Visualization of Turkish for Autistic and Mentally Retarded Children

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Abstract—**The use of software technologies for supporting the education of disabled children continues to increase both in quantity and quality. L2I is a set of computer programs that assists the education and training of autistic and mentally retarded children. These children are known to have difficulties in grasping fairly abstract concepts. L2I is intended to circumvent the abstractness of linguistically encoded conceptual structures via visual images. The software has also the potential to teach and/or assist a variety of basic skills including reading, writing and communicating. Each component constituting L2I has been tested with a group of students with autism and mental retardation in a special education center. In the light of the observations made over these tests, this paper presents how L2I can be benefited from in a special education program.**

Keywords-Educational Technology; Autism; Mental Retardation

I. INTRODUCTION

Particularly with personal computers that have advanced by leaps and bounds and become cheap enough to be ubiquitous in the last thirty years, software technology offers great opportunities for disabled people to communicate and socialize.[1] It is well-known that people with autism experience crucial problems in thinking and communicating using linguistic structures. Among these problems are:

- under-developed language skills;
- use of words without attaching the usual meaning to them;
- communication with gestures instead of words; and
- short attention spans.

Reference [6] lists 'poor comprehension of abstract concepts' among other cognitive problems exhibited by individuals with autism. It is also observed that some people with mental retardation experience the same sort of problems: as they have difficulties in grasping abstract concepts, they tend to think in terms of concrete visual images rather than linguistic expressions [10]. A crucial claim bearing particular relevance to the matter under discussion is that computer-based technologies have a potential to significantly alleviate educational and social handicaps that individuals with mental retardation or autism face [7, 11]. To this effect, we have developed a set of software programs to assist the education and training of the autistic and mentally retarded. Several experiments have been performed using these programs with 88 children in Yağmur Çocuklar Psychological Counseling and Special Education Center, Istanbul. An improvement between 20 to 25% was observed in the learning performances of the children when they were assisted with the software.[2] The software is intended to fill in the gap between linguistic expressions and what they denote by decoding their semantic content as visual images.[3]

II. PROGRAM SPECIFICATION

As the tool is intended to be used for assisting the education of children with mental retardation and autism, it is naturally expected to satisfy the requirements stemming from such education. Below is the set of requirements imposed on the software from this educational point of view:

- to help mentally retarded children grasp the content of a Turkish expression by visualizing that content
- to set up a flexible training framework
- to offer visual materials fitting various levels of disability (starting from word referents up to scenes corresponding to temporally differentiated sentences)
- to have the child repeat what s/he has learnt and thereby assure the transfer of what has been learnt from short to long-term memory
- to establish a context for the referent of the expression to be taught
- to allow the child to actively participate in the learning process
- to motivate the child with positive and negative feedback
- to provide the teacher with a multi-level test module

[1] See [9] for a comprehensive and detailed account of computer-based technologies that can serve to include people with disabilities into the mainstream of society.

[2] See [11] for a detailed discussion of the experimental results.

[3] The work leading to that version of the software was disseminated in a special issue of the IEEE Journal of Pervasive Computing dedicated to works in progress in healthcare systems and other applications [2].

The University of Trakya Scientific Research Project Office supported this work with grant number TUBAP-760.

PERVASIVEHEALTH 2008, 30 Jan - 1 Feb. Tampere, Finland

DOI 10.4108/ICST.PERVASIVEHEALTH2008.2493

How each requirement is satisfied is to be explained in the subsequent section.

III. PROGRAM DESIGN

A well-known fact about children with mental retardation and autism is that among the factors that contribute to the lack of their academic success is delayed language development. As many researchers (e.g. [1]) point out, visualizing verbal expressions improves language comprehension and expression for individuals experiencing mild to severe weakness in comprehension. The main expectation from L2I is to help autistic and mentally retarded children grasp the content of a Turkish expression by visualizing that content. For example, a Turkish equivalent of a sentence like:

The child is reading the newspaper. (1)

will be assigned the image in Fig. 1.

It is noteworthy that the software is flexible enough to map the same image to all more or less paraphrasable expressions. When the situation above is encoded with different grammatical mechanisms, such as using there-insertion sentences (e.g. there is a child reading a newspaper) or relative-clauses (e.g. a child who is reading a newspaper is sitting down), L2I will be capable of detecting that the same content is encoded and will map the sentences to the same image. This flexibility is gained through a Natural Language Processing Engine which we have developed in order to extract the semantic content of Turkish sentences in tandem with their grammatical analysis. Fig. 2 shows the interaction of this and other components of the module of L2I responsible for sentence-to-image mapping.

Figure 1. The image matching the Turkish equivalent of a sentence like 'the child is reading the newspaper'.

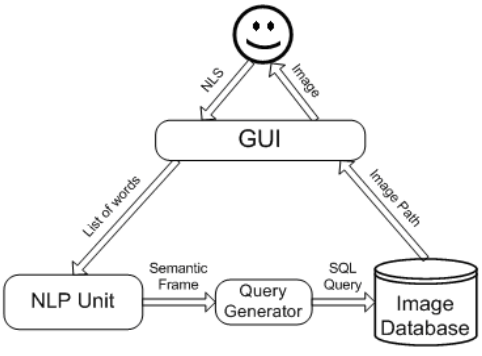

Figure 2. The architectural design of the sentence-to-image-mapping module.

This module is composed of four main components: a *Graphical User Interface* (GUI), a *Natural Language Processing Engine* (NLP-E), a *Query Generator* (QG), and an *Image Database* (IDB). The GUI serves as an interface between the user and the system. More specifically, it takes in a natural language sentence from the user and provides the user with an image representing the semantic content of that sentence. The input to the NLP-E is the list of words yielded by the GUI. The output of this component is a semantic frame representing the meaning of the input sentence as a conceptual structure that describes the denoted type of situation, object or event and the participants and other peripheral entities involved in it.

