**The **accuracy** of the developed system is **84.4 %.**

The goal of any future improvement should be to improve the detection rate, to minimize the number of false positives, and to improve the speed of the detection process.

5. REFERENCES

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8) Yale Database available at http://cvc.yale.edu/