Tangible Interaction: Arduino Watch

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ABSTRACT

Our concept is of an interactive home where the contact with surfaces enables the user to control devices. The input device, a wristwatch with built in gyrometer and accelerometer can read movements in six degrees of freedom. By pattern recognition the movement made by by the user's hand are read as signals and sent to an Arduino board. The Arduino board then sends out commands to different devices chosen by the user. Small vibrations in the wristband give the user haptic feedback to enhance the interactions with the device.

Keywords
Arduino Controller, Universal Controller, Interaction Gesture, Six Degrees of Freedom

1. INTRODUCTION
The goal of this research is to build a controller that simplifies and enriches the user's experience when interacting with electronic devices. This is done by pattern recognition within a wristwatch, interpreted by an Arduino and executed by the device chosen. By implementing this technology in an everyday token which the user always carries with him/her we hope to make interaction more natural and intuitive.

2. BACKGROUND
The way people interact with electronic devices has changed drastically from being almost none at all, through the industrialization and where we are today. With having technology so cheap and easy accessible a new understanding has come to grow. This understanding is based on the everyday handling of devices, causing them feels like a natural part of the environment. Often this natural way of interaction is lost though. The devices way of taking commands can bring people to behave in the most extraordinary ways; screaming at a voice recognition device while being down town, pressing two red buttons and one yellow while aiming at a 45 degrees angle at the multi controllable TV and so on. This is something we wanted to tackle when given the chance to work with tangible interactions. We wanted a system which felt natural for the user while not being in the way and blending in with the users' natural environment as much as possible.

3. CONCEPT
While working on this project our concept was to make the user's everyday life more simple and fun. The goal was not to give the user another tool to keep track of, but rather to use an already frequently used tool - the wristwatch- and make it more useful as a tool for controlling devices. This decision was partly based on Ishii's and Ullmer's thoughts about seamless interaction[1] enabling the user to control input by using intuitive hand movements. It was also a part of our bigger concept, of an interactive environment that interpret the different surfaces and textures the user interact with and executes commands according to these.

4. REALIZATION

4.1 User Scenarios
Before we begun working on the actual design, a set of user scenarios were designed to show the concept of having a wireless controller to make everyday life simple and fun.

1. Sara comes home from a day at work. She points at the hallway lamp and it lights up. She turns her wrist to dim the light as it is hurting her eyes. She walks by the living room on her way to the kitchen. When passing the stereo she turns it on by directing her hand at it. Simultaneously as dropping her bag and getting the newspaper she switches radio channel by flicking her hand sideways. When tuning in to the channel with right kind of music she turns up the volume by twisting her wrist. When finally sitting down with the paper she increases the brightness by indicating her hand at the kitchen lamp and twists her wrist.
2. Peter is parking his car in a very narrow parking space. By getting out of the car when it is correctly positioned he is able to control the cars forwards movement by indicating his hand forward. When it has its final placement he locks it by turning his wrist and "withdrawing the key".
3. Markus is entering school and heading towards the elevator. He aims his finger towards the doors he wants to go. By the time he reaches the elevator, it is already there waiting with open doors to take him to the floor he wants to go.

4.2 Research and Design
In the beginning of the project we used a bottom-up model, brainstorming to see different aspects and limitations of the different elements we could control. A long list of projects was produced of which we discussed the ones possible to make, the affordances and haptic feedback possible.

After we decided on what kind of different digital devices we wanted to control, a user study on the natural movement patterns was performed. The device we decided to control was a lamp and a music player, therefore different movement patterns of controlling physical lamp and music player were studied and tested.

The user study was carried out on some of the Interaction Design and Technology student at Chalmers University, answering the question: how would you prefer to control the lamp and music player if not having a physical interface? The result showed a tendency of people having different way of controlling these devices mostly due to variation in design of the devices. The movement pattern we did find in common for many users were in dimming the lamp and changing the volume of the music player. A majority of the users' preferred to dim the lamp and change the volume by holding the knob and twisting their wrist, since this movement is quite symbolic for dimming the lamp and change the volume of music player on a physical device.

Therefore the decision was made to build a device that involves the movement pattern of the user twisting his/her wrist. After some discussion, we agreed to make an Arduino wrist watch (A-watch) that could use the same movement patterns as a wireless lamp dimmer and tuning button.

The design of A-watch was motivated by the possibility of being a part of a bigger concept while still being tangible with clear affordances. A general idea about the importance of the size of the A-Watch was encouraged by the various user tests. The watch should be easy to carry in daily life since the user shouldn´t feel hindered they do not want to hindered when tuning their music and handling devices.

4.3 User test

When finishing the major design parts of the product we did another user test, to discover things that might have been missed out. The prototype of A-watch was handed to users and the users were asked to control the lamp and music player, firstly without given any instructions and simply letting them play around with the A-watch and the devices to be controlled. Then the users were given specific instruction how each component works and asked to perform the task again. The performance of both attempts were recorded, and afterwards the users suggestions of improvement were also collected.

The second user test gave very valuable feedback and contributed to the makings of the final prototype. Unlike what we initially thought the task of just controlling the devices turned out to be more complex and a bigger part of the interaction than we expected. Such interactions as activating the control command, haptic feedback improvement and change the sensitivity of the movement pattern showed to be more complex than expected.

4.4 Final prototype and functionalities

After analyzing the feedback from users, we improved the design according to the suggestions from users and the issues discovered during the user test.

