TERAPERS - Intelligent Solution for Personalized Therapy of Speech Disorders

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Abstract - **The aim of this paper is to describe an intelligent system designed for assisting the personalized therapy of dyslalia for the Romanian pre-scholars children. This system is developed in the framework of the TERAPERS project which includes informational technologies in response to society challenges for health early diagnosis and personalized therapy. The Romanian language is a phonetic one that has its own special linguistic particularities, there is a real need for the development and use of audio-video systems, which can be used in the therapy of different speech problems. The system has a high degree of originality because his objective is to treat the pronunciation disorders in the Romanian language. Furthermore, the complexity of the project results from the high number of different research areas involved: artificial intelligence (expert system), virtual reality, digital signal processing, digital electronic and psychology (assessment procedures and therapeutically guide).**

Keywords - ***intelligent system; expert system; mobile device; speech disorder; personalized therapy***

I. INTRODUCTION

Individuals with disabilities have become more prominent and with the advent of new information technologies that have been applied to the diagnosis and treatment of these individuals, the implementation of more efficient systems has been realized.

A speech disorder is a problem with fluency, voice, and/or how a person says speech sounds.

Classification of speech into normal or disorder is a complex one. Statistics points out that only 5% to 10% of the population has a completely normal manner of speaking, all others suffer from one disorder or another.

The most common speech disorders are: stuttering, cluttering, voice disorders, dysartria and speech sound disorders.

Dyslalia is articulation disorder that consists of difficulties with the way sounds are formed and strung together. These are usually characterized by omitting, distorting a sound or substituting one sound for another.

Dyslalia has the greatest frequency among handicaps of language for psychological normal subjects as well as for those with deficiencies of intellect and sensory. Thus, the opinion of Sheridan (1946) is that at the age of eight years dyslalia are in proportion of 15% for girls and in proportion of 16% for boys.

Speech disorder therapy should begin as soon as possible. Children enrolled in therapy early in their development (younger than 5 years) tend to have better outcomes than those who begin therapy later.

In the process of therapy, speech therapists use a variety of strategies including: oral motor or feeding therapy, articulation therapy and language intervention activities.

In the step of oral motor/feeding therapy the therapist will use a variety of oral exercises, including facial massage and various tongue, lip, and jaw exercises, to strengthen the muscles of the mouth. It is also important to work with different food textures and temperatures to increase a child's oral awareness during eating and swallowing.

The exercises used in order to get the correct articulation, or sound production, involve to have a correct therapist model of sounds and syllables for a child and it is often used during his play activities. Child's play level is in accordance with the child's specific needs. The therapist will physically show the child how to make certain sounds, such as the "r" sound, and may demonstrate how to move the tongue to produce specific sounds.

During the language intervention activities the therapist will interact with a child by playing and talking. He may use pictures, books, objects, or ongoing events to stimulate language development. The therapist may also model correct pronunciation and use repetition exercises to build speech and language skills.

In the area of speech disorder, there are some European projects developed as part of the European Union (EU) Quality of Life and Management of Living Resources program.

II. STATE OF THE ART

The priorities on the international level are represented by the developing information systems that permits personalized therapeutically pathways. The following main directions are considered: development of expert systems that personalize therapeutic guides to the child's evolution and the evaluation of the motivation and progresses that the child's achieves.

The most important objective is the determination of methods for the evaluation of speech impairments [3] where the data set is based on children, aged between 2 and 2 years and 11 months old and have English language skills. To date, there are only a few articles about the results obtained on this subject, although research in this area is progressing.

The potential users of the system are children affected by speech impairments and logopaed professors (speech therapists).

The OLP (Ortho-Logo-Paedia) project [2] for speech therapy began in 2002. The EU finances this complex project. It involves the Institute for Language and Speech Processing in Athens and seven other partners from academia and the medical domains. The scope of this project aims to establish a three – module system (OPTACIA, GRIFOS and TELEMACHOS) capable of interactively instructing the children suffering from dysarthria (difficulty in articulating words due to disease of the central nervous system). The proposed interactive environment is a visual one and is adapted to the subjects' age (games, animations). The audio and video interface with the human subject will be the OPTACIA module, the GRIFOS module will make pronunciation recognition and the computer-aided instruction will be integrated in the third module – TELEMACHOS.

An interesting developing project is Speech Training, Assessment, and Remediation (STAR) [4], which began in 2002. STAR members -AI. duPont Hospital for Children and The University of Delaware- aim to build a system that would initially recognize phonemes and then sentences. This research group offers a voice generation system (ModelTalker) and other open source applications for audio processing.

On the international level, is Speechviewer III developed by IBM [5] that creates an interactive visual model of speech while users practice several speech aspects (e.g. the sound voice or special aspects from current speech).

