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Computers Helping People with Special Needs

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MOPED

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Moped is an aid for blind and partially sighted persons following three major goals: participation at modern, mobile methods of communication and information retrieval, orientation in unknown territory and carrying and managing of personal information. In the project framework an innovative hardware platform and a corresponding information infrastructure will be developed, following the concept of ultra-portability.

1.Motivation

Advances in production engineering has resulted in smaller and at the same time more powerful microprocessors. Based on these new devices the new research areas ubiquitous computing and wearable computing, i.e. non stationary information processing, have emerged. This development has been supported by the progress in the area of ad hoc networks. Though these technologies have a high potential for blind and partially sighted persons, development is limited to isolated areas and the synergetic potential isn't realized.

To meet the concrete and daily demands of people with special needs, to remove barriers and to make accessible the world of international communication the concept of Moped was developed. It will allow free and open access in living, working and communication for blind and partially sighted people. Using information technologies as much as different services will be made accessible (nearly) anytime and anywhere.

In the project Moped a flexible platform will be developed, that integrates a set of different applications in wearable non monopolizing system. Three application areas will initially be targeted.

1.1.Mobility

Initially some simple self sustaining services beginning with distance measurement via ultrasonic or infrared rays and location information via GPS will be implemented. Accelerator sensors could additionally be used to interpolate the motion data when GPS is not or at least not fully available for a time, like in or directly beneath buildings.

Using this data a heading and direction guidance will be possible. This will allow the user to declare his destination and then be told to turn left or right when appropriate while walking. The position data of important buildings and locations may be downloadable from internet sites or distributed on CD-ROM's just like with recent car navigation systems. Personal locations can be added from each user by either typing in the position data or by adopting GPS data when being at this location.

Of course it will be possible to define a pathway leading from one point to another passing different landmarks.

In a later project phase an external information infrastructure will be used to determine the state of traffic lights or information about direction and route information for public transport systems. Passing buses, trams and trains could transmit their complete timetable using the same wireless low range communication system that Moped uses for its ad hoc networks in museums and the like. Which kind this communication systems will consist of does not need to be fixed. Flexible additions of small communication modules are easily implemented in the existing software and hardware Moped consists of.

1.2.Personal information management

Conventional methods of personal information management like the well known filofax are mostly unavailable for blind persons. The recent advent of personal digital assistants for sighted users has carried over to this field to a certain extent, but the available devices are limited in functionality and not very well integrated with other services and the desktop workplace.

There is a multitude of possible applications: addresses and phone numbers, time tables for work and study, timetables of public transport systems, some kind of electronical Post-It's and the like. Additionally, larger projects like items of homework, making transcripts, reading of study literature and writing a diploma thesis are possible, too. Time and data will be made accessible as the transmission of digital visit cards.

1.3.Non stationary access to conventional and modern information systems

In the professional area as well as in private life the importance of access to information systems is growing rapidly. On the desktop most services can be made accessible to a large degree, but in the mobile area the use of devices is difficult or impossible without sighted assistance.

With Moped it will be possible to read and write E-mails and to transmit them from or to the internet. In the future Moped will allow online-banking, so the transfer of money and the withdrawing of the statement of account will be possible. Modern standards like HCBI are being used by more and more banks. They allow safe transactions on the one hand while setting an open standard usable by any computer system on the other hand.

Additionally access to for sighted persons conventionally available information like explanation of exhibits of a museum could be made available with an according infrastructure.

Such a system will be realized for some exemplary cases in three steps: first, a non dynamic information system will be implemented and the user will have to download prepared datasheets. Based on this system the appropriate item data will be selected, when the user approaches an appliance and finally the data will be downloaded automatically via an ad hoc network and give a blind user the same immediate access a sighted person has.

2.System design

The hardware of Moped consists of a multitude of highly specialized modules surrounding two center modules. One the one hand, this is a very flexible way of combining different tasks on a single system. On the other hand, this concept allows for a high synergetic potential, showing that the whole is more than the sum of its parts.

The primary center module contains a microcontroller unit (MCU), external RAM, communication ports and voltage regulation. The secondary center module allows the connection of the external while using only two I/O-ports of the MCU.

2.1.Primary center module

Moped uses an E-Series Motorola MC68HC11 MCU. This MCU combines a 8 bit CPU with high-performance and on-chip peripherals like RAM and EEPROM. It has an E-clock rate of 2 MHz and 38 programmable I/O-ports. The MC68HC11 operates with very low power consumption. The powerful assembler code allows very memory efficient program code.

Currently the external RAM on the primary center module has a size of 512 kilobytes. As the MCU has an address range of only 64 kilobytes the RAM is organized in 16 banks with 32 kilobytes each. For the switching between the banks 4 I/O-ports of the MCU are being used. 16 ports are used for the connection of the RAM itself, and 4 ports are used for communication purposes. As the remaining ports are mostly only suitable for unidirectional data input, a possibility to expand the I/O-capabilities had to be found (see later).

The communication between Moped and a host computer (to upload software, connect to an intranet or perform tests) is realized with a standard RS-232 serial port. A RS-232 level shifting circuit is implemented on the primary center module. Alternately to using this port for the connection to the host a keyboard called "Twiddler" may be connected. Twiddler allows the input of data using only one hand while being light and easy to read the data from.

