Face Recognition and Detection Using AI

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Abstract

One of the most essential applications of image processing and biometrics is face detection. The usage of artificial neural networks has aided image processing and pattern detection (ANNs). Literature studies that give a holistic viewpoint are absent in many papers and investigations on face detection using AI. This paper examines face identification tests and systems that employ various ANN approaches and algorithms. In addition, the research and system's strengths and flaws were considered.
Experimental analyses are also offered in order to compare and extract meaningful data from various approaches. A few prospective research areas and goals in face detection and neural network-based learning systems have been mentioned.

1. Introduction

Face recognition has gotten a lot of attention in the last few years and is considered one of the most effective image analysis applications [1]. An individual's face is a powerful visual stimulant because it is so diverse and significant. A computer model for facial recognition is challenging to develop [2]. In terms of face recognition systems, the ability to concentrate computing resources on the area of an image where a face is present is crucial. Detecting faces in photographs is a difficult task because of the wide range of variations in human features, such as the way people stand, the expressions on their faces, the location and orientation of their eyes and hair, and even the color of their skin. In the past, psychologists were the primary researchers in the subject of facial expression analysis [4]. Face detection, tracking, and identification [5][6]; pattern recognition; and image processing have all made major contributions to studies in autonomous facial expression recognition.
In spite of this, real-time requirements for a given frame rate are difficult to achieve due to the complexity of the applications' algorithms [9]. Face identification has seen several improvements over the last decade [9][10][11][12][13][14][15][16][17][18][19]. Other sections are arranged in this way: Face detection and identification are covered in detail in Section 2. ANN-based face-detection systems are discussed in Section 3, Section 4 compares and contrasts the results of the various research investigations. Finally, in Section 5, we provide some suggestions. Lastly, the sixth and final portion wraps everything up.

2. Face Detection and Recognition

Face detection, feature extraction, and face recognition [14][24] are only a few of the numerous phases in a generic face recognition system. Each component of face detection and identification works in harmony with the others. Each component may function independently, depending on the regular system. Facial recognition is a computer technique that uses a set of algorithms to identify and locate human faces in digital photographs.
When it comes to human vision, face recognition is a vital aspect of our abilities, but developing an equivalent computer system is still in its infancy. Researchers in the fields of psychology (Bruner and Tagiuri 1954), as well as engineering (Bledsoe 1964), have been working on facial recognition since at least the 1950s. Darwin [1972] (see also Ekman [1998]) and Galton [1888] are two of the early researchers to look at the expressions on people's faces to determine their emotional state. It wasn't until Kelly 1970 and Kanade's fundamental work in 1973 that work on automated machine identification of faces truly got under way.

Each processing step in the system must be built to meet application requirements if a high-performance face recognition system is to be achieved [14]. In order to identify people in a picture, face recognition entails comparing an image to a database of previously recorded faces. Images must first be processed before they can be recognized, hence face detection has a direct impact on the job of recognition. Focusing the computing resources of a face recognition system on detecting faces in a picture might improve the system's speed and performance [3]. Figure 1: A face-recognition system's basic framework. Image windows are divided into two sections: one for faces and one for the rest of it. These similarities (age, skin tone and facial expression), as well as differences in lighting circumstances; picture quality; and geometric shapes make the procedure complex. Any face may be detected by the face detector, regardless of the illumination or backdrop.

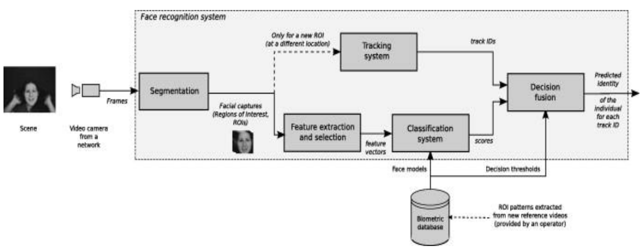

Figure1. Basic Framework of Face Recognition

To get the best recognition impact, we anticipate identifying the perfect transformation function, however the search procedure has been difficult.

