Modern Communication Techniques For Children With Cerebal Palsy

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Abstract

This paper examines new systems of representing the meaning of words and sentences using visual representations to the specially challenged people. One of the systems is "Shikshak" that can be used to provide personalized education to people having special needs. Moreover, for people with Severe Speech and Motor Impairments, "Sanyog" is developed. Sanyog is a speech enabled vernacular Alternative and Augmentative Communication (AAC) system that helps an SSMI affected user to perform daily communication in a natural way. Another system that is discussed in this paper is "Sweepstick", which is an alternative mechanism to access computer by severely disabled users.

Keywords SSMI, Cerebral Palsy, AAC, Icons, NLP, Access Switch, Disability, Self-learning, Adaptive system, Communication Components

1. Introduction

There are approximately 22 million people in India who suffer from different types of disabilities.[1] These include people with learning disabilities, hearing impaired persons, persons suffering from Autism, people with neuro-motor disorders and so on.

A majority of this segment has cerebral palsy and 40% to 60% of this population is non-speaking. Though cognitively quite capable, this segment of population is deprived of accesses to the modern tools for education and communication that could have alleviated their problems partially. Different Alternative and Augmentative Communication techniques have been proposed and implemented for these people. However, most of the tools that are available today are in English and do not cater to the socio cultural needs of the people in India, as well as of those in other non-English speaking countries. Secondly, the tools are all imported and are not affordable to the Indian population.

In response to this need the task of developing a multilingual communication tool and a multilingual education tool for the children with cerebral palsy and speech impairment has been taken up. Presently, the education of this category of children is carried out using iconic boards, which are individually made for every student. The process is not only inefficient, but also costly. The speech impaired children points to an icon to express themselves, while the teachers also point to the icons and utter words or phrases to convey the concept. Separate boards are made using stamps with stickers to illustrate different phrase level and word level concepts. There are tools like Boardmaker[3,4], Clicker4 etc. for making such iconic boards. However, these tools are restricted to English only and also the icons are alien to the socio cultural context of the Indian children.

Keeping in mind the situation stated above, some systems have been developed that can be used for the education and communication purposes. These systems are developed specifically for the Indian users though they can be extended to other socio-economic contexts

as well.

With the support of Media Lab Asia, a multilingual communication tool have been developed, that allows the speech-impaired users to form natural language sentences, through selection of iconic concepts. The sentences, thus formed can be fed to an Indian Language TTS, to have these sentences uttered. The system is

- Aimed at pre-literate children with speech impairment and motor disabilities
- Icon based
- Extendable for children of other age groups
- Based on Indian lingua-cultural icons and vocabulary.

The system relies heavily on the techniques of natural language processing, cognitive aspects of icon interpretation among other things.

1.1 The Education Tool

The salient features of the tool are enumerated below.

- The software provides the teachers and the students with cerebral palsy with the advantages of information technology by helping them to prepare and use image and icon based study material.
- The system allows preparation of books, directed at different cognitive levels, suitable for the variety of student categories. Children with cerebral palsy can themselves read through the books using the special access mechanism.
- The system facilitates the preparation of an effective and large vocabulary of icons, so that a larger gamut of concepts can be taught.
- The system is geared to vernacular based teaching (Indian languages) and this is probably the most important feature of the present system. Presently, English, Bengali and Hindi are the languages supported by the system.
- The system is also provided with an iconic keyboard GUI, through which the children can write sentences directly using alphabets.

1.2 Technology Issues

Java programming language is used to design the system. Icons are stored in a database structure, also implemented using Java. The database, named as Icon Gallery, has icons as tuples with three attributes, namely, some text, an image file("jpg" or "gif" file) and a voice file ("wav" file). The text associated with each icon is stored as string. The text is used as the primary key,

through which the icons are searched. The "wav" file for the voice is created at the run-time when the voice is recorded during creation of icons. The pages are saved as text files containing the primary keys (i.e. the texts) of the icons and the co-ordinate positions of the corresponding icons. The books are also saved as text files containing the page numbers and the corresponding page file names.

