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HUMABIO 1st Newsletter

Human Monitoring and Authentication using Biodynamic Indicators and Behavioural Analysis

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European Commission 6th Framework Programme (FP6) Information Society and Media

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EDITORIAL

Welcome to the first newsletter of the European project HUMABIO. HUMABIO is a STREP funded from the EU IST 6th Framework Programme, and has officially come to life since 1st January 2006. The project aims to develop a robust biometric security authentication system which derives from the multimodal fusion of a 'new' biodynamic physiological profile, unique for each individual, with already existing and tested biometrics. HUMABIO also aims to enhance safety in critical operations by the continuous monitoring of the physiological behaviour of the individual.

The purpose of this issue is to introduce to the reader the concept of "Biometrics" and "Authentication" and address the main shortcomings of current biometric authentication systems that HUMABIO aims to solve. Following HUMABIO solution and objectives are presented as well as various projects' features. Even though we are at the beginning of the project, a considerable progress has been made and the main results are included in this issue. More specifically the HUMABIO approach to gait recognition, the first results from the use of EEG as a biometric signature and the steps towards the development of a sensing seat are presented.

Please note that further information and contact points can be found on the project web site: http://www.humabio-eu.org/

The 2nd issue of HUMABIO Newsletter will be released on January 2006 presenting the progress of the project for the period since the first issue.

When security meets Technology...

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WHAT IS BIOMETRICS?

Biometrics measure individuals' unique physical or behavioural characteristics as a means to recognize or authenticate their identity. Common physical biometrics include fingerprints; hand or palm geometry; and retina, iris, or facial characteristics. Behavioural characteristics include signature, voice (which also has a physical component), keystroke pattern and gait. Although some technologies have gained more acceptance than others, it is beyond doubt that the field of access control and biometrics as a whole shows great potential for use in end user segments, such as airports, stadiums, defence installations but also the industry and corporate workplaces where security and privacy are required.

THE CHALLENGE

The primary issues that current biometric technologies face today are:

Universality: refers to the ability to apply the specific biometric to the totality of the population. It is estimated that 2-3% of the population is missing the feature that is required for the authentication, whether this feature is a fingerprint, voice, or retina or that the provided biometric sample is of poor quality.

Template ageing: refers to the need to update the templates on regular basis since the specific biometric feature changes over the course of time. This process typically requires the re-enrolment of the individual to the system.

Feature alterations: Every external organ or trait that is used for biometric authentication can be subject to physical damage. Alterations from severe accidents and surgical operations to minor everyday damages on the biometric feature, such as scars and dry skin at the fingertips, can result to rejection of the individual by the system and high false alarm rates. In this problem category we can also classify the changes in appearance that do not derive from physical damage. Such changes in appearance could be facial hair, change of haircut, the use of glasses, etc. To cope with this situation re-enrolment of the individual to the system is required.

Aliveness detection in a biometric system ensures that only "real" fingerprints, facial images, irises, and other characteristics are capable of generating templates for enrolment, verification, and identification. From a security and accountability perspective, requiring a live biometric characteristic makes it difficult for an individual to repudiate that he or she executed a transaction, accessed a secure facility, or applied for a benefit.

Intrusiveness: Intrusive methods such as DNA authentication require from the subject to provide a sample of his/her genetic material. While this method is considered to be the ultimate biometric authenticator, it can only be applied in very restricted application scenarios and certainly not in everyday operations, due to its intrusive nature and the low user acceptance rate.

Attacks at a biometric sensor level can be divided into several scenarios. Attacks can include forcibly compelling a registered user to verify/identify, presenting a registered deceased person or dismembered body part, using a genetic clone and introduction of fake biometric samples or spoofing.

Biometrics measure individuals' unique physical or behavioural characteristics as a means to recognize or authenticate their identity

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HUMABIO SOLUTION

HUMABIO will explore the use of physiological biometrics that, contrary to commonly used biometrics, describe the internal physiology of a person and have either never been used in the past, or they are still in research phase that has clearly demonstrated the authentication and identification potential of these features, [but has not led to conclusive or exploitable results due to the limited number of subjects participating in the research or the technical and user-acceptance restrictions imposed by the existing measuring means respectively. By investigating the authenticating capacity of biodynamic indicators such as EEG baseline, Event Related Potentials (ERP), heart dynamics (ECG), blood related parameters (such as pressure, oxymetry and others) and implementing the ones that show strong potential into the final system, HUMABIO aims to overcome several of the previously mentioned shortcomings of the current biometric solutions.