The ICATIANI device developed by TLATOA Speech Processing Group, CENTIA Universidad de las Américas, Puebla Cholula, Pue, México uses sounds and graphics in order to ensure the practice of Spanish Mexican pronunciation [6].

A recent project Articulation Tutor (ARTUR) [11] goal was to obtain an integrated speech therapy system with an intuitive graphical interface named *Wizard-of-Oz* and a virtual speech tutor named ARTUR. Based on audio (user's utterance) and video (facial data) information, the system recognizes and reproduces mispronunciations. Then, ARTUR suggests the correct pronunciation (audio data) and the correct speech elements' position (virtual articulator model).

At the national level, little research has been conducted on the therapy of speech impairments. What has been funded has been focused on traditional areas such as voice recognition, voice synthesis and voice authentication. These studies were conducted in the Psychology and Education Science Department from "Al. I. Cuza" University of Iasi. These studies have lead to development of software for aided instruction that provides feedback regarding oral fluency. Although there are a lot of children with speech disorder, the methods used today in logopaedia are mostly based on individual work with each child. The few existing computer-assisted programs in Romania don't provide any feedback.

There are expensive ($500-$1,500 USD) software applications but are not appropriate for the phonetic specifics of the Romanian language, which has its own special linguistic particularities. Therefore, we considered the real need for the development and use of audio-video systems, which can be used in the therapy of different pronunciation problems.

III. System Objectives

The information systems with real-time feedback that address pathological speech impairments are relatively the new due to the increasing amount of processing power they require [7]. The progress in computer science allows at the moment for the development of such a system with low risk factors. A child's pronunciation is also used to enrich the existing audio database and to improve the current diagnosis system's performances.

Our system has reached some specific objectives [1]:

- initial and during therapy evaluation of children and identification of a modality of standardizing their progresses and regresses (at the level of the physiological and behavioral parameters);
- rigorous formalization of an assessing methodology and development of a pertinent database in this area;
- development of an expert system for the personalized therapy of speech impairments that allows designing a training path for pronunciation, individualized according to the speech disorder category, previous experience and the child's therapy previous evolution;
- development of a therapeutic guide that allows mixing classical methods with the adjuvant procedures of the audio-visual system ; and
- design and the achievement of a database that contains the child's dates, the set of exercises and the results obtained by the child.

The high degree of complexity of the project is due to the high number of different research areas involved: artificial intelligence (learning expert systems, pattern recognition), virtual reality, digital signal processing, digital electronic (VLSI), computer architecture (System on Chip, embedded device) and psychology (evaluation procedures, therapeutic guide, experimental design for validation).

IV. System Architecture

Assisted therapy is based on the interactions between six functional blocks: child, speech therapist, lab monitor program, expert system, 3D model and the child monitor program. The system's information flow is presented in Fig 1.

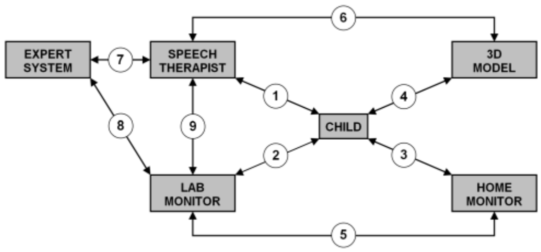

Figure 1. The system information flow

1. There is a close interpersonal relationship between the speech therapist and the child. All the other modules assist the teacher in his therapeutic action.
2. The monitor program allows the introduction of a complex examination's information and offers the possibility of making periodically records with the child's speech. The child receives an instant audio feedback and he can see the history of his audio recordings.
3. The role of home monitor program is to create a virtual interface between teacher and child (home speech therapy). This component is implemented both for personal computer (PC) and personal digital assistant (PDA). It can run exercises in a game manner, can offer feedback and can perform statistics base on current subject scores [18]
4. The 3D model provides viewing of the correct positioning of language, lips and teeth for each sound. The child may change the transparency of these items.
5. The monitor program performs homework transmission to the child PC or PDA. Later, when the child comes back, he can receive the activity report.
6. The professor will analyze the images offered by the 3D model and can correct some of the mistakes.
7. Expert system, if it is activated make suggestions regarding some training parameters like session frequency, length and content (exercises) according with some input variables. If the teacher observes erroneous conclusions, he can view the inferential route and can change the knowledge base.
8. The expert takes the data input from the monitor program and generates, upon request, sets of personalized exercises.
9. Monitor program is an interface between the speech therapist and other components like data base, expert system and child monitor program. At this level, speech therapist can collect both textual and audio information regarding each child, can administrate exercises and can manage all therapy aspects: selection of children, scheduling for therapy, offer all statistical reports that are required.

