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A Robust Intelligent Tutoring System for the Integration of People with Intellectual Disabilities into Social and Work Environments

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1. Introduction

The integration of people with disabilities into work and social environments is one of the principle issues in the EU strategy lines, clearly focused into the Seventh Research Frame Program (FP7). Particularly, it is necessary to pay special attention to the integration problem of people with intellectual disabilities. In order to face the problems that people with disabilities find in their integration into work environments in actual competitive market, one of the key issues is the implementation of solutions offered by new technologies by using what experts call "Support Technologies". The development of Intelligent Tutoring Systems (ITS) based on mobile platforms offers new perspectives for better integration of people with disabilities.

The integration into social and work environments of people with disabilities is a fact nowadays. Tutoring systems are intended for helping this community in their life (Gonzalez et al., 1991). These tools are very helpful; although at the moment do not completely meet their needs. This work presents a robust and intelligent tutoring system that will cover several new aspects, coping with more complex tasks, but doing it in a flexible and useful way. One of the main objectives of this work is incrementing the user autonomy, both in social and work environments. Due to the fact that it there exist many different cases among people with disabilities, we will incorporate an intelligent structure that may achieve an appropriate tutoring system configuration for each case. This implies a personal study and a related profile to each person, made by human tutors or relatives. All these items lead to design a system with a configuration profile easily accessible to the user.

This work is included in a new research project focused on the study and control of human factors. Besides, a big effort is made in new research subjects for attending and tutoring people with disabilities. The design of devices for solving the daily problems of these persons is one of the first objectives of this work. Moreover, it is trying to invest in economical supports, grants and human efforts in order to increase their quality of life.

Nowadays, it is necessary to solve in an appropriate way the current problems in the integration of people with disabilities into work and social environments that daily are

increasing. Furthermore, it has to consider that the rules in the industry environments are harder everyday, and there exist bigger difficulties for the people integration. These difficulties can be overcome, only if new technologies and multimodal performances are developed. These strategies make up the Support Technologies where new ideas are appearing.

The development of these technologies has been improved due to the permanent study in human factor organization and control. In this field, the personal security and health, the prediction and control of risk situations, as well as the emerging risk surveillance compose the most important subjects. Moreover, it is necessary to obtain suitable responses of the designed systems, in order to reach an appropriated interaction in the handling process of devices that will be to advantage of the users. The results of these studies will produce an application set which has to be used everyday, mainly by people with special disabilities in their work and social environments.

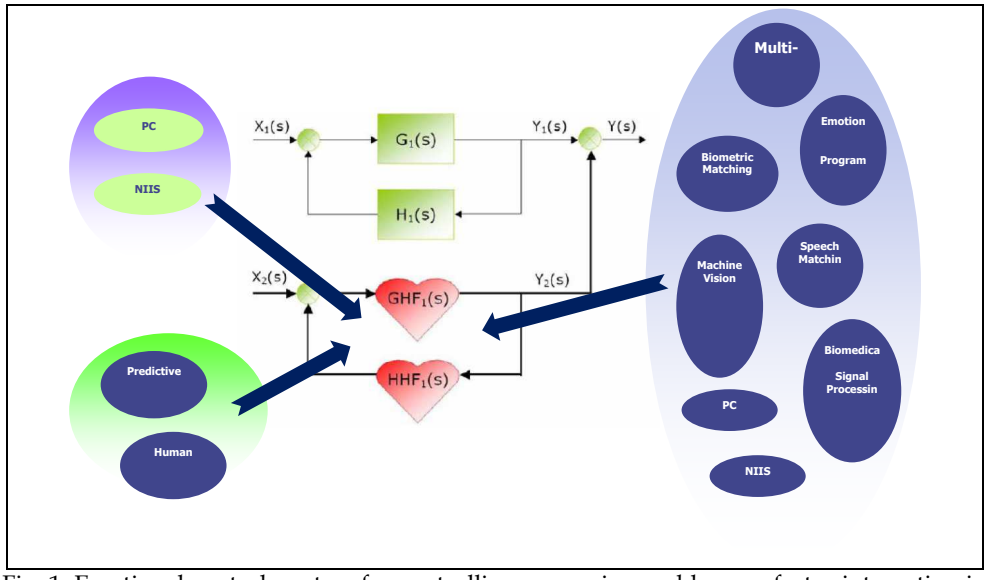

Fig. 1. Emotional control, system for controlling, managing and human factor integration in a technological application