Specifically:

- It can be applied to the totality of the population since these features exist in everyone.
- Biodynamic indicators ensure the aliveness of the individual, and the measurements take place in a non-intrusive way, in contrast to DNA biometrics for example.
- Spoofing is minimized in two ways: the aliveness check which is inherited in the biodynamic indicators and the use of multimodal biometrics. While the unimodal use of each of these biometric features may have less than the desired distinctiveness and not allow the authentication of a person, their fusion into an updateable physiological profile should serve the scope of the project.
- Finally, HUMABIO biometric features allow the **continuous and real time** authentication and monitoring of the individual in a controlled environment, thus minimizing the possibility of spoofing.

Advanced conventional biometric modalities, namely face, voice and gait recognition will be developed and combined with the new biometrics in order to increase the robustness, unobtrusiveness, reliability and accuracy of the final system. Anthropometric profiles using “sensing seats” will also be considered.

Furthermore, the use of the new types of biometrics will also enable HUMABIO system to act as an **initial state validation** and **monitoring system** that guarantees the normal emotional and physiological state of employees and operators and safeguards the proper execution of critical and sensitive tasks that involve risks to the environment and the people. The aim is to detect possible deficiencies (deriving from drug consumption, sleep deprivation, etc.), risking situations or reduced working capacity in critical operations that could lead to poor performance, inattention and accidents.

The final objective of the project will be the development of a **modular, robust, multimodal biometric security authentication and monitoring system** for the authentication of the person’s identity, the validation of their capacity to perform their tasks and the continuous assessment and monitoring of the physiological and emotional state (only for critical operation scenarios).

The final objective of the project will be the development of a modular, robust, multimodal biometric security authentication and monitoring system

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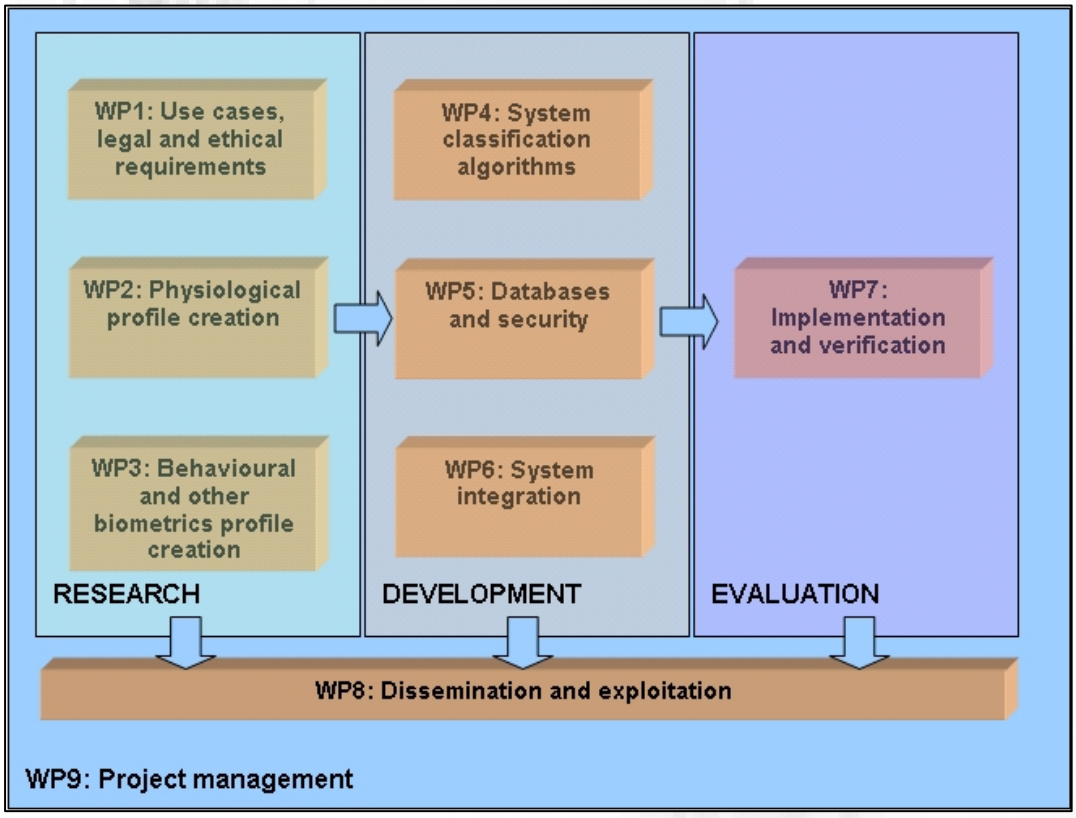
HUMABIO PROJECT MAIN AXIS AND STRUCTURE