The process of enhancing the system's performance and speed. Figure 1: A face-recognition system's basic framework. Image windows are divided into two sections: one for faces and one for the rest of it. These similarities (age, skin tone and facial expression), as well as differences in lighting circumstances; picture quality; and geometric shapes make the procedure complex. Any face may be detected by the face detector, regardless of the illumination or backdrop.

3. Face Detection and Recognition

A frontal face detection system using an artificial neural network is presented. The system used integral image for image representation which allows fast computation of the features used. The system also applies the AdaBoost learning algorithm to select a small number of critical visual features from a very large set of potential features.

The Development Stage of Face Recognition and Related Technologies:

3.1 Principal Component Analysis (PCA)

Data dimensionality reduction (PCA) is the most often used approach. PCA is used to extract features from face in face recognition algorithms. Face recognition was revolutionized in 1991 by MIT Media Lab researchers Turk and Pentland [5].

PCA is often used as a preprocessing step before other statistical studies. There is a way to minimize the number of dimensions of data while still keeping the important qualities, allowing for faster data processing while reducing the quantity of resources needed to process it [6], [7]. Because of this, this approach is often used for dimensionality reduction and multi-dimensional data visualization.

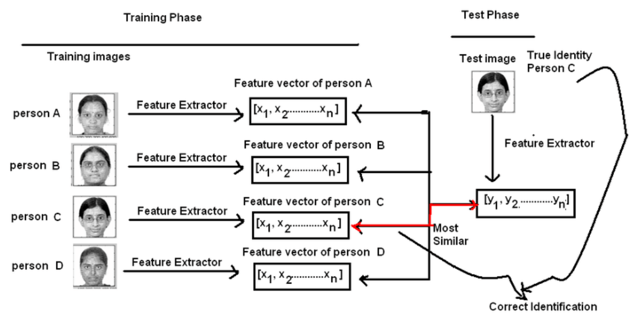

Figure2. Phases of Face Recognition

The eigenface is a classic approach in PCA-based feature extraction [8]. Using the K-Nearest-Neighbor (KNN) technique, PCA is integrated with face recognition in Figure 2 to extract features. The covariance matrix's eigenvalues and eigenvectors are derived from sample data, and the biggest eigenvalue is used to choose the major component. Data from testing may also be reduced in dimension, resulting in the same feature matrix. Finally, the KNN classifier identifies the test set's face picture category.

3.2. Fast Neural Networks (FNN): Fast neural networks (FNN) were introduced by Hazem El-Bakry (2002) [31] to minimize the calculation time required to locate human faces. Images are broken into smaller sub-images and then examined individually using a rapid artificial neural network (ANN). With FNN, great speed is attained in comparison to traditional neural networks. IJMA, Vol. 6, No. 1, February 2014, International Journal of Multimedia & Its applications the process of learning. Finally, the KNN classifier identifies the test set's face picture category.

3.3. Linear discriminant analysis (LDA):

There are a number of ways to utilize LDA as a classifier in machine learning [7,10,13,14], including finding the optimum linear combination of characteristics to distinguish two or more classes of object or event. Prior to classification, a multidimensional space is mapped into a space with fewer dimensions, a process known as feature reduction. Several classification-related applications make use of LDA. One of them is face recognition, in which each face is reduced to a smaller set of linear combinations before categorization. Fisher-faces are the linear combinations created by LDA. Face recognition in [8] is based on discriminant analysis of eigen features and uses linear discriminant analysis (LDA).

3.4. Convolutional Neural Network (CNN): Facial expression recognition and face identification using a convolutional neural network were reported by Masakazu Matsugu in 2003 [27]. (CNN). This work attempted to address the issues of subject independence, as well as translation, rotation, and scale invariance in the identification of facial expressions.

Neural Networks that use convolutional layers. It is possible to build a neural network with several convolutional layers, known as a convolutional neural network (CNN). For this thesis, we'll concentrate on using CNNs in image processing applications such as classification and segmentation. RGB images are often used as inputs in image processing (three color channels matrix Red, Green, and Blue). For the sake of clarity, we'll stick to grayscale photographs for the time being (two-dimensional matrix, one color channel). ILSVRC-2012 20. Some well-known CNN architectures, including VGG, GoogLeNet, and ResNets, have excellent results and performance.