Fig. 2 presents therapeutic steps and necessary knowledge bases:

- dyslalia therapeutically guides
- speech therapy centers experience

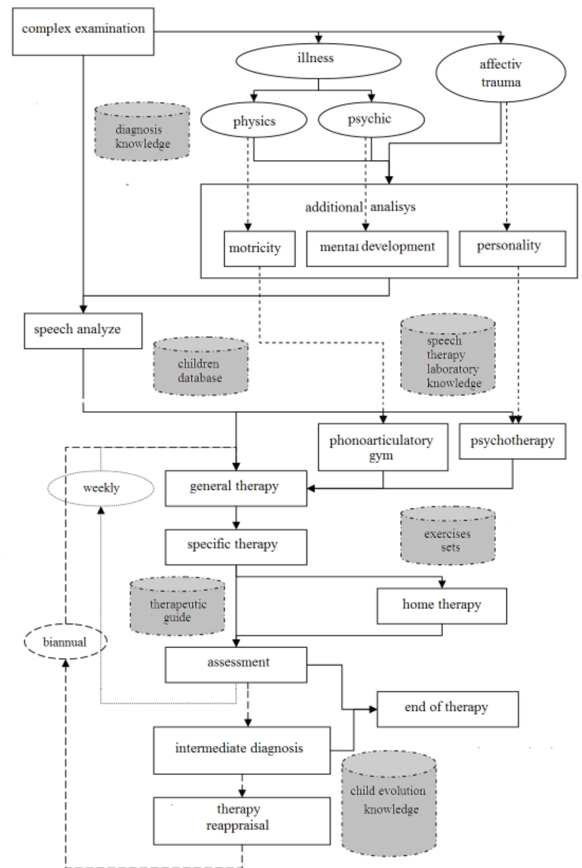

Figure 2. Therapeutically steps and knowledge bases

- dyslalia exercises sets
- historical data of therapy

According to Levitt [13], speech therapy software can help speech problem diagnostic, can offer real-time, audio-visual feedback, can improve analysis of a child's progress and can extend speech therapy at the child's home.

The architecture of TERAPERS - the personalized therapy system of dyslalia - is presented in Fig. 3. The system contains two main components: an intelligent system installed on each speech therapist's office computer and a mobile system used as a friend of child therapy. The two systems are connected. The intelligent system is the fix component of the system and it is installed on each speech therapist's office computer. This system includes the following parts:

- a child information management module,
- an expert system that will produce inferences based on the data presented by the evaluation module,
- a virtual module of the mouth, that allows the presentation of every hidden movement that occurs during speaking and
- an exercises management module that allows for the creation or modification of the exercises corresponding to various stages of therapy and grouping them in

complex issues.

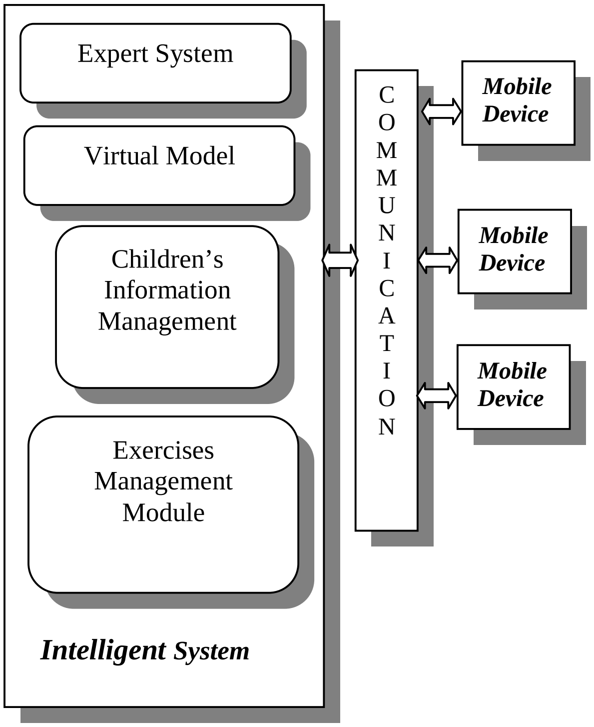

Figure 3. The architecture of TERAPERS

The mobile device of personalized therapy has two main objectives. It is used by the child in order to resolve all homework prescribed by the speech therapist and delivers to the intelligent system a personalized activity report of the child.