The project research revolves around two main axis:

- the **biometric authentication enhancement** via the use of new types of biometrics that describe the internal physiology of the subject, their cooperation with existing behavioural biometrics and the improvement of widely used system solutions
- the **improvement of security and safety** through the minimization of human operator related accidents in critical operations. This is accomplished through research on algorithms and systems that guarantee the capacity of the individual to perform his or her task before and during the execution of the task.



The implementation flow of the project is shown above. The research activities begin with the gathering of user, ethical and legal requirements and the definition of use cases. The centre of gravity of the project is the research for the detection of the physiological parameters that can constitute a reliable physiological profile for authentication and monitoring purposes. The research for the implementation of a corresponding behavioural profile takes place in parallel in WP3. The findings of the research phase WPs are then implemented in the development phase WPs, which include the development of the system's classification and recognition algorithms, the databases and hardware infrastructure. The integration of these components leads to the HUMABIO prototype which will be tested in versatile pilot sites and scenarios in order to highlight the system's multimodality.

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HUMABIO APPLICATIONS

Three pilot applications are considered in order to demonstrate the modularity and test the applicability of the HUMABIO system in various environments:

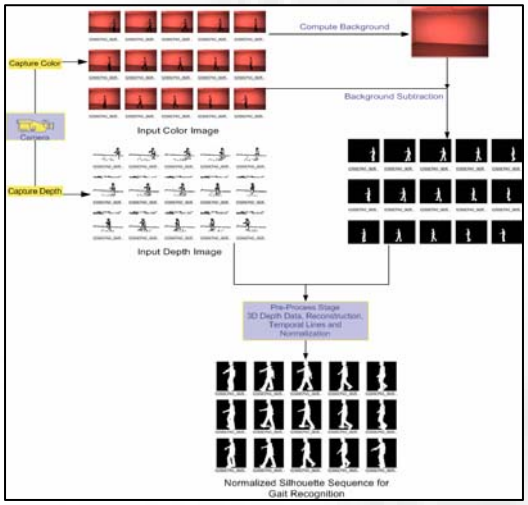
- The truck pilot: the system will authenticate the driver of a vehicle in order to prevent unauthorized operation and also monitor the condition of the drivers in order to prevent accidents due to hypovigilance or other causes.
- The office pilot: the system will continuously authenticate and monitor equipment operators in high security environments.
- The airport pilot: the aim is the unobtrusive on-the-move authentication of authorized personnel using only face and gait recognition and potentially physiological modalities captured unobtrusively with the use of novel physiological sensors.

GAIT RECOGNITION MODULE

Gait is one of the behavioural biometric **features of the multimodal HUMABIO** authentication system**.**

Gait Recognition in HUMABIO is a multistage process: A stereo camera captures video of people walking in a controlled environment. Then, the walking person (object) is separated from its background using **background subtraction** image processing techniques. **Pre-processing** methods are then used to the extracted silhouette sequences in order to remove noise data. Depth data are also analyzed to further reduce noise in the Silhouette Sequences.

Feature extraction from the silhouettes follows, where the input silhouettes (Probe or Gallery video sequences) are being transformed using spatial, temporal and mixed spatial-temporal methods.



Stages for generating the Gait Silhouettes

Within HUMABIO features are extracted using either Radon Transformations (Radial Integration Transform-**RIT,** Spherical integration Transform-**SIT)** or Krawtsouk moments. In the last stage, the feature data of an input (probe) sequence are compared with the feature data of the gait database for recognition.

First results of the HUMABIO gait module are promising and comparable with the best reported in the literature**. Future work** includes the creation of a proprietary Gait Database and the utilization of the 3D Depth data. 3D Depth data could be used in both stages (preprocess and feature extraction) of the gait recognition system.

