Effect of DCT Image Compression on Eye Gaze Direction Detection

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Abstract. The prediction of eye direction detection is the one of the popular research topic in human computer interaction area. This paper defines eye gaze detection by using Discrete Cosine Transform. Actually, determining the position of eyes is difficult to estimate the location of gaze which is more challenging. The database of the suggested research is organized as gaze directions of right, left and centre. The database is created with varied ages of images. In this paper, Discrete Cosine Transform has been applied to the image database and the effect of image compression is tested by using back propagation neural networks.

1 Introduction

In human body, every organ has its own importance, however eyes provide communication with the world [1]. In researcher's work area, the direction of eye is estimated and classified by using different techniques in recent years. With the development of techniques, like virtual reality and human computer interaction (HCI), gaze tracking support that it is very useful in practical applications [2]. Especially, monitoring of eye-gaze movements is frequently studied on HCI, usability testing, visual systems, psychology and many other areas. It is mainly used to create an alternative user interface in the field of HCI [3]. The process of the finding gaze direction classification is to detect eye in the images first and then to process the obtained information by using various types of implementations. The point of view of the eye is a good display to attract attention and attention of a person [4]. In recent years, the nature of eye movements has been considered like a biometric pattern in some HCI researches [5-6].

Basically, three different approaches are used for monitoring eye gaze and eye movements detection. These are user views from normal sensor cameras using image processing techniques on image based methods or to the skin region around the eye based on the measurement of electric field with sensors installed with electro holographic methods or infra-red light source [7]. The most commonly used method is the first method. In operation, the display will eye gaze monitoring has been performed. Figure 1 represents sample input images from the database.

When the system takes selected input images, the function of face detection will be activated [8]. Then eyes and mouth positions was detected. However, detection of eye gazes is a challenging topic [9-10]. Purpose of this research is just focusing on obtaining real gaze positioning.

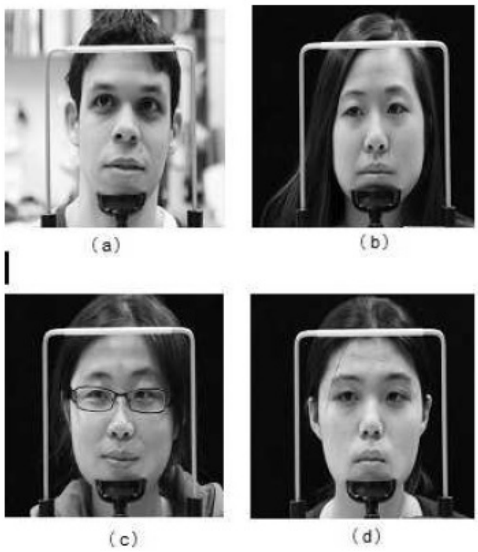

Fig. 1. Sample input images.

Image processing and neural networks are frequently used in detection purposes in different fields of the daily lives [21-22]. This paper represents the way of eye detection and direction of gaze classification. The research database is organized according to the direction of gaze images considering the three directions, right, left as well as centred. All database images are converted to grayscale and image resizing has been applied following the Discrete Cosine Transform (DCT) in order to prepare the database for the input of neural network [20, 23].

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2 Related Works

In literature, the classification of gaze of eye direction are based on different/numerous approaches [11]. In this research [11], classification techniques are also used to estimate eye detection and gaze direction. As stated earlier, different techniques such as Electrocardiogram (EOG) are used by the placed electrodes to measure electric potentials around the eyes for estimating and analysing eye gaze [12]. In this EOG method, eyes are needed to be in original position, and the electrodes are used to detect the electric potential field. The movements are observed for approximate calculation of the eye location by measuring EOG signal [12].

Lui et al. [13], proposed a real-time system on detecting eyes. In this system, a detector for face and Template Matching (TM) are used together for detecting the face and locating the eyes. Additionally, Zernike Moments (ZM) are applied to extract rotation invariant eye features, and Support Vector Machine (SVM) is considered for the eye/non-eye patterns classification. Eye positions are estimated by selecting the maximum values for left and right positions in the eye probability map.

Recently another approach using component separation to detect eye direction is proposed by Vranceanu et al. [14]. A Machine Learning framework is proposed to classify the gaze direction for Iris, sclera, and skin. Additionally, gaze estimation is calculated by using Convolutional Neural Network (CNN) [15]. They combined face pose estimator's data with eye region. In the output layer of the CNN model is trained as a regression model.

The remaining part of this paper is organized as follows. Section III describes the proposed approach for system. An approach for feature extraction and an encoding is described in Section IV. The proposed novel matching schemes by SVM and ANN are presented in Section V and VI respectively. The experimental results and discussions are shown in Section IV.

3 Proposed Approach for System

This section is divided into two. In image processing phase, DCT compression has been applied to the eye database, and in second phase, compressed image set is applied for detecting direction of eye gaze, by using a 3-layer back propagation neural network (BPNN) using an image size of 256 x 256.

3.1 Discrete Cosine Transform (DCT)

Discrete Cosine Transform (DCT) exploits cosine functions, it transforms a signal from spatial representation into frequency domain. The DCT represents an image as a sum of sinusoids of varying magnitudes and frequencies. DCT is an example of transform coding.

The Joint Photographic Expert Group (JPEG) system, based on DCT, has been the most widely used compression method.

3.2 Back Propagation Neural Networks (BPNN)

A back propagation neural networks (BPNN) with 65536 input neurons is created. Output neurons classify the existing images as left, right and middle gaze. In order to activate neurons in the hidden and output layers, the sigmoid activation function is used.