V. INTELLIGENT SYSTEM IMPLEMENTATION

In order to manage a child's logopaedic activity we have designed and implemented a complex software system named LOGOMON. The speech therapy teachers use this system for [10]:

- introduction and analysis of child's specific information (automatic obtain special reports);
- production of audio recordings with phonemes and scoring them (for each altered sounds);
- obtaining decision support from an integrated expert system;
- creation and evaluation of a large set of exercises for children; and
- performing homework transmission to the child's PC or PDA and receiving the activity report.

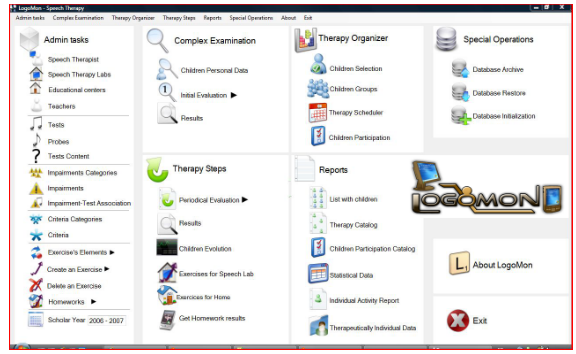

Figure 4. The LOGOMON Interface

To assess the way in which therapy evolves including the child's attendance at therapy sessions and the activity report downloaded from the mobile device. This activity report gives information regarding the exercises that have been done, how many times each exercise has been repeated, the time needed for each exercise and the results. Fig. 4 presents the interface of LOGOMON. This is a graphical user interface that allows the therapist to perform all these activities.

A. *Children Information Management*

LOGOMON is an intelligent system which assists the individually therapy of the speech disorders. It consists of software that performs the specific tasks of a monitor system. The aim of this system is: the initial evaluation for determining those children with speech disorders, registration of them in a database, suggestion of the diagnosis with the possibility for the expert to confirm or to modify this diagnosis, the selection of children for the therapy, the management of the therapy process and the supervision of the children's progress.

Moreover by using LOGOMON we collect and process the data such as we can remove any manual action of collecting or processing of data. Also we can eliminate the data storage on the paper.

The previous objectives are achieved using the following distinct activities:

- detection and recording data regarding children affected by dyslalia. Detection is made through an initial evaluation, based on tests applied to children. These tests are conducted in educational establishments (schools or kindergartens) by the speech therapists. It has five standardized tests for examination of pronunciation of sounds s, ş, ţ, ci, and r, each of them containing nine samples. Each sample consists of three trials, in sequence, the score obtained may vary between 0 points - when all the trials are wrong, and 3 points if all attempts are successful
- establish a presumptive diagnosis based on the sum of scores obtained as a result of the tests. A less than a minimum threshold, set by the specialist, show the existence of a deficiency.

- selecting the children that follow the speech therapy according to legal criteria. These criteria, specified in the order of priority, are: the type and the severity of the deficiency, the age of the child and the family implication. Each child is associated with a particular type of therapy (for groups of diagnosis G, or for individual activity A).
- design the personalized therapy according to the identified diagnosis. This involves specifying the stages of therapy and the choice of the right exercises for each stage of therapy.
- programming the therapy sessions and looking after the therapy progress.
- evaluation of the progress made by children and, if it is necessary, redesign of the intervention. This evaluation is based on the same tests that have enabled the detection of deficiencies, applied at the end of each phase of therapy or at fixed intervals. A comparison of test scores from the current to those achieved in previous tests can provide information regarding the evolution of a child. The result of this comparison may lead to one of the following conclusions about the current state of the child: corrected, ameliorated or stationary.
- collecting and recording all the data that allow preparation the logopaedic summary of each child. These data refer to anamnesis, complex logopaedic examination, diagnosis and various recommendations, the evolution during therapy or other final comments.

All the collected and processed data are stored in a relational database implemented in Oracle database management system.

B. Recording and Evaluation of Children Phonemes

An important part of our research refers to the automatic parsing of audio recordings. These recordings are obtained from children with dyslalia and are necessary for an accurate identification of speech problems. We have developed a software application that helps parse audio and real time recordings [10].

The main objective of this task is to record the children, using different audio environments during recording (some phonemes will be used for training a real-time recognition system). The speech therapist's voice must be ignored and after recording is necessary to split the stream into phonemes. The cost of recording devices and the children's impact must be minimized.

We utilize a digital voice recorder in high quality mode and with Variable Control Voice Actuator (VCVA) activated. The record format is IMA-ADPCM, 16 KHz and 4 bits (16 bits PCM). A microphone was placed at 10 cm from mouth in order to minimize environment noise.

A software set of classes (C#) was created for handling audio stream (read, conversion between different format, and write). We also have proposed an original solution for placing markers in audio stream. These markers are needed for correct parsing of full record.

