AN AUTOMATIC FACE RECOGNITION SYSTEM BASED ON 3D GEOMETRIC FACE FEATURES

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ABSTRACT

In this paper, a new approach for face recognition system is developed based on 3D geometric face features. This paper presents a unique face recognition system which considers information from frontal and profile view of face images. The proposed system are generating the automatic personal identification system, improvement of fast and accurate face recognition and developed algorithm for computing the accurate 3D measurement of face features. The approach is based on the perspective projection of a triangle constructed from any three points in a 2D image. To determine the structure of an object, the set of non-linear equation is established the nodal points of a triangle built by any three points in a 2D scene and their corresponding projected image points... The performance of the final result is fast and accurate than other methods.

1. INTRODUCTION

In recent years, considerable progress has been made on the problem of face detection and faces recognition, especially under stable conditions such as small variations in lighting, facial expression and poses. Face recognition is one of the most important applied aspects of visual perception. It is of great importance in many applications such as personal identification, employee access to high security areas, human-machine interfaces, and image retrieval. The main objective is to study face recognition system which is not only one of the most challenging computer vision problems but also has many commercial and law enforcement applications. The primary goal of this research is to develop an algorithm for computing the accurate 3D measurement of face features and improvement of fast and accurate face recognition. The purpose of system is to extract the accurate personal records and improvement of fast and accurate face recognition. The system can be used in security system, credit- card verification, notice criminal identifications, and teleconferences and so on. The system of non-linear equations is derived to compute the parameter of the face features. The approach is based on the perspective projection of a triangle constructed from any three points in a 2D frontal and profile view images.

Most of the research in face recognition has focused on 2D intensity images. V. Starovoitov et al. [1] performed the face recognition by two dimensional geometric features. Eigenface approach is applied in face analyzing [2]. Brunelli R., and Poggio T. [3] used the templates matching approach for face recognition. Facial Feature Points tracking with Gabor Wavelets and shape models are discussed by McKenna S.J., Gong S., et al. [4]. In most of them faces are
considered as flat surfaces and the difference in orientation of the compared faces are ignored. Actually, a face is a 3D convex object with ability to rotation and shape changing. The main difficulty in the face recognition is to find a robust feature set for a unique description of a human face. Therefore, our approach is a new system to solve these conditions. The proposed research is to create an automatic face recognition system and to obtain reliable recognition even with varying poses and lighting conditions based on 3D Geometric Features. The number of faces a computer can “remember” accurately is also much more than the average human.

This paper is organized as follows. Section 2 deals with 3D structure estimation based on the perspective projection of a triangle and processing steps for face recognition system. Face recognition system based on the 3D geometric feature are discussed in section 3. Experiments and results are implemented in Section 4. And Section 5 described the brief discussion and conclusion of the proposed face recognition system.

2. 3D STRUCTURE ESTIMATION BASED ON THE PERSPECTIVE PROJECTION OF A TRIANGLE

3D structure of a face is estimated using the face feature points. 3D measurements of any three points on a face can be computed based on the perspective projection of a triangle. These three feature points derived from the eyes and the middle of the mouth.

![Figure 1. Illustration of Perspective Projection of a 3D Triangle](image)

The three feature points are denoted by \( P_1(X_1, Y_1, Z_1), P_2(X_2, Y_2, Z_2) \) and \( P_3(X_3, Y_3, Z_3) \).

\[
\begin{align*}
    d_1 &= |P_2 - P_3| \\
    d_2 &= |P_3 - P_1| \\
    d_3 &= |P_1 - P_2| \\
    (X_2 - X_3)^2 + (Y_2 - Y_3)^2 + (Z_2 - Z_3)^2 &= d_1 \\
    X_2^2 + X_3^2 - 2X_2X_3 + Y_2^2 + Y_3^2 - 2Y_2Y_3 + Z_2^2 + Z_3^2 - 2Z_2Z_3 &= d_1^2
\end{align*}
\]

