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FACE DETECTION AND RECOGNITION USING MORPHOLOGICAL SHARED-WEIGHT NEURAL NETWORK

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Abstract

In this paper we introduce an algorithm based on the morphological shared-weight neural network. A Logitech Quick Cam is used to capture a gray scale image. The image is processed by a morphological shared-weight neural network to detect the human faces in the input image. Feature extraction is performed on grayscale images using hit-miss transforms that are independent of gray-level shifts. The output is then learned by interacting with the classification process. The feature extraction and classification networks are trained together, allowing the MSNN to simultaneously learn feature extraction and classification for a face. Detected faces are matched against images of known candidates in a database using a simple and fast modified closest neighbor algorithm.

INTRODUCTION

The subject of face detection and recognition has recently gained a lot of attention because of its many potential applications (e.g. monitoring access to restricted areas, image and video indexing, etc.). Despite the fact that other identification methods (e.g. fingerprints or iris scans) can be more accurate, face recognition has become a hot research subject because it is noninvasive and seems natural and intuitive to users [1]. The approaches include template matching, shape decomposition using morphological operators, and feature vector extraction using principal component analysis (PCA) etc [1]. Many of these approaches are sensitive to lighting of the input image and the size and orientation of the faces. Many approaches also require a time-consuming preprocessing and/or normalization step before the images are scanned for faces, which makes them unsuitable for real time implementation. A good face detection and recognition system must be accurate but also fast. The system we are describing in this paper uses a shared-weight morphological neural network (MSNN) in its face detection phase. MSNNs have been used in many automatic target recognition applications and have shown to be un-affected by variations in lighting level and robust enough to handle some variation in target size and/or orientation. MSNNs have also been shown to detect targets that are partially occluded [3].

Two main approaches formed the early core techniques of facial feature analysis: the geometrical approach and the pictorial approach [5].The geometrical approach uses spatial mapping of facial features. Faces are classified according to geometrical distances, perimeters, areas, and angles determined from point to point. We apply this technique to find the distance between the left and the right eye.

II. NEURAL NETWORK

A neural network is an information-processing system that has been developed as generalizations of mathematical models matching human cognition. They are composed of a large number of highly-interconnected processing units (neurons) that work together to perform a specific task. According to Haykin [2], a neural network is a massively parallel distributed processor that has a natural prosperity for storing experimental knowledge [3]. It resembles the brain in two respects: Knowledge is acquired by the network through a learning process; Inter-connected connection strengths known as synaptic weights are used to store the knowledge; Each neuron has an internal state called its threshold or activation function (or transfer function) used for classifying vectors. Neural classification generally comprises of four steps:

Pre-processing- e.g., atmospheric correction, noise suppression, band rationing, Principal Component Analysis, etc;

Training - selection of the particular features which best describe the pattern;

Decision - choice of suitable method for comparing the image patterns with the target patterns;

Neural technology simulates the way neurons work in the human brain. This is seen as the main reason for its role in face recognition [4]. A neural network has the ability to adjust its weights according to the differences it encounters during training. As a result, it delivers high efficiency in the classification of linearly as well as nonlinearly separable classes [7].

III. SYSTEM ARCHITECTURE

The system is composed of three major components: image capture, face detection, and face recognition. Figure1 shows an overview of the system and its three components. First, a Logitech Quick Cam captures an image which is converted into a usable format for the next processing step (face detection). The captured image is then processed by an MSNN to determine likely locations of faces in the image. The output of the MSNN is interpreted through a clustering algorithm that associates groups of pixels and determines their centroids, resulting in the coordinates of possible faces in the input image. Each possible face is extracted from the input image, the average pixel value is adjusted to compensate for lighting conditions, and the resulting image is compared to the database images. Based on the comparisons with the database images, the face candidates are either labeled or discarded, and the results are superimposed on the original captured image

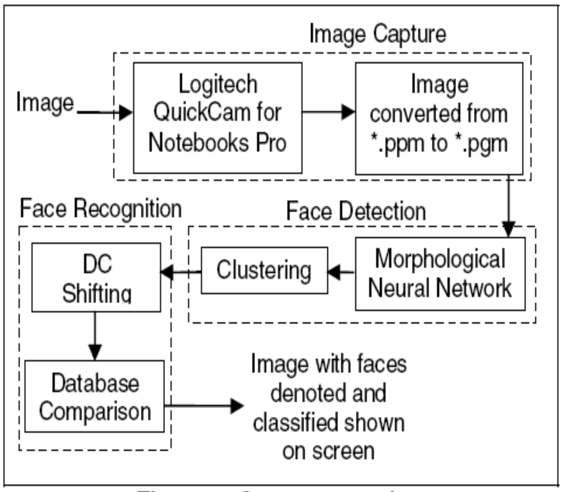

Figure 1. System overview

A. Image Capture

A Logitech Quick Cam for Notebooks Pro webcam is used to capture 320×240 grayscale input images in ppm format. The control of the camera operation is done using functions from the Open CV package which is a free, open source image processing and computer vision library of C functions that can be downloaded from the web [6]. Once an image has been captured, it is converted to pgm format required by the MSNN code. An imaginary square around a face from just above the eyebrows to just below the mouth should ideally occupy about 5-6% of the entire image area. A greater variation will produce acceptable results on occasion, but the MSNN used to identify the location of faces in the image looks for faces that are around 64×64 pixels in size (±13pixels).