Future plans are the implementations of wireless low range communication systems. Due to the high hardware needs these small communication modules must be connected directly to the primary center module. Data transmission will use in every possible case standard hardware parts and standard transmission software implementation to allow the user to connect to as much possible ad hoc networks as possible. As it is at the moment not foreseeable which transmission protocol will become established different systems will be tested with Moped in the near future. These systems includes already existing hardware like infrared devices (IRDA) or radio telemetry transmit modules

(RTTM) operating at UHF frequencies. These devices do work over a distance of approximately 5 meters (IRDA) and 200 meters (RTTM).

An other very promising concept is a radio transmission standard called bluetooth. As there is no small and cheap bluetooth development kit available at the time of writing there have been no tests with Moped. Bluetooth will for example allow the wireless transmission of voice and data between moped, a mobile phone and a wireless head set. Implementing Computer Telephony Implementation (CTI) is possible with a minimum of effort. The Moped user may select an address within his Moped-database and then command to connect. Moped will tell the telephone via bluetooth to connect to the corresponding telephone number and then tell via wireless headset that the call is initiated. The telephone itself may use any of the existing or planned phone standards like DECT, GSM and UMTS. When the connection is ready the phone will connect to the headset until the user via Moped tells it to Disconnect.

Alternatively the connection to the phone may use either IRDA or a cable between Moped and the phone. The headset could also be connected via wire to the telephone. As bluetooth will be available soon in many new devices it will be convenient to wait for an implementation of CTI until then.

The integration of appliances like telephone and fax are as easily possible with bluetooth as all the other communication methods mentioned above.

2.2.Secondary center module

The secondary center module is a general adapter device between the MCU and the external modules. It allows the use of many (at the moment 24, but easily expandable to 128) external I/O-ports while occupying only 2 ports of the MCU. The disadvantage of this great enhancement is the loss of communication speed. Data transmission using the secondary center board is now possible with slightly more than one kilobyte per second. While being insufficient for external data upload and ad hoc networks, this speed is enough to handle many other tasks.

The communication between the MCU and the secondary center module is implemented by using the I^2C standard invented by Philips. With only two lines, data (SDA) and clock (SCL), 128 devices may be connected simultaneously to the same bus with the current 7-bit-adressing mode. Each device (=chip) has a unique device number. Most I^2C-chips are installable on different I^2C-adresses, so many of the same kind of these chips may be used at the same bus. The 8-bit-I/O-I^2C-chip for example can appear on one of 16 addresses, so 16 of these chips can be connected simultaneously for a total of 128 I/O-ports.

Additionally to providing general I/O-ports the secondary center module allows the direct connection of I^2C-chips. With these possibility the expansion with different I^2C-chips is possible without a change in Moped hardware. This flexible concept allows to connect devices like storage, clock/calendars, audio processors, radio or digital video teletext decoders. As the I^2C-transmission is the same for each of these devices, the software implementation of hardware additions is very easily done.

An enhancement of the I^2C-bus will allow an address range of 10 bit with new chips, coexisting on the same bus with 7-bit-mode chips.

2.3.External modules

There are a lot of different modules conceivable. Currently ready modules include:

- Keyboard with four caps. This is used for a flexible, small yet powerful software menu system using "up", "down", "select" and "special". The number of the keys is easily expandable up to 10. An unlimited number of these boards may be connected in sequence with little effort, but as the key input process would get more and more inefficient this keyboard scheme is sensibly up to a size of about 30 keys.

- LCD-Module for large print output and interaction with sighted persons

Planned but drawing too much current and not being small enough is the connection to a standard PC keyboard for more easy input of data at home

The main work in the next future will be the development of these modules:

- Braille module with new menu pad

- Output of sound and speech

Modules that may be developed in the far future are:

- Barcode reader
- Transponder receiver for "Smart Labels"

With any of these two modules blind persons could for example find out the contents of boxes and canned food with ease.

3. User interaction

Though Moped implements a number of traditional services, the user interaction pattern as a wearable device differs from the traditional desktop systems and even mobile information appliances, where the user interface is based on traditional techniques*. The user interface of a wearable mustn't monopolize the attention of the user and isn't based on the prepare – use – shutdown cycle. Consequently interaction has to use the available bandwidth very sparingly, because it is needed elsewhere - a sonic range finder for example, that distracts the user from his surroundings would be more of a danger than a tool. This limits interaction to very short bursts of activity , e.g. short utterances with speech output, or simple continuous background processes, e.g. non intrusive sound events. The infrastructure for this has already been implemented and tests in a simple scenario have been promising. The results seem to indicate, that even with this limited interaction the intended application domain can be covered.

4. Conclusion

Mobile and especially wearable computing will have a high impact on information processing in the immediate future. Most of the research has been directed to squeeze as much computing power in a small volume at the expense of cost and power consumption. Moped is exploring the other end of the spectrum with a base hardware, that is less powerful than most PDA on the market today, but can be manufactured for a price of 50-100$ by a hobby developer. The key concept is the flexibility

* WinCE and PalmOS are examples, that use the standard windowing techniques with direct manipulation.

in the design, that allows the expansion of the base hardware by adding simple modules over the I^2C bus. This concept allows a very rapid development and low cost testing. Sample devices have been produced and some simple applications have been implemented. In the next step a wireless ad hoc communication infrastructure will be implemented based on RF transmission.

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