Accessible Gaming through Mainstreaming Kinetic Controller

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Abstract. Leisure is a very important aspect in our everyday life; and gaming is one of the main ways to it. Depending on the particular situation of each person, the way of playing could be very different. Motivation, preferences, skills, knowledge are some of the factors that influences this experience. When the person has a disability, additional agents come to scene such as cognitive level and mobility. Besides the design of the game, these factors clearly affect how the person interacts with the game; its user interface. In this paper we present a tool that allows people with disabilities to play games with a normalized user interface. This tool a) manages several wireless kinetic remote controllers, e.g. the Wiimotes; b) can be configured to capture any voluntary movements users could do and c) convert them into the specific inputs required by existing adapted games. As a result, users with disabilities can experience and enjoy games that were previously inaccessible to them.

Keywords: user interface, people with disabilities, accessibility, games, kinetic controllers, design for all.

1 Introduction

Nowadays the “design for all” concept is arriving to many fields including ICT, industrial design, etc. Nevertheless, this is not being applied in leisure and gaming because these businesses have to be very innovative. As a result, universal design is relegated to a second place hindering access of people with disabilities people to games [1].

Leisure is an important part of everyday life allowing us to mix with other people, relax, have fun, etc. And these factors are of special importance in the case of elderly and disabled people. In the case of children and teenagers is also relevant the interrelationship that comes with the games. Games lead them to share experiences, practice together; in other words, socializing. As a result from not doing games accessible, children with disabilities are not able to play and consequently not included [2].

Games, are not only for having fun, they have many others important applications. As a powerful motivation tool that helps children to learn and also motivates people with disabilities and elderly [3]; for example, Groenewegen et al. use games to teach

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activities of the daily life such as shopping or preparing the meal [4]. Finally, gaming may also have a strong cognitive and physical therapeutic contribution [5, 6].

Currently there are some systems developed to provide alternative access to the games and include people with physical disabilities in the use of computers [2].

Waber et al. use a webcam to have an accurate head tilt detection as a mouse system [7]. Other head tracking driven camera mouse system, called HMouse calculates the user's head roll, tilt, yaw, scaling, horizontal, and vertical motion for further mouse control [8]. Others camera mouse systems based on visual face tracking [9, 10] and eye tracking [5].

Capturing biological signals is also used when the user can hardly make a controlled movement [11]. As a quite common alternative, brain-computer interfaces provide good results when user is not able to move at all [12].

Different interfaces for people with visual disabilities have been described by Alonso [13] and Miller [14] who use auditory and haptic displays. Raisamo uses a low cost vibro-tactile device [15].

In the following sections we present the requirements from which we started our project and the approach we decided. In section 3, the architecture of the solution is showed. Section 4 outlines the evaluation procedure we underwent and finally, the conclusions are stated in section 5.

2 Requirements from the End Users and Approach

The final objective we had from the beginning of the project was to enable people with a wide range of disabilities to enjoy themselves with games. It is evident that to play an electronic game, the user has to command a machine (computer, video console, etc.). This commanding has to be done through specific actions done by the user; pressing a button, moving him/herself, etc. This interaction has to be ruled by user's cognitive procedures stimulated by the game. Thus, to enjoy games, people need to understand and know how to interact with the game and be able to command it according to their thoughts.

We collaborated closely with a special education school where very diverse physical and cognitive disabilities exist. It is clear that games have to be adapted to the user's cognitive capacities to allow proper interaction. This is solved adapting the game to the user's motivation and intellectual level. We considered developing adapted games to be used with video consoles, but we discarded it because it is complicated and expensive to get game-developer licenses and it would force us to use a specific platform. Thus we decided to use the games already used in the school that the children knew very well. Most of these games are designed for PC platform (Windows and Linux).

Choosing the right game has the same importance as selecting the appropriate user interface to the user's kinetic capacities. These capacities can be very diverse depending on the user disability. Nevertheless, regardless of this diversity, we found common features transversal to the disabilities that helped us in the decision about the final design. For example, some users with physical disabilities can do movements but not controlling their strength or direction; in the end, these users just can do intentionally few movements. Others can only perform very small movements but very precise, for example slightly move a finger. Others don't have any control on their upper limbs or cannot move them at all; but they can intentionally move the head, foot or knee.

In the disability world, capture of these movements is done by means of different adapted switches connected to a computer. The professionals working with the end users wanted **one common interface** for the majority of the children. It had to be **able to interact with existing software, cheap, wireless and easily configurable** to be robust to hits, sensible to slight movements and immune to tremors. Moreover, it was desired that **several interfaces could be connected simultaneously** to play collaborative games.