C. Expert system

The expert system is based on a therapy guide, written in a natural language. This guide formalized in knowledge base consists of [19]:

- the muscular of phonon-articulator system development methods (e.g. setting up exercises for cheeks, lips and tong);
- the rhythm of respiration controlling methods (e.g. supervised inspiration and expiration from the temporal and intensity standpoint);
- the phonomatic hear development methods (e.g. the onomatopoeic pronunciation, rhythmic pronunciation exercises, distinguish along the paronyms);
- the method for the sound consolidation (e.g. the pronunciation sound of direct, inverse and complex syllable, of words, of paronyms, etc); and
- the sound's utilization in complex contexts (e.g. sentence, short stories, poems, riddles).

In this project we have used a fuzzy expert system for therapy of dyslalic children. With fuzzy approach we can create a better model for speech therapist decisions. A software interface was developed for validation of the system.

The main objectives of this task are:

- personalized therapy (the therapy must be appropriate for the child's problems level, context and possibilities);
- speech therapist assistant (the expert system offer some suggestion regarding what exercises are better for a specific moment and from a specific child);
- (self)teaching (when system's conclusion is different that speech therapist's conclusion the last one must have the knowledge base change possibility).

We use a rule-based expert system which has two major advantages: usually that kind of systems do not requires a large training set, and since the expert thinking is explicitly spelled out, we know how he thinks about the problem. Regarding that, it has the disadvantage that the knowledge acquisition phase may be difficult. A great advantage of fuzzy expert systems is that most rules can be written in language that the expert can directly understand, rather than in computer jargon; communication between domain expert and knowledge engineer is greatly eased. Another advantage of rule-based expert systems is the potential ability to learn by creation of new rules and addition of new data to the expert knowledge data base.

Fuzzy logic has ability to create accurate models of reality. It's not an "imprecise logic". It's a logic that can manipulate imprecise aspects of reality. Recently, many fuzzy expert systems were developed. [14][15]

In the next set of figures, we present an example of fuzzy inference. There are three input linguistic variables (speech problems level – Fig. 5, family implication – Fig. 6 and children age – Fig. 7) and one output linguistic variable (weekly session number – Fig. 8). We consider five fuzzy rules and, base on these rules, we illustrate specific fuzzy result (Fig. 9). If the system user wants a crisp value, defuzification is a good solution (Fig. 10).

To express a number in words, we need a way to translate input numbers into confidences in a fuzzy set of word descriptors, the process of *fuzzification*. In fuzzy math, that is done by *membership functions* [7].

Defuzzification is the reverse process of fuzzification. We have confidences in a fuzzy set of word descriptors, and we wish to convert these into a real number.

