LAGUNTXO: A Rule-Based Intelligent Tutoring System Oriented to People with Intellectual Disabilities

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Abstract. In order to face the problems that people with disabilities find in their integration into working environments, 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 LAGUNTXO System aims to achieve the performance of human tutors, going a step beyond classical tutoring systems which perform organizational tasks. Due to the wide diversity related to people with disabilities, an intelligent structure that may achieve a convenient tutoring system configuration for each case has been incorporated. With an appropriate design of the structure and architecture of this task handler, it is very easy to operate by stakeholders. An automaton-based mechanism has been performed to technologically adapt the large amount of possibilities related to the interaction between people with disabilities, the task that is going to be made autonomously by these people, and the mobile system elements. In this paper, LAGUNTXO architecture, operational ways, and several use cases are presented.

Keywords: People with intellectual and physical disabilities, intelligent tutoring system.

1 Introduction

Integrating people with disabilities into working and social environments is one of the main issues in applying ITC into the assistive field. Particularly, it is necessary to pay special attention to the integration problem of people with intellectual disabilities.

This project's origin lies in a request of GUREAK ARABA S.L. (GRUPO GUREAK), a company that works in the integration of people with disabilities. GUREAK ARABA, S.L. considered that a computer aided support system may help to grow the autonomy, both in social and working environments, of users with intellectual disabilities.

Computer aided systems have been successfully applied in many fields [1]. Intelligent Tutoring Systems (ITSs) are computer-based instructional systems with models of instructional content that specify *what* to teach, and teaching strategies that specify *how* to teach [2, 3]. The ITS monitors the learner performance to determine the student's mastery on certain topics or tasks and how to satisfy his/her requirements by selecting the most appropriate pedagogical strategy and content to be taught.

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Intelligent Tutoring Systems working into mobile platforms are an appropriate response to one of the main problems of people with disabilities: their integration into social and working environments. These devices are designed in order to reach the user adaptation and to obtain an interaction that compensates personal disabilities, for increasing the performance, individual autonomy, working capability, personal security and a healthy environment in workplaces [4].

Initially, the Intelligent Tutoring System will have to cope with several features:

- To allow tutoring every task of people with disabilities, giving more autonomy in working environments.
- To have a multimodal Task Management System for data integration from different sources (speech, images, videos, and text) associated with each personalized profile.
- To be integrated into a mobile platform, i. e. a mobile telephone or PDA.
- To contain a multimedia interface that has to be friendly, reliable, flexible, and ergonomically adapted.
- To integrate a human emotional predictive management in order to prevent risk, emergency and blockage situations that can damage these people and interfere with their integration into working and social environments.
- To be entirely configurable by stakeholders without technological knowledge in order to enable an easy and flexible access.
- To show the capability of exporting the system to other collectives, i. e. the elderly.

Ethical issues also have to be taken into account [5] while developing Assistive Technology, in the particular case of people with intellectual disabilities. The pitfall of generalization must be avoided. Therefore, it is of great importance not typifying each person with an intellectual disability with general labels.

Due to broad diversity of people with intellectual disabilities, we have incorporated an intelligent structure that may achieve an appropriate tutoring system configuration for each particular case. This implies a personal study and a related profile to each person, made by human tutors, caregivers or relatives. All these items lead to design a system with a configuration profile easily accessible to the stakeholder.

At the moment, the project has been carried out by a multidisciplinary research group with researchers from different fields such as Computing, Psychology, Medicine, and Engineering. These studies have also caused several works with social environment associations and companies devote to the industrial integration of people with disabilities. The level of success achieved within the project life is described in detail in the next sections. Section 3 describes in detail the architecture of LAGUNTXO SYSTEM. Finally, some conclusions and future work are shown in section 4.