In our research team we have big experience working with sensors, wireless communication, digital electronics, etc. Thus we started the design of an interface fulfilling the requirements…till we realized that we were reinventing the wheel. What users were demanding was a cheap, wireless device able to capture a wide range of movements (push of buttons, movement of head, hands, foot, etc) and able to be personalized to interact with existing games in a PC. Thus we decided to use the kinetic controllers used in some commercial video consoles (Miwi, Technigame or the better known Wii from Nintendo) to control the already existing games in a PC. In particular, due to its availability, global development community and accessories we selected the Wiimote and Nunchuk.

Wii remote controls also offer some extra advantages, thanks to its innovative physical interface, rather distant from traditional consoles. The Wiimote is fairly light and compact, which allows an easier attachment to any member of the human body. It can be handled with only one hand. Its use is intuitive and usually requires no previous experience. On the other hand, it may seem that its nine buttons are too much for some users; when most games used by people with disabilities just would need one or two of them. Also, its configuration is enough versatile to allow the user to understand its layout horizontally or vertically. In addition, the remote control has two non-visual communication elements—sound and vibration—both essential for adaptations for people with visual disabilities.

There are many projects that connect the Wiimote to a computer, but none of them fulfill the functionalities required. Most of them are not suited for people with disabilities; being not versatile enough or too complicated for non computer experts (some are just source code) [16]. Others, specially developed to enhance computer accessibility of people with disabilities, are too specific and have limited functionalities; e.g. adapted text-entry interface [17], mouse pointer emulator [18].

3 System Architecture

As we have said in last section, all the target games run in a PC being controlled by means of keyboard and mouse. Thus, the objective is to connect the controller to the PC and translate its outputs to keyboards and mouse events that would be sent to the game (see fig. 1). Specifically the actions would be the following:

- Buttons in the controller would be mapped to any keyboard or mouse event: move cursor to any direction and quantity of pixels, any keystroke, any mouse button or wheel event, execution of an application or command or any combination of them; e.g. key bindings.

- Acceleration ranges would be mapped to any of the preceding events and it also should be possible to emulate the mouse movement. Customizing acceleration thresholds, it is possible to tune the application to the user needs. It can be sensible to slight movements using low thresholds, or immune to large tremors using higher ones.
- Infrared pointer should be able to emulate the mouse movement.

Each user has different ways of interaction with the Wiimote. Besides the software configuration we just described, a physical adaptation of the device can be required; some examples following. A user totally paralyzed that can just do slight finger movements will control the knob in the Nunchuk that has to be placed under his/her hand. A user that can only control the head movement can wear a cap with the Wiimote attached and translate acceleration movements. Other user that can just move a leg can have the Wiimote tied and also capture the accelerations.

Fig. 1. System architecture. The Wiimote and the Nunchuk are connected to the computer through Bluetooth.

Wiimotes use Bluetooth as wireless communication protocol to connect to the video console. Thus, besides the physical controller for each user, the host PC where the game runs has to be Bluetooth enabled (see fig. 1).

3.1 Software Architecture

We identify two different scenarios where the system will run. One is when the educator first shows the game to the child; where it will be necessary to configure the tool to recognize the user specific actions and map them to the desired keyboard and mouse events. Resulting from this configuration stage, there will be different configuration files pairing users and games. This is motivated because each user will have different ways to interact the computer, and each game will have different controls.

Once these configuration files are created, the second scenario would be when the user plays the game. In this stage, the game is running, the tool captures the outputs from the interface and—according to the configuration file—translates them into the

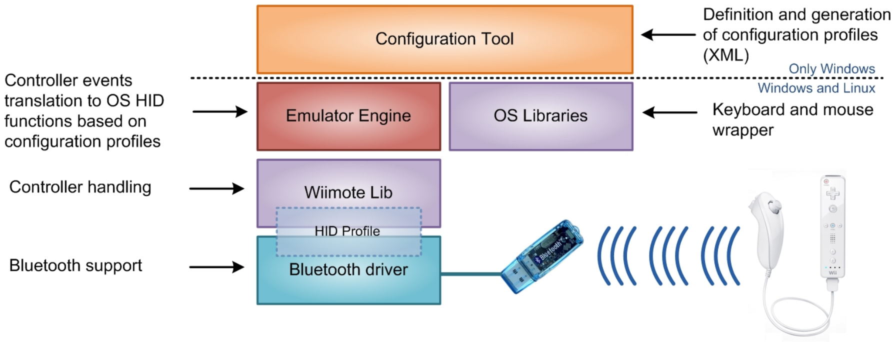

Fig. 2. Software architecture. Most of the components that compound the system are multiplatform and works on Windows and Linux, whereas Configuration Tool is only available on Windows.

adequate keyboard and mouse events. In figure 2 we can see the software architecture that supports these two scenarios.