The developed application will include intelligent tools for processing the needed information for creating individual tutoring systems. These intelligent tutors take into consideration the wide diversity related to people with disabilities, as well as the kind of task to carry out and each mobile platform where tutors will be loaded. Moreover, the system has to include a new module to analyse comparative user emotions measures, in order to prevent blockage situations. In figure 1, a simple schema shows the different tools used into the application to generate an intelligent tutor.

At the moment, all the developed studies have been carried out by a multidisciplinary research group in which researchers from different groups converge on, with special attention to the Computational Intelligence Group. These studies have caused several works

with social environment companies devote to the industrial integration of people with disabilities, for instance ATZEGI, GUREAK and TASUBINSA. Besides, many prototypes have been made in different economical supported projects, and new ideas have been grown up in Intelligent Tutoring Systems and Human Emotional Matching (García et al., 2006; Cearreta et al., 2007; López de Ipiña et al., 2005; Barroso et al., 2007-a; Barroso et al., 2007-b).

2. Intelligent Tutoring System

The Intelligent Tutoring Systems (ITS) adjustment into mobile platforms achieve a appropriate response to one of the principal problems of people with disabilities, their integration into social and work environments (Yazdani, 1987; Sung, 1999). These devices are designed in order to reach the user adaptation and to obtain an interaction that compensates the personal disabilities, for increasing the performances, individual autonomy, work capability, personal security and a healthy environment in work places (Gunderson, 1994; Myers, 1995; Candela et al., 1997).

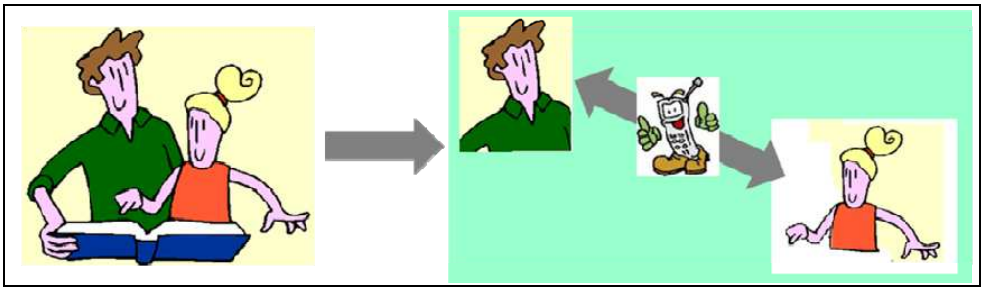

Fig. 2. Transition from a Human Tutor to an Intelligent Tutor based on Mobile Platforms

Therefore, one of the main objectives of this work is to allow the user autonomy, both in social and work environments. We will incorporate an intelligent structure that may achieve an appropriate tutoring system configuration for each case of people with disabilities. This implies a personal study and a related profile to each person, made by human tutors or relatives. All these items lead to design a system with a configuration profile easily accessible to the user.

In this paper, a task handler functionality included in the tutoring system will be presented. This tutoring system achieves the performances of human tutors, giving a further step than those classical tutoring systems which perform organizational tasks (García et al., 2006 ; López de Ipiña et al., 2005; Wenger, 1987; Yazdani, 1987). The task handler contains three basic modules: operation module, human factor prediction module and ergonomics module. Having an appropriate design of the structure and architecture of this task handler, it will be very easy to operate by the users (tutors and relatives), doing it easily configurable by characteristics of the operational tasks and the variability of the disabilities.

