Face Identification

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The Problem: To develop a pose invariant face identification system.

Motivation: The development of automatic visual surveillance system is a popular research topic in computer vision. Current systems for face detection and identification are primarily based on classifying frontal views of faces, assuming that the person is looking straight into the camera. The frontal face recognition approach is adequate in access control applications where the user is consistent from session to session, e.g. accessing a personal laptop or a cellular phone. However, in surveillance applications where the user is often not aware of the task, it is important for the system to handle faces rotated in depth.

Previous Work: Focusing on the aspect of pose invariance we divide face recognition techniques into two categories: i) global approach and ii) component-based approach. i) In the global approach a single feature vector representing the whole face image is used as input to a classifier. Several types of classifiers have been proposed in the literature e.g. minimum distance classification in the eigenspace [7], Fisher's discriminant analysis [1], and neural networks [4]. Global techniques work well for classifying frontal views of faces. However, they are not robust against pose changes since global features are highly sensitive to translation and rotation of the face. ii) An alternative to the global approaches is to classify local facial components. The main idea of component-based recognition [5] is to compensate for pose changes by allowing a flexible geometrical relation between the components in the classification stage. In [3] face recognition was performed by independently matching templates of three facial regions (both eyes, nose and mouth). The configuration of the components during classification was unconstrained since the system did not include a geometrical model of the face. A similar approach with an additional alignment stage was proposed in [2]. In [8] a geometrical model of a face was implemented by a 2-D elastic graph. The recognition was based on wavelet coefficients that were computed on the nodes of the elastic graph. In [6] a window was shifted over the face image and the DCT coefficients computed within the window were fed into a 2-D Hidden Markov Model.

Approach: Both the global approach and the component-based approach are implemented and evaluated. The global approach consists of a face detector that extracts the face part from an image and propagates it to a set of SVM classifiers that perform face recognition. By using a face detector, the face part of the image is extracted and the background around the face is removed, so that translation and scale invariance is achieved. Due to changes in the pose and viewpoints, there are many variations in face images, even of the same person, which make the recognition task difficult. For this reason, the database of each person is split into viewpoint-specific clusters. A linear SVM classifier is trained on each cluster so as to distinguish one person from all other people in the database. A real-time face recognition system based on the global approach is also built. The component-based approach uses a face detector that detects and extracts local components of the face. The face detector consists of a set of SVM classifiers that locate different facial components and a single geometrical classifier that checks if the configuration of the components matches a learned geometrical face model. The detected components are extracted from the image, normalized in size, and fed into a set of SVM classifiers for face recognition. The performance of the global approach and the component-based approach recognition with respect to robustness against pose changes were compared. Tests were performed on both systems with a test database that included faces rotated in depth up to about 40. The component-based approach outperformed the global approach. This shows that using facial components instead of the whole face pattern as input features significantly simplifies the task of face recognition. However, the performance of the global approach with clustering is just slightly worse than the performance of the component-based approach. The speed of the component-based approach is much slower than that of the global approach, since a lot more SVM classifiers are used in the component-based approach for extracting the facial components, so this approach is not suitable for applications involving real-time systems for the time being. This is the reason why our real-time system is implemented based on the global approach.

Difficulty: The main challenge of this project is to develop a system which is able to identify faces under different viewing angles in real-time.

Impact: Among all the applications of biometrics identification, face recognition is most suitable for automatic visual surveillance systems. The availability of cheap and powerful hardware also lead to the development of commercial face recognition systems. Rotation invariant face recognition is an important issue to address because of its many real-world applications, especially in surveillance. It is clear that if a robust system is created, it will have a huge impact on many different areas of commercial and military technology.

Future Work: We will explore techniques for reducing the number and size of facial components in order to speed-up the system. Furthermore we want to investigate the use of 3-D head models for training our view-based face identification system.

Research Support: Research at CBCL is supported by ONR, Darpa, NSF, Kodak, Siemens, DaimlerChrysler, ATR, ATT, Compaq, Honda, CRIEPI.

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