Summer School for Advanced Studies on

BIOMETRICS for SECURE AUTHENTICATION:
New Sensors, Evaluation and Database collection

Alghero, Italy - June, 5 – 9 2006

COURSE ABSTRACTS

Monday June 5th

Tuesday June 6th

Wednesday June 7th

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Friday June 9th

Large scale biometrics identification: Issues and challenges

Nalini Ratha

IBM Thomas J. Watson Research Center, Hawthorne - USA

As more and more civil applications require reliable and accurate citizen identification, law makers rely on biometrics as a useful tool in building identification card projects. In this talk, we briefly review the existing methods used in large-scale biometrics identification applications. We also present a review of algorithms used in fingerprint identification in particular. Contrary to the common belief that fingerprint identification is a solved problem, we will show that there are several research issues in building a large scale identification system. The impact of the biometrics system errors on the workload and efficacy of the overall system will be demonstrated. The challenges for large-scale biometrics identification are significant both in terms of improving accuracy and response time. The performance of the identification algorithms need to be significantly improved to successfully handle millions of persons in the biometrics database matching thousands of transactions per day. Current large scale biometrics identification techniques will require a fresh approach in designing systems that can handle very large populations. We will conclude that only then biometrics will be able to successfully help in citizen card issuance.

Support Vector Methods and Biometric Classification

Alessandro Verri

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.

Iris recognition

Tieniu Tan

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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.

Testing Biometric Systems 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.

Human indentity 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.

Biometrics with direction

Josef Bigun

Halmstad University and Chalmers University of Technology, Sweden

Face is an important trait with which humans recognize and identify other humans. There is significant evidence, both from studies of prosopagnosia and from studies of brain damage, that face analysis engages special signal processing in visual cortex that is different from processing of other objects [1, 4, 5]. There is a general agreement that approximately at the age of 12, the performance of children in face recognition reaches adult levels, that there is already an impressive face recognition ability by the age of 5, and that measurable preferences for face stimuli exist in babies even younger than 10 minutes [3]. For example, human infants a few minutes of age show a preference to track a human face farther than other moving nonface objects [7]. While there is a reasonable rotation-invariance to recognize objects though it takes longer times, turning a face upside down results usually in a dramatic reduction of face identification [2]. These and other findings indicate that face recognition develops earlier than other object recognition skills, and that it is much more direction sensitive than recognition of other objects.

Perhaps recognition of face identities is so complex that encoding the diversity of faces demands much more from our general-purpose, local direction, and frequency-based feature extraction system. If so, that would explain our extreme directional sensitivity in face recognition. Parallely, there is mounting evidence that faces [1, 6, 8, 9], just like color, disposes its own "brain center". Face sensitive cells have been found in several parts of the visual cortex of monkeys, although they are found in most significant numbers in a subdivision of inferotemporal cortex in the vicinity of the superior temporal sulcus. Whether these cells are actually necessary and sufficient to establish the identity of a face, or if they are only needed for gaze-invariant general human face recognition (without person identity) is not known to sufficient accuracy. In humans, by using magneto resonance studies, the face identity establishing system engages a brain region called fusiform gyrus. However, it may not exclusively be devoted to face identification, as other sub-categorization of object tasks activate this region too. On the other side, directional processing of images is the most ubiquous signal processing of the known mammalian vision. It feeds nearly all other visual processing areas and subsystems, including face recognition/spotting [hubel,orban,zeki,baylis]. This means that when humans act as supervisors or operators of even other biometrics data that are images, such as fingerprints and iris, they rely on directional processing.

It is therefore not surprising that many of machine biometrics methods that rely on directional features are among the most successfull, regardless the trait, e.g. face recognition, fingerprint recognition, iris recognition. In 2-D, the earliest solutions to the problem of finding direction of an image patch, consist in projecting the image onto a number of fixed orthogonal functions. The thus obtained projection coefficients are used to derive the orientation parameter of the model. When the used number of filters is increased, the local image is described increasingly better but the inverse mapping of the projections to an optimal direction increases in complexity rapidly. Here we will present an approach that models the shapes of iso-curves of images via direction tensor fields. The concept offers a unified theory to both Gabor filtering based direction tensor field estimation and

Gaussian derivatives based direction tensor field estimations, both being among the most popular features used in biometric authentication, e.g. face, fingerprint, and iris. Examples illustrating the theory will be detailed.

References

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Fingerprint recognition

Davide Maltoni

University of Bologna, Italy

This lecture introduces fingerprint recognition in a top-down fashion. Some general schemes are povided 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.

Introduction to Speaker Recognition

John Mason

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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 .

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.

3D Face recognition

Charles Beumier

Royal Military Academy of Belgium

Biometric solutions have recently gained much interest due to emerging security needs related to the increasing mobility of data and people. Although technical and commercial biometric solutions exist today (fingerprint, iris, retina, …), face analysis kept an important advantage of being well accepted by users.