In this sense, an automaton-based mechanism has been performed to adapt technologically the large variability of the possibilities existing in the interaction between people with disabilities and the task that has been made autonomously. This mechanism is designed in a generalized way for providing some characteristics as portability for people with different

disabilities, as well as solutions for another communities, p. e. elder people. It will be basically designed in two modules, one for including the people profile with disabilities, and another one for describing the task which will be performed.
The Intelligent Tutoring System is designed to have the possibility of integrating in several mobile platforms where each personal interaction can be customized based on the personal disability. In this way, it is possible to configure different devices that are involved with different interfaces, for instance keyboards, touch screens, audio devices, and any combination of them. Furthermore, some devices for working in outside environments will be designed (Gauvain et al., 2000).
Moreover, an emotional module to increase the reliability and tutor scope will be included. The emotional module will analyze several non intrusive biomedical signals, for instance: heart rhythm, skin perspiration and relative movements. This module will identify the emotional changes of those persons that are being tutored. By means of this identification, the critical blockade states will be detected. In this way, it will be possible to perform direct interventions for solving these eventualities.
For testing the emotional module, a new experiment set is being performed. This is being made with a standard biometric testing system that obtains several biological signals. The experiment set consists of several changing environmental situations and the research of those tested signals through intelligent machine learning techniques.

3. Task Management System

Intelligent Tutoring Systems apply Artificial Intelligent techniques and methodology to the development of computer based learning systems in order to construct adaptive systems (Wenger, 1987). An ITS focuses education as a process of cooperation between tutor and student in which the tutor tries to teach concepts to the student. In general, the process is guided by the tutor, who must analyse the behaviour, the knowledge and the satisfaction of the student. The tutor has to determine and apply the more appropriate teaching strategies at every moment (Case et al., 2001; Nowak, 1999). These strategies must answer a series of questions to ensure that the learning process is carried out successfully (Chia-Fen, 1999). These questions are: what to explain, what detail level is necessary, when and how to interrupt the student and how to detect and to correct errors. The four basic components that classically are identified in a ITS are: Domain Module, Pedagogic Module, Student Model and Dialogue Module(Wenger, 1987; Yazdani, 1987).
Linguist engineering and intelligent tools have to be included in these systems in order to increase the reliability when are used for tutoring people with disabilities, especially with cognitive disabilities. Due to the integration and adaptation of these devices is necessary to made bigger efforts in finding out solutions. In the development of appropriate tools, the ergonomic directives as well as the specific necessities of these persons are fundamental. For instance, people with cognitive disabilities as Down Syndrome have physical and psychological common characteristics that has to be considered: heavy and fine mobility altered, smaller capacity to stay out, difficulty to anticipate or to understand consequences of their conduct, better visual perception and retention than auditory, longer response time, difficulty in understanding a number of instructions given in sequential form.
One of the main objectives of this work is the development of an ITS integrated on wireless portable devices (PDA, mobile phone,…). The mobile tutoring system will help in the tasks

people with any kind of disability perform when working and living in several environments. Based on the characteristics of the people who will use these devices, it is absolutely necessary to design an interface (Edwards, 1995; Schneider-Hufschmidt et al., 1993) that shows the following features: friendly, comfortable, flexible and ergonomically adapted to their characteristics. As first objective of this project is to provide to these users with a cognitive tool that contributes to the improvement of their autonomy, quality of life as well as help in the prevention of accidents in the workplace. Another objective tries to integrate into the portable device a task management. Intelligent technologies based on fuzzy systems will be used to improve this management. The next figure shows the different parts of the task management.

