Automatic Feature Detection Using Pattern Projection for Person Identification

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Synopsis

In this paper an efficient algorithm is proposed for person identification based on the analysis of 2D images of a designed mask projected onto the person's face in a cooperative environment. The cooperative environment is essential for the accomplishment of the images under a certain condition. The importance of the designed mask is for avoiding the complexity of feature selection from the face image. The mask contains a number of designed patterns with single center, minor and major axis. Due to the structure differences of human faces in 3D, 2D images of the projected mask contain different information about the shape of an individual face. Each boundary of a pattern on the original mask is considered as an individual object's shape on the image plane. For an image plane each shape is matched with the same number of pattern in the image. Simulations are conducted with real data to confirm the effectiveness of our method.

KEYWORDS: feature detection, person identification, pattern-mask, shape matching

1. Introduction

For the architects of pattern recognition algorithms, face recognition is a very disputing problem. The destination is to formulate an algorithm that can distinguish among the number of inhabitants in a given place of 3-D slewed objects that all have the same basic pattern. Additionally, the face itself is a dynamically varying object: facial manifestation, make-up, facial hair, and hairstyle all change over time. The circumstances under which facial photograph is collected also add to the difficulties of the originating face identification algorithm. The lighting, background, scale, parameters, and pose of the face image acquisition are all variables in facial imagery collected under real-world scenarios.

A key to successfully developing a general face identification system to systematically solve a sequence of sub-problem is the development of an algorithm that can identify faces from a database of frontal facial imagery under some condition. Some researchers used varying illumination[1)], masking, projecting grating and a fringe pattern[2)-7)] to extract the facial features.

In this research work we propose a method to extract features from the face surface projected a mask of a pattern, which have been selected among various patterns testing them to acquire the image as expected. Due to the variation of 3-D face structure for person to person, 2D images of an identical mask projected from a stationary position of a projector vary among them for a stationary viewpoint. This variation gives rise all the information about the person. The database for the image gallery is made for simple facial expression under certain conditions, which are maintained at the same state as the time of processing database.

Although face recognition is substantially different from classical pattern recognition problems, in this research work, we consider face as a combination of a large number of different shapes of objects as the case of tomographic slices. Therefore, a perceptual structure of the individual object bounded by the pattern is compared with the object in the keyed out image plane.

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2. Feature detection Method

A human face is a curve shaped object of self-identity. This identity makes different from person to person. In a certain limit we can differentiate them but it is difficult to make an artificial system to recognize any person from a large database system. The objective of this work is to make a system to enhance the differentiation to recognize the person easily.

In this method we project a pattern of a mask onto the face and the deformation of the pattern due to the differentiation of the human face identifies the person. All the faces are imposed under such a condition before making the data base system for those persons to be identified appropriately in a well tight security system. For making the candidate data for the recognition, the person is checked under the same condition imposed during the time of assembling the database system. The most important part of the research work is to design the pattern of the mask and acquire the boundary.

2.1 Image Acquisition System

To make the security system reliable a designed mask of a selected pattern is projected onto the face surface to acquire the face image. Camera and projector are set in such a way that they can get the frontal view of the face surface. Optical axis for the camera is slightly inclined with optical axis for the projector to set the center of the pattern on the point that is very near to the center of the image plane. The area bounded by a pattern on the mask is considered as the boundary of an individual object. This boundary is extracted by using the image enhancement process, which is discussed in Section 2.2. The projected system with the designed mask is shown in **Fig. 1**.

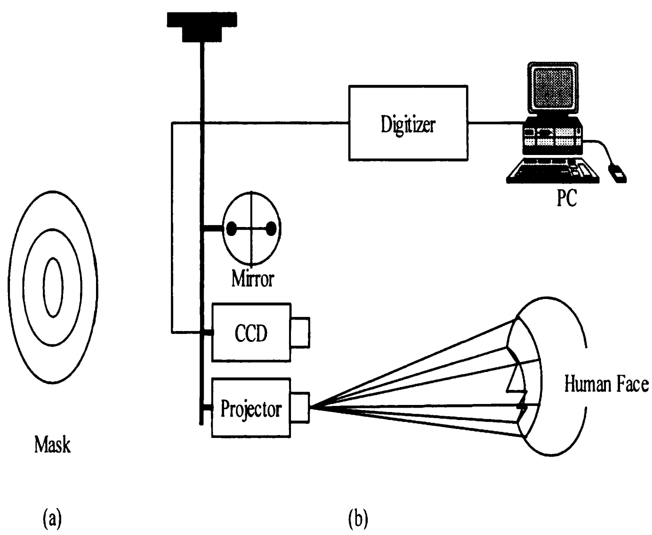

Fig. 1 Image acquisition system, (a) Mask pattern, (b) Block diagram of the system.

