Multimodal WIMP system for Blind and Deafblind People

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ABSTRACT
In the current work we discuss a multipurpose hardware and software system for board games that was designed to give blind and deafblind people the opportunity to play chess or other board games over the network. We describe a server-client application that allows blind players as well as sighted people to play several types of board games and also different types of non-standard chess. Also, we detail the prototype of a special interactive device that will be the main tool for the blind and deafblind people to interact with the software environment and to play online board games.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces And Presentation**]: User interfaces - *Input devices and strategies*, H.5.2 [**Information Interfaces And Presentation**]: User interfaces - *Haptic I/O*, K.4.2 [**Computers And Society**]: Social Issues – *Assistive technologies for persons with disabilities*, K.4.2 [**Computers And Society**]: Social Issues – *Handicapped persons/special needs*, D.1.5 [**Software Engineering**]: *Object-oriented programming*.

General Terms
Design, Human Factors.

Keywords
Multimodal feedback, haptic device, blindness, deafblindness, board games, chess, polymorphism.

1. INTRODUCTION
The role of computers and the Internet drastically influenced board games and especially chess. However, even in nowadays not everybody can benefit from the possibility to play board games over the network: there is no special tool that takes into consideration the blind people who are not able to use standard input and output peripherals. Concerning online games, there are even more significant barriers especially for blind people who are also deaf [1]. Thus, once again, they are positioned on the edge of the society just because they are not in the same condition as normal players.
Hence, in the next section, we discuss the design of a natural interaction model, based on an innovative device, in which information about the content of the board is provided exactly in the same manner as in the over-the-board game.

2. SYSTEM AND INTERACTION DESIGN
Blind and deafblind people usually interact with technologies that are suitable for text-based interfaces such as screen readers; however linear output devices are known to be tedious because they do not allow the users to freely navigate over two axes. Therefore, we designed our tool with the aim to overcome this limitation, allowing the user to receive constant feedback about the spatial position of the mouse pointer.

2.1.1 *Interaction model and feedback strategy*
We projected an interactive haptic interface and we added a force-feedback response to its design: we embedded sensors which are capable of detecting bi-dimensional movement over a flat surface and we incorporated actuators which provide tactile-feedback to the user in reaction to the movements of his hand, to the content of the screen and to the status of the software that is running. Also, it has additional sensors that allow the user to issue commands and to manipulate the application environment. The main focus of the software architecture is having a polymorphic solution so that the user interaction can be adapted by just adding a new application to the environment (i.e. adding a board game will require only the logic behind that particular game) as all the core part that deals with feedback, user management and, in this case, board games, is general is already provided and implemented. Meanwhile, the architecture ensures (using the power of polymorphism) to handle different types of players: sighted, blind and deafblind. Whenever the player requests a new game to play, the information about the player status is transformed and the board configuration is set to fit the particular player needs.

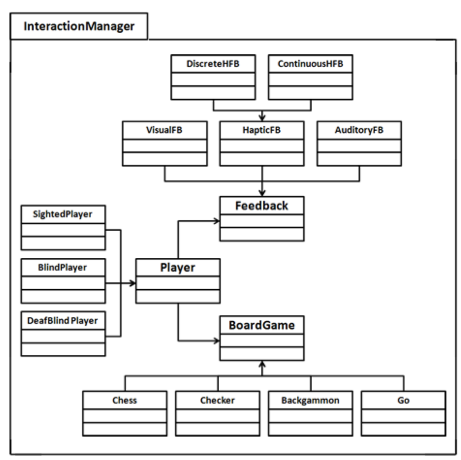

Figure 1 - A system high level design

Our peripheral is based on sense of touch, specifically tactile and vibrotactile feedback [2], which stimulates the human subcutaneous tissue. However, the system provides multi-modal feedback to the user and it supports three channels: the visual, the audible and the tactile; by doing so, the sighted, the blind and the deafblind people can use it. In particular, while standard interfaces with tactile feedback use the modality simply to convey warnings or other binary notifications, we defined a bi-modal tactile interaction and designed a more expressive feedback environment based on several types of information.