Similarly

\[
\begin{align*}
    (X_3 - X_1)^2 + (Y_3 - Y_1)^2 + (Z_3 - Z_1)^2 &= d_2 \\
    X_3^2 + X_1^2 - 2X_3X_1 + Y_3^2 + Y_1^2 - 2Y_3Y_1 + Z_3^2 + Z_1^2 - 2Z_3Z_1 &= d_2^2 \\
    (X_1 - X_2)^2 + (Y_1 - Y_2)^2 + (Z_1 - Z_2)^2 &= d_3 \\
    X_1^2 + X_2^2 - 2X_1X_2 + Y_1^2 + Y_2^2 - 2Y_1Y_2 + Z_1^2 + Z_2^2 - 2Z_1Z_2 &= d_3^2
\end{align*}
\]

Using Equation above,
\[
\begin{align*}
&\frac{1}{f^2}x_2^2Z_2^2 + \frac{1}{f^2}x_3^2Z_3^2 - \frac{2}{f^4}x_2x_3Z_2Z_3 + \frac{1}{f^2}y_2^2Z_2^2 + \frac{1}{f^2}y_3^2Z_3^2 \\
&- \frac{1}{f^2}y_2y_3Z_2Z_3 + Z_2^2 + Z_3^2 - 2Z_2Z_3 = d_i^2 \\
&\frac{1}{f^2}(x_2^2 + y_2^2 + f^2)Z_2^2 + \frac{1}{f^2}(x_3^2 + y_3^2 + f^2)Z_3^2 - \frac{1}{f^2}(x_2x_3 + y_2y_3 + f^2)Z_2Z_3 = d_i^2 \\
&aZ_2^2 + bZ_3^2 - 2cZ_2Z_3 = d_i^2
\end{align*}
\]

Similarly \(bZ_3^2 + cZ_1^2 - 2gZ_3Z_1 = d_2^2\) and
\(cZ_1^2 + aZ_2^2 - 2hZ_1Z_2 = d_3^2\)

Where \(a = \frac{1}{f^2}(x_2^2 + y_2^2 + f^2)\); \(e = \frac{2}{f^2}(x_2x_3 + y_2y_3 + f^2)\)

\[\begin{align*}
b &= \frac{1}{f^2}(x_3^2 + y_3^2 + f^2); g = \frac{2}{f^2}(x_3x_1 + y_3y_1 + f^2) \\
c &= \frac{1}{f^2}(x_1^2 + y_1^2 + f^2); h = \frac{2}{f^2}(x_1x_2 + y_1y_2 + f^2)
\end{align*}\]

The 3D measurement of lengths \(d_1\), \(d_2\) and \(d_3\) of all edges of the triangles are computed from the Equation (2.1), Equation (2.2) and Equation (2.3), respectively.

3. FACE RECOGNITION

The flow chart of the automatic face recognition system is shown in figure 2. Firstly, preprocessing steps which include resizing, converting to grayscale, noise filtering, etc, are performed once acquire the images from camera or scanner. Second, a region approximation algorithm is developed for of eyes and lips regions.

![Face Recognition Process](image-url)
Then corner detection is performed to obtain the accurate corner points of eyes and lips. Next, drawing triangle and computing 3D measurements of each side of the triangle and angles between them. Finally, matching process has been done by face parameters of the frontal and slant view of face images for improving the performance of face recognition.

For proposed system, frontal and slant view of face images are taken by changing a camera position and direction. The performance of the image acquisition system is illustrated in figure 3. To obtain the face parameters, the specified rectangles are drowning by connecting between eyes and lips. The proposed system is obtained at least 24 triangles (See figure 4) from frontal or profile of faces by automatic marking on the face. ‘Seven’ feature points are marked on each face. Some images in database are shown in figure 5(a) and 5(b), respectively.
4. EXPERIMENTS AND RESULTS

The face images include both frontal and slant views are taken by changing the camera position and angles. The images, in this experiment, are taken by Canon and focal length is used 24 mm. Figure 6(a) and 6(b) shows the images of the first and second selected persons. And Figure 6(c) illustrated the recognition result.

Figure 6 Implementation of the recognition result.
5. CONCLUSION

The paper presents the accurate results of the face recognition study based on the Geometric Face Features. In this paper, the system is simple and efficient. The perspective transformation between 2D image and 3D object in static scenes is used in this approach. The feature points are extracted by automatically using corner detection method. Euclidean distance approach is used to compute the length of edges and the orientation parameters of a triangle with Cosine Rule. Own database is built with distinct persons, each with 2 faces that vary head pose for front view and slant view. These experimental results show that the proposed system can correctly recognize of the face from own constructed database. So the accuracy rate is good.

REFERENCES