To observe the pose by the person himself/herself a mirror is mounted with the camera and projector in such a way that, it can move freely up and down to adjust them with the height of the person. Two crossed-lines (horizontal and vertical) with bold points at both ends of the horizontal line are marked on the mirror. The person is trained to adjust the vertical line on the mirror passes onto the nose as a bisector and the end points are adjusted onto the end points of two eyes. This adjustment is tested for taking the image after the projection of the pattern-mask onto the face in such a way that the major axis of the most inner pattern behaves as the bisector of the human nose on the image plane. The center of the pattern is also set at any point near the center of the image plane. The most important thing is to remember the pose during the time to make the candidate data because the system works automatically, as there is no operator to identify the person for the security system. A computer monitor can be replaced instead of a mirror but it will be costly.

2.2 Image Segmentation

Each image is processed in such a way that it gives a number of object's boundaries of various shapes equal to the number of patterns on the mask. The image is first transformed into monochromatic image. One of the very well known edge-finding algorithms, rotationally symmetric Laplacian of Gaussian with standard deviation is implemented onto the monochromatic image to get the sharp edge of the original pattern on the image plane. It is to be noted that other well-known algorithms: Sobel, Prewitte, Laplacian, Gaussian, and Average filters are tested but the above mentioned filter gives the best result. As the center of the image plane is not far from the center of the innermost pattern, boundaries have been searched developing an efficient filtering algorithm called, vertical edge filtering (VEF) or horizontally edge filtering (HEF) from the center of the image plane, which extracted a number of object boundaries.

It should be mentioned here that for searching edge points using VEF or HEF there are some missing points on the edge. We implemented two ways independently and combine them then the possibility of missing edge points is diminished. We call this algorithm a combination of vertical and horizontal edge filter (CVHEF). The overall basic idea of the algorithm, which is developed to extract the boundary of each object, is shown in **Fig. 2**.

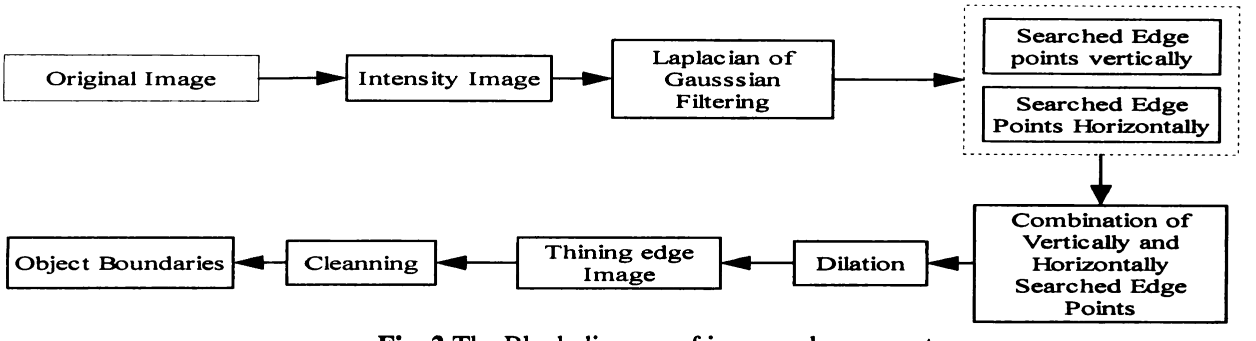

Fig. 2 The Block diagram of image enhancement.

Because the major axes for all the patterns on the mask are considered as the common axis and it is adjusted onto the nose-bisector vertically. The upper and lower edge points are searched as the maximum distances from the origin of the image plane. From these two optimum-points, other points on the edge are searched horizontally by increasing the number of pixels along the false matches. If the algorithm meets with the appropriate match it stops and takes as an edge point. The algorithm does the same thing increasing single-pixel step along vertical direction. To search the points vertically the basic idea of the algorithm remains the same. The outputs from the vertical and horizontal search points are combined to make the whole boundary of an object. The next boundary is decided by imposing a threshold number, which means there is no possibility to find out any edge within these numbers of pixels without altering the basic idea of the algorithm. **Fig. 3** shows the basic idea for finding the object's boundary roughly.

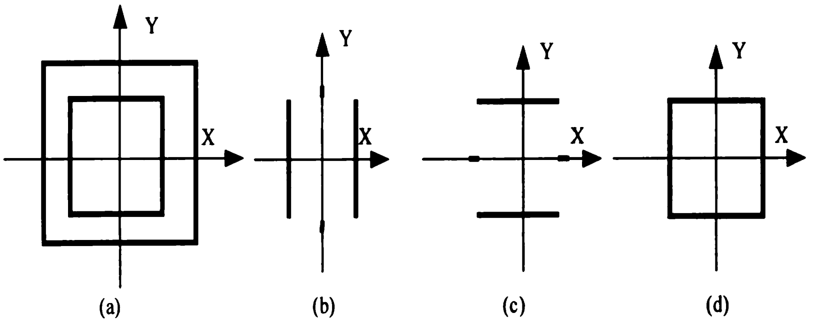

Fig. 3 Basic idea for finding the edge boundary: (a) edge boundaries, (b) vertical edges are obtained by HEF, (c) horizontal edges are obtained by VEF, and (d) complete boundary of inner edge is obtained by CVHEF.