First results of the HUMABIO gait module are promising and comparable with the best reported in the literature

USE YOUR BRAIN WAVES TO ACCESS RESTRICTED AREAS

Biodynamic signatures (such as EEG or ECG) open a new dimension in biometrics. Some of the main advantages of these new authentication systems are their universality and the fact that they are very difficult to fake. In this article we will briefly explain our approach to EEG biometrics and our first results in this field.

After recording the EEG of a subject, and in order to obtain relevant information that is unique to the person, some characteristic features of this EEG need to be extracted. In our preliminary study, we have selected the Fourier Transform Coefficients and the Autoregressive Model Coefficients as the characteristic features of the EEG signal. These features are to be compared with an existing database to authenticate the subject. In our procedure, we have cut the registered EEG signal in artifact-free epochs of several seconds, and features have been calculated for each one of these epochs.

A real life application could be the following: when a person needs to be authenticated (for example to access a restricted area), his EEG is recorded during one minute. This EEG is cut in 15 epochs of 4 seconds. The Fourier Transform of each one of these epochs is compared with the existing data base of authorised persons and the more repeated classification result would be the final answer of the system.

Using this approach in our study we reached a 93% success rate using just one EEG electrode (best case) and a 100% using 32 electrodes (with a database of 13 subjects).

In order for this method to be practical, the number of electrodes, as well as the EEG duration, must be minimised. Further investigation will bring us to a good compromise between these parameters and good classification rates.

Furthermore, other EEG techniques, such as brain responses to auditory stimuli, are promising alternatives since they minimise the number of channels (down to 2) and the extracted features are very characteristic of each individual.

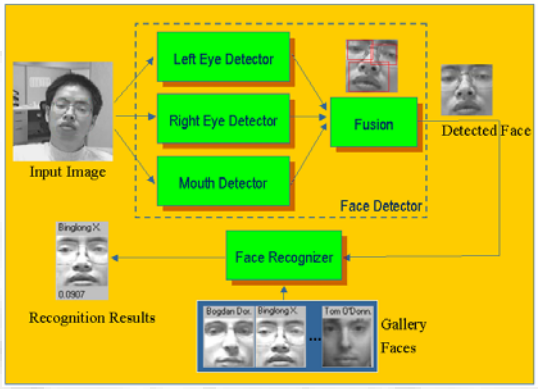
Using this approach in our study we reached a 93% success rate using just one EEG electrode (best case) and a 100% using 32 electrodes (with a database of 13 subjects)

FACE RECOGNITION MODULE

Face recognition will function in conjunction with the physiological authenticators. Specifically, while the physiological profile of the individual is not complete, the face recognition will enhance the reliability of the password or smart card identification.

The face recognition technique that will be used utilizes the cropped, warped, normalized face images. Three components (left and right eye, nose and mouth) are detected. Then the components are fused and the image is registered. Finally the face is identified by comparison with the stored images in the database.

Major limitation of the state of the art techniques: the system is not able to tell automatically if a face is still in the database or not. It always provides a confidence level with respect to image stored in the data base. This is a major limitation to the use of such systems and a very challenging task to bring a solution to that point.



Face recognition process

HUMABIO innovations related to face recognition include:

The design of an automatic enrolment process:

- Decide if the face is known and is still in the database (automatically).
- Build automatically a representation of a new face in the database.

Algorithmic improvement necessary to enhance the robustness of the recognition:

- Use of non-linear model (Kernel PCA or Gaussian mixture) for better distinction of inter vs intra-individual appearance variation.
- Introduction of pair wise discriminants to better separate top two matches.

SPEAKER AUTHENTICATION

The work in HUMABIO relating to speaker authentication will take the following steps:

- Identification of the most interesting on long and short-term, biodynamic speech parameters, taking into account the simplicity of robust acquisition in viable HUMABIO scenarios (text dependent / independent tradeoff). The choice will be driven by the desirable properties proposed by Jain that any biometrics system would have.
- Specification of the interface layer in accordance with the BIOSEC Integrated Project architecture.
- Detailed algorithm design of the speech feature extraction model.
- Software design and implementation of the speech feature extraction model using :
- Exploitation of Bayesian network approach for combining innovative speech parameterization using more complex psychoacoustics model than spectral envelop feature and relevant long term measures like speaking habits, idiolect (word usage), speaking rate or prosodic characteristics.
- Tracking and classification of selected biodynamic characteristic using Support Vector Machine classification tool.
- Assessment on limited scenario to identify the best biodynamic combination of speech parameterization integrating both new psychoacoustics model and long term information.

