Assisting Robotic Personal Agent and Cooperating Alternative Input Devices for Severely Disabled Children

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Abstract. A multi-component cooperating system have been designed for severely disabled children having various disabilities. Different input tools have been developed to exploit possible 'outputs', e.g., head motion or leg motion. Specific software tools serve to convert such 'outputs' in different computer aided tasks. Extendable software enables configurable networking. *Robotic personal agent* helps the communication.

1 Introduction

Recent technology provides a variety of hardware devices and software tools for people having only very limited control over their muscles, being restricted in speech or in other ways to communicate and to interact with their environment. They need sophisticated solutions. They cannot use typical devices so technology must adapt to them. These subjects need care and the most appropriate devices need to be utilized. In typical cases, adaptive devices are necessary, including adaptive filtering of signals and the recognition of behavioral patterns.

There are several commercial devices that were designed for severely handicapped people. For a survey on current state-of-the-art interfaces see [1]. Tools, however, are typically expensive. Thus, our goal is twofold: (i) use novel tools, such as wireless sensors and robots, and (ii) develop simple software that can be used by caretakers to select optimal feasible components.

We review our efforts on developing tools and personal agents for severely handicapped non-speaking but speech understanding children.

2 Cooperating Tools and Devices

We are to integrate different alternative input devices, hardware tools, software applications and personal robotic agents into a common framework. These means should cooperate both each other and with the user. We will briefly review some existing building blocks of this framework: *'input devices'*, that are responsible for capturing one or more of the *'outputs'* of the user, *'applications'*, i.e., software components designed to facilitate the user's interaction with the framework, *'software communication tools'* that connect the applications with the input

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tools, and *'learning algorithms'* that are designed to adapt the computer by detecting performance, mood, and non-typical states or behaviors of the user.

Input devices: *Head Mouse* is a head movement detector that translates head motions to cursor motions. It works with a webcam. *Voice Mouse* was developed for subjects who are able to control the pitch and volume of their voice. The user initializes the interaction by giving a reference voice and moves the cursor by altering its properties. Varying the pitch or the volume change the x or the y coordinates, respectively. *Tilt Mouse* is for children who are able to control certain parts of their body, e.g., one or more limbs. The rapid evolution of the RF-MEMS devices makes possible to measure and communicate, e.g., the acceleration in real-time and in a wireless manner. Tightening these devices to the subject we get alternative input devices. Present day RF-MEMS tools are inexpensive and some of them are already built into cloths like shoes and shirts, e.g., to measure the number of steps, heart rate, etc. [2]. *Utterance recognition* can be used by subjects being able to say recognizable utterances that can be translated to operations on the computer. *Eye Tracking:* For severely disabled people sometimes eye motion is one of the last possibilities. Despite the existence of reliable specific solutions there is still a need for a cheap and simple ones even at the price of reduced accuracy. Our system is equipped with a webcam and we have promising results in giving commands by 'eye gestures'.

Applications: Although alternative devices can give an input to the computer, disabled people usually need more support from the application side. A typical example is *Dasher*, the writing tool, which has been developed at Cambridge University[1]. Dasher is driven by pointing gestures, typing is achieved by choosing the appropriate letter. Dasher has a predictive language model. Probable pieces of text are made larger and can be selected [3]. We have provided Hungarian text for Dasher. *iConnTab* is our application designed for patients who cannot control the cursor accurately enough to keep it on the target icon and click on it. The idea is to execute leaky integration for each items on the screen. The value increases if the cursor is above an item and decreases towards zero if it is not. Irregular motion patterns can be integrated by this simple method: if the subject can ensure that the cursor spends the most time over the target item then proper selection can be made. *Aibo:* Sony has developed a robotic dog. It is ideal for disabled children to communicate with others. With our tools, the dog behaves as a personal agent, it can be controlled to move around in the flat. It has a camera and can send the image through WiFi. It also has a microphone and a speaker, so it can record, produce and transmit sound. *Dashboard* is a tiny application with user defined buttons to control running applications. Dashboard can be activated without clicking: The cursor should be moved to it. Dashboard contains iConnTab-like buttons so no click function is necessary. *TTS:* One of the most important function of technical assistance for non-speaking but speech understanding subjects who can produce texts is the text-to-speech tool. A standardized speech API interface under Windows

[1] http://www.inference.phy.cam.ac.uk/is/

XP is applied. Synthetic voice can be transmitted to the speakers of the user's computer, the partner's computer, or to the personal agent.

