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A PORTABLE DEVICE TO IMPROVE THE COMMUNICATION ABILITY OF PEOPLE WITH CEREBRAL PALSY

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Improving the communication ability of people with cerebral palsy largely influences the achievable success in many other areas at different life stages. The development of sophisticated low-cost augmentative communication aids is now possible due to recent microelectronics technology, namely in miniaturization (surface mount technology, complex integrated circuits) and integration density (due to feature size reduction and sophisticated computer-aided design – CAD – tools), which make it possible to design portable devices for this purpose. This paper describes a portable device based on programmable-logic devices (PLD) and large-scale integration (LSI) technology, designed to provide a flexible augmentative communication aid both for small groups and single users.

INTRODUCTION

Electronics and information technology can largely improve the quality of life for people with disabilities [1:4] and play a major role in the field of augmentative and alternative communication [5:11]. The assistive communication device described in this paper uses one medium-complexity PLD to implement the user interface and control functions, and one dedicated LSI component to select and synthesize the required message from a library stored in memory. The device can be controlled by one on/off switch and supports group communication simply by inserting additional switches.
The target user groups are located at the Rehabilitation Center of Cerebral Palsy of Porto and at the northern branch of the Portuguese Association of Cerebral Palsy. Three main user requirements were identified:

- The device should be simple to operate and entirely controllable through one single switch,
- it should support a simple group communication mode and
- it should be portable (dimensions and weight should be as small as possible and battery life should be optimized)

AN INNOVATIVE SOLUTION

The first two requirements referred in the previous section are related to the interface and control functions and are embedded in the device functional specification. Portability is essentially related to the technological aspects, where the decisions taken are described in the following paragraphs.
Battery life was optimized by automatically switching off the device when no activity is detected after a pre-defined time interval. Speech synthesis is performed by a dedicated LSI component, which provides a highly integrated solution for the speech synthesis circuitry. The difference between two consecutive samples of the audio signal is quantified, using only 4 bits per

sample, although a 12-bit resolution is used for analog-to-digital conversion (for the same amount of memory available, this method allows a higher sound quality, since a large number of samples is allowed per time unit). Sampling frequencies for digitizing speech can be selected between 4 KHz and 32 KHz.
All interface and control functions are integrated into one medium-complexity PLD, which is a field-programmable type of ASIC (application-specific integrated circuit). PLD technology has developed very fast in the last few years, with sophisticated low-cost components now widely available on the market, able to provide a compact solution to integrate complex circuitry.
The user interface consists of two digits (to specify the message code) and one on/off switch. Upon power-on (pressing the selection switch) the left digit starts to be incremented, continuously cycling from 0 to 9. When the switch is pressed, the left digit maintains its present value and the right digit then starts to cycle from 0 to 9. When the switch is pressed once more, a unique two-digit code has been identified, which is internally converted and transferred to the speech synthesizer LSI component and then used for message selection and synthesis. The complete process then restarts from the beginning to select the next message. When two or more switches are plugged in, the first switch to be pressed (setting the left digit) will be the only one able to set the right digit. This will ensure that the user selecting the first digit will be the one that specifies the message to be synthesized. Figure 1 shows the state diagram of the circuit master controller (SWi refers to switch i and /SWi means that SWi has not been pressed), which defines all the interface and control procedures.

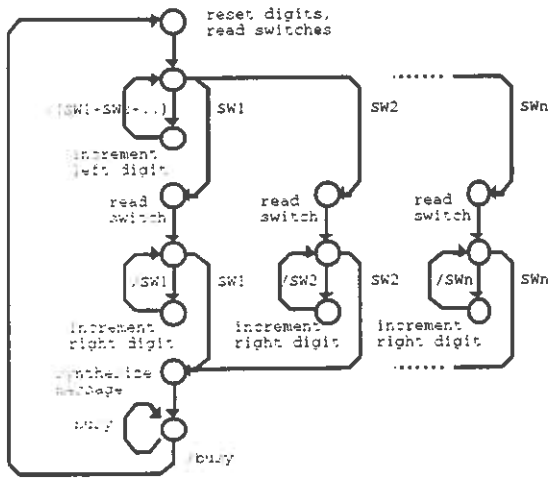

Fig. 1: Master controller state diagram.

The master controller block generates all the internal control signals required to operate the circuit. Additionally, two counter blocks (to increment the digits), code conversion blocks (to interface the digits and to convert the message identifier to the LSI component) and a debouncing block (for the switches) were successfully integrated into one medium-complexity PLD.
A first prototype was implemented providing 39 messages and supporting 4 user switches. The 39 messages were digitized at 16 KHz and occupy approximately 300 Kbytes in memory. This prototype accepts up to 100 messages, its number being defined by two 10-position microswitches located inside the device.

EVALUATION METHODOLOGY

The use of this portable augmentative communication device is being evaluated with three main groups of users: children from 7 to 15, young adults under 18 and adults over 18 years old. The evaluation phase is taking place in the Rehabilitation Center of Cerebral Palsy of Porto and in the northern branch of the Portuguese Association of Cerebral Palsy. The first institution is a state-owned center providing care to people aged under 18 and the second is a private association providing care to those over 18.
The evaluation is performed by studying the evolution of each individual according to several parameters, such as the number of conversation cycles that take place, the rate at which each individual is able to increase its vocabulary and the improvements in the communication structure.

FUTURE WORK

Further work is oriented towards providing additional features to the portable augmentative communication device described and developing a PC-based software tool to provide rehabilitation professionals with a straightforward procedure to customize each device to the specific requirements of each user.

A PORTABLE COMMUNICATION DEVICE

A number of additional features can be included, although simplicity was one of the key requirements set up for this prototype. Examples are alternative operating modes, such as allowing the selection of a sequence of messages before synthesis, or allowing the user to modify a choice if a wrong selection was made for any of the digits. Also, a visual output could be provided, such as the word or phrase to be synthesized. The cognitive skills required from the user will however increase significantly.
The PC-based software tool under development accesses a database of messages stored on disk and creates a file containing all the messages required by the user.

CONCLUSION

The portable augmentative communication device described in this paper provides both single user and group communication capabilities and was well received by the target user groups which have started to use it. The present prototype uses a PLD and LSI technology to provide a highly compact solution and is able to provide high quality sound output at moderate storage requirements. It is now possible to have "speech-per-area" rates of nearly 1 second per square mm (using the lowest 4 KHz sampling rate and 32-pin 1 Mbyte programmable memories already available on the market), which means that a 1 Mbyte memory could be used to store up to nearly 10 minutes of speech. The implemented prototype was limited to 100 messages only because a larger number of messages was not required.
A second generation of devices is already under development, which will provide enhanced functionality, although at an extra cost in terms of the required user skills. A Windows 3.1 based software tool is also under development to support the rehabilitation professionals in customizing each device to the specific requirements of each user.

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