2 Intelligent Tutoring Systems

Intelligent Tutoring Systems apply Artificial Intelligent techniques and methodology to the development of computer based learning systems in order to construct adaptive systems [2]. An ITS is based on the education as a process of cooperation between tutor and student. In general, the process is guided by the tutor who must analyse the behaviour, the mastery level and the satisfaction of the student. Tutor has to determine and apply the more appropriate teaching strategies at every moment [6]. These strategies must answer several questions to ensure that the learning process is successfully carried out [7]: what to explain, what level of detail is necessary, when and how to interrupt student, and how to detect and to correct errors. The four basic components that classically are identified in a ITS are the Domain Module, the Pedagogic Module, the Student Model and the Dialog Module [2, 3]:

- Domain Module: It contains the knowledge to be taught, and it fits pedagogical principles in order to facilitate the work to the Pedagogic Module. In this work, the domain module contains the information that guides people to perform the task they have to do on their environment.
- Pedagogic Module: This module determines the content or tasks to be assigned to the student, as well as the pedagogic strategy to be applied based on the information of the Domain Module and the Student Model.
- Student Model: It represents the belief of the system about the student's mastery during the instruction process. Besides, it includes information about his/her preferences, performance, motivation, and so on. It is used to observe and evaluate the learning progress of the student.
- Dialog Module: It provides the communication interface between the system and the user.

3 Architecture of LAGUNTXO System

The LAGUNTXO system has been developed in order to facilitate the integration of people with intellectual disabilities into their working and social environments. It has to achieve the performance of human tutors, going a further step than those classical tutoring systems [3, 7, 8] by dealing not only with the management of the tasks to be performed but also with the broad diversity of people with cognitive disabilities. A Task Management System (TMS) has been developed in order to achieve this goal.

In order to improve the integration of people with disabilities using computer supported systems, the characteristics of each person have to be considered in order to determine not only Domain Module of the tutoring system but also the device where it will be installed. The kind of disability may impose some constraints on the type of tasks and some devices might be more accurate for some users than others. This implies a personal study and a related profile for every person, made by human tutors, caregivers or relatives. However, the diversity of people with disabilities is so broad that tools for lightening this work are needed. LAGUNTXO provides an assisting tool that allows any stakeholder (tutors, caregivers and relatives) to configure the ITS in two dimensions considering the characteristics of the operational task and the diversity of the disabilities. In this sense, an automaton-based mechanism has been performed to technologically adapt the large amount of possibilities related to the interaction between people with disabilities, the task that is going to be made autonomously by these people, and the system elements. This mechanism is designed in a general way for providing some characteristics such as portability for people with different disabilities, as well as solutions for other communities, e. g. the elderly. The tasks that have been considered so far are related to working environments, like labelling products in stores and cleaning surfaces in complex buildings, but at the moment tasks devoted to independent living in tutored housed are being developed.

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 are considered.

Moreover, an emotional module to increase the reliability and tutor scope has been included. The emotional module analyses several non intrusive biomedical signals, for instance: heart rhythm, skin perspiration and relative movements. This module identifies emotional changes of those persons that are being tutored. By means of this identification, the critical blockage 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 has been performed. This is 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.

Hence, the designed LAGUNTXO prototype has been structured in four main subsystems that will be described in next sections: the Task Management System (TMS), the Intelligent Tutoring System in Mobile Platform (ITS-MP), the Intelligent Dialog System (IDS), and the Human Emotions Analysis System (HEAS).

3.1 Task Management System (TMS)

The Task Management System (TMS) has been developed to overcome the lack of suitable tools that deal properly with the broad diversity of people with disabilities when defining the tasks to perform. In this work, a system that provides the configuration possibility has been created; it handles any possible case in separate profiles due to the diversity. The TMS is composed by three modules where the information is divided in the following parts:

- The tasks to carry out: Taking into account the work features, the specified characteristics of workers, the subtask divisions, etc.
- Ergonomic characteristics: Defining more specifically characteristics that can be used for increasing the reliability of the jobs perform by people with disabilities. It is relevant to introduce information about these people's interaction with the different devices of Intelligent Tutoring.
- Users' personal information: In order to know how workers can manage in different environments, it is necessary to introduce their personal profile. In this way, it is possible to prevent accidents and emotional blockage situations for avoiding personal and physical damage. The purpose of this information must be helping and attending these people with disabilities in the integration into social and working environments, not to control them. Thus, it has to be carefully stored and used.