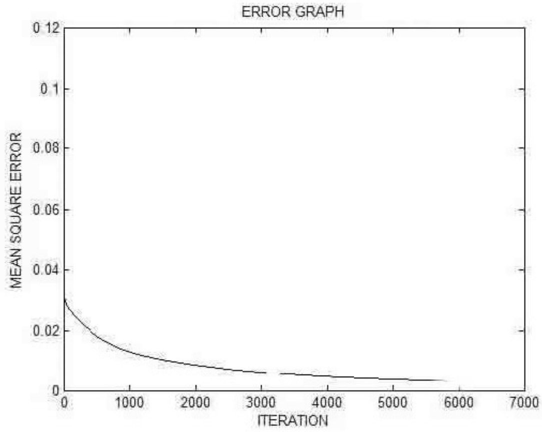

Fig. 2. BPNN Curve Graph.

Figure 3 shows the topology of the suggested BPNN that is a supervised learner algorithm. Since the implementation of BPNN is simple, and the availability of sufficient "input – target" database for training have been preferred.

In this research phase's learning or training and generalization are comprised. The organization of image database is shown below:

- Learning set: 60 images
- Generalization set: 90 images

Values between -0.4 and 0.4 were used in the learning state for initial random weights. The learning rate as well as the momentum factor has been chosen experimentally to achieve the required minimum error value and meaningful learning. 0.002 was considered as sufficient error value for this application. Table 1 shows the final parameters.

4 Results and Discussions

Considering the proposed application, similar to existing studies [16-19], results of the system are obtained from a virtual machine that has a configuration of 2012R2 64 bits OS. It is connected to a super computer with 1 Gbits speed. The super computer's specifications are listed as IBM Blade HS21 XM with 1280 Intel Xeon core units of 2.33 GHz CPU. Intelligent eye gaze detection system has been demonstrated with the robustness, flexibility and speed. Eye gaze identification results that use the training image set resulted 100% recognition ratio as expected.

The image set for testing of the proposed BPNN results were prosperous and reassuring. An overall correct identification of BPNN resulted 84.4% where, 76 out of 90 images yielded. This successful result was obtained by using only the database of images for training the neural network.

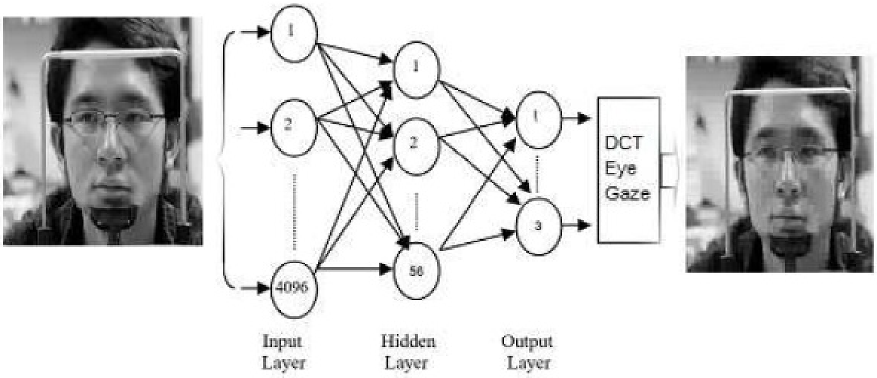

Fig. 3. BPNN Architecture.

Table 1. BPNN Training final parameters.

Input layer	65536
Hidden Layer	56
Output Layer	3
Learning Coefficient	0.005
Momentum Factor	0.5
Minimum RMS Error	0.002
Number of Iterations	5835
Training Time (Sec.)	95

5 Conclusion and Future Works

In this research, image processing and neural network approaches for the detection of eye gaze were developed. Image processing techniques are very useful and significant in many application fields.

The developed DCT system to notice the presence of gaze of the eye directly by the first look.

The system is based on an algorithm that reads an image, and performs DCT.

The images used in testing the proposed system are collected from database to get a total of 150 images for 60 images for training (20 images for left, middle and right), and 90 images for testing where 30 images for left, middle and right.

The experimental results obtained when testing the proposed system proved that the developed eye gaze detection system is a robust image processing system that is capable of detecting eye gaze direction in particularly right, left and middle. Also, a back propagation neural networks, named as BPNN is created. The developed BPNN uses original images with size of 256 x 256, in order to detect eye gaze, whereas 0.002 seconds is needed for detection.

When DCT algorithm is considered, a recognition ratio of 84.4% has been reached with 76 images out of 90. When BPNN is considered, a recognition ratio of 92% has been reached, using the original image set.

Future work will include the effect of image compression using a 64 x 64 size of images, and also, image enhancement will be applied in pre-processing phase.

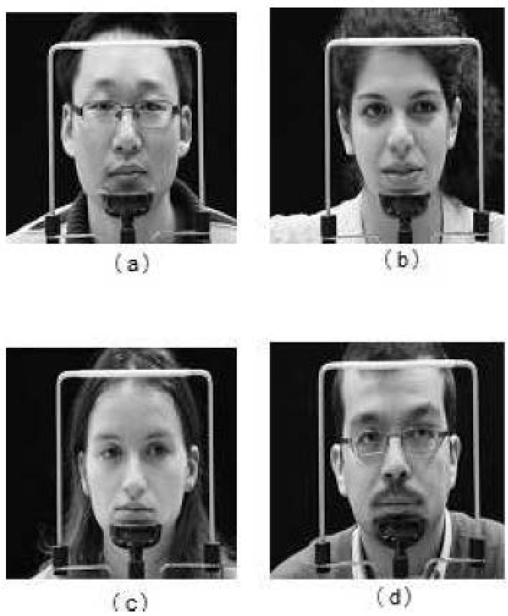

Fig. 4. Output images.

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