As already said, the connection between the PC and the Wiimote uses Bluetooth thus, in the lower layer it is needed a Bluetooth driver that grants this communication. As each manufacturer can incorporate different stacks (Toshiba, Widcomm…) on their drivers, it is needed that the connection is configured through the operating system.

Above the driver there is a Wiimote library that handles communication with the controller, which care of which buttons were pressed or what accelerations are registered by the Wiimote or the Nunchuk. This library access the controller as a Human Input Device (HID) through the Bluetooth HID profile, which is intended to provide access to devices such as keyboards, joysticks, etc.

The core part of the system is the Emulator Engine, which is responsible of translate the actions performed with the controller to HID actions in the Operative System. The Emulator Engine determines which actions must be performed on each controller event, regarding the user profile configuration loaded from the XML file.

Although configuration will be mainly defined to work with a specific game, it will not be controlled by the emulator, but the actions are sent directly to the OS which will drive the game. This task is accomplished by the OS Libraries component that provides such functions to inject HID events into the OS. Actually, if the Emulator Engine translates a button push to any keystroke, the following event is indistinguishable from the real keystroke.

These components are the ones required by the second scenario, and are available for both Windows and Linux OS, but for the first scenario, it is needed a Configuration Tool that allows to define the user profile configuration files. That tool currently is only implemented on Windows, but generated configuration files are also suitable for Linux.

3.2 Configuration Tool

The purpose of the system presented is to enable people with disabilities using mainstreaming PC games, looking for accessibility. But it is also important that the

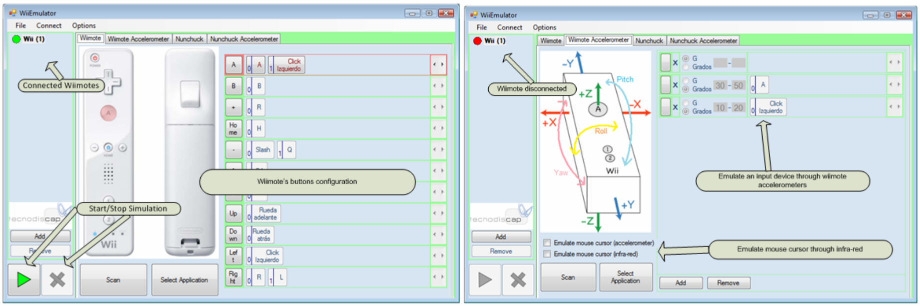

Fig. 3. Configuration tool. It allows assigning keystroke sequences and other OS events to controller actions such as push of buttons or controller movements.