The lecture will describe the activities of the RMA/SIC department in the field of Automatic Face Recognition. After outlining the difficulties for lighting, pose and stable features in the frontal face analysis, a prototype developed for automatic profile identification will be presented. The advantages of this geometrical approach were the motivations of our 3-dimensional face recognition approach. We will describe the structured light system developed for the 3D capture of faces and the approach for the comparison of 3D facial surfaces.

Signature recognition

Jana Dittman and Claus Vielhauer

Otto-von-Guericke-University Magdeburg, Germany

Handwriting Biometrics: From Algorithm Fusion to Cross-Cultural Aspects.

In order to increase the security of biometric systems some approaches attempt to reach a better performance by combination of various biometric modalities. Another possibility to increase the performance of biometric systems is the combination of several experts of one single individual modality. The talk addresses new challenges in the fusion of different online handwriting verification algorithms for user authentication and introduces an approach with different distance measures in connection with one particular feature extraction algorithm, the so-called Biometric Hash. We review these different distance measure functions and evaluated five alternative strategies for a matching score level fusion. Furthermore the talk discusses the impact of meta data to improve the biometric verification result in a cross-cultural context.

Security Aspects in Biometric user Authentication Application.

In the talk we focus on design requirements to ensure the security aspects confidentiality, data integrity, data origin authenticity and entity authenticity, non-repudiation, availability as well as privacy, anonymity and pseudonymity for biometric user authentication applications. On the example of a login application we summarize the potential vulnerabilies and enumerate exampel approaches from IT security to minimize the security risks.

3D touchless fingerprinting

Giuseppe Parziale

TBS Holding AG

The current fingerprinting technologies rely upon either applying ink (or other substances) to the finger tip skin and then pressing or rolling the finger onto a paper surface or touching or rolling the finger onto a glass (silicon, polymer, proprietary) surface (platen) of a special device. In both cases, the finger is placed on a hard or semi-hard surface, introducing distortions and inconsistencies on the images.

Touchless technology is a novel approach to acquire fingerprints. Introduced the first time by TBS, touchless fingerprinting combined with the 3D representation of the finger can achieve superior results than traditional enrollment methods in terms of image quality and fingerprint matching.

The lecture on 3D touchless fingerprinting will provide:

1. an overview of the new involved image-processing and 3D matching algorithms introduced by TBS for this innovative capture approach;
2. a new liveness and fake detection approach;
3. a demonstration of the Surround Imager™, a live-scan device able to capture a rolled-equivalent fingerprint without the need of touching any surface; and
4. an overview of the current development of the Touchless Sweep Sensor™, a new fast-capture device able to acquire all the fingerprints and the palmprints of both hands.

State-of-the-art in multimodal biometric databases

Javier Ortega-Garcia

Universidad Autonoma de Madrid, Spain

There is an increasing need for biometric databases in order to conduct biometric evaluation campaigns. As far as technology performance increases, more and more data are needed so that error figures are bounded within given confidence intervals. Together with this, the growth of multibiometric scenarios has oriented database acquisition to incorporate variety of modalities and sensors, increasing the number of participants and the number of sessions. We will focus on all these issues, in order to guide database design. Together with this, also legal and privacy issues will be discussed.

Exploiting biometrics in industrial applications

Behnam Bavarian

Biometrics Business Unit, Motorola, Anheim – USA

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.

Biological recogntion of human faces

Alice O'Toole

University of Texas at Dallas - USA

The accuracy of computational models of face recognition has been tested extensively over the last decade. Virtually nothing is known, however, about the accuracy of face recognition algorithms relative to humans.

In the last two years, we have begun a series of direct comparisons between state-of-the-art face recognition algorithms, being tested in the U.S. Government-sponsored “Face Recognition Grand Challenge” with human performance on the same task.

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.

The evaluation of algorithms relative to humans provides insight into both the pitfalls and advantages of the human system relative to computer-based algorithms and is informative for the development of hybrid systems that use algorithms and humans to their best advantage.

Exploting the time domain in face-based biometrics

Massimo Tistarelli

Università di Sassari, Italy

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 face image analysis under a new perspective: i.e. the exploitation of the time dimension.

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

Large-scale biometric data collection, management and evaluation

Patrik J. Flynn

University of Notre Dame - USA

Evaluations of biometric identification technology are increasingly prevalent as broad deployments are contemplated and executed by government and industry.

While the application scenario typically dictates the sort of experiment(s) to be used in the evaluation, the design and execution of an appropriate data collection strategy has many inherent choices and constraints. The need for statistically reliable estimates of error rates often provide large lower bounds on the amount of data to be collected, and the imbalance between the proportion of false matches and true matches is tremendous in any large-scale experimental data set. This session will provide some historical perspective on data set sizes used in biometric ID experiments, and discuss at some length a four-year biometric data collection effort underway at Notre Dame, that has supported three government biometrics programs, generated terabytes of raw data, and consumed thousands of person-hours of effort from dozens of students. Special attention will be given to the barriers to efficient management, annotation, and postprocessing of large data sets.

System issues in biometric technologies

Ben Schouten

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European Biometric Forum

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