Int.l Summer School for Advanced Studies on

BIOMETRICS for SECURE AUTHENTICATION:
New Technologies and Embedded Systems

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COURSE ABSTRACTS

Monday June 11th

Biometrics Systems

Massimo Tistarelli

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Biometric recognition has attracted the attention of scientists, investors, government agencies as well as the media for the great potential in many application domains. It turns out that there are still a number of intrinsic drawbacks in all biometric techniques. In this paper we postulate the need for a proper data representation which may simplify and augment the discrimination among different instances or biometric samples of different subjects. Considering the design of many natural systems it turns out that spiral (circular) topologies are the best suited to economically store and process data. Among the many developed techniques for biometric recognition, face analysis seems to be the most promising and interesting modality. The ability of the human visual system of analyzing unknown faces, is an example of the amount of information which can be extracted from face images. This is not limited to the space or spectral domain, but heavely involves the time evolution of the visual signal. Nonetheless, there are still many open problems which need to be “faced” as well. This not only requires to devise new algorithms but to determine the real potential and limitations of existing techniques, also exploiting the time dimensionality to boost recognition performances.

This talk will survey the general concepts and technologies of biometrics systems and will cover in more detail face image analysis and recognition.

This lecture will review several methods for face matching, based on diverse similarity measure and image representations. Some new methods are described, tested with conventional and also new databases from real working environments.

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Fingerprint Recognition

Davide Maltoni Raffaele Cappelli

University of Bologna - Italy

This lecture introduces fingerprint recognition in a top-down fashion. Some general schemes are provided to explain the overall architecture of a fingerprint recognition system. Then, the main components (acquisition device, feature extraction, and matching) are discussed in detail. Different state-of-the-art approaches are presented and compared, and the most critical difficulties characterizing fingerprint recognition are pointed out referring to FVC2002 and FVC2004 (Fingerprint Verification Competition) results.

Hot topics like aliveness detection and synthetic generation of fingerprints are also discussed. Live examples and demos of several techniques are shown during the lecture to better explain some concepts.

Machine Learning Techniques in Biometrics

Alessandro Verri

Department of Computer Science, University of Genova - Italy

In this talk the learning from examples problem is presented within the framework of Regularization Networks. The important notion of Reproducing Kernel Hilbert Space is briefly reviewed. We then show that within this framework several learning methods can be easily obtained. In particular we derive Support Vector Methods and discuss their basic mathematical properties: existence, uniqueness, and consistency. We then illustrate methods for tuning the SVM parameters and in particular for selecting the regularization parameter. The main computational issues behind the implementation of SVMs are presented and, finally, some experimental results in biometric applications are described.

Introduction to Speaker Recognition

John Mason

University of Wales Swansea - UK

There are several components or levels of information embedded in the acoustic speech signal, the most obvious of which is the spoken message itself. In the context of biometrics the key question is the identity of the person speaking. These two ideas lead respectively to automatic *speech* and automatic *speaker* recognition. This presentation covers the fundamental aspects of automatic *speaker* recognition, many of which just happen to be common with the complementary task of automatic *speech* recognition.

The first part deals with features. Speech is very much a behavioural biometric in that the important information components are buried in the time domain signal and this signal is practically infinite variation, encompassing differing messages, different people, different times, different conditions, and so on. The task of *speaker* recognition is to extract the identity of the person speaking while neutralising variations such as the text. Likewise the task of automatic *speech* recognition is to extract the message or text component while neutralising all the other unwanted variations, including that of the speaker. Interestingly, and perhaps a little counter-intuitively, features that tend to be used in both of these tasks are the same short-term spectral based cepstral representations. The fundamental ideas behind cepstra are presented.

The second part of the presentation considers aspects of classification with emphasis on the idea of data-driven models and the important concept of normalisation. In *speech* recognition vast quantities of speech data, perhaps more than any one person might hear in a lifetime, can be used to train a speech recogniser. Clearly this is not possible in the case of a *speaker* recogniser, since typically data for a given speaker is likely to span only seconds or minutes. Strategies for speaker modelling must reflect this practical limitation. The importance of the quantity and, as with all biometrics, the quality of speech data is discussed.