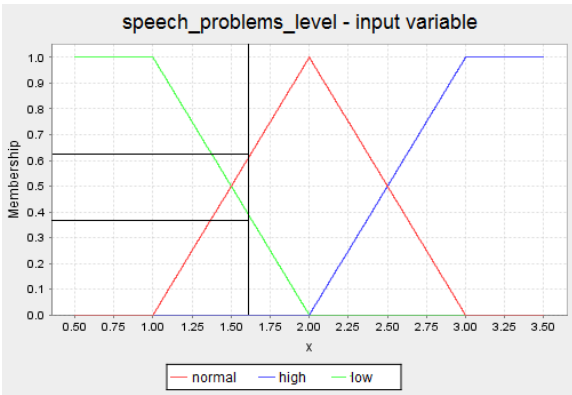

Figure 5. Speech_problems_level language variable

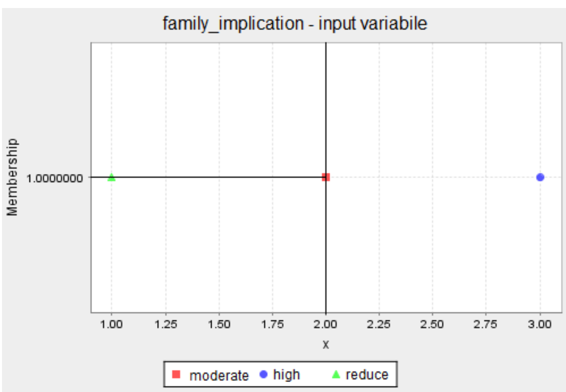

Figure 6. Family_implication language variable

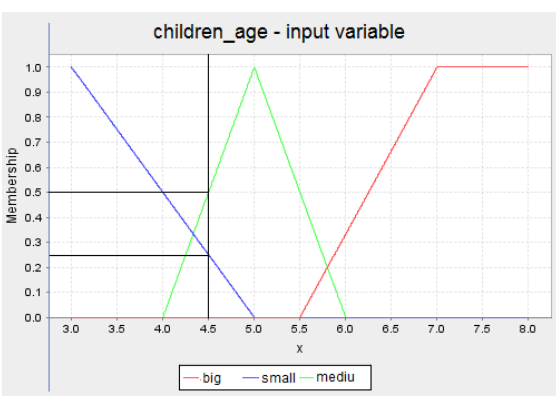

Figure 7. Children_age language variable

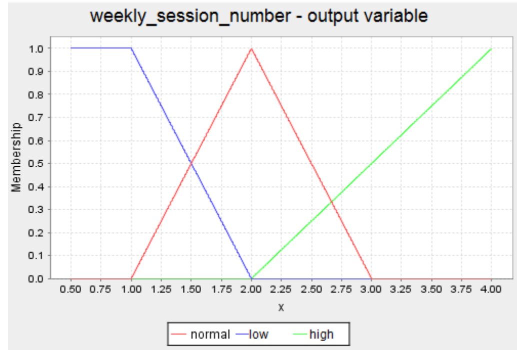

Figure 8. Weekly_session_number language variable

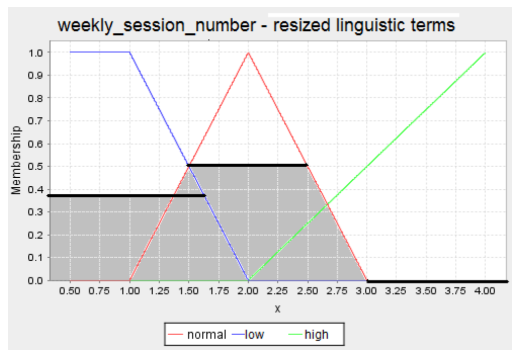

Figure 9. Obtain a fuzzy result

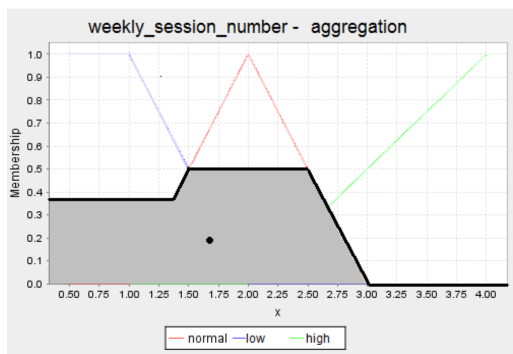

Figure 10. Obtain a crisp value

The first three variables have the following representation:

speech_problems_level (1.62)
= {“low”/0.37,”normal”/0.62,”high”/0.0}

family_implication (2.00)
= {“reduce”/0.0,”moderate”/1.0,”high”/0.0}

children_age (4.50)
= {“small”/0.25,”medium”/0.5,”big”/0.0}

We consider five rules for illustrate the inference steps:

- IF (speech_problems_level is high) and (child_age is medium) and (family_implication is reduce) THEN weekly_session_number is high;

min (0.00, 0.50, 0.00) = **0.00** for linguistic term **high**

- IF (speech_problems_level is low) and (child_age is small) and (family_implication is moderate) THEN weekly_session_number is low;

min (0.37, 0.25, 1.00) = **0.25** for linguistic term **low**

- IF (speech_problems_level is low) and (child_age is medium) and (family_implication is moderate) THEN weekly_session_number is low;

min (0.37, 0.50, 1.00) = **0.37** for linguistic term **low**

- IF (speech_problems_level is normal) and (child_age is small) and (family_implication is moderate)THEN weekly_session_number is normal

min (0.62, 0.25, 1.00) = **0.25** for linguistic term **normal**

- IF (speech_problems_level is normal) and (child_age is medium) and (family_implication is moderate)THEN weekly_session_number is normal

min (0.62, 0.5, 1.00) = **0.50** for linguistic term **normal**

Final confidence coefficients levels are obtained using max function:

- **high** = max (0.00) = **0.00**
- **low** = max (0.25, 0.37) = **0.37**
- **normal** = max (0.25, 0.50) = **0.50**

Each linguistic term of output variable has another representation and in this manner is obtained as the final graphical representation of weekly_session_number variable. If the system user wants to get a single output value, then the area center of gravity is calculated. In our case (value 1.62), the child must participate in one to two session (but two is preferred).

We implement over 150 fuzzy rules for control various aspects of personalized therapy (19 variables presented in Fig. 11). These rules are currently validated by speech therapists and can be modified in a distributed manner.

