A Tutorial-Based System for Children with Intellectual Disability

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Abstract—We propose in this work a tutorial-based system using Arabic language for mentally disabled children who are resident at Shafallah Center for children with special needs in Doha, Qatar. The system is flexible and can be used by teachers, students and parents. The contents are developed by special education instructors and can easily be uploaded to the system. The tutorials cover a range of topics including basic mathematics and sciences. The animated images used in the tutorials are taking from the child environment, so he can feel more comfortable and confident when using the system. After studying the tutorials, the child can solve a puzzle based on the topics that he learnt. A simple intelligent algorithm is used to guide the child reaching a solution. Many other features are being added to the system to enhance the learning process.

Index Terms—Tutorials, Intellectual Disabilities, Education.

I. INTRODUCTION

The number of disabled people in the world is increasing dramatically. Sik Lányi et al. mentioned in [13] that around 10% of the world’s population has been identified with some kind of disability. In the USA about 14% of the population suffers from disabilities [11]. According to the forecast in Europe at least 18% of the population will be disabled during the next 20 years. The present population of Europe is 450 million. This means that more then 81 million people will have disabilities by 2040. Unfortunately, there is limited statistical information about people with disabilities in the Arab countries. A recent study conducted by Al Gain and Al-Abdulwahab [1], estimates that 3.73% of Saudis have functional disabilities. In the state of Qatar, a new census process is being conducted by the Qatari planning council to determine the effective number of disabled people in the country. We think that there is at least 5% of the population which requires personal assistance in their daily living activities due to developmental, intellectual or physical challenges. Qatari children with disabilities currently receive excellent services and care in Shafallah Center in Doha city.

It is well known that information technology assistive tools improve the living of disabled people and increase their abilities to manage independently their lives. Extensive research works have been carried out since 1995 to propose the best assistive tools for intellectual disabled children. Mechling [10] has conducted an extensive literature survey on research works (1990-2005) about assistive technology as a self-management tool for prompting students with intellectual disabilities to initiate and complete daily tasks. She mentioned that, “although Kimball, Kinney, Taylor and Stromer (2003;204) outline instructions on how to create computer-based activity schedules with photographs and video models using Microsoft Power Point, to date no research base exists to support this new and creative use of high tech systems in providing students with visual, auditory, and animated cues for following and transitioning between activities or use in other forms of self-management”.

We propose in this work a tutorial-based system that can enhance the capabilities of the children with intellectual disabilities to learn concepts and communicate more effectively with others and receive fair access to education. In addition, these tutorials are used also to allow the disabled student to initiate and complete daily tasks (i.e., preparing a school day). This would play an important role in accelerating the integration of these categories of students into the society and improve their self-reliance and independency. Whether a child's disability is emotional, physical, or cognitive, interactive tutorials can assist him in performing a number of everyday tasks. The multimedia tutorials can allow the kids to practice pronunciation, spelling, grammar, word meaning, and reading comprehension skills. With improved language skills inevitably comes better social interaction which helps the children to sharpen their language skills. Note that, there are no available interactive educational programs to train Qatari children with special needs. Thus, there is significant need for an interactive tutorials based system. Our project was initiated in May 2007 by a group of Qatari students to develop a prototype and test it on a set of specific children from Shafallah Center. In the next phase of the project, we plan to develop a version for a PDA and a mobile phone devices as these tools can be acquired by the majority of the students.

II. BACKGROUND

Research works in the Arab world to develop assistive tools for children with special needs are at the premature level. Al-Salman et al. from King Saud University have developed a prototype of an Arabic Braille system for blind people [2]. They have launched also a new project to develop Arabic Sign Languages education tool. Another research project to use modern techniques in teaching children with Dyslexia is carried out in the Prince Salman Center for Disability Research, Saudi Arabia [12]. Jenni and Elghoul presented in [8] an untested web based tool called WebSign that translates text to sign language. It may allow people with hearing impairments to understand written texts thru sign and gesture. This tool needs to be validated by the deaf community. ALfakheer from King Saud University has developed recently
an educative web-based tool entitled FAHEEM for children with Autism. In addition, many special needs instructors have individually developed Arabic tutorials for children with special needs. However, these educative tutorials are very primitive with low attractiveness. They are developed mainly in Microsoft Power Point software with low quality images [10].