The final part of the talk introduces assessment strategies that have evolved out of the open evaluations over the last 10 years .

Video-based Face Recognition

Rama Chellappa

University of Maryland - USA

Most existing face recognition algorithms and systems use one or a few still images. Even when video sequences are available, one often selects one or more best still frames and pass them on to still-image based recognition systems. Processing a video sequence for face recognition has many advantages; first, there is more information to be exploited. Second, it is possible to incorporate models for facial motion and illumination variations yielding a robust solution. Third and most importantly, temporal continuity present in video sequences enables simultaneous tracking and recognition algorithms to be developed. In this talk, we will describe three types of video face recognition (VFR) algorithms, one using 2-D appearance, the second using a 2-D feature graph and the third using a 3D cylindrical model for the face. The general approach is to formulate the VFR problem as a simultaneous tracking and recognition problem and maximize the posterior density of finding a face in th e video using Monte Carlo Markov Chain (MCMC) techniques. We will also discuss related works that use hidden Markov models and dynamic time series models. Methods for handling illumination variations, fusion of video-based face and gait recognition algorithms and 3D modeling of faces for creating novel views that can be used for VFR will also be discussed. Finally, evaluation protocols for VFR will be presented.

Classifiers for Multimodal Biometrics

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Individual biometric modalities are continuously developed to improve their performance by sensor, system and algorithmic improvements. However, a very attractive alternative is to gain enhanced performance and robustness of biometric systems by combining multiple biometric experts. Recent research has demonstrated that both, the fusion of intra-modal experts as well as multi-modal biometrics impact beneficially on the system performance. In the former case the benefits derive from pooling the opinions of individual intra-modal experts. In the latter, complementary biometric information is brought to bear on the personal identity authentication problem. The issues involved in multiple biometric expert fusion and its potential will be discussed and illustrated on the problem of combining face and voice based identification.

Human Identity Recognition from Gait

Mark S. Nixon

Electronics and Computer Science, University of Southampton - UK

This talk will survey gait as a biometric and place it in the context of other (vision-based) biometrics. Automatic recognition by gait is now subject to increasing interest and has unique capability to recognize people at a distance when other biometrics are obscured. Its interest is reinforced by the longstanding computer vision interest in the automated non-invasive analysis of human motion. Its recognition capability is supported by studies in other domains such as medicine (biomechanics), mathematics and psychology which continue to suggest that gait is unique. Further, examples of recognition by gait can be found in literature, with early reference by Shakespeare concerning recognition by the way people walk. Many of the current approaches confirm the early results that suggested gait could be used for identification, and now on much larger databases. This has been especially influenced by the Human ID at a Distance research program with its wide scenario of data and approaches. Gait has benefited from the developments in other biometrics and has led to new insight particularly in view of covariates. As such, gait is an interesting research area, with contributions not only to the field of biometrics but also to the stock of new techniques for the extraction and description of objects moving within image sequences.

Biometric Evaluation and Standardization

Farzin Deravi

Department of Electronics, University of Kent - UK

A review of best practice guidelines for testing biometric systems. The distinction between, technology, scenario and operational testing will be studied.
Performance metrics will be reviewed and methods of reporting test results will be covered. Emerging issues for biometric test and evaluation will also be explored.
This talk will also provide an overview of ongoing standardisation efforts in the area of biometrics. Major parts of the ISO SC37 work programme will be covered. Insights to the standardisation process will be provided and the upcoming new work items will be highlighted.

Iris Recognition

Tieniu Tan

National Laboratory of Pattern Recognition
Chinese Academy of Science, Institute of Automation, China

With an increasing emphasis on security, automated personal identification based on biometrics has recently gained extensive attention from both research community and industry. Iris recognition is becoming one of the most active topics in biometrics due to its high reliability for identification. Great progress has been achieved since the concept of automated iris recognition was first proposed in the 80s.

This lecture will cover the fundamentals and state of the art of iris recognition, including discussions on each step of a complete iris recognition system (from iris sensor design, iris image databases, liveness detection, iris image quality assessment, iris image synthesis, iris region detection and normalization to iris feature representation and matching). Current applications and remaining issues in iris recognition will also be discussed.