In the TMS (Figure 1) this information is organized in several databases which can be continuously updated by users, tutors, caregivers and relatives. These databases are in a server in order to provide access from any remote stations for performing each device configuration. The particular profile configuration is loaded into the intelligent tutoring devices of any user. Encryption of databases and transmissions are ensured to prevent personal data misuse.

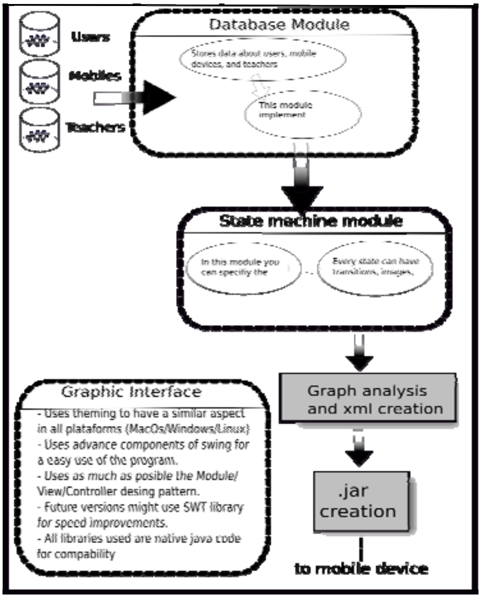

Fig. 1. Structure of the TMS

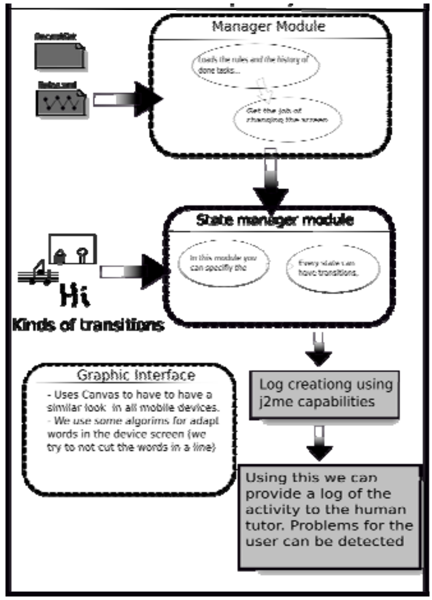

Fig. 2. Structure of the ITS-MP

Moreover, the TMS has been designed to allow a comfortable and simple configuration, giving to users an easy way to build the profile that will be loaded into ITS-MP (Figure 2). In this sense, TMS has inside an automaton-based mechanism supporting several functions. First, the automaton handles the communication with tutors, caregivers and relatives in order to allow better understanding of its functionality. Also, it organizes in a correct way the information supplied by users. Finally, it generates the characteristics map of all Intelligent Tutoring configurable devices which will be activated. Figure 3 shows an edition screen to configure automaton states. These states are organized in several levels which are connected by conditional transitions. Each state represents a different subtask to perform in order to solve the entire tasks. Depending on users disabilities, tasks profiles, and handled mobile platforms, appropriate states and transitions will be charged on those platforms. Furthermore, the appropriate media type (image, sound, etc.) will be used considering both, the user profile and the device features.