As the numbers of icons are different in different pages, but the page size is constant, the icon size varies. Also the image width and height are not constant. Hence, to make the appearance of all the icons in a page uniform the image size is reduced programmatically at runtime, during displaying the pages, if the icon size is less than the image size. Another design issue is to make the software as fast as possible. One book consists of a number of pages and each page has many images. As a result, while a book is browsed through, all the images are being stored in the RAM, occupying memory space. This was ultimately leading to slowing down of the system. To circumvent this problem, all the non-referenced memory locations are programmatically freed after a book is closed.

Icon based language is found to be very effective for the AAC users. The icons can be of different complexities, starting from simple concepts like "apples" to a relatively complex icon depicting " a busy street". The iconic language needs to be supported by intelligent processing to translate the icons to words or phrases and ultimately generate meaningful sentences. A major hurdle in developing such a language has several bottlenecks. First, the icons must be unambiguously capturing the central theme of the expression. This is essential in order that the user can recall the sequence of icons that lead to a specific output. Second, the icons must be socio culturally relevant to the user, so that (s)he can easily associate icons to expressions. Third, there should be consistent iconic modal operators that can modify the expressions according to tense, number, mood etc.

1.3 Scalability and Possible Enhancements

The tool can be used in a networked environment, where the books and pages prepared by the teachers/parents can be kept in a server. The students can connect to the server as clients and download the book(s) they want to read. It will obviate the requirement of allocating one PC to every student. Instead the students of the schools may be provided with thin-clients or low cost portable devices to access the contents. This will effectively make the use of the system cheap and affordable. Moreover, it will facilitate the remote

on-line access of the study material by remote schools from resource centers, such as Indian Institute of Cerebral Palsy. Thus, the study material developed at one place can be used elsewhere. In this way we can enhance the reusability by many folds.

A Context Sensitive Browsers can be developed that will allow the user to switch among pages as required by the education session. The browser technology will be adaptive to the session depending on the cognitive level required, context and theme.

The GUI using which the users browse through the pages of the books, can be made adaptive to the access mechanism of the users.

Presently, while preparing a page, the page is first divided into a grid and the icons can only be placed on any cell in that grid. But this feature can be extended to place the icons anywhere in the page without first dividing it into a grid.

The icon making process can be delayed as late as the page making process. Icons may contain either image or text or both and associating voice with it may be made optional. A group of icons can be associated with each other so that when one is selected the other icons of the same group will be highlighted. This feature will help the teachers to teach the relation between a group of words or concepts.

At present teachers need to record the voice to associate it with some icon. This recording process can totally be eliminated. The voice output can be achieved using text to speech (TTS) synthesis.

A communication tool or an education tool, requires navigation of the icon space and icon selection. In order to make the tools usable by this segment, special access switches and interfaces that replaces mouse based interaction have been developed. The aspect of access switches has been discussed and illustrated in the final section of the paper.

The paper is organized as follows. In section 2, we present an education system that can be used by persons with special needs. In this system, the teachers will have the facility to create education materials, edit them at will and disseminate the material to the students. The students will be able to access the educational material, either on teacher's guidance or in the self teaching or testing mode. Section 3 deals with a multilingual communication tool for people with speech impairment and neuro-motor disorders. The system augments the communicative abilities of the target users. In section 4,

the special access mechanisms that we have developed to make our systems usable to persons with different types of motor disorders are briefly touched upon. Section 5 concludes the paper.