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<wiiconfig>
  <Peripheral Type="controller">
    <Device Type="button|accelerometer|IR ">
      <emulation>keystroke|mouse event|app. path</emulation>
                ...
    </Device>
          ...
  <Peripheral Type="Nunchuk">
    <Device Type="button|accelerometer|joystick">
      <emulation>keystroke|mouse event|app. path</emulation>
                 ...
    </Device>
          ...
  </Peripheral>
</wiiconfig>
```

Fig. 4. Configuration file. Controller actions are mapped to OS events such as keystrokes, mouse events or application launching.

system itself is accessible too. For that reason, an effort was done in the configuration tool to ensure that definition of configuration files can be easily done, especially for people that are not supposed to have high informatics skills.

The tool shows a list where connected Wiimotes are listed (it is possible to have more than one controller connected with the same PC), and allows assigning OS events to every button in both Wiimote and Nunchuk as well as to some movement patterns (see fig. 3). The operation is quite simple: the user has to indicate the button it wants to assign a SO event—by clicking on the button list or directly in the controller image—, and press the “Scan” button, after which the tool will wait for a PC event from the keyboard or the mouse. When that event occurs, the tool grabs it and assigns it to the previously selected button. It is possible to assign a sequence of events to a controller action, for instance a sequence of keystrokes for writing a word or performing an actions-combo in the active game. It is possible also to assign the launching of an application to an action, so the game can be started directly with the controller.

Acceleration measurements from the controller can be used to trigger events when some thresholds are exceeded, or to drive mouse pointer as a virtual joystick and infrared sensor can be used as mouse pointer too, which will require a led bar like the one supplied with the Nintendo Wii to work.

The tool allows checking that the configuration generated works properly with the game desired, and in that case, generate the respective XML configuration file (see fig. 4), that can be used with the emulation tool in both Windows and Linux Platforms.

4 System Evaluation

Our work and experience in Tecnodiscap has taught us that any technological development is useless if user has not been taken into account. Therefore, the assessment of services and devices that we implement is made through a final user evaluation. There, we consider all the potential users involved in all steps of use of the product (carers and other professionals that give support to the beneficiary user, the beneficiary user himself, the family…).

To conclude and check the service as a whole, we have applied the principles of "Design for All" as a work guide, and we followed the criteria of ISO 9126 as a quality foundation to be met.

Thus, the evaluation of this project was conducted with the professional advice of the experts who originally participated in the project requirements, and the involvement of two children from the center, each one of them with some different features and needs. One of these children (male, aged 11) had mild cognitive disability and no physical disabilities. The second one (male, aged 13) besides a mild cognitive disability, also had an important physical disability (very reduced mobility, with high spasticity in upper limbs). Two games were tried; one to learn drawing and the other emulating a football penalty round. In both cases the software was firstly explained to the children. First one, they had to copy different forms choosing colors from a palette. Both children used the mote as a mouse; first with the pointer and second with the accelerometer. They also used one button to change color. Second game just required the children to press the space bar to kick the ball; we associated this key press through an accelerometer threshold and with one button.

Always looking toward both types of user (carers and end users), the assessment was tackled from several perspectives, which allowed us to check the interface possibilities from the following points of view:

- **Interface usability (Carer):** The overall impression was in every case very favorable. All users highlighted the simplicity of programming and learning the management of the interface, and its intuitive use. They found the program very efficient, with a high degree of consistency between the appearance and the operations requested, and all of them maintained that they had felt comfortable with the application. It was checked that the graphic design was clear and practical for all users, and they all considered it attractive and clean.
- **Improvement in quality of life (End user):** Through this assessment, we could also show a clear improvement in quality of life of the end user, in this case children with diverse disabilities. This interface allowed both children

participate in gaming and learning activities that were previously inaccessible to them, and could be optimally adapted to the particular needs of each one. This was especially relevant for the child with severe physical disability.

In this sense, the experts reported that this tool could also help them to develop more easily their "curricula tracking for the end users" and also they pointed out that it could have more applications in their daily work, especially in physiotherapy and physical education.

Currently we are facing a more extensive and long term evaluation. In the school many other children are using the tool during this academic year; also a research group from the Royal Institute of Technology (KTH) in Sweden is testing the it with elderly people with very good results; and our research group is delivering it to any user interested.

5 Conclusions