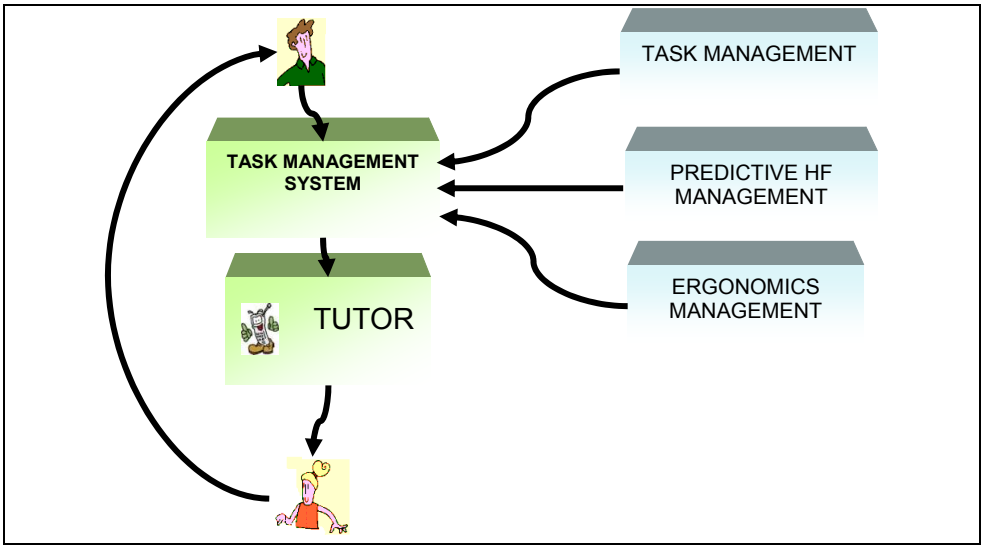

Fig. 3. Task Management System and its modules

It was necessary to design a Task Management System because of the broad variability in people with disabilities for doing diversified tasks. Classical tools provide tutoring systems where the whole task to perform is charged, giving a fixed task profile in order to attend to the people who will use it. In this work it will be created a system for obtaining the configuration possibility, additionally to the handling of any possible case in separate profiles due to the variability. The Task Management System is composed by three modules where the information is divided in:

a) The tasks to carry out: Taking account the work features, the specified disabilities of people whose will perform, the subtask divisions, etc.
b) Ergonomic characteristics: Defining more specifically those characteristics that can be used for increasing the reliability of the jobs perform by the people with particular disabilities. It is relevant to introduce information about the interaction of that people with the different devices of Intelligent Tutoring.
c) Personal information of users: In order to know how workers can manage in different environments it is necessary to introduce the personal profile of them. In

this way, it is possible to prevent accidents and emotional blocks for avoiding personal and physical damage. This information must be at all times for helping and attending to these people with disabilities in the integration into social and work environment, not to control them each moment.

This information will be organized in several open databases which can be updated at any time by tutors and relatives. These databases will be in a server where the access will be able to connect from remote stations for performing each device configuration. Besides, the particular profile configuration will be load into the intelligent tutoring devices of any user.

Moreover, the Task Management System has been designed to allow a comfortable and simple configuration, giving to the users an easy way to build the profile that will de load into the Intelligent Tutor. In this sense, the Task Management System has inside an automaton-based mechanism supporting several functions. First, the automaton handles the communication with tutors and relatives in order to allow better understanding of its functionality. Also, it organizes in a correct way the information supplied by the users. Finally, it generates the characteristics map of all Intelligent Tutoring configurable devices which will be activated.

First data set to introduce into the database will be obtained by a previous study about the real situation of people with disabilities at different work environments. That information will be noted by human tutors and relatives in observing how the attended people develop in different jobs and with several mobile platforms. This study will be carried out in several workshops of some social organizations, respecting all familiar and personnel privacy rights, considering ethical questions, as well as observing the law under these circumstances.

In this way, the performance of these workers would be enhanced and also their integration process to the work and daily life. In addition, we plan to register the designed system like a health product through a clinical research plan according to the current legislation.

4. Automaton-based Mechanism

In order to achieve an appropriate organization of the Task Management System databases, it has been designed an automaton-based mechanism where are included the personal characteristics of the people with disabilities, and the features of the workshops and tasks to carry out. Taking into account that this kind of information covers a large variability of cases changing frequently and it is necessary the adaptation to the new technologies, the solution implemented allows adding new information to the databases at any time. This strategy achieves intelligent tutor with better assistances.

The automaton-based mechanism is composed by a program that consists of two generic ordered lists: One representing the people with disabilities; another one the existing mobile platforms. In figure 4 it is shown the structure where the list are implemented as vectors. Due to the variability of disabilities, in the devices list the user mobile platforms will appear referring their resolution screen, but on the other hand the interface and designed figures have to be particularly designed. Meanwhile the people list contains their personal information, as well as the personal involved tasks.