2. The Education System

Shikshak is meant for students who are unable or are not suitable for attending traditional classes. Using the system, a teacher can develop course materials for a class of students, including students with special needs. The system can then be used by individual students in a self-learning mode. In this mode, the students are taught by the system itself. The tasks performed by the system during the learning process are,

i. The system decides which study materials are appropriate to an individual student. This is required since for a concept, the system may have multiple study materials (added by the teacher). For example, there can be more than one study materials in the system to teach the concept of "addition". Based on the student's ability (the ability refers to learning as well as physical ability), the system decides which one to use to teach "addition" to a particular student.

ii. While teaching a concept to the student, the system also takes care of the speed with which the student can learn and accordingly adjusts the teaching process. The adjustment is done by the system using multiple study materials to teach a concept. For example, a particular student may not be able to understand "addition" with the first study material shown to him/her. Then the system shows to him another study material that teaches "addition" in some other way and the process goes on until the student learns the concept or there are no more study materials in the system for that particular concept.

iii. The system takes tests to understand whether a student has understood a particular concept. Unless a student clears the test, the system doesn't go to teach the next concept.

iv. The sequence of concepts to be taught to a student is also decided by the system, based on the test results. For example, based on the results, the system may decide that the student will be taught "division" after "addition" and so on.

2.1 Structured organization of a Course in the System

The course organization in Shikshak resembles the structure of a book. Just like a book, which has a title, sections and chapters, any course in Shikshak has a **root**

concept, **intermediate topics** and **atomic topics**. The atomic topics come under any appropriate intermediate topic, under a particular root concept. For example, 'Addition of Fractions' may come under the intermediate topic, 'Addition' under a root concept 'Preliminary Arithmetic'.

2.2 Plan of Course Materials

The system is adaptive and flexible. The teacher can create any kind of materials, such as plain text, audio and video clips, slide shows, flash movies etc. and incorporate them into Shikshak. Thus an expert teacher has all the freedom to prepare course materials and can create materials keeping in mind the nature of the students. For example, a student with hearing impairment may need a separate kind of presentation than a student with autism. Also Shikshak supports creation of **virtual books** in which each page consists of a grid of icons. These types of virtual books are found to be suitable for students with disabilities.

2.3 Major Advantages of Shikshak

The major advantages of Shikshak over traditional teaching methods are,

- Students with different learning abilities can be effectively taught simultaneously. This is absolutely not possible in traditional teaching. Students having various disabilities can also be taught using the same system.
- There is a one to one correspondence between the system and the student, so the student interacts freely with it, without feeling shy. It is quite difficult for a slow student to do so, in a large classroom.
- There is a dearth of trained teachers, who are expert in teaching children with multiple disabilities. So the education of these children gets hampered for this poor teacher to student ratio. Using Shikshak, this problem can be overcome.
- The system can be interfaced with special access switches and techniques. This helps in making the system usable to the people with severe neuro-motor disorders, who are unable to use keyboard or mouse. Due to this facility, teachers with disabilities can also use this system to design course works.

2.4 SHIKSHAK: Aid for People with Multiple Disabilities

2.4.1 For Learning disability

To manage a child with learning disabilities, a detailed educational assessment should be done to find the deficit areas, and Shikshak can help in that. Shikshak always take some tests after teaching a certain concept. From the test it gets an idea of the student's performance and performs a detailed assessment of the student's abilities. Based on the assessment, Shikshak itself can identify the deficit areas and pay some special attention towards them.

2.4.2 For Autism

For students suffering from autism, followings should be done for their betterment:

- Arrangement for a special education.
- Highly structured and encouraging classroom environment should be provided.
- Opportunities for the student to use self control/self monitoring techniques to control behavior should be provided and taught.
- Teach self talk to relieve stress and anxiety.
- Use visually stimulating material for assignments/learning presentations.
- Use specialized technology and software.

Almost all of the above requirements can be met from Shikshak. Since the autism affected student can interact with Shikshak personally, the negative aspects of a real classroom can be avoided. An expert teacher can always create special presentations for such students and incorporate them into Shikshak, which will further encourage and help them. Moreover, personal interaction can increase self confidence and self belief.

2.4.3 For hearing impaired

Due to the flexibility of Shikshak, a teacher can incorporate study materials suitable for persons with hearing impairments. These materials include images, slide shows or flash movies without sound and so on. Moreover, technologies specially built for the hearing impaired can be delivered to a student using Shikshak, like implementing sign languages. All this may not be available in a classroom, so easily. Another advantage lies in the fact that since the student is learning personally, he/she does not feel discriminated.

