ACTIVE VISION AS AN ENABLING TECHNOLOGY FOR USER-FRIENDLY IRIS IDENTIFICATION

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Abstract

Large-scale electronic transaction systems, such as ATM networks and E-commerce applications, place high demands on biometric identification systems. Users must be identified rapidly, securely (few false accepts), and reliably (few false rejects). These demands are typically fulfilled by the use of microscopic morphological features because the largely random nature of their morphogenesis produces highly unique phenotypes. However, the microscopic scale of such biometric features usually requires contact or close proximity of the imaged tissue to the sensor, which can impede the user acceptability of the identification system. We have solved this problem cost-effectively by developing a real-time active vision system that allows us to image the microscopic features of the human iris at a comfortable distance, automatically and without user effort. The result is a high-accuracy iris identification system that is intuitive and easy to use and that has already been fielded in several pilots by banks in Europe, Asia, and the United States.

Keywords: Biometrics, iris identification, active vision, user interface

I. Introduction

Humans are accustomed to recognizing each other at a comfortable distance by voice and appearance, and have done so for many thousands of years. Facial and voice recognition skills developed for interactions in small communities of people but still serve the average individual in an industrialized society who may interact with hundreds, perhaps thousands of different people over the course of a year. However, even the tremendous human ability to rapidly recognize thousands of individuals withers in the face of the identification demands of large-scale, impersonal point-of-sale electronic transaction models. Nonetheless, from a user-centered design perspective we would like a personal electronic identification device to present an interaction model similar to the traditional style of our everyday interactions while still maintaining high accuracy.

Motivated by these demands, we have designed a personal electronic identification system that combines high identification accuracy afforded by the use of microscopic biometric features (iris microstructure) with the ability to interact with the sensor at a comfortable "conversational" distance of between 1 to 3 feet. We achieved these conflicting design goals through the use of an active vision subsystem. Active vision [1] is defined as the goal-directed control of vision sensors to carry out a particular task. It includes the allocation of sensing and computing resources such that processing goals can be achieved efficiently. In our case, the active vision subsystem automatically directs a telephoto-based sensor that images a customer's iris at a comfortable distance, without any alignment or focus effort on the part of the customer. Adopting the active vision paradigm enables this approach because a passive vision system with a single sensor of sufficient electronic and optical resolution to image the eye from a single wide-field-of-view scene image is technologically infeasible at the current state of the art.

After the active vision subsystem has located and remotely imaged the eye, the iris pattern is analyzed and rapidly matched against a database, using a highly accurate and scalable biometric technique [2, 3]. The resulting personal identification system provides a very natural user interface and has received a correspondingly high degree of consumer acceptance.

II. Microscopic Morphology and the User Interface

In general, higher-accuracy biometric systems sense and analyze smaller morphological features. For example, fingerprint, retina, and iris biometrics require the analysis of small-scale structures, with the features of interest concentrated in an area of the order of $1cm^2$. The high feature density allows for a large of number of discriminating characteristics to be measured, enabling highly accurate personal electronic identification.

Gross anatomical features such as facial and hand features and eye or hair color are determined to a large degree by genetic factors. This “genetic penetrance”, as defined in [3], puts limits on the discrimination power of methods that are based on genetically determined features since individuals with similar genetic factors will share macro-features, leading to a higher incidence of false accepts. Micro-features of anatomical structures, on the other hand, are more often influenced by essentially random processes in the development environment, such as the production and diffusion of tissue growth factors during fetal development. Examples of such microstructures include retinal vasculature, iris stroma and fibrils, and the dermal ridges of the fingertips.

In order to sense these smaller-scale features, most systems have required close contact between the sensing element and the tissue. Fingerprint, retinal, and some iris systems have forced the user to bring the structure to be analyzed close to the sensor. The close proximity to or contact with a sensor can be undesirable for the user. For example, some users might find the prospect of rolling a fingerprint on a platen used by many other customers in a public kiosk unappealing. Similarly, bringing the eye close to a small eyepiece or near some other aperture can be an unpleasant prospect and could be an impediment to widespread consumer acceptance of electronic personal identification systems.

A second critical issue is that many systems that sense micro-features require additional training of the user in the presentation of the anatomical structure to be analyzed for biometric measurement. For example, some fingerprint systems may fail when users press too hard or too softly, causing a false reject and a negative user experience. Iris systems that require user self-focus can fail due to poor focus judgement on part of the user. In contrast, our system does not require user training and presents a pleasant and comfortable user interface, similar to interfaces found in a facial or voice identification system yet far outperforming them in terms of recognition rate.

III. Description of System and Processing

Our personal electronic identification system consists of a wide-field-of-view stereo vision and face detection subsystem and a telescopic narrow-field-of-view subsystem which is used to image the subject's iris at a distance (Fig. 1 and Fig. 2).

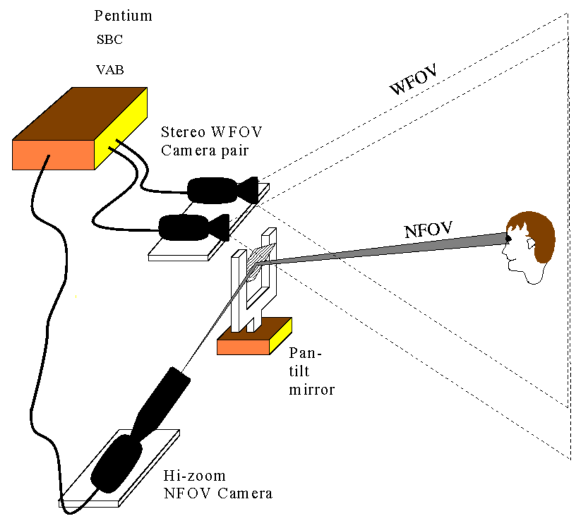

Fig. 1: Functional system component overview

Fig. 2: External system appearance (M765-R1)

In the wide-field-of-view subsystem, custom-designed image pyramid-generating hardware, developed in conjunction with Sarnoff Corporation, generates stereo disparity images in real-time, yielding the average distance to the subject's head. The depth map (Fig. 3) is also used to restrict the system's attention to the closest person out of a possible line of people.