Biological Recogntion of Human Faces

Alice O'Toole

University of Texas at Dallas - USA

Human face recognition is thought to be the gold standard against which automatic face recognition algorithms should be evaluated. I will provide a background overview of the characteristics of human face recognition performance—with special emphasis on how humans recognize very familiar faces. I will also present recent studies in which the evaluation of algorithms relative to humans provides insight into both the pitfalls and advantages of the human system relative to computer-based algorithms. This kind of data can be informative for the development of hybrid systems that use algorithms and humans to their best advantage. In these recent studies, we have compared algorithm performance in the U.S. Government-sponsored "Face Recognition Grand Challenge" (2005-2006) and Face Recognition Vendor Tests (2007) with humans matching face identity from images that vary in illumination. The results indicate that machine performance is competitive with human performance. I will also present data on fusing human and machine estimates of face identity matching. This fusion improves system performance over that which can be achieved by either by humans or machines working along. In this presentation, I will discuss the methods we have used in these comparisons, the lessons learned, and the results to date. I will also discuss the challenges to sampling the enormous amounts of data available from algorithms for making useful and valid comparisons to human memory and perception.

On-line Signature Verification

Sonia Salicetti

GET-INT (Groupe des Ecoles dea Télécommunications/Institut National des Télécommunications) - ***France***

This talk will be first focused on a review of the different existing state-of-the-art approaches in online signature verification and their evaluation: statistical approaches based on Hidden Markov Models, Dynamic Time Warping, classical distance-based approaches, global approaches, etc. Existing works based on fusion of such different types of approaches will also be briefly presented. Results of the recent international evaluations in the field will be described: Signature Verification Competition (SVC'2004), First BioSecure Residential Workshop (2005).
Then, an applicative context, that of the signature modality in mobile platforms, will be presented; the IST-2002 506883 SecurePhone project in which signatures are captured on the touch screen of a Smartphone and used to authenticate the user with face and voice modalities, will be briefly described. Finally, trends and challenges for on-line signature verification will be discussed.

Exploiting Biometrics in Industrial Applications

Fred Preston

Motorola Biometrics – UK

Motorola's 30 years' experience in providing the latest identification technology to the law enforcement community – and more than 65 years of delivering public safety technology solutions - gives us the broader perspective needed to analyze the biometric options available today. Our conclusion is that all biometric technologies offer promise – some today and some in the future. A matrix of factors – accuracy, ease of use, stability, vendor and technology experience in the field, track record and acceptance – combine to make some specific biometric applications more widely deployed. The pressing needs of homeland security demand biometrics that can be put to work today. Thus the three leading biometric technologies for homeland security applications are:

- Fingerprint scan
- Facial scan
- Iris scan

These three technologies – fingerprint, facial and iris recognition – offer the most promise for defending homeland security. When iris scan becomes accepted for mass application, this biometric could add another layer of protection to our border security. But right now the International Civil Aviation Organization (ICAO) has defined the need with a published standard that requires nations to certify that they have programs to issue their nationals machine readable passports that incorporate two biometric identifiers – digital fingerprints and photos.
Whatever the need – whether for one biometric measure or for technology that creates biometric fusion of more than one measurement – Motorola stands ready to apply our vast experience and expertise to create an integrated biometric solution for border security as well as other applications.

What does it take to build and deliver a Biometrics Identification Solution (BIS)? What is the value chain of components making up the BIS? In this lecture these questions are answered together with examples of real implementation to help understand the path from R&D laboratory innovations to operational production systems deployed at customer sites.

Embedded Biometric Systems

Salil Prabhakar

Digital Persona – USA

In this talk, I will cover embedded biometric solutions in general with examples from embedded fingerprint recognition systems. I will cover principles of architecting and designing embedded biometric algorithms and systems. I will discuss the challenge in designing biometric algorithms and systems for embedded platforms in balancing several tradeoffs such as memory bandwidth, cache utilization, and accuracy, under the constraints of limited resources such as processing power and memory. I will also discuss target applications and scenarios, security issues, costs, template size/protection and other considerations taken into account during design. I will demonstrate a working embedded fingerprint recognition system, discuss how it was designed and developed, under which constrained, for which target application, and what lessons were learnt during the process.