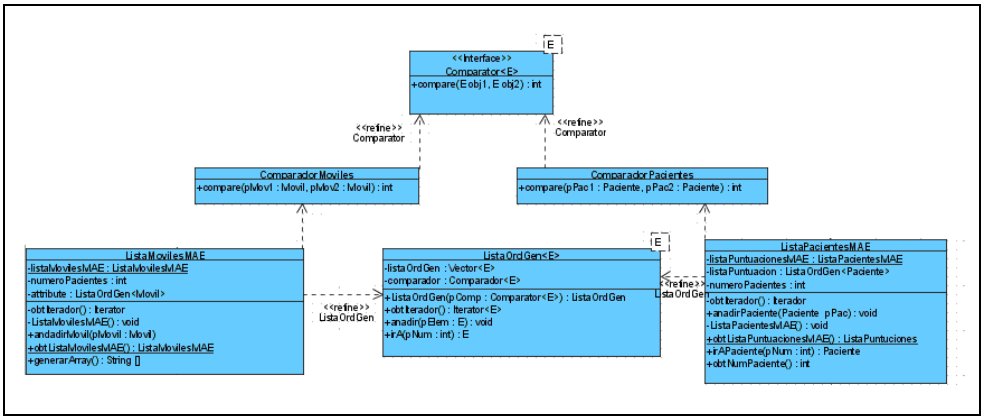

Fig. 4. List organization

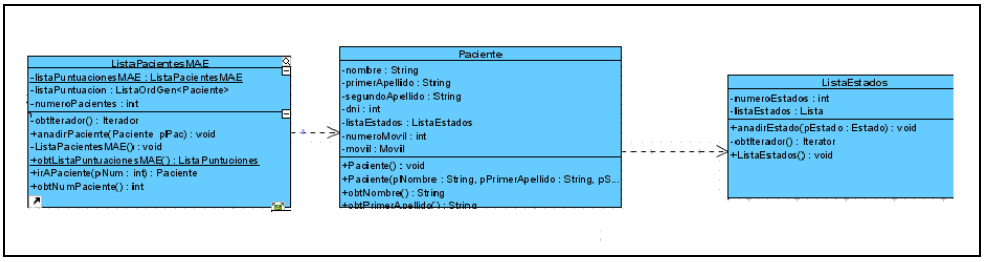

Fig. 5. List representing people with disabilities

The database structure is composed by several states. These states have items as images, videos, texts, etc., configuring the skeleton task. There exist two kinds of states:

a) Simple state: With a single feasible task, but not abstract description.
b) Complex state: With a complex task that has to be defined into the automaton-based mechanism. In order to adapt the feature of the task to one person, it will be necessary to define several particular items.

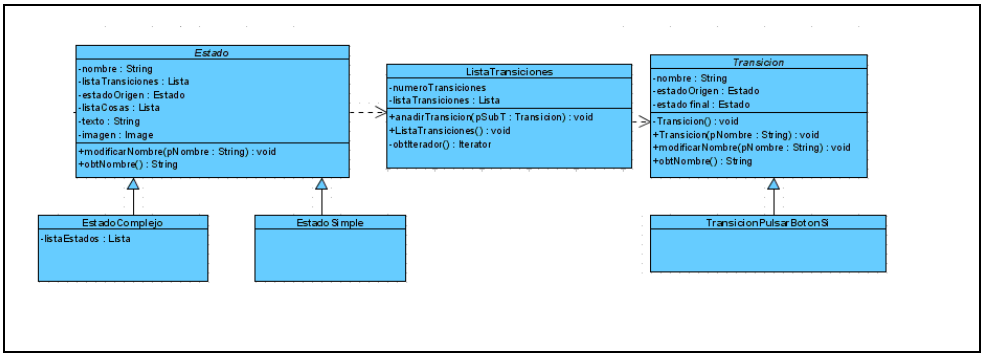

Fig. 6. States structure

For states interconnection different associated transitions have been created. Each transition has a condition for relocating from one state to another. At first, the number of transitions is unknown. Because of that, new transitions will be created by the users, tutor and relatives.