The main problem of the above simple algorithm is that if it finds any match point from the noise inside the boundary, the algorithm stops here and takes this point as an edge point but the original edge point remains missing because the algorithm does not search further. To recover the missing points on the edge boundary the image is dilated. The dilation operator takes two pieces of data as input, the first is the image, which is to be dilated and the second is a (usually small) set of coordinate points known as a structuring element (also known as a kernel). The structuring element determines the precise effect of the dilation on the input image. The mathematical definition of dilation for binary images is as follows:

> Let us suppose that *X* is the set of Euclidean coordinates corresponding to the input binary image, and that *S* is the set of coordinates for the structuring element. Let *Sx* denote the translation of *S* so that its origin is at *x*.
> Then the dilation of *X* by *S* is simply the set of all points *x* such that the intersection of *Sx* with *X* is non-empty.

After the dilation the edge boundary is obtained by applying morphological operation called thinning on the binary image. The noises for the isolated pixels in the image plane are cleaned with another morphological operation, which is called cleaning.

2.3 Boundary Tracing

The important note is that the pattern no longer remains the original shape in the image plane, each shape depends upon the surface construction of the human face. Each area is considered as an individual identity and its boundary gives the information about the shape of the object. Giving the binary data of the edge pixel the coordinate are traced with 8-neighbours connected regions. This is obviously useful when deciding which edge points to link together. Local edge linking methods usually start at some arbitrary edge point and consider points in a local neighborhood for similarity of edge direction as shown in **Fig. 4**. If the points satisfy the similarity constraint then the points are added to the current edge set. The neighborhoods based around the recently added boundary points are then considered in turn and so on. If the points do not satisfy the constraint then we conclude we are at the end of the boundary, and so the process stops. A new starting boundary point is found which does not belong to any boundary set found so far, and the process is repeated. The algorithm terminates when all boundary points have been linked to one boundary or at least have been considered for linking once.

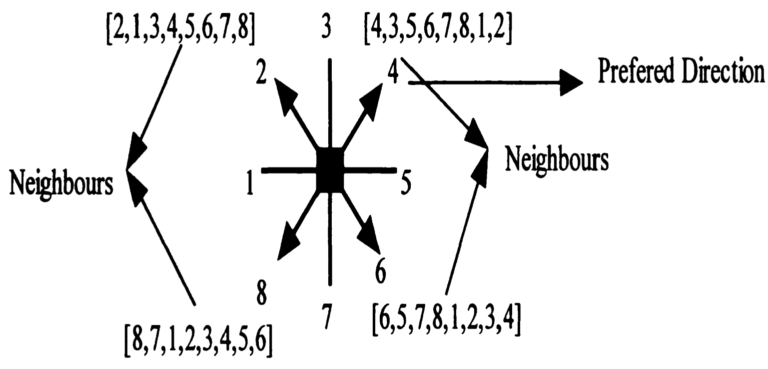

Fig. 4 Boundary linking.

The algorithm used to extract features to identify a person automatically in the system that may be necessary to maintain its security tightly. The person is advised to take the image with the proper way. In the experimental setup a mirror is mounted with the camera and projector in such a way that it can move freely up and down to adjust them with the height of the person. This type of arrangement gives a stable image of a human face if the orientation and positions both for camera and projector are stationary with respect to the original situation. The optical axis of the camera is slightly inclined with the optical axis of the projector, therefore the center of the inner most pattern is placed at a point very near to the center of the image plane.

To perform the effectiveness of the proposed method for the identification of a person in the system, we conducted computer simulations using real image of a person. Various types of filters are tested to get the edges of the patterns but among them rotationally symmetric Lapalacian of Gausssian gives the best results. After getting the edges, CVHEF is carried out on the image to select and separate the boundaries of a pattern.

4. Summary

An algorithm, which can identify a person automatically in a cooperative environment to maintain the system's security tight and reliable, has been proposed and demonstrated. One of the most difficult parts of any pattern recognition algorithm is to find out the boundary of an object without any break and traced the boundary points accurately. In our algorithm this problem has been solved using symmetric of Lapalacian of Gaussian filter, CVHEF, dilation, thinning, and cleaning morphological operations. The only one drawback of the algorithm is that the person must be cooperative otherwise the candidates are not be matched with the training sets and the person is to be declared false for the security system. The robustness of the algorithm is that it creates feature vectors for the deformation measurement projecting a pattern mask onto the face surface, which is very much related with the 3-D face structure. Our future goal is to find out the 3-D feature vectors for making more reliable person identification system.

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