Most of the Arab software engineering companies do not develop multimedia programs and tutorials for special users because they do not see great financial benefits from this market. Commercial software proposed by Sakhar [14] like IBSAR assigned to help blinds in usage of the computer is expensive (i.e., $3000 for a single license) and few number of disabled families can afford such cost. It is time nowadays in the Arab world to develop advanced tools for disabled people and make them freely available to this community.

Effective research about people with disabilities has been done primarily in USA, Europe and other western countries. Governments and private sector companies highly supported these research works through specific funds and grants. Hundreds of researchers were allocated to conduct deep research to build software and multimedia tutorials to assist the people with disabilities and help them to integrate the society. The European Commission supported the pan-European project proposed by the adaptive system research group of the School of Computer Science, University of Hertfordshire, United Kingdom [3], and involves several partners across Europe. The project recognizes the important role of play in child development as a crucial vehicle for learning about the physical and social environment, the self, and for developing social relationships. It targets children who are prevented from playing, either due to cognitive, developmental or physical impairments which affect their playing skills, and is investigating how robotic toys can empower children with disabilities to discover the range of play styles from solitary to social and cooperative play. This family of robots has been used in the Aurora project [5] which investigated the possible use of robotic systems as therapeutic or educational tools to encourage social interaction skills in children with Autism.

The Spanish project AmlVital [4] creates intelligent communication tools and devices for elderly and disabled people. Seventeen top Information and Communication Technology companies and research groups take part in this initiative. The total allocated funds from the Spanish Ministry of Industry, Tourism and Trade exceeds 20 million Euros.

Scott [15] launched the project Archimedes which promises accessible technology for the disabled. Archimedes has expanded and now includes the Archimedes Foundation to raise money for research and development, as well as Archimedes Access Research and Technology International Inc. to bring the project’s products to market.

Chelin et al. proposed a system that uses natural language to assist visually handicapped people in writing compositions [6]. Dunlop et al. proposed a digital library of frequent conversational expressions to help profoundly disabled people communicate more effectively [7].

Silk Lányi et al. [13] spent 10 years to write more than 30 programs for people with disabilities in Hungary. Around 70 Masters Theses have been done to realize these programs with many grants from the government and private sectors. They proposed some tutorial and entertainment programs for children with disabilities respecting their own language, culture and tradition, in addition to rehabilitation programs for stroke patients and persons with phobias. These multimedia programs were mainly for handicapped children having different impairments: partial-vision, hearing difficulties, locomotive difficulties, mental retardation, Dyslexia, etc. They are also accessible to the potentials users with the necessary help. LifeShare Assistive Technology project [9] (Mississippi, USA) aims to better the lives of children with disabilities through the use of technology. It offers free for download all of the software and resources it develops, and in Mississippi currently offers one-on-one consulting with children, parents, teachers and therapists, also free of charge.

III. CURRICULUM FOR CHILDREN WITH DISABILITIES

The current curriculums used at Shafallah Center for children with special needs are divided into three main categories as follows:

1) Pre-Academic,
2) Academic and
3) Post-Academic and professional qualification.

This curriculum covers a wide broad of topics including: organs movement and body control, reactions, object and pattern recognition and differentiation, speech expression and control, memorization and information retrieval, self-confidence, clothing, cleaning, toiletry, possession, playing, social relationships, transportation means, animals and plants, foods, use of tools, safety, time and date notions, travel and circulation, entertainment, sports, quantities and qualities, counting, measures, relations, images and symbols, communication means, simple reading and writing, music and songs, and sports. The instructors are currently using the traditional ways of teaching. They use MS-Power Point to present their materials to the children. These instructors face a major problem in knowledge transmission. They have to keep the focus of the children, repeat the same lesson many times and re-ask the same questions many times. An assistive computerized system will highly help these instructors to deliver effectively the lessons. It helps also the students to gain self-confidence and to improve their learning skills.

IV. THE SYSTEM FEATURES

The expected features of our system can be summarized as follows:

1) To develop short Arabic tutorials for children with intellectual disabilities on different topics. The tutorials should give short and simple sentences, clips, images and sounds. The background and images used in the tutorial should be from the children’s environment. For instance, the user should see the desert, the males that he goes with...
his family to purchase foods, the local street, etc. We propose to draw the outlines of the local images by hand and input them to Photoshop to add the necessary effects. In addition, a digital camera is used to make short clips from the local environment. The child will see his preferable personality as a mascot like ‘BaBa Linga’ in Qatar. This will help him/her to feel familiar and confident. We selected a character from the Qatari environment to be used in the tutorial.