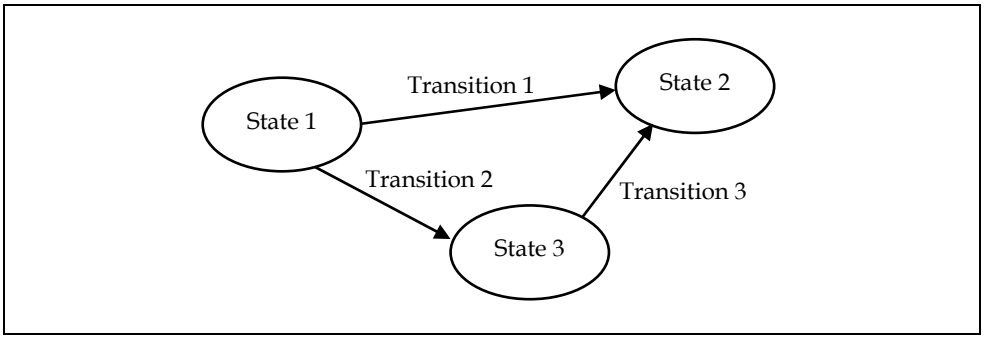

Fig. 7. Graphical representation of States and Transitions

The program has to be easy to use, reliable, usefulness, agreeable, with a clear interface for people with low informatics knowledge that will use it. JAVA language is high time consuming in programming. Due to that two different interfaces have been created for trying to adapt in a correct way the program for users.

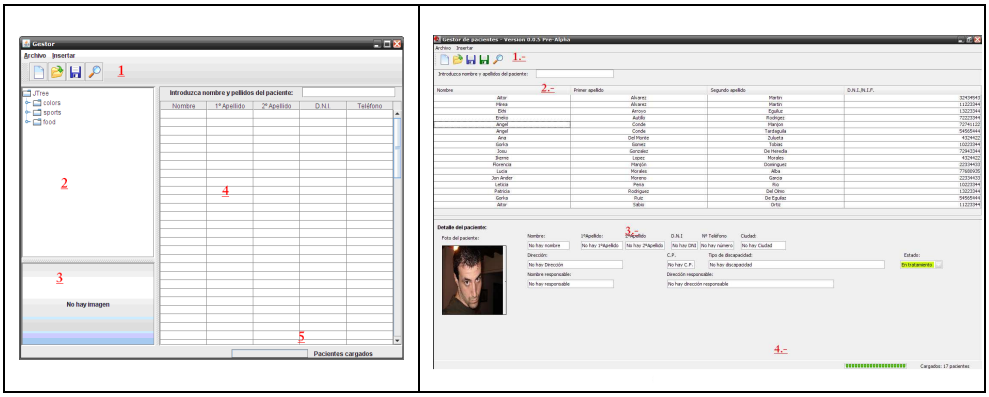

Fig. 8. Interfaces for configuring the Task Management System

5. Human Emotions Module

Human emotions appear as response to this changing and partially unpredictable world where any intelligent system (natural or artificial) needs the emotions for surviving due to limited abilities and multiple causes (Cañamero, 2005; Taylor & Fragopanagos, 2005-a; Sander et al., 2005). Emotions are composed by similar components to the cultural, subjective, physiologic, and behaviour components that express the personal perception with respect to the mental and body status, and the way for interacting with the environment (Cowie et al., 2005).

Emotions describe clearly the whole universe, far from constituting a big obstacle for understanding. Emotions are mechanisms that allow a description of the universe to the mind when there is not a symbolic representation. An artificial emotional system that generate and process different emotions based on physiological reactions and predictable experiences (emotional memory, social emotion) can improve automatic systems where is included if interact with the environment.

One of the first objectives of this work is to develop of a convenient measure system for identifying non visible human emotions, by mean of human behaviour emulation based on an automatic emotional learning. Emotion per se, it is an interdisciplinary topic which can be studied in Philosophy, Neuroscience, Computational Intelligence, Machine Learning, and Robotics fields (Taylor et al., 2005-b; Fragopanagos & Taylor, 2005). At the same time the crucial question of data and possible databases to be used in emotion research has to be addressed.

The form and range of modern databases of subjects are in a variety of emotional states, with speech, facial changes and possible body gestures and most of them are based on perceivable emotions with physiological signs. It is necessary the creation of artificial recognition systems of emotional states, either guided by the brain architecture thought to support emotions or by using more machine-based learning approaches.