Communication: Practical configurations will be complex. Basic elements should be connected through platform independent extensible mechanisms. Standardized messages are necessary for modular construction. To each child, the optimal components need to be "plugged in". Communication between software components running on different machines is enabled by our TCP/IP based communication framework. Messages are transported through TCP/IP sockets. Interfaces that adapt by analyzing the user as well as adaptive communication layers are under development.

User Analysis: The users' interaction with the computer can be efficiently assisted if we can analyze the interaction and optimize performance, e.g., the typing speed. We have performed a series of Dasher experiments with healthy volunteers, who used different input devices. Traditional mouse was used for comparison. The trace of the cursor was analyzed [4]) by means of Hidden Markov Models ([5], [6]). We found that emergent behavioral patterns are similar for all input devices, can be interpreted and enable computer assistance.

3 Cooperating Tools and Personal Agent

A particular arrangement is detailed here. This arrangement is being implemented at the Alternative and Augmentative Communication (AAC) Center, Budapest. A framework of specific applications - including a personal message delivering and video transmitting personal agent - is outlined in Fig. 1. The child has a notebook mounted on his/her wheelchair. A webcam monitors his/her face. The notebook receives the camera stream. HeadMouse analyzes head motion and translates it to cursor movements. The motion of the cursor can be analyzed to assist and improve performance. The child can edit messages by using iConnTab

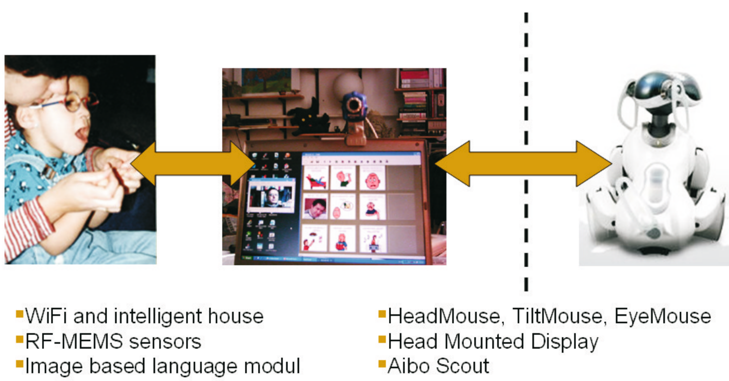

Fig. 1. Schematics of alternative input devices and personal agent

or Dasher. Each message is converted to an acoustic stream via the Speech API and the utterances are produced by local, or remote notebook speakers, or, by Aibo, according to the user's intentions.

Present state of the implementation: Children at AAC Center are practising the use of Head Mouse. It was found, to our surprise, that many children could learn to use them, even that they seemed not to use their head before. Although it was typical that the first trials were disappointing for us, those delighted the children, because they could not control anything before. Suitable pointing precision was achieved in many cases. AAC is now equipped with laptops, webcams. RF-MEMS ultrasound distance measuring devices, acceleration meters, and the intelligent house will start to operate in the fall when the children return from their summer vacation. Collection of data will start afterwards.

3.1 Conclusion and Outlook

With the development of robotic technology and decrease of prices, personal robotic agents find their place in assisting disabled people. Our framework has been designed to enable flexible and standardized communication between components that can be configured for each individual differently. Technology should increase the choice of wireless sensors quickly. Components of the system shall become less and less expensive alike to trends we have witnessed over the years. We expect that intelligent motion analysis and motion prediction can assist severely handicapped people. This seems the main bottleneck now, because the quality of the sensors is satisfactory. Robotic personal agent should be part of the scheme. Communication is crucial for the cognitive development of the children at the AAC Center. It is expected that similar tools may be learned and used by elderly people. From this point of view, our project is a prototype project.

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