2.1.2 Hardware design

The project consists of three independent components: the physical, the control and the communication subsystems. The physical layer has the purpose of acquiring input and providing output; it directly interacts with the user and is managed by the control layer. The transport layer, which aim is to communicate with the computer, is connected to the computer and transfers the incoming and the outgoing flow of data to (and from) the control layer.

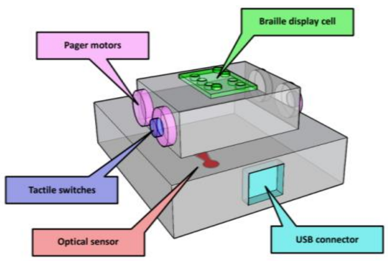

Figure 2 - Design of the hardware prototype

The physical layer of the system was conceived as split into two separate peripherals embedded into one: the input and the output components. The input device consists of two main parts:

- The *board navigator* is an optical or an opto-mechanical component which is capable of detecting the two-dimensional motion relative to its underlying plane. It basically consists of an optical sensor whose purpose is to acquire continuous movements over a flat surface and to determine the distance between their starting and ending points within a certain time window. This can be implemented with a light-emitting diode (or an infrared laser diode) and photodiodes. Then, a microcontroller translates the information provided by the board navigator into the movement of a pointer over the computer screen, as if it was a mouse cursor. We employed a common LED and a standard CMOS sensor.
- The *move selector* basically consists of two buttons, located in a position which is easy reachable by fingers (preferably the first and the third) when the device is held. The purpose of the buttons is to issue commands (as sequences of button-click actions) that, in the case of chess, mainly regard moves. We employed low-profile tactile switches to acquire impulses.

The output subsystem consists of two components:

- The *provider of navigation feedback* is realized with four pager motors that were used as transducers for the conversion of electrical signals into tactile stimuli to provide vibrations. The system device implementation consists of four miniaturized button-style pager motors.
- The *provider of positional information* consists of one light-weight and small-size Braille display cell. While the user navigates over the board, information about the value of each position is provided in real-time using a piezoelectric display unit which is capable of representing a refreshable Braille character. We implemented an International Building Standard compliant cell [3].

The control layer mainly consists of the processing unit (microprocessor) that manages the device operation. Its purpose is to decode (respectively encode) output (respectively input) feedback messages (respectively signals). When the user navigates over the board or when he selects a starting and an ending positions, the microcontroller receives sequences of electrical inputs from the sensors located in the physical layer, converts them into messages and sends them as control signals to the computer; when it receives data from the computer, it realizes a conversion of messages into tactile stimuli and it operates the actuators (by firing the pager motors or displaying a symbol on the Braille cell). The communication layer consists of the electronic components that allow the device to transfer data and to interact with the computer. The system is designed to support several types of wired or wireless connection protocols. The control system natively implements a standard serial RS-232 communication. Also, we added USB support.

As a result, according to the movements, at each turn the player receives different messages. The opponent can check, mate, capture a figure or finally after his move the stalemate can happen where neither of the players win and for all of these situations the system has to provide the adequate feedback to the player. For instance, for coding the opponent move and the blind player turn the codes of O and T letters of the Braille Alphabet are used.

3. CONCLUSIONS AND FUTURE WORK

We designed a tool that gives blind people the opportunity to play whenever they want and, even if it is not always easy for them to find the corresponding opponent to play with, making it easy to organize chess competitions or just single games for visually impaired players via the local network would decrease the actual barriers and help them to be more integrated in social activities. Simultaneously, the tool we designed will be suitable not only for standard and variations of board games but also a general one that includes different applications. Also, several wireless solutions, such as Bluetooth and ZigBee can be used, but they require an additional battery. All the components required to implement the peripheral of the system are very cheap and they can be easily found on the market. The cost for a complete hardware device can be estimated about $100. Further experiments will be developed in a real game situation, having the aim of identifying the time it takes a blind player to recognize the configuration and make the move. This will give us information about the real benefits we obtain with the use of the tool we implemented.

4. REFERENCES

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