'Emotion-based' robots are often designed taking inspiration from theories of human emotions, and in some cases, in close collaboration between engineers and theorists—usually psychologists, less frequently neuroscientists. Autonomous robots constitute excellent tools not only to test theories, but also to investigate problems that would be difficult to study in humans, due for example to ethical implications, the difficulty of isolating the relevant elements, or the repetitious nature of the task. In this respect, artefacts can serve as 'virtual laboratories' for the study of emotions (Cañamero, 2005).

In the research community grow two different aspects based on these hypothesis: modelling of psychologically perceptible emotions, and modelling non perceptible ones. Thereof different frameworks appear to classify human emotions. Silvan Tomkins proposed in 1962 that there exist nine basic affective states (two are positive, one is neutral and six are negative), each indicated by a specific configuration of facial features. But when a person camouflages emotions due to cultural learning (socialized emotions), a perceptible physiologic response is not produced and the classical emotion measure system cannot be used.

In this work a different measuring system will be developed which incorporates both individual artificial emotional patterns (emotional data base of human emotional patterns) and emotional memories (data bases of human experiences). In these patterns the individuality of the people like the cultural components is due to consider as much. The devices intended for the data capture of emotional states information will measure hearth rhythm, body temperature, movements, facial expressions and blood pressure. The new human emotions model will rest on emotional human patterns, databases of human emotions memories, and databases of human emotions experiences. Therefore, the system of measurement in this case will be equipped:

a) Of artificial emotional patterns of individuals.
b) Of emotional memories and will base its answer to measure the emotion in an automatic learning based on the human brain.

The developed system in this work will contain several technical innovations and contributions with respect to the classical architectures used nowadays. The classical emotion measure systems are principally based on information coming from gestures, speech, or vocabulary by a direct measurement (Chen et al., 2001; De Jong et al., 2000; Foote, 1999; Witbrock & Hauptmann, 1997). The new measure system proposed in this work is building by a hybrid structure where next components are integrated:

a) A Machine learning module, trained by knowledge previously acquired about human emotional answer. The module management sub-modules based on Neural Networks, Genetic Algorithms, Decision Trees, and Hidden Markov Models.
b) Simple perception information by non-intrusive sensors.
c) Emotional Predictive Control, by simulating brain performance.
d) Emotional knowledge based system. Three databases which store, organize and index knowledge about:
    1. Human emotional experiences.
    2. Human emotional patterns.
    3. Emotional memories.
e) Evolved System. On-line information obtained from the measurement platform will be used to update and to evolve the system.