B. Face Detection

The face detection phase of the system is done using an MSNN. An MSNN takes a gray scale image as input and produces *n* outputs. Each output *Oi* represents the network confidence that the input image belongs to class *i*. The MSNN used in our system has two output classes: face

and background. The MSNN is composed of two stages: a feature extraction stage followed by a classification stage. The feature extraction stage can have one or more layers and each layer can have one or more feature maps. Each layer in this stage performs feature extraction using the

morphological operation of gray-scale hit-miss transform with a pair of structuring elements. The output of the feature maps can be sub-sampled, which results in smaller size feature maps in the next higher layer. The output of the highest feature layer provides the input for the classification stage which is a standard feed-forward neural network (Figure 2).

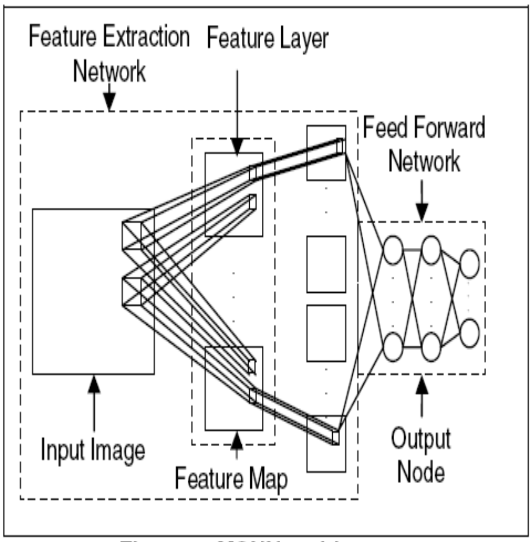

Figure 2. MSNN architecture

C. MODELING THE NEURAL NETWORK

The MSNN is a heterogeneous network composed of two cascaded sub networks:

The feature extraction phase followed by the training and classification phase. . Modeling the training network involves the development of learning algorithms according to the desired behavior and the functionality of the network.

While developing our MSNN model, the following issues were our main concerns:

A. Complexity

How large is our image database? How large should one image be? Should we make them smaller or larger by resizing?

B. Performance and Reliability

We need to know which neural network is reliable and learns fast. In terms of classification quality, we have to know how these various networks perform their computations. Are these techniques suitable for training digital images.

IV. IMPLEMENTATION RESULTS

A. Learning Rate-

The performance of the MSNN is very sensitive to the proper setting of the learning rate. It cannot be set too high; otherwise, the network may oscillate and become unstable. If the learning rate is too small, the algorithm will take a longtime to converge. Several trainings should be performed using a variety of learning rates before determining the optimum η.We conducted experiments with learning rates ranging from 0.05 to 0.4, each time increasing by 0.05. Recognition accuracy increases with the learning constant until it reaches full recognition at η= 0.25, after which the performance starts to deteriorate. The recognition rate finally drops to 0% at η=0.4 .Our observations are plotted out in Fig. 3

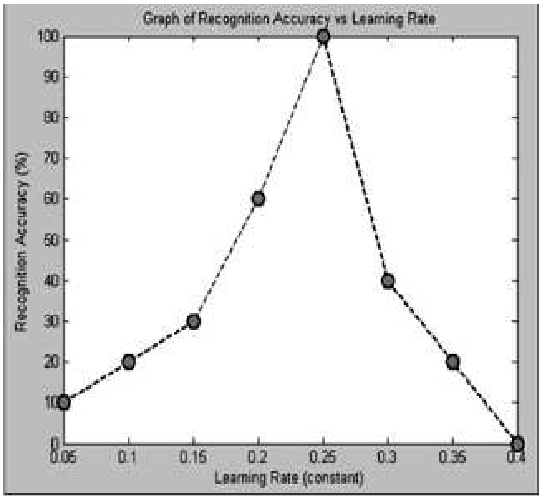

Fig. 3 Graph of recognition Accuracy vs. leaning rate.

B. Number of Hidden Neurons-

In our experiments, we trained the MSNN with different numbers of hidden units (5 to 40) and recorded their recognition rates. For a network with 10 to 20 hidden neurons, the recognition accuracy is 100%. Any number of hidden units beyond 20 will experience a gradual decrease in performance, eventually hitting zero recognition at 40 neurons. As the graph in Fig. 4 indicates, efficiency increases as the number of neurons increases from 5 to 10; it remains constant between10 to 20 neurons, and drops drastically after that. Although it is true that increasing the number of hidden neurons can extract more implicit information, an excessive number may cause over fitting and high generalization error. On the contrary, the MSNN will not converge if the number of hidden units is too small under fitting results in high training and generalization error.

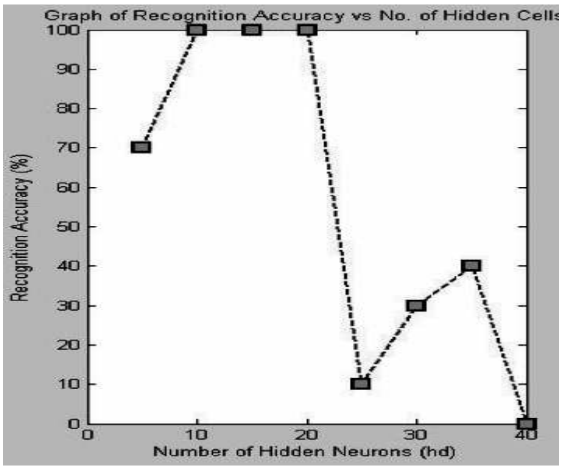

Fig. 4 Graph of recognition Accuracy vs. NO of Hidden Cells.

V. CONCLUSION

Our experiment presents an MSNN-based face detection and recognition system. The system was shown to be reliable and fast enough to detect and recognize faces of fairly different sizes and under different lighting conditions without the need of computationally-costly pre-processing of the input images. The extraction of facial features .To increase the size range of faces that can detected, we apply the MSNN to input images at different resolutions.

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