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A Novel Approach To Track The Facial Image Forging Using Face Recognition Techniques

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ABSTRACT

In contemporary world, the technology is used more in fraudulent ways as much as in constructive ways. Using technology to deceive and forge is rampant, so there is an urgent need for a better technique to track the perpetrators. Various Biometric solutions have been developed to ensure security in diverse fields such as finger prints, iris scanning, etc. A novel approach is to use the face recognition technique to provide a robust technology against the infringement. This technology is the most challenging of the lot, as forging of facial image can be done in different ways and entails comprehensive analysis of various dimensions of a facial image. This study has wide spread applications in the field of national security and anti-terrorism measures.

This thesis addresses two main variation problems in face recognition, i.e., pose and illumination variations. To improve the performance of face recognition systems, the following methods are proposed: (1) a face feature extraction and representation method using non-uniformly selected Gabor convolution features, (2) an illumination normalization method using adaptive region-based image enhancement for face recognition under variable illumination conditions, (3) an eye detection method in gray-scale face images under various illumination conditions, and (4) a virtual pose generation method for pose-invariant face recognition. The details of these proposed methods are explained in this thesis. In addition, we conduct a comprehensive survey of the existing face recognition methods. Future research directions are pointed out.

1. INTRODUCTION

1.1 FACE RECOGNITION

In recent years, the need for accurate and automatic human recognition techniques has seen much growth. Face recognition is a form of biometrics that can assist in the human recognition process. Biometrics uses distinguishable forms of the human anatomy (physical characteristics) or traits (behavioral characteristics) to determine or verify the identity of an individual. Physical characteristics include facial patterns, fingerprints, eye retinas and irises, DNA, and hand geometry. Behavioral characteristics, on the other hand, include signature, gait, voice and typing patterns.

Among the available biometrics methods, such as, face recognition, iris recognition, fingerprint matching, and DNA matching, face recognition is much more desirable and has the most applications. Therefore, the focus of my research and the dissertation is on face recognition technology.

Face recognition has a wide range of applications, from identity authentication, mug shot matching, access control, and face-based video indexing/browsing, to human-computer interaction.

Face recognition technology is the least intrusive and fastest biometric technology. For example in surveillance systems, instead of requiring people to place their hands on a reader (fingerprinting) or precisely position their eyes in front of a scanner (iris recognition), face recognition systems unobtrusively take pictures of people's faces as they enter a defined area. There is no intrusion or capture delay, and in most cases, the subjects are entirely unaware of the process. People do not necessarily feel "under surveillance" or their privacy being invaded.

Building an automatic face recognition system has been an active research topic in computer vision and pattern recognition for few decades. A general statement of the face recognition problem is simply formulated as follows: given still or video images of a scene, identify or verify one or more persons in the scene using a stored database of faces. The solution to the problem involves three steps in general: (1) segmentation of faces (face detection) from cluttered scenes, (2) feature extraction from the face regions, and (3) face classification or verification. Even though humans can detect and identify faces in a scene with little effort, building an automated system that accomplishes such an objective is not that simple. The challenges are even more profound when one considers the large variations in visual stimulus. These variations become the concern of my research.

Variations associated with face images are attributed to the following factors:

- Pose - The images of a face vary due to the position of the face relative to the camera (e.g., frontal, 45 degree, profile, and upside down).
- Illumination and imaging conditions - When an image is formed, factors such as lighting (spectra, source distribution and intensity) and camera characteristics (sensor response, lenses) affect the appearance of a face.
- Facial expression - The appearance of faces is directly affected by a person's facial expression.
- Scale - Face images may have different sizes.
- Occlusion - Some facial features such as beards, moustaches, and glasses may be present in some pictures of the same person. In these pictures, some facial characteristics get occluded. Faces may also be partially occluded by other objects.

Based on the above observation, my research mainly focuses on proposing face recognition techniques that are robust against the two most significant variations involved in face images, pose and illumination variations.

1.2FEATURE-BASED APPROACHES

Lades *et al*. used an artificial neural network, which employs the so-called dynamic link architecture (DLA), to achieve distortion-invariant recognition. Local descriptors of the input images are obtained using Gabor-based wavelets. By conveying frequency, position, and orientation information, this approach performs well on relatively large databases. For a practical implementation of the dynamic link matching, elastic graph matching (EGM) has been proposed. This is a neural network with dynamically evolving links between a reference model and an input model image. To characterize a face, the EGM method utilizes an attributed relational graph, with facial landmarks (fiducial point) as the graph nodes, the Gabor transform around each fiducial point as the node attributes or jets and the distances between nodes as edge attributes. To compute the jet values, the fiducial points have to be located first. The is done through an elastic graph matching process, where the nodes of a model graph are tentatively overlaid on the test image, and the jets are extracted from the local image area around each node. Then the similarity of the model graph and the test image graph is optimized by dynamically varying the node positions in the image until the best matching location is found. Each time when a node location is changed, the jet value of the node has to be recomputed through the Gabor transform. Hence, the elastic matching process is very time consuming. This limits the EGM method in many practical applications.