In this paper we have described an innovative tool that allows people with disabilities to play games. There is no restriction in the games that could be played, they have to run in a PC (Windows or Linux) and be controlled with keys or mouse. Although technically possible, we found that users with disabilities are not usually able to play fast games or those needing large combinations of buttons; but this is mainly because of their physical or cognitive disabilities. This tool also improves the computer accessibility disabled people as it can be also used to control any application such as word processor, navigator, e-mail client, etc. So far, we have successfully tried flash games, specific adapted-for-disability games, mainstreaming games (pinball, arkanoid, sims, etc.) and other applications such as text editor and browser. Although not already evaluated with elderly users in Spain, we can say that this tool is also very useful for then due to the good results from the experiments being done in Sweden.

Several users with diverse disabilities can play simultaneously using different wireless kinetic controls, and also they can share the game and compete against other persons without disabilities, inside or outside the family. This is a very important step in the integration and socialization of people with disabilities. We have developed the system to be used with the Wii's remote controller, although it could be used with any other. The person specific disabilities highly condition how he/she can interact with the controller: slight and precise movements of just a finger, head inclination, brusque arm movements, etc. Our tool personalizes this interaction and translates it to any input required by the game.

We have successfully tried the tool with users with disabilities and games that were previously inaccessible to them. Thus, following the "design for all" principles, we have extended the target users of an already existing product.

Inherent to the gaming experience, this tool also allows therapeutic leisure, because this way of interaction stimulates the physical movement and empowers socialization.

We also realized that this tool can be also used in other fields of interest such as turning more enjoyable and funnier the initiation to computers for elderly and disabled. It is obviously more intuitive to point where you want to go than move the mouse. It also enhances the accessibility of computers for disabled people offering an alternative way of interaction.

Summarizing, we can say that this tool can improve the quality of life of elderly and disabled people allowing them, among other activities, new gaming experiences. Moreover this is done in a cost effective way; just using mainstreaming and cheap devices and free software that can be downloaded from our research group site (http://tecnodiscap.unizar.es/)

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References

1. Tollefsen, M., Flyen, A.: Internet and accessible entertainment. In: Miesenberger, K., Klaus, J., Zagler, W.L., Karshmer, A.I. (eds.) ICCHP 2006. LNCS, vol. 4061, pp. 396–402. Springer, Heidelberg (2006)
2. Iacopetti, F., Fanucci, L., Roncella, R., Giusti, D., Scebba, A.: Game Console Controller Interface for People with Disability. In: Proceedings of the 2008 international Conference on Complex, intelligent and Software intensive Systems. CISIS, pp. 757–762. IEEE Computer Society, Washington (2008)
3. Pearson, E., Bailey, C.: Evaluating the potential of the Nintendo Wii to support disabled students in education. In: ICT: Providing choices for learners and learning. Proceedings Ascilite, Singapore (2007)
4. Groenewegen, S., Heinz, S., Fröhlich, B., Huckauf, A.: Virtual world interfaces for special needs education based on props on a board. Comput. Graph. 32(5), 589–596 (2008)
5. Lin, C., Huan, C., Chan, C., Yeh, M., Chiu, C.: Design of a computer game using an eye-tracking device for eye's activity rehabilitation. Optics and Lasers in Engineering 42(1), 91–108 (2004)
6. Foulds, R., Saxe, D., Joyce, A., Adamovich, S.: Sensory-motor enhancement in a virtual therapeutic environment. Virtual Reality 12(2), 87–97 (2008)
7. Waber, B., Magee, J., Betke, M.: Fast Head Tilt Detection for Human-Computer Interaction. In: Proceedings of the ICCV Workshop on Human Computer Interaction, Beijng, China. Springer, Heidelberg (2005)
8. Fu, Y.; Huang, T. S.: hMouse: Head Tracking Driven Virtual Computer Mouse. In: Proceedings of the Eighth IEEE Workshop on Applications of Computer Vision WACV. IEEE Computer Society, Washington, DC, 30 (2007)
9. Tu, J., Tao, H., Huang, T.: Face as mouse through visual face tracking. Comput. Vis. Image Underst. 108(1-2), 35–40 (2007)
10. Shin, Y., Ju, J.S., Kim, E.Y.: Welfare interface implementation using multiple facial features tracking for the disabled people. Pattern Recogn. Lett. 29, 1784–1796
11. Shima, K., Bu, N., Okamoto, M., Tsuji, T.: A universal interface for video game machines using biological signals. In: Kishino, F., Kitamura, Y., Kato, H., Nagata, N. (eds.) ICEC 2005. LNCS, vol. 3711, pp. 88–98. Springer, Heidelberg (2005)

12. Nijholt, A., Tan, D., Allison, B., del, R., Milan, J., Graimann, B.: Brain-computer interfaces for HCI and games. In: CHI 2008 Extended Abstracts on Human Factors in Computing Systems CHI 2008, Florence, Italy, pp. 3925–3928 (2008)
13. Alonso, F., Fuertes, J.L., Martínez, L., Szabo, H.: Design Guidelines for Audio–Haptic Immersive Applications for People with Visual Disabilities. In: Miesenberger, K., Klaus, J., Zagler, W.L., Karshmer, A.I. (eds.) ICCHP 2006. LNCS, vol. 4061, pp. 1071–1078. Springer, Heidelberg (2006)
14. Miller, D., Parecki, A., Douglas, S.A.: Finger dance: a sound game for blind people. In: Proceedings of the 9th international ACM SIGACCESS Conference on Computers and Accessibility Assets 2007, Tempe, AZ, pp. 253–254 (2007)
15. Raisamo, R., Patomäki, S., Hasu, M., Pasto, V.: Design nd evaluation of a tactile memory game for visually impaired children. Interact. Comput. 19(2), 196–205 (2007)
16. http://www.wiili.org/index.php/Main_Page (2009)
17. http://www.inference.phy.cam.ac.uk/dasher/DasherSummary.html (2009)
18. González, M.L., Muñoz, A., Valero, M.A.: A low-cost multimodal device for web accessibility. In: 6th Collaborative Electronic Communications and ecommerce Technology and Research Conference (2008)