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Special Issue
Artificial Intelligence: Future, Impacts, Challenges
Part 3

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EYES DETECTION FOR FACE RECOGNITION

LUIGI STRINGA
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A correlation-based approach to automatic face recognition requires adequate normalization techniques. If the positioning of the face in the image is accurate, the need for shifting to obtain the best matching between the unknown subject and a template is drastically reduced, with considerable advantages in computing costs. In this paper, a novel technique is presented based on a very efficient eyes localization algorithm. The technique has been implemented as part of the "electronic librarian" of MAIA, the experimental platform of the integrated AI project under development at IRST. Preliminary experimental results on a set of 220 facial images of 55 people disclose excellent recognition rates and processing speed.

INTRODUCTION

There is a growing interest in face-processing problems (Young and Ellis, 1989). The recognition of human faces is in fact a specific instance of 3D object recognition—possibly the most important visual task—and provides a most interesting example of how a 3D structure can be learned from a small set of 2D perspective views. Moreover, among several practical reasons for developing automatic systems capable of recognizing human faces, faces provide a natural and reliable means for identifying a person.

The first examples of computer-aided techniques for face recognition date back to the early 1970s and were based on the computation of a set of geometrical features from the picture of a face (Goldstein et al., 1971, 1972; Harmon, 1973). More recently the topic has undergone a revival (Samal and Iyengar, 1992), and different applications have been developed based on various techniques, such as template matching (Baron, 1981; Yuille, 1991), isodensity maps (Nakamura et al., 1991; Sakaguchi et al., 1989), or feature extraction by neural and Hopfield-type networks (Abdi, 1988; Cottrell and Fleming, 1990; O'Toole and Abdi, 1989). At present it is still rather difficult to assess the state of the art. However, a first significant evaluation is reported in (Brunelli and Poggio, 1991), where a comparison of different techniques is performed on a common database—the best results were obtained with a template matching type technique.

Following a correlation-based approach, excellent results have also been obtained with a procedure recently developed for the "electronic librarian" of MAIA, the experimental platform of the integrated AI project under development at IRST (Poggio and Stringa, 1992; Stringa, 1991a). The procedure is based on the analysis of filtered edges and grey-level distributions to allow a comparison of the directional

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derivatives of the entire image (Stringa, 1991d). On a set of 220 frontal facial images of 55 people, a recognition rate of 100% was obtained, at a processing speed of about 1.25 sec per face on an HP 350 workstation. A second set of experiments, using binary derivatives, disclosed excellent improvements in computing time: with a two-layer S_Net [see Stringa (1990)] the processing speed was reduced to less than 0.05 sec per face (Stringa, 1991e).

Such performance provides evidence for the validity of the approach. Moreover, the procedure proved very efficient with respect to the task of rejecting "unknown" faces, i.e., faces of subjects that are not included in the database. Apart from high recognition rates, low processing costs, and good flexibility under variable conditions, this is another important feature for a real (i.e., industrially applicable) face recognition system.

It must also be stressed, however, that such performance depends on the use of very effective normalization, registering, and rectification techniques. This is in fact a general requirement for any correlation-based approach to face recognition (and more generally to 3D object recognition), particularly when the image to be recognized is freshly captured with a video camera rather than scanned from a standardized photograph. In general it is rather natural to expect the user to look straight into the camera, for even in human interaction people tend to turn their heads so as to look at each other in the eyes. However, a certain flexibility must be tolerated concerning such variable factors as the distance and position of the user's face from the camera. Hence, some adjustment and normalization is necessary before the system can proceed to the recognition step by comparing the input image with the available set of prototypes.

In our procedure, the normalization of the image to be recognized is obtained by first locating the position of the eyes and then rotating the image so as to align them horizontally. As a result, the need for shifting to obtain the best matching between the unknown face and a template is drastically reduced, with considerable advantages in computing time. In particular, the eyes localization algorithm developed for this purpose (Stringa, 1991c) proves very sensible, allowing very precise positioning of both pupils for each facial image included in the data base.

The purpose of this paper is to illustrate this algorithm in detail. To emphasize better its crucial role for correlation-based facial recognition tasks, a brief outline of the system developed at IRST is first given, along with the experimental scenario that led to its formulation. The eyes localization algorithm is then fully described. The final sections report on the current experimental results obtained and offer some general remarks on the algorithm's performance.

OUTLINE OF THE SYSTEM

General Background: The MAIA Electronic Librarian

As already mentioned, the reported work is part of a more general AI project (labeled MAIA, acronym for "Modello Avanzato di Intelligenza Artificiale") pres-

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