2) To assist the children to write simple Arabic words correctly by offering a list of items and words to select from. These words and items are split into rubrics according to their meanings and belongings.

3) To allow Arabic word prediction and abbreviation expansion. Whenever the child begins to type a word or pronounce a word, the system will display a list of frequently used words that begin with those letters. The child can then select the appropriate word from the display. We add also the corresponding images to validate the child choice.

4) To integrate a group of strategies and techniques, symbols, picture boards to enhance the disabled communication and interaction with their surroundings. The child can select pictures and symbols that communicate what he is feeling or thinking. A similar and manual technique is currently used in the center.

5) To store and retrieve phrases and sentences which have to be grouped according to subjects, such as family matters, sports, personal needs, food, transportation mean, etc.

6) To be interactive by using attractive multimedia which has an effect on more then one sense, and would be more effective. The display presentation should be adjustable to fit with the different needs of the children (i.e., size, contrast, color).

V. DESIGNING TEACHING MODELS

When designing a tutorial based system for children with special needs, one can think to base it mainly on the ordinary curriculum that is taught in normal schools. We can then use the text and add the interactive animations. However, children with intellectual disabilities need specific treatment and deep care. In order to improve their understanding skills, the tutorials should attract the maximum number of their senses. In addition, to seeing, hearing and eventually reading, the children should taste and touch whenever possible. For instance, if we want to teach them the concept of “coldness”, drinking cold water and touching ice would highly increase their understanding. The images used in the tutorials should also be from the children’s environment so they can recognize them more easily. Thus we draw first the outlines of the images by hand, and we then input them to Photoshop to add the effects as shown below. The following images are used in the tutorials to teach the child about the day school, from getting up in the morning till going to bed in the evening. For every displayed picture, the child can hear a clear message about the activity. For instance, the children will be asked about what he has to do when he gets up in the morning. An explanation is given with each picture. The student is prompted about the next activity to perform. The system will track the children and shows his progress in remembering the tasks to perform. Note that the mentally disabled children cannot remember very well the tasks. In addition, he can forget very quickly. Instead, of repeating the same lesson in the traditional way, the computer based system and help to overcome with this problem. The following figure shows the images used in the daily activity concept to be taught to the children.
The content of the tutorial can be customized to allow individualized teaching. The images can be taken from the real environment of the disabled child like his house, family, local streets, etc. depending on the tutorial's topic. They are stored in an independent database. The system can then retrieve the images relative to each child and displays them in the tutorials.

VI. PUZZLES AND GREEDY ALGORITHMS

After learning a specific concept through the tutorial like for instance the school day, the child will be asked to solve some puzzles of different difficulties levels. These puzzles include assembling parts pictures and images, ordering the tasks to be performed during a specific activity, matching images, assigning the corresponding images to text and vice versa, listening to a dialogue or specific audio sentence and select then the right image and text, etc. The puzzles are seen as optimization problems and we solve them using a local greedy algorithm which guides the child in each move to finally converge to the solution. At each move that the child perform, he will be alerted through sounds and animated mascot the either encourage him to go ahead or to change the move. We will discuss in the second paragraph the greedy algorithm that we are using. An optimization problem is formulated as follows:

Minimize f(x) subject to x in D

We call f the objective function, D the feasible region that satisfies all the given constraints, and a solution x in D a feasible solution. If D has combinatorial features, then the problem is called a combinatorial optimization problem. The set of solutions of an optimization problem, which may be potentially visited in a local greedy algorithm, is called the search space. The simple local greedy algorithm starts from an initial solution or configuration x, generated randomly or by a greedy algorithm, and repeat replacing it with a better solution x' (i.e., f(x') < f(x)) in its neighborhood N(x) until no better solution is found in N(x), where N(x) is a set of solutions obtainable from x by slight perturbations. The algorithm can be presented as follows:

```
LocalGreedySearch()
Begin
  x = Initial Solution
  Repeat
    x' = SelectSolution(N(x))
    If (f(x') < f(x)) Then x = x'
    Until Stopping Criterion is met
  Return x
End
```

The algorithm randomly generates the puzzle parts (i.e., solution x) and calculates then the value of the objective function f(x). This function represents the number of conflicts between the puzzle parts. The higher the value of f, the far the solution is. The child will try then to rearrange the parts of the puzzle by moving them one at a time. He will be prompted at each move that he performs. Whenever the value of f decreases, the student will know that he is going towards the expected solution. For instance, after learning the daily morning concepts, the student will then try to solve the following puzzle about the concept which is generated randomly. The value of the objective function is the number of conflicts of the activities. Let us assume f(x) = m.