3. The Communication Tool

An AAC system Sanyog is developed to help

people with SSMI to communicate with other people in as much a natural way as possible.[4,5,6,7,8,9,10,11] The system can accept icons as input through an iconic interface. It is possible for an icon to represent a word or a phrase. For the neuro-motor disordered, special access switches are provided for selection of icons. On accepting the icons, the system can automatically form natural language sentences that are syntactically and semantically correct. Sanyog allows the user to inflect the sentences with respect to tense, aspect and mood. The generated sentence can be spoken out using text to speech systems that are incorporated with Sanyog. For those having a better syntactic grasp over communicative language, an on-screen keyboard is available which can also be operated with the special access switches. Furthermore, for faster communication, it also supports communication through pre-stored sentences/phrases. Presently, the system works in three languages - Bengali, English and Hindi.

The salient features of Sanyog are:

1. Accepts icon selection as user input, using mouse/stylus or special switches for people suffering from neuro-motor disabilities unable to use the pointing device.

2. Aimed at preliterate children with speech and motor disabilities and based on Indian lingua-cultural icons and vocabulary.

3. Forms syntactically and sematically correct sentences in Bengali, Hindi & English.

4. Finally, the generated sentence is uttered by an Indian Language Text to Speech system. The working of the system can be divided into the following modules:

Icon Selection: The system displays a set of icons organized in a hierarchy of contextual categories representing different concepts. These icons depict elements of a sentence like Verbs, Nouns, Adverbs, Qualifiers etc. The user has the choice of selecting multiple options from the different selection screens to express the concept(s) to be communicated.

Natural Language Generation (NLG): After the user has selected all the concepts required to express his feelings, the NLG module forms natural language sentences in his/her chosen language inflected with mood,tense & person to form assertive, negative & interrogative sentences. Text to Speech Synthesis: The text output is to fed into the TTS Shruti for generating the corresponding speech output.

3.1 Different approaches of Communication

Any AAC system like Sanyog uses "component of communication (CC)" for their operation. The nature of CC can vary widely depending on the underlying system and the user's cognitive ability. These include letters of the alphabet, words, phrases, sentences, discourses, icons, icons with text etc and even mix of the previous item. As there nature suggests, the user "selects" a subset from a set of CC to convey something.

Depending on the nature of CC, we can define different communication modes. Each mode corresponds to a particular type of CC. For example, if CC is letters of an alphabet, then we can say that the corresponding communication is carried out in "letter mode", if CC is pre-stored sentences/phrases, then it is "stored sentence communication mode" and so on. In our system, three modes of communications are supported. They are "letter mode", "stored sentence mode" and "iconic mode".

3.1.1 Iconic Communication Mode

In this mode, the components of communication are icons. This mode is suitable for persons having lower cognitive abilities for whom the syntax of the language is difficult to grasp. The basic idea in this particular communication mode consists of the following steps.

  i. The user will select icons using the interface provided by the system.
  ii. The system will automatically generate a sentence from the selected icons.
  iii. This sentence will be conveyed to the communication partner as natural language text and/or speech.

These icons are designed keeping in mind the Indian socio-cultural context. Moreover, each icon represents a single concept only.

How the User Selects Icon

The interface of Sanyog have been designed to work in a user-friendly and intuitive way. The mechanism used to achieve this objective can be described as question-answer based mechanism. In this mechanism, the system poses a series of questions to the user. Each question is accompanied by a set of possible answers. There are special icons for such questions. Each answer is also represented as an icon. User can either answer a question by selecting one/more answer icons or can ignore it.

The interactive process starts when user selects an icon representing the concept of a verb. For each verb, the system knowledge base contains a set of possible

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questions that can be asked with that verb. For each question, the system knowledge base also contains a set of possible answers that will be shown to the user along with the question. The set of operations that are allowed during the interaction process are,

i.   selecting one/more answers for a question
ii. ignoring a question and going to the next question
iii. undoing a wrong selection
iv. going back to previous question
v.   Ending the icon selection process

After completion of the icon selection process, the user can form different types of sentences with those icons. Production of the sentences or equivalently, output production in the Sanyog system is described next.