3.4.1 CNN Pooling Layers Fully Connected Layer: An image's feature map is extracted by a sequence of convolution and pooling layers, and the feature map may then be converted into a fully linked layer. Each layer of neurons is linked to every other layer of neurons in a system called a "completely connected layer" (FC). For every n number of neurons in a layer, FC makes 2n connections, to the power of n.

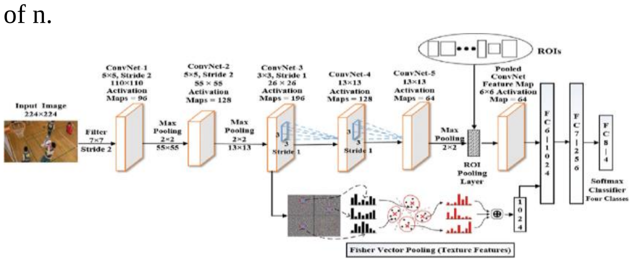

Figure3.1 CNN’s Fully Connected Layers

3.5. Evolutionary Optimization of Neural Networks: To determine whether or not a pre-processed picture area depicts a human face, Stefan et al. (2004) [34] used ANNs. They explained how a hybrid technique combining evolutionary computation and gradient-based learning was used to optimize this network. With no sacrifice in accuracy, the evolved solutions outperform the well-developed ones. In order to address the issue of lowering the number of hidden neurons in a face recognition network without sacrificing detection accuracy, the suggested hybrid approach was developed. About a third of the time, it takes to determine whether or not a portion of a picture is associated with a face might be saved.

4. Artificial Features and Classifier Stage

4.1 Viola-Jones Face Detector: When Paul Viola and Michael Jones released their Viola-Jones Object detector [9] in 2001, it was hailed as a rapid and accurate model for detecting objects, including faces. The AdaBoost Algorithm, the Cascade Classifier, the Haar-like Features, and the Integral Images are all part of the Viola-Jones paradigm for object identification.

4.2 Haar-like Features:

Dark and bright cells alternate in a Haar-like pattern. The result is a single number that may be used to learn about the input image's edges, straight lines, and diagonal lines by adding the pixel values of the bright cells and subtracting the pixel values of the dark cells. There are several haar-like characteristics, but Viola-Jones chose to focus on only four of them (see picture) (4.1). Images with Haar-like Features: Every pixel in the feature regions may need to be obtained for each calculation in Haar-feature. An integral picture, in which each pixel's value is equal to its summing of other gray values, may be used to avoid this process. This means that it only uses the integral picture to determine the pixel value for four-pixel lookups.

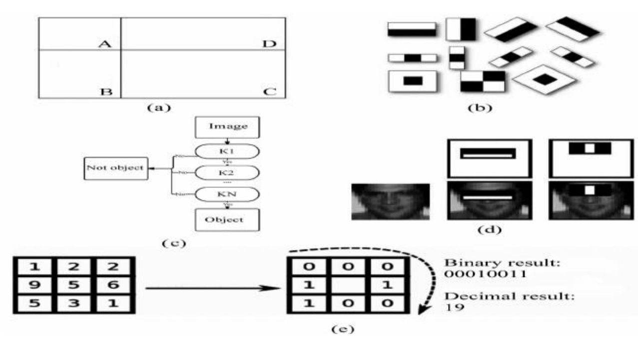

Figure4.1Viola-Jones algorithm parts: (a) combination of regions, (b) Haar Features, (c) cascade classifier, (d) Haar feature application to the image, and (e) LBP feature.\