The QG takes the semantic frame generated by the NLP-E as input and translates it into an SQL query. As should be expected, the IDB serves as a store of paths leading to the images used to visually represent the contents of input sentences.

As Green, Dorr and Resnik [5] note, semantic frames effectively "address the paraphrase problem through their slot-and-filler templates, representing frequently occurring, structured experiences" (p. 375). Our system ensures the sameness of the interpretations of paraphrasable sentences by assigning them the same semantic frame.

Another fact about children with mental retardation and autism is that the subject that is to be taught should be chosen considering the child's capacity to learn [8]. L2I has been designed to reflect also this sort of flexibility. It is able to offer visual materials at various levels. The sentences that can be analyzed by the tool range from two-word sentences (i.e. one-word subject plus intransitive verb sentences) to sentences containing various sorts of phrases modified by a number of adjectives. Besides, L2I is capable of visually discriminating among different temporal conjugations (namely past, present and future). One of the most abstract concepts is that of time. It is our opinion that visualizing three sentences each of which expressing the pre-, mid-, and post-phases of an event will help an individual with autism grasp the temporal development of that event. Consider the following sentences:

a. The child will eat the apple. (2)

b. The child is eating the apple.

c. The child ate the apple.

When the Turkish equivalents of these sentences are given as input to our system, the pictures shown in Fig. 3 will be generated in the left to right order:

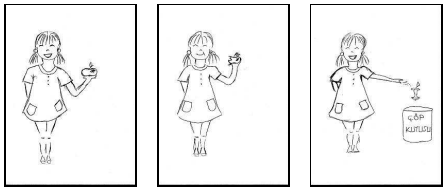

Figure 3. The three phases of an apple-eating event.

Both autism and mental retardation are spectral disorders with a wide spectrum of severity, symptoms ranging from person to person. Therefore, it should be wiser for software like L2I to operate at a level as simple as that of words. L2I can also be used to visualize isolated Turkish words. The module responsible for word-visualization is a simple mapper between input words databased images. Visualized words range from nouns denoting daily used objects (e.g. chair, table, and book) to those denoting less familiar objects (e.g. compass, car jack, archaeologist) or complex activities (e.g. shopping, training, volleyball) and to nouns denoting abstract entities (e.g. angle, darkness). It is, of course, up to the teacher to use the software at a level appropriate for the student's capacity.

Another dimension along which L2I allows the complexity of the education program to be scaled is through a multi-phase test module. What has been taught to a child can be tested by placing the correct image among two or more diverting images, as illustrated in Fig. 4.

Mentally retarded children are known to experience considerable difficulty in transferring what they learn from short-term memory to long-term memory. For this reason, these children should be made repeat the process of learning a particular subject. The teacher can have the child repeat what has been taught via the test module, increasing the level of challenge progressively.

Speaking about tests, the mentally retarded or autistic child should be given feedback indicating whether his/her answer is correct or not. This will increase the motivation of the child. L2I provides the mentally retarded student with auditory and visual feedback differing depending on the correctness of his/her response.

A requirement which probably applies to all types of teaching is that the learnee should actively participate in the process for more effective learning. As the software communicates with the child via visual objects, the child can be asked to point to an object (or, perhaps more preferably, to touch an object when the computer is equipped with a touch screen). The name of each databased object has been pronounced by a human speaker and recorded so that it can be used to prompt the child to point to a particular object.

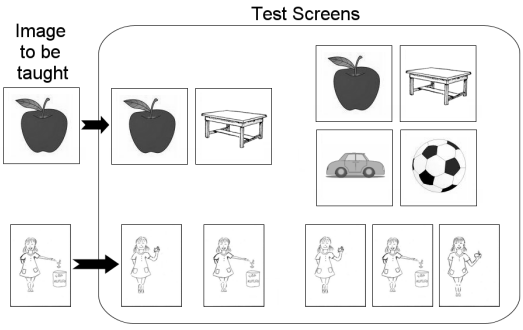

Figure 4. A sample training and test environment.

The education of a mentally retarded or autistic child requires the same concept to be taught in the context of differing situations and relations. Obviously, the test module allows for establishing such a context for the referent of a word or sentence to be taught. Furthermore, visualizing the temporal sequence of events can be thought of another way of contextualization, temporal contextualization. At this juncture, it is worth noting that with this capability of visualizing temporal sequences L2I can be used also as a story teller. Stories are often used to allay an autistic child's fears about a future event or to encourage different behaviors (cf. [3] and [4]). The sequence of pictures in Fig. 3 can be regarded as a very short story about a child. Admittedly, such stories can be considered too simple. However, this simplicity should rather be viewed as an advantage taking into consideration the fact that children with autism are very reluctant in keeping the track of a sequence of events.

IV. CONCLUSION

Many children with autism and mental retardation suffer from speech and language problems. It is widely acknowledged that with the aid of methods of visual education, language barriers can be lowered, and learning and understanding with all senses can be promoted. Autistic and many mentally retarded children can speak without grasping the meanings of the words they use. They may experience a difficulty in establishing the relation between a word and its referent. For example, such a child hearing the word 'orange' may not be able to apply that word to an actual orange that s/he sees. In just such cases, computer software linking expressions and pictures and/or images representing the referents of these expressions can come to scene to help speed up and facilitate the education of these children. Hopefully, our current work and possible improvements added to it in the future will contribute to the education of such children.

ACKNOWLEDGMENT

We are indebted to Armağan Dönertaş Education, Rehabilitation and Research Center for Disabled Children and Yağmur Çocuklar Psychological Counseling and Special Education Center for very valuable comments and co-operation at different stages of this work.

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