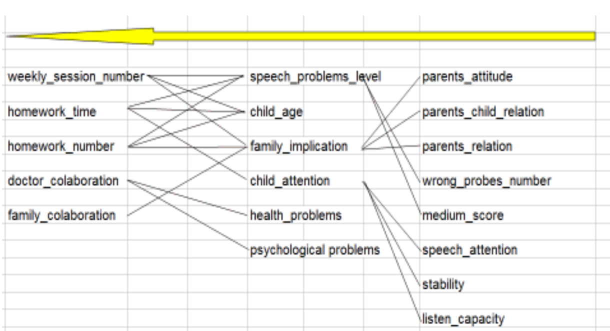

Figure 11. Fuzzy variables used for expert system

D. Exercises generator

All kind of exercises, part of different phases of speech therapy, are grouped in two main categories:

- general therapy (mobility development, air flow control, hear development);
- specific therapy (sound obtaining, consolidation and regular utilization).

Each therapy session contains a formative assessment and will be followed by home training. After three months, the speech therapist can finalize the treatment or can consider continuing it.

In order to help children with dyslalia we have created a consistent set of software exercises. This set has a unitary software block (data base, programming language, programming philosophy) and a big number of multimedia items for each Romanian language sound (over 5000 audio recordings and over 1000 image).

The speech therapist has the possibility to create and save exercises. They can also transmit these exercises to mobile device of children.

For example, the aim of phonematic hearing phase of therapy is to educate the ability to distinguish and differentiate sounds and words. As a result, appropriates exercises should allow including a) to identify words that contain certain phoneme, b) to identify the word that does not contain certain phoneme from a set of word, and c) to distinguish certain phoneme from pairs of paronyms (a word from pair contain certain phoneme and the other word contain a similar phoneme). This type of exercise can run in two ways: a words is represented by significant images, or the words are represented by flags, because there are many words in paronymic pairs which can not be associated with images (such as verbs, adjectives, adverbs, etc…).

Fig. 12 presents an example of an exercise which request to identify the words that contain the *r* sound.[16][17]

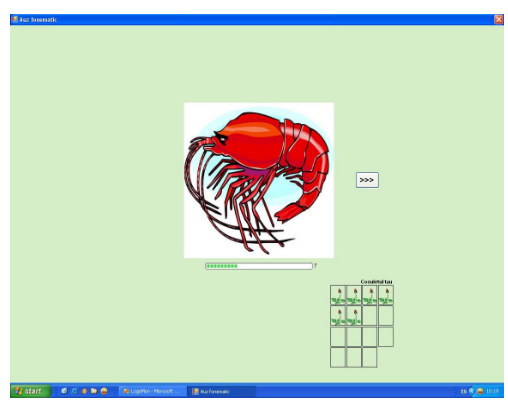

Figure 12. Example of an exercise interface

We observe that the interface is very simple. The child must only click on the image if the sound is present in the corresponding word. The feedback offered by the system is appropriate to the child’s age. Every successful attempt is recompensed with a flower in the matrix from the right corner.

At the end of exercise some statistics are presented. These statistics refers: total number of words from the exercise, the number of correct answers and the number of wrong answers, the percentage of success (one to must be achieved) and the percentage obtained by the child.

Fig. 13 presents such a statistic.

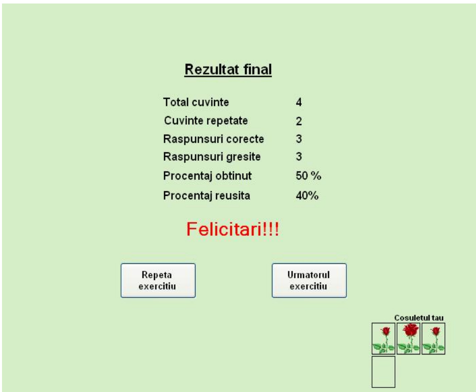

Figure 13. Final statistics of an exercise

VI. THE MOBILE DEVICE

The mobile device of personalized therapy system has two main objectives. It is used by the child in order to resolve the homework prescribed by the speech therapist and delivers to the intelligent system a personalized activity report of the child. The functions of the mobile device for assisted training are: presenting the exercises that the child should solve by himself, a personalized interaction with the human subject during therapy, the possibility of evaluating and encouraging the progresses obtained by the human subject through out an appropriate feedback, the capacity of collecting of the audio samples for learning and of the exercises solved by the child and the ability to communicate with the speech therapist's computer.

The device has two kinds of facilities: multimedia (to be able to record, to process and to play audio samples) and graphics (a friendly and accessible interface). Fig. 14 ilustrates the main page of the application implemented on the mobile device (a) and two types of exercises: (b) the child must detect if a sound is present inside a word (indicated by an image) and (c) where the child must select a word from a group of paronyms.

a b c

Figure 14. Three interfaces on the mobile device

VII. DISTRIBUTED FRAMEWORK

TERAPERS system was conceived as an assistant for the personalized therapy of speech disorders. In addition it provides a solid basis for improving the speech therapy at the national level through sharing experience of successful therapies from various speech therapists' offices and through collecting data that will lead to synthetic accurate information.