Output production

This system can produce output in different ways catering to the needs of the users with different cognitive abilities. The ways in which the output can be produced by the system can broadly be divided into three types. They are discussed in the following.

For those users who have higher cognitive abilities, the system can produce single sentence most specific output. In this type of output, user specifies the exact tense (like past, present or future), aspect (like simple, perfect or continuous) and modalities (like wish, desire, command, request etc) of the desired output as well as the type (like assertive, negative or interrogative). The system then generates an appropriate single sentence textual output based on the inputs. Speech impaired users can "speak out" this generated text also using a specific output production option.

There is another group of users who have basic language knowledge. However, they lack the grammatical knowledge required to provide exact type information of the desired output. For this group of users, our system generates all possible sentences (for all tense, aspect and modality) that can be produced from the user-selected input. User can then choose from this set of sentences the one appropriate for him/her. In this particular type of output production, the sentence selected by the user will automatically be "spoken out".

This system also produces purely iconic output sentence. This is required for those users having very little or no language knowledge. These users can verify from this visual sentence whether the output properly reflects the communicative requirement of the user.

3.1.2 Letter Mode Communication

Iconic mode communication is primarily aimed at people having lower cognitive abilities. This mode is not very expressive in the sense that every communicative need cannot be expressed using this mode. It can help only in expressing simple things. However, there are people with very high level of cognition who require much more expressiveness to communicate. For them, letter mode communication is more suitable than iconic mode. Using this mode, they can compose their texts on their own.

In our system, this mode of communication is carried out with the help of a virtual on-screen keyboard. The keyboard includes the conjugate symbols (specialties for Indo- Aryan languages) along with vowels, consonants, numerals and punctuation marks. The keyboard layout has been optimized to minimize the navigation delay encountered by users using access switches. Also prediction mechanisms are being incorporated to reduce the text composition time. Apart from composition, speech impaired users can "speak out" the composed text also.

3.1.3 Stored Message Mode Communication

In this mode, the system shows to the user a set of pre-stored sentences and/or phrases that are frequently used. The sentences can be accompanied by icons. The user can select one/more from this set to convey his/her communicative need. Whenever user selects a sentence/phrase, the system automatically speaks that out.

Our system provides a special save option in iconic communication mode. The purpose of this option is to save the sentences generated by the system in this mode, if the user so requires. The sentences saved in this way can be accessed later in stored message mode, thus relieving the user of the effort required to generate it again in iconic mode.

3.2 Personalization

One important feature of our system is that its content can be personalized for individual users. The system content consists of icons and pre-stored sentences/phrases. A user-friendly content development interface has been developed for this purpose and it can be used with very little training and basic knowledge of language.

4. Special Access Mechanism

The normal way to access any computer-based system is by using standard peripheral devices. These devices include keyboard, mouse, joystick, stylus and so on. All these devices in their commonly occurring form have one shared characteristic. They all require fine motor control on the part of the user to be used. But a

significant portion of AAC users lacks this power due to their physical disabilities. So for them, these peripherals are not of much use. Special access devices supported by suitable mechanism is required for these people to make them able to use any computer-based system . The mechanisms along with hardware devices are collectively called special access mechanism.

4.1 Sweepsticks

Sweepsticks is a software interface that can be used to replace a mouse. That is, using the Sweepsticks system, one can operate a computer without needing a mouse. The Sweepsticks can be operated with either one or two special access switches. Depending on the degree of disability, the user can decide on the number of switches needed.

5. Conclusion

In this paper, we have described some of the systems that have been developed for the people with multiple disabilities. Three systems were discussed. They are, a system that can be used for education purpose, named Shikshak, a system for communication purpose named Sanyog and a special access mechanism Sweepstick.

Boardmarker for Iconic Boards

Communication Tool

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