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

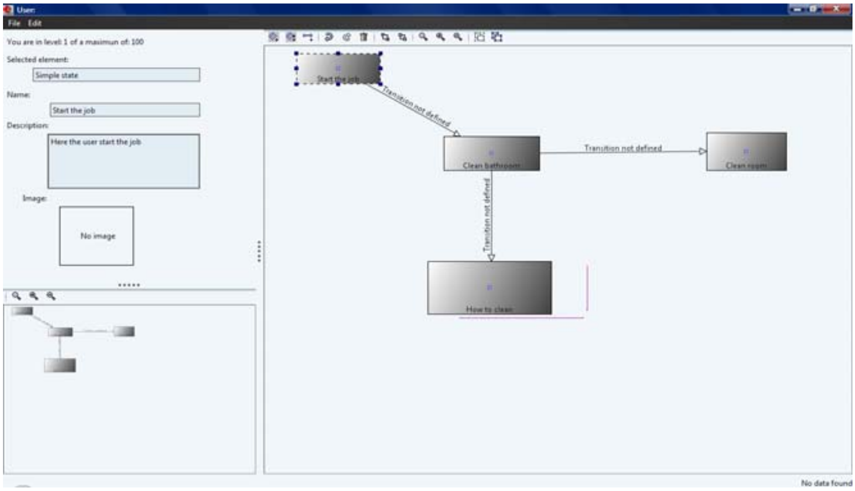

Fig. 3. Interface to create the automata

In this way, the performance of these workers and their integration process to the working and daily life would be enhanced. Besides, designed system is registered like a health product through a clinical research plan according to the current legislation.

Taking into account that the stored information covers a large diversity of cases frequently changing and it is necessary the adaptation to new technologies, the solution implemented allows adding new information to databases at any time. This strategy achieves intelligent tutoring with better assistance. TMS manages information about people with disabilities and existing mobile platforms. For every device, information that might be used in order to determine if it is appropriate for a particular user or characteristic is provided. Meanwhile the people list contains their personal information, as well as the personal involved tasks.

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

- Simple state: With a single feasible task, but not abstract description.
- Complex state: With a set of steps 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 or steps.

For interconnecting states, different transitions have been created. Each transition has an associated condition for moving from one state to another. Initially, the number of transitions is unknown. This is the reason why new transitions have to be created by stakeholders. The program is user-friendly, reliable, usefulness, agreeable, with a clear interface to be used by people with low computing knowledge. These interfaces are presented on tables or menus, depending on the data handled (Figure 4).

3.2 Intelligent Tutoring System in Mobile Platform

Looking at ITS-MP in Figure 2, based on the characteristics of the people who will use these devices, it is absolutely necessary to design an interface that shows the following features: friendly, comfortable, flexible and ergonomically adapted to their characteristics. The main objective of this project is providing these users with a cognitive tool that contributes to the improvement of their autonomy, quality of life as well as help in damage prevention of accidents in the workplace. Another objective tries to integrate a task management into the portable device. To improve this management, intelligent technologies based on fuzzy systems are used [2]. The basic structure of ITS-MP is based on rules and an automaton mechanism to communicate with all sub-system of the ITS, similar to the above-mentioned mechanism.

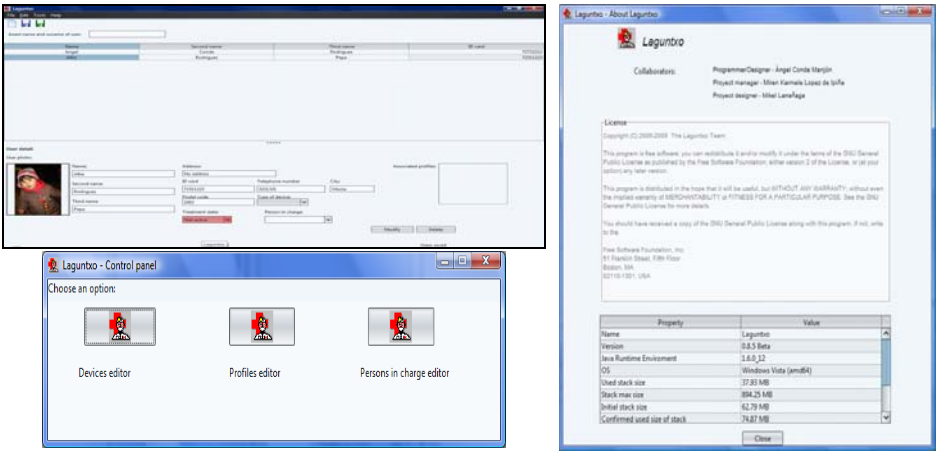

Fig. 4. Several interfaces for configuring the Task Management System

An interface example can be seen at Figure 5. It shows several screens where users can select the next subtask step by audio-video messages.