Table 1. DB and Performance measures used in literature studies

Research	Topology	Data Base: Training & Testing	Performance
[27]	Retinal connected neural network	Three training sets of images. Test SetA: 42 scanned photographs Test SetB: 23 images contain 155 faces Test SetC: 65 images, 183 faces (images with more complex backgrounds and without faces to measure false detection.)	Detect 78.9% - 90.5% of faces in a set of 130 test images Acceptable number of false detections.
[30]	PCA with ANN	Select 700 pictures in Kah-Kay Sung's data set of 1488 faces to train ANN with 700 random noise pictures as negative examples remaining 788 faces in Kah-Kay's data set, followed by 788 random noise pictures	1.2% error after training for 50 epochs 1566 examples, 35 mis classifications made (2.23% error).
[32]	PNN	First set: 3257 images downloaded from several websites (384×384), with one face in each image. Second set: 130 images downloaded from website of CMU	Detection rate = 84.6% False rate=3:51 × 10-6
[33]	CNN	training of CNN, the number of facial fragment images used is 2900 for the FD2 layer, 5290 for the FD3, and 14,700 (face) for the FD4 layer, respectively. Number of non-face images, also used for the FD4 layer, is 137.	Recognition rate = 97.6% for 5600 still images of more than 10 subjects
[37]	BPNN	Training set contains 12000 face images collected from various face DBs. These samples also include the scaled versions at the same face with factor (0.8 - 1.12)	Detection rates measured for a separate test set of 500 faces and 4000 non-faces. Performance=94%.
[39]	Gabor wavelet with ANN	ORL dataset: 400 frontal faces: 10 tightly cropped (92×112) with 256 grey images of 40 individuals with variations in pose, illumination, ..etc.	Detect (77.9% - 90.3%) of faces in a set of 130 test images
[36]	MLP and MRC	Training set: face images from MIT DB. Images (scaled to 20×20) Test set: 2000 face/non-face images from MIT DB. Non-face patterns generated at different locations and scales.	Detection rate = 91.6% Error rate = 7.54%
[38]	BPNN	50 real images taken under different lighting conditions (digital camera images and web images from several websites).	Detects 97.3% of faces in a set of 50 real images. Processing Time (s) of image (63×180)= 3.8 Processing Time (s) of image (200×219)= 6.2

Neural network

On the basis of literature research, this work presents ANN-based face detection algorithms. Each of these studies used a different ANN face detection framework. The Multilayer Perceptron (MLP), Backpropagation Neural Networks (BPNN), Retinal Connected Neural Networks (RCNN), Rotation Invariant Neural Networks (RINN), Fast Neural Networks (FNN), and Polynomial Neural Networks (PNN) are among the ANN designs employed in these investigations (PNN). Other research employed a variety of techniques and processes, including PCA and ANN, Evolutionary Optimization of Neural Networks, Gabor Wavelet Faces with ANN, and Skin Color BPNN.

Each of these literary disciplines, however, has advantages and downsides. We haven't been able to figure out what structure would be best for a high-performance face detection system. A vast number of these researches have supplied information on the topology, database, and performance of face-detection algorithms, as shown in Table 1.

As indicated in Table 1, literature study used a variety of databases for picture training and assessment. Table 1 does not contain studies that rely on camera pictures rather than a known database. For each specific research, there is no criterion for how many samples are required. The study [38] uses just 50 photo samples as an example. Previous studies, such as [27][32], utilized many photo sets as examples, however this study just used one.

RECOMMENDATIONS FOR FACE DETECTION SYSTEM

Detection of the face begins the process of locating and extracting the face from the rest of the image. An overview of the study on face detection systems that used ANN has been provided earlier in this report.

• 2D image detection was used to detect faces in the examples above.

• There was a lack of information in several of these studies concerning the databases that were utilized for training and testing.

• Many of these researches did not give sufficient information about performance measures used for face detection. There is a lack of equations related to these performance measures.

• Most of these studies of face detection systems were adopted by ANN in combination with other approaches and algorithms to obtain better results for detection and improve the performance of face detection systems. But this may increase the system complexity, required memory and time for face detection.

• Lack of using other significant ANN architectures such as self-organizing map, PatternNet ANN, Fast BPNN and so on.

• Lack of literature related to face detection based on a combination of ANN and genetic algorithm (GA).

CONCLUSION

This paper includes a summary review of literature studies related to face detection systems based on ANNs. Different architecture, approach, programming language, processor and memory requirements, database for training/testing images and performance measure of face detection system were used in each study. Each study has its own strengths and limitations. In future work, a face detection system will be suggested based on using Pattern Net and Back propagation neural networks (BPNN) with many hidden layers. Different network architectures and parameters' values of BPNN and PatternNet will be adopted to determine PatternNet architecture that will result in best performance values of the face detection system.

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