In Romania, the logopaedic assistance and therapy system has a hierarchical structure. Each speech therapist's office represents a node of a County Logopaedic Center network. At one superior level there is a National Center. In this context it is necessary to have access to data of each office in order to achieve a summary of the national condition. This situation refers to the number of children detected with speech impairments, grouped by age and diagnosis, the number of children included in the therapy program at the national level or synthetic results obtained through the application of different schemes of personalized therapy.

The fix part of the system is installed on each speech therapist's office computer. Because on each of these points create and maintain a database, it can be said that each of these local databases is a fragment of a distributed database and each speech therapist's office is a node in a distributed system. Communication between nodes can be done through an internal network, dedicated to this purpose, or using Internet technology.

The main advantage of this kind of system is that data are located near the place where the greatest demand is and that conduct faster data access, faster data processing and reduced operation costs.

Our project consists of a homogeneous distributed system, because all the nodes have the same operating system and the same application LOGOMON, so there is a unique database management system. Since all local schemes are identical we have used a horizontal fragmentation, in which each site has complete data regarding the children treated in the office and the exercises created by the therapist.

Regarding data replication there are two aspects. Personal data of children are not replicated. They are found only on the node where are managed. Instead, all the tables containing data regarding the exercises and themes are replicated in all nodes. This type of replication is necessary not only for security but also because it is necessary to share the experience and results, in particular the success ones, with all in the system. Thus each specialist can easily see the full set of exercises.

VIII. SYSTEM VALIDATION

The therapeutic system including the expert system has have been validated from three distinct perspectives:

- *Theoretical validation of the knowledge base*. From theories and models offered by psychology and speech therapies on tried to build a coherent set of rules

- *Practical validation of the therapeutic system*. The TERAPERS system was tested by the Interschool Regional Logopaedic Center of Suceava.
- *Experimental validation of therapeutic and expert system*. We have implemented two experiments in order to validate the system.

The subjects were 40 children, boys and girls selected by the speech therapists from Interschool Regional Logopaedic Center of Suceava, age range 5 and 6 years, with difficulties in pronunciation of R and S sounds.

They were divided into equal groups a control group and a program group. Each child attended two meetings weekly and was rated weekly. The two groups were constructed so as to be equivalent in terms of characteristics and in terms of initial tests assessment scores. Session length and course was designed to be the same for both groups. All preparatory actions, including the exercises selection, were developed before the session began.

The first group used the classical method of therapy, where the speech therapist select the exercises, while for the second group used the TERAPERS system, particularly the exercises were selected by the expert system.

Because the small number of subjects in each group (under the limit of 30), scores' distribution was not in generally normal. That is why, statistic data were processed using nonparametric tests: ManWitney test for difference between groups and Wilcoxon for difference between pretest and posttest scores [20]. The experiment conducts to the following results: a) groups were parametrically and statistically equivalent (ManWitney, session 0); b) both groups have progressed (Wilcoxon); c) both groups have arrived at the same performance (ManWitney, session 24).

We have not achieved significant differences between the two groups at the end of the 24 meetings, so we may consider that the exercises' choice can be performed either by speech therapist or expert system. This may be explained by the fact that the expert system has been tested during a six month period. All this time speech therapist have compared its decision with those suggested by the expert system and has adjusted knowledge base.

During the experiment were observed certain advantages of expert system utilization: speech therapist has possibility to be more concentrate on therapy because he don't spent time creating exercises (average time is 7 minutes per session) and rigor and predictability.

IX. CONCLUSION AND FUTURE WORK

In order to improve speech therapy activity, we have developed an integrated system that can be used for assisting the personalized therapy of dyslalia for the Romanian pre-scholars children. This system is actually tested by Interschool Regional Logopaedic Center of Suceava.

We estimate that this research will stimulate the preoccupation for the classical therapy efficiency compared with the therapy assisted by computer, at national and also European level. The after results will be compared with the similar smart systems from other countries, which use a similar phonetic language to the Romanian language.

The use of informatics applications in order to assist and to track the speech therapy has provided huge volumes of data. This has been possible due to the development of database technologies and the development of media storage, which have the capacity to keep an impressive amount of data.

However increased volume of available data does not lead immediately to a similar volume of information to support the decisions regarding therapy because classical methods of data processing are not applicable. For this reason we think that data mining, as techniques for automate detecting of relevant patterns in databases may helps therapists to build personalized therapy programs by identifying and anticipating the needs and the evolution of different types of patients. Consequently we intend to extend the capabilities of TERAPERS system by using some adequate data mining techniques.

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