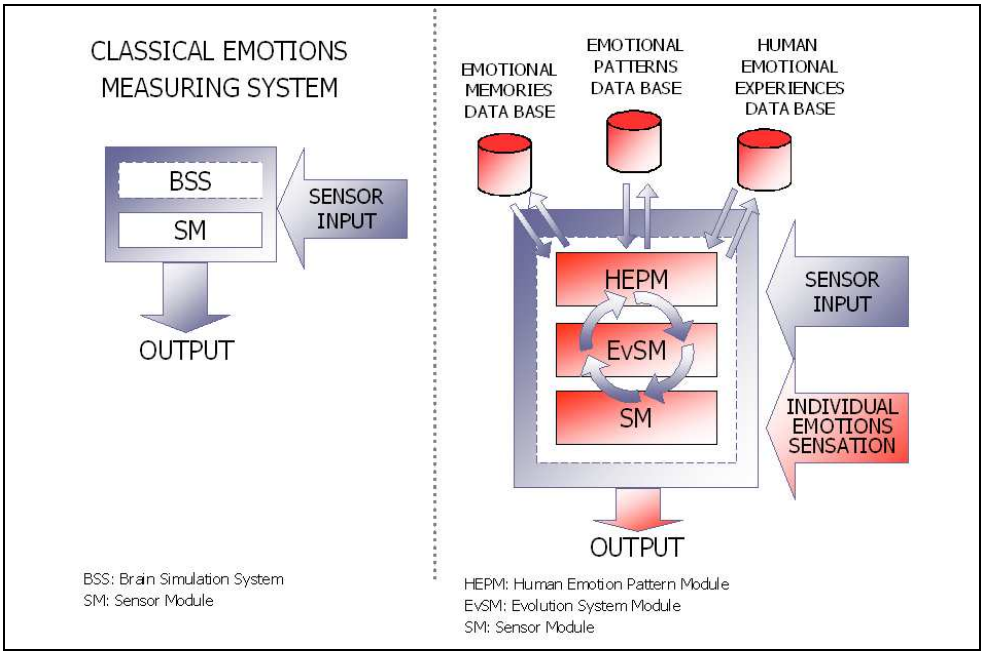

Fig. 9. Classical and Hybrid System for Human Emotions Measure

Another objective in this work is to develop a device for predicting the transition between two human emotional states in order to generate the corresponding action. In this sense, the Model Predictive Control strategies will be studied for applying the fundamentals (Camacho & Bordons, 2000). Besides, the Artificial Neural Networks will be used for

implementing the model structure where the human emotions and emotional state changes will be modelled.

6. Testing and Validation

After several previous tested works, new experiments have been made in order to have a more extensive study in the present work. To this end, it has been necessary to take into account recent studies about technological solutions for configuring of Intelligent Tutor (García et al., 2006 ; López de Ipiña et al., 2005), and studies about human emotional rules through emotion measure and mapping based on new methodologies (Cearreta et al., 2007; Barroso et al., 2007-a; Barroso et al., 2007-b).
From now on, the new experiments will be made in two different fields. First tests will be prepared in a sensing laboratory where there are different devices devoted to capture biological signals, for instance heart rhythm, breathing rate, skin perspiration, and relative movement. A specific human pattern set is being selected in order to configure a broad sample. An exhaustive database is designed for the tests, so that using controlled film pieces obtain several emotional responses from the human set. All the devices in the laboratory have been tested previously for achieving reliable and truthful data.
Furthermore, in order to provide information to the Task Management System, some daily behavioural parameters of a people with disabilities group will be recorded. This will be always made under supervision of human tutors in the job social centres where these people are working. In this sense, several meetings have been carried out with dedicated centres as GUREAK, ATZEGI Y TASUBINSA which agree with configuring the behavioural analysis in order to improve, as possible, the integration of these people into work environments (Chia-Fen, 1999; Zajicek, 2004).

7. Conclusions

In order to face the problems that people with disabilities find in their occupational integration in a very competitive market, one of the keys are the solutions that new technologies offer through what is called “Support Technologies”. Nowadays the specific devices and products offering are reduced, especially in fields as cognitive disabilities attending. New devices designing can offer a better autonomy and integration for these people in work environments as service sector.
The development of intelligent tutors based on mobile platforms offers new perspectives in the integration of the disabled people collectives. These kinds of tutors are user adapted and compensate user abilities, improving the personal performance, the training and the safety and health at workplace.
The goal of this project is to deal in depth with the investigation and the development of workplace oriented “intelligent and robust interaction systems for disabled people”. The main investigation fields to be faced are oriented to develop a workplace task manager, task that will be integrated in a mobile platform (smart phone, PDA). This manager will allow non-technical support personal (tutors, family, psychologist...) to configure and plan complex tasks easily. The system, intuitive and friendly in use, will have at users disposal multimodal resources (images, voice, texts) and human emotions and ergonomics

(hardware & software) managers, that will help this group of workers to overcome some of the complex and usual barriers they find at work, as the emergency or blocking situations.

The designed Intelligent Tutoring System will have to cover several features:

a) To allow tutoring the whole task of people with disabilities, giving more autonomy in work environments.
b) To have a multimodal Task Management System for data integration from different sources (speech, images, videos, and text) associated with each personalized profile.
c) Integrated in a mobile platform, p. e. a mobile telephone or PDA.
d) To contain a multimedia interface which it has to be friendly, reliable, flexible, and ergonomically adapted.
e) To integrate a human emotional predictive management in order to prevent risk, emergency and block situations that can cause damage to these people, interfering with their integration into work and social environments.
f) To be fully configurable by people without technological knowledge in order to enable an easy and flexible access.
g) To show the capability of exporting the system to another collectives, for instance elder people.

The project origin lays in a need of GUREAK ARABA S.L. (GRUPO GUREAK) an employer company for people with disabilities. It was performed to improve the integration of these people into work environments, and to extend it to social environments and another collectives.

8. Acknowledgements

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