SENSING SEAT: RESEARCH ACTIVITY FROM UNIPI

The bioengineering research team at the Interdepartmental Research Center "E. Piaggio" of the University of Pisa (UNIPI) is currently involved in HUMABIO Project with the aim to realize a system devoted to discriminate among different persons which may seat on a workstation. Such an ambitious goal can be addressed thanks to the past experience of UNIPI people in organic and polymeric materials, and to the design of sensors, intelligent structures for bioengineering and robotics. In particular, in the last decade UNIPI group focused its research activities in wearable sensor systems and in artificial neural networks. As a first step, the research for designing and implementing a sensing network embedded in lycra fabric patches of the foreseen seat cover started. A sensorized fabric patch responds to simultaneous deformations in different directions by means of a piezoresistive network which consists of a Conductive Elastomers (CEs) composites rubber screen printed onto the fabric. CE composites show piezoresistive properties when a deformation is applied and they can be easily integrated into fabric or other flexible substrate to be employed as strain sensor. In figure 1 the Transduction principle is illustrated.The integral impedance pattern is a function of the overall shape of the sensorized fabric and allows mapping between the electrical space and the shape space . Sensors are elastic and do not modify the mechanical behaviour of the fabric. UNIPI strategy to evenly cover the deformable surface of the truck seat is to realise several 12 channels single sensor arrays soft fabric distributed on the seat surface. A drawing and a picture of a single sensor array are shown respectively in figure 2. As a second step, a software framework for the management and synchronization of data and processes has been developed. As a further step we tried to code in real-time the shape space by a two-dimensional artificial neural network (ANN). The neuron model proposed by E. Izhikevich was adopted because of the high computational efficiency and biological accuracy. The Theory of Neuronal Group Selection (TNGS) proposed by G. Edelman was adopted as the learning strategy of the ANN. The TNGS suggests a novel way for understanding and simulating neural networks. To take into account this theory we have to use the time variable in the learning task, so that neural groups may raise from a selection process. In the artificial neural network model, the synaptic connections are modified according to the computationally efficient Spike-Timing-Dependant Plasticity (STDP) rule. In order to test the classification capabilities of such a system a single neural network of 1000 artificial neurons consisting in 200 inhibitory neurons and 800 excitatory neurons has been realised as the main application process inside the framework core. A running process was delegated to actuate an array of servo motors in order to generate random actuation patterns during the training and test phases. The network design has been inspired to the anatomical structure found in the mammalian cortex. The test phase was conducted generating in a random order 100 low-amplitude deformations and 100 high-amplitude deformations for each servo motor. As a result of the training process a large number of groups appear. Different patterns of strain stimuli are able to select different groups inside the network showing its capability to deconstruct a complex shape. According to the biological sensory systems, where environmental stimuli are deconstructed and then reconstructed in the brain to create perceptions, the presented architecture may serve as an initial step in the reconstruction of a shape space from its deconstructed features for identification purposes.

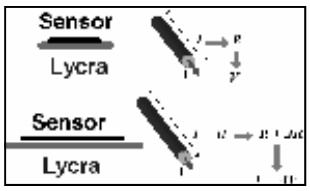


Figure 1 – Transduction principle of the strain sensor

Figure 2—A sensor array

HUMABIO END USER FORUM

Join now the HUMABIO END USER FORUM and:

- ✓ Regularly receive the HUMABIO Newsletter
- ✓ Receive invitations for project events, workshops etc
- ✓ Provide feedback on the project's activities by filling in questionnaires etc.

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In case you are interested to participate please return this form to:

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Email: lgait@certh.gr

Thank you for your support!

Note:

- *All interested people are welcome to the forum.*
- *All data will be kept confidential and will be used only for the purposes described above.*
- *The members participation to any of the HUMABIO activities is strictly on voluntarily basis.*
- *You can unsubscribe from the forum by a simple e-mail to the address above at any time you may wish.*

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FOR MORE INFORMATION VISIT PROJECT'S WEBSITE:

www.humabio-eu.org

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