Security in Biometrics

Hervè Chabanne

SAGEM -France

This lecture gives a view on different security models encoutered for biometric systems. On one hand, some recent cryptographic scientific publications are analysed. And an emphasis is made on the techniques of secure skecthes. On the other hand, a synthesis of different common criteria protection profiles requirements on this very subject is made.

Iris Recognition: On the Move, At a Distance and Related Technologies

James R. Matey

Sarnoff Corporation, New Jersey - USA

Iris recognition is one of the best biometrics available. As with all biometrics, ease of use is crucial to its successful deployment. We have developed hardware, algorithms and software for iris image acquisition that substantially reduce the constraints on subjects in comparison to current commercial off the shelf systems – making it far easier for non-habituated subjects to use iris recognition in many scenarios.

This presentation will review the development of "on the move" and "at a distance technologies", present the latest developments and discuss how these technologies might be integrated with other developing technologies.

New Technologies in Video Surveillance

Roberto Cipolla

University of Cambridge - UK

We review methods for detecting faces, hands and the human body in a monocular image sequence. In particular we present a novel algorithm for tracking faces using a Relevance Vector Machine (RVM) based displacement expert. The framework provides a much needed sparsity in template matching for locating and estimating the pose of objects. The framework will also be extended to estimate the 3D poses of articulated objects such as hands and the human body in a multiple hypothesis framework.

Biometric Systems and 3D Face Recognition Technologies

Ben Schouten

Centre for Mathematics and Computer Science (CWI), Amsterdam - The Netherlands
European Biometric Forum

Manuele Bicego

Computer Vision Laboratory, Università di Sassari - Italy

New sensing and distributed technologies will enable transparent biometric applications integrating in our daily life. Following the value chain model for implementation of biometrics, a successful design, deployment and operation of biometric systems depends highly on the scientific results for existing biometrical technologies and components. These existing technologies as well as new solutions need to be evaluated on their performance. However it is often forgotten that the biometric is only one part of a fully deployed application.

System developers should be aware that requirements capture and system definition for biometric enabled systems are demanding, time-consuming and expensive activities than for most other IT systems. System integrators will need to address the security require-ments of the deployed application in this light and the fears and concerns of a significant segment of the user population need also to be addressed as early as possible in the design process, to ensure that appropriate mechanisms are in place to reassure such users. The concerns may relate to privacy or to safety issues, which may be addressed in part through legal and regulatory measures.

In this course we will elaborate on the requirements, design and application scenario's of biometrical systems from different perspectives. Consequently we will shed light into the future of new sensing technologies and cognitive biometrics for smart environments.

As reader we will use the BIOVISION roadmap for biometrics in Europe to 2010.

http://www.eubiometricforum.com/index.php?option=com_docman&Itemid=26

Extended Feature Set in Fingerprint Matching

Yi Chen

Michigan State University - USA

There are fundamental differences in the way fingerprints are compared by forensic experts and current Automatic Fingerprint Identification Systems (AFIS). For example, while AFIS focus mainly on the quantitative measures of fingerprint minutiae (ridge ending and bifurcation points), latent experts often analyze details of intrinsic ridge characteristics and relational information. The process of qualitative friction ridge analysis includes examination of minutiae shape, dots, incipient ridges, local ridge quality, and ridge tracing, This explains the challenges that current AFIS face in processing poor quality prints, especially latent prints. In fact, most of the features used by latent experts have not even been quantitatively defined for AFIS matching. The forensics as well as the AFIS communities have become very active in standardizing the definition of extended feature set, as well as quantifying the relevance and reliability of these features for automatic systems. CDEFFS (Committee to Define an Extended Feature Set) has proposed a draft on possible definitions and representations of extended features. The FBI Lab is also completing a study on the permanence of various friction ridge characteristics including these extended features. This lecture will describe the foundamental characteristics of extended feature set. We will introduce and discuss previous work on utilizing them in fingerprint matching as well as algorithms that have been recently developed to automatically extract extended features. A systematic framework that automatically utilize multi-level fingerprint features will be demonstrated at last.