3.3 Intelligent Dialog System (IDS)

Linguist engineering and intelligent tools have been included in these systems in order to increase the reliability when they are used for tutoring people with disabilities, especially with intellectual disabilities [8]. Due to the integration and adaptation of these devices it is necessary to made bigger efforts in finding out adequate solutions. In the development of appropriate tools, the ergonomic directives as well as the specific needs of these persons are fundamental. For instance, people with intellectual disabilities have several physical and psychological common characteristics that have to be considered, such as 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 times, and difficulty in understanding instructions given in sequential form.

The IDS interacts with other sub-systems through the automaton mechanism. It uses the information of the automaton states and the user profile to present the information the user needs to perform the assigned task or subtask (Fig. 3).

Fig. 5. ITS-MP interfaces

3.4 Human Emotion Analysis System (HEAS)

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 [9]. 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 [10].

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 generates and processes 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 a convenient measuring 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 [11]. At the same time, the crucial question of data and possible databases to be used in emotion research has to be addressed, like the ontology described in [12].

In this work a different measuring system has been developed incorporating both individual artificial emotional patterns (emotional data base of human emotional patterns) and emotional memories (data bases of human experiences). LAGUNTXO platform will be more accurately managed by including human emotion analysis. This system also gives information about emotional state transitions, in order to prevent potential blockage situations.

The devices intended for the data capture of emotional states information will measure heart 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. At the moment several bio-signal provide by BIOPAC system are been analysed in order to adjust the HEAS.

The final HEAS system will contain several technical innovations and contributions with respect to the classical architectures so far used. The new measuring system proposed in this work is building by a hybrid structure with the integration of several components. The first component is a machine learning module, trained by previously acquired knowledge about human emotional answer. Also, an emotional knowledge based system is created. Simple perception information is measured by non-intrusive sensors to develop an Emotional Predictive Control based on simulating brain performances. On-line information obtained from the measurement platform will be used to update and to evolve the system.

4 Concluding Remarks and Future Outlines

Intelligent Tutoring Systems into mobile platforms oriented to people with intellectual disabilities have been developed. Due to the wide casuistic of the problem a friendly, comfortable, flexible and ergonomically adapted system has been designed. User-centred approach has been suited when developing all modules of the system.

A prototype called LAGUNTXO has been developed. It works as an active distributed support system, and allows compensating user disabilities through task programming, facilitating suspension and resume of tasks, offering help in blockage situations and reminding key points or steps of a task. It also facilitates tasks by offering to stakeholders an easy and innovative tool to be used specially in training processes.

Pilot tests indicate a high level of satisfaction of both the users and the stakeholders. On the one hand, it is increasing the users' autonomy, improving their training and the quality of their work. On the other hand, stakeholders have a new and easily configurable tool that reduces the time they have to dedicate in training. Especially in the working environment, the better quality of service and the cost reduction in hours can be an opportunity to advance in professional integration of disabled people collective. In any case, in order to get more significant results new tests will be made in the new situations that are being created at the moment.

Despite everybody could benefit of the results of research on assistive technology, accessibility and intelligent environments, participation of people with disabilities in these research experiments is fundamental, since these persons have many great difficulties of adaptation, and they are very sensible to bad technological design.

Moreover, the job made so far has offered an opportunity to establish a solid link of communication between the social world of disabled people, caregivers and trainers, and the technological world of researchers. This link is leading to improve the knowledge and to overcome the gap between these two often separated worlds.

In these sense, this work is already being done to fulfil the new challenges that the project collaboration is generating. Complementary tools are being integrated in the system to improve its usefulness and to include the system within an ambient intelligence architecture. These tools are based on pattern matching (images and speech), human emotional feeling analysis, contextual information deployment (GPS, networking), and Artificial Intelligent (AI) techniques, giving the system the capacity of dynamic adaptation to the learning process.

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