Elastic bunch graph matching (EBGM) recognizes a human face from a large database containing one image per person. This method differs from EGM in three aspects. First, the phase of the complex Gabor wavelet coefficients is used to achieve a more accurate location of the nodes and to lessen the ambiguity in patterns that are similar in their coefficient magnitudes. Secondly, object-adapted graphs are employed, so that nodes refer to specific facial landmarks, called fiducial points. The correct correspondences between two faces can then be found across large viewpoint changes. Thirdly, a new data structure, called the bunch graph, is introduced; this graph serves as a generalized representation of faces by combining jets of a small set of individual faces. The success of EBGM is due to its resemblance to the human visual system.

1.3 RESEARCH OBJECTIVE

The objective of my research is to investigate and propose appropriate face recognition techniques that are robust against the two most significant variations involved in face images, pose and illumination variations.

1.4 RESEARCH APPROACHES AND MAJOR CONTRIBUTIONS

In order to achieve the objective, we tackle the problems from two aspects: (1) to propose a new face feature extraction and representation technique and (2) to propose new problem-specific pre-processing techniques. Thus, this dissertation describes new methodologies to make automatic face recognition systems independent from the acquisition conditions of the images (mainly geometrical transforms and illumination), as well as a new technique for automatic extraction of highly discriminating characteristics from human face images.

The performance of a face recognition system highly depends on the representation of the face patterns (i.e., feature extraction). Generally speaking, a good representation should have characteristics such as: (1) small within-class variations, (2) large between-class variations, and (3) low-dimensional space (i.e., short vector length) in order to avoid the high computational cost in the classifier. Furthermore, its extraction should not depend much on manual operations. Intuitively, one should derive a face representation from the 3D face shape and skin reflectance if we could recover the above intrinsic information from a given 2D face image. Unfortunately, this is an ill-posed problem in computer vision. Therefore, most current well-known face recognition methods derive a face representation directly from the 2D face image matrix.

Another popular strategy for representing face patterns is to exploit some mathematical transformations of the 2D image. Typical transformations include the Fourier transform and various wavelet transforms. Among them, Gabor wavelets have been widely accepted by researchers in face recognition community, mostly because its kernels are similar to the 2D receptive field profiles of the mammalian cortical simple cells and exhibit desirable characteristics of spatial locality and orientation selectivity. Previous work on Gabor features has also demonstrated excellent performance.

As an outcome of the first part of my research, a new feature extraction and representation technique has been proposed. In this dissertation, we present a new face representation method that employs non-uniform multi-level selection of Gabor features. The proposed face representation method has the advantages of low complexity, low- dimensionality and high discriminance. The proposed method works well for cases when multiple sample images are available for each person for training as well as when only one sample image is available for each person.

When the face images are highly varied due to severe pose and illumination changes, the sole dependency on feature extraction is not enough. We strongly believe that adding more delicately designed pre-processing methods before feature extraction can substantially increase face recognition performance in cases of heavy variations, which is the focus of the second part of my research. We propose problem-specific pre-processing methods to deal with different variations.

Variable illumination conditions in face images, especially the side lighting effect, form a main obstacle in face recognition systems. In this dissertation, for face recognition under variable illumination conditions, an illumination normalization method using adaptive region-based image enhancement is proposed.

Localization of eyes is a necessary step for many face recognition systems. Before two face images can be compared, they should be aligned in orientation and normalized in scale. Since both the locations of the two eyes and the intraocular distance are relatively constant for most people, the eyes are often used for face image normalization. In this dissertation, a new method of automatic localization of eyes in face images that is invariant to pose and illumination changes is presented.

The pose variation involved in face images significantly degrades the performance of face recognition systems. After a comprehensive survey of the existing methods dealing with the pose variations including both 2D and 3D methods, in this dissertation, a novel facial- component-wise virtual pose generation method for facilitating pose-invariant face recognition is proposed. With this efficient facial-component-based pose normalization method, both visual quality and recognition rate are shown to increase.

In summary, in order to achieve the research objective, we have proposed: (1) a new face representation method, (2) a new illumination normalization method, (3) a new facial feature localization method, and (4) a new face pose generation method. With these new methods, we are able to substantially improve the performance of an automatic face recognition system in terms of recognition rate, processing speed and resource consumption. The improvements have been proven by numerous experimental results on the most popular face databases.

The proposed methods can act to improve performance independently or to collaborate as a whole system to deal with more complex cases. Development of a complete face recognition software tool integrating all these methods is under plan and will be a promising and worthwhile work to do after my PhD research.

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