<table>
<thead>
<tr>
<th>Go to School</th>
<th>Take Breakfast</th>
<th>Take the bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash your hands</td>
<td>Go to Toiletes</td>
<td>Get Up</td>
</tr>
</tbody>
</table>

The student will then make a move. For instance, he may put the Get Up activity at the first position. Thus, the value of the objective function will be decreased and the student will be prompted accordingly. He will see a pictorial prompt encouraging him to continue in this way.

<table>
<thead>
<tr>
<th>Get Up</th>
<th>Go to School</th>
<th>Take Breakfast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take the bus</td>
<td>Wash your hands</td>
<td>Go to Toiletes</td>
</tr>
</tbody>
</table>

If now the student will put the activity, “Take the breakfast” in the first position, the value of the objective function will be increased. The student will be prompted that he is going in the wrong direction. This process is reiterated until reaching the solution. The system will display then the number of moves carried out and the time. A score will be provided to the students and stored in his file in the database. The student can repeat the same puzzle with a different random pseudosolution and test himself. The teacher and the parents can consult the database to see the performance of each student.

The following figures show a simple puzzle to be assembled by the child. It consists of grouping together the different parts of an apple. The mascot is used to explain to the child what to do in each step. It gives him some encouragement when performing a right move. A progress bar is displayed below the puzzle. It indicates the work progress using red and green colors. An indicative number is displayed in the small box to indicate the percentage of the current state of the solution.
VII. CHILDREN LEVELS

The children in Shafallah center are of different levels of intellectual disability regardless of their ages. We can have a child of 15 years old with a maturity level of a child of 6 years old. Thus the designed tutorials should take into consideration the different levels of the handicapped children. These levels are as follows:

- Level 1: The children can understand one picture at a time with sound effect.
- Level 2: The children can understand one picture at a time with sound effect and one word.
- Level 3: The children can understand some pictures with sound effect and short sentences of three words each.
- Level 4: The children can understand pictures with sound effect and long sentences of six words.

The developed tutorials are taking into consideration all the four levels. The difficulties that we are facing, a tutorial designed for a specific level may not be suitable for all the children in that level. For this reason, we have made the system open to accept updated content in terms of texts, sounds and images.

VIII. POTENTIAL USERS OF THE SYSTEM

The system allows three categories of users. The teachers can use the system during education sessions. They can upload their materials which will be stored in a separated database and retrieved by the system. The parents can use the system at home to help the child review the lessons taught at school. In addition, they can select images from the child environment and upload them to the system. For instance, to teach the child about his family members, parents can take their photos and let the system expose them through puzzles. The child is asked then to assemble the puzzle in order to recognize the characters. The greedy algorithm is used to help the child to converge toward the solution. When the child makes a right move, an indicative bar with growing up green color is used to show him the progress he has made to reach the solution. An encouragement sound is announced through a well known local personality. The system allows changing easily the content of the sound files and the personality. This will allow the parents to insert their sounds and their photos. We have adopted this strategy due to the fact that the children in the same level may have different understating of the Arabic words. In fact, these children are of different nationalities and have different dialect to talk about things. The following figure shows the potential users of the system.

IX. CONCLUSION

We have developed the first prototype of the proposed system that offers currently some tutorials on different topics. We have also designed the corresponding puzzles using multimedia and greedy algorithms to guide the child reaching a solution. The first feedback coming from the potentials users (i.e., teachers and students) is very promising. We intend then to continue the development of the system features in our next research work. We think that the system will be fully operational in the coming months. The potential users of the system are teachers, children and parents. We think that, involving the parents are active teachers help the mentally disabled children to gain more self-confidence and increase the learning skills.

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