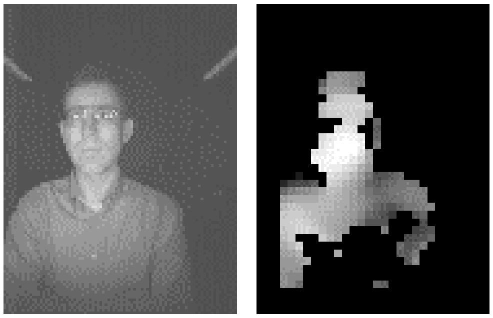

Fig. 3: Stereo-derived depth map for segmentation and ranging

A face template-matching algorithm is used to determine the (x,y) position in image space of the subject's eyes (Fig. 4), even if the subject is wearing glasses (Fig. 5). The eye position, along with the depth estimate of the subject's eye region (z), is mapped to actuator coordinates for a pan/tilt mirror and a fixed focal-length lens to precisely track, center and focus a high-resolution image of the subject's right or left eye [4].

The narrow-field-of-view subsystem locates the eye in the high-resolution image and extracts a 256-byte "iris code", which captures the unique structure of the iris [2, 3]. The image processing is performed on a 233MHz Pentium-based motherboard. In verification mode (one-to-one), the extracted code is compared to the subject's enrollment iris code stored in a database. Due to the feature-richness of the iris and the high-speed search properties of the iris code [2,3], the system can also operate in a large-scale recognition mode (one-to-many), which permits tokenless (card-free) use of an ATM by searching for the matching code within a large database of users.

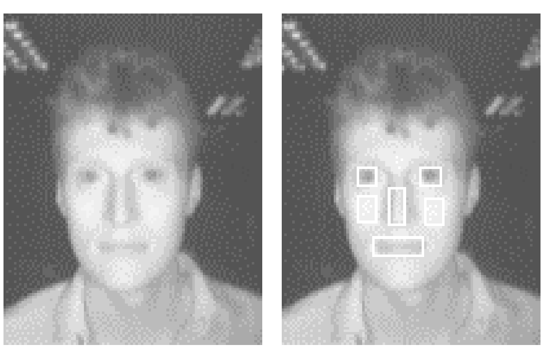

Fig. 4: Intensity and orientation-based face template output

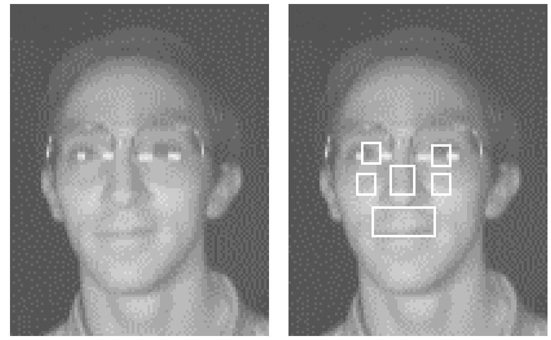

Fig. 5: Intensity and orientation-based face template for glasses

The system configuration achieves an average processing time of approximately 2.5 seconds. The only cooperation required from the customer is to gaze at the optical unit while the system is in operation (Fig. 6).

The current generation of the system, the Sensar…Secure® M765-R1, has been piloted with Nationwide Building Society (NBS) in England at an NBS bank branch. The system was installed at teller and ATM machine positions and used in verification mode. In this pilot, which enrolled over 1,000 participants, consumer opinion of the system was very positive. A post-study survey indicated that 94% of the customers using the system were comfortable or very comfortable with its use [5].

The system is currently being evaluated in a number of pilots in Japan, Germany, Italy, Spain, Turkey and the United States. These pilot trials are intended to allow additional banking institutions and banking equipment manufacturers to better familiarize themselves with the benefits and issues in the fielding of this novel approach to personal identification in retail financial services.

IV. Cost Considerations

The current generation of our product (M765-R1) uses conventional CCD sensors and mechatronics and was produced in low volumes for pilot purposes, leading to relatively high per-unit costs. With the availability of CMOS sensors and a significant redesign for manufacturability underway, the system price will decrease significantly in the next-generation product, which is currently under development.

Furthermore, the general-purpose and flexible active vision platform provides a substrate for future additional functionality in ATMs. Potential secondary uses of the active vision platform include enhanced user interfaces and secure video at the point of contact with the customer, which may allow the initial cost of the system to be amortized among multiple value-added system functions.

Fig. 6: System installed in an ATM (above the monitor)

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IriScan, Inc. of Marlton, New Jersey, USA, holds the exclusive worldwide patents on the iris identification concept developed by Drs. Leonard Flom and Aran Safir and the software and process technology invented by Dr. John Daugman, Cambridge University, England. Sensar uses, under license, the iris identification process developed and owned exclusively by IriScan. IRISCAN is a trade mark of IriScan, Inc. of Mt. Laurel, New Jersey, and is used by Sensar, Inc. under license from IriScan, Inc.

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