The watch is able to distinguish different motions of the wrist and translate these into functions in devices. Users can start to command the lamp and the music player by pointing towards the device. This interaction is metaphor of "You will now listen to my command". What actually happens is the gyro meter inside the A-watch activates the laser pointer, and while the laser pointer hit the receiver on the lamp or the music player, user has x seconds to adjust the brightness or turn up and down the volume of the music.
When the device is starting to or is done with receiving your command, the lamp and music player tuner will blink twice to demonstrate the beginning or end of listening to your command, and the A-watch will preform a long vibration as feedback. This blink is metaphor of "Receiving your command" and the vibration is telling the user that the device "is performing your command". The mechanisms behind these feedbacks are the LDR sensor detects the laser light, and it triggers the LED light placed on the lamp the music player tuner. At the same time, the lamp dimmer or music player tuner will send a message wirelessly to your watch, tells you it is ready to receive your command. As this message received the vibrator of A-watch start to vibrate.

Now the user can twist his/her wrist to change then brightness or the volume of the device as the way they prefer to interact with the physical prototype. The A-watch measures rotation in steps of about 15 degrees each, when a new step is reached the watch vibrates shortly. After a set amount of time the device will send a end signal to the watch, the watch will use a long vibrate to tell the user it is no longer in control of the watch. User can control the device again by pointing toward to the device they would like to control.

4.5 Components

The A-Watch

Gyro – (Yaw) measuring rotation around the x-axis .
Accelerometer – (Pitch and Roll) for measuring angles of wrist movement. A tri-axis accelerometer is used to measure the roll of the wrist. This enables the user to simulate the control the device with a twist of the wrist. (Horizontal rotation, twisting)
Transceiver – this let the user interact via radio with different devices.

The Controllable Lamp and the Controllable Music Tuner

LDR – acting as trigger for listening command.
Transceiver – sending and receiving command via radio.

5. EVALUATION

The system we have built works well and is scalable. This is truly a universal remote that can control most electronic devices in our vicinity. As the time limit of our project only allowed us to program the recognition of four movements into the watch, a sweep to the left or right and rotation of the wrist clock or -counterclockwise . With more time we could have programmed the watch to recognize many more movements and even advanced patterns. The drawbacks of our project is the need for a receiving device connected to what you want to control and the need for the device to be in line of sight. The later problem can be fixed by creating some other way of choosing which device to control, e.g. a button on the watch or a representation of that device in another room. Then by telling the watch witch device it should control a bit more refined communication protocols could allow the watch control over the device as long as it is in range of the wireless transciver.
- **The vibration feedback.** The haptic feedback with the vibrator worked well, It was very helpful when using the watch, and

helped to understand what movements it thought you were performing. However it had a learning curve. First time users felt like the watch was vibrating all the time. The users who tested the clock more than once showed a much higher skill level in distinguish the different kind of vibration and interpret there meaning. The different settings we used for the haptic feedback, the vibrations, were only the time the vibrator was active, differing from 75 to 200 milliseconds. More elaborate settings can be created using pulses or other kinds of time multiplexed feedback.

-The users hand would often block the visible red laser, forcing the user to bend the hand to be able to use laser. To avoid this laser could be put higher up on the watch to give the user full reach.

6. RELATED WORK

Our project is far from the first one attending the field of wristwatch integrated controls. One of the most common approaches is the multi button solution, which for example Casio uses in CMD40B-1T1[1]. This model enables the user to control a broad spectrum of devices by using a combination of buttons together with infrared light. This concept has much in common with ours by trying to enrich and make the users' everyday life more effective. The means of making this happened are opposite though. Casio CMD40B-1T gives the user more control by moving the interface from the devices to a watch. Our aim is to make the interaction seamless by replacing the traditional way of interacting with a tangible user interface and instead use movement patterns which we believe will be more intuitive.

A project using an accelerometer to control an independent unit is Qbots mobile robot23[2,3]. This project evaluates the possibilities of controlling a robot arm by moving an iPhone in different directions. The arm has 5 degrees of freedom and responds to the wrist/iPhone movements directly by doing the same kind of motion. It is similar to our project in the sense of executing commands by hand movements but also in the general aspect of controlling external devices by simple and intuitive movement patterns. The major difference between the A-Watch and Qbot is that the A-watch also reads the movement patterns as digital commands like play, fast forward and so on. This gives an extra element of difficulty since the watch not only reads the movement patterns but also makes these into digital commands who are not a natural part of the body language. For example if the user wants to us the A-watch to switches song on a music player it may be translated into swiftly sweeping your hand in left or right direction. In the Qbot this would make the robot arm swiftly turning its "body", a more natural and understandable movement.

In Human Performance in Six Degree of Freedom Input Control[4], Shumin has investigates human performance in relation to various dimensions of 6 degree of freedom (DOF) interfaces, including device resistance, transfer functions, muscles groups and joints, and input display formats. From that paper we have learned (1) The physical properties of a 6 DOF input device should provide rich feedback so that the user can easily feel her control actions proprioceptively and thus learn the task quickly. (2) To the extent possible, fine small muscle groups and joints should be included in the operation of input devices. (3) The transfer function used to interface a device with the computer should be compatible with the physical device. (4) The visual representation of the user's actions should be designed to allow immediate exteroceptive feedback and the application of semi-transparency serves this purpose well. These findings from Shumin are quite helpful to our project.

7. DISCUSSION

Individual movement patterns are harder to map than we thought. Since everyone has different movement patterns naturally this makes the mapping of what is universal quite hard and if not done correctly, unreliable. Before making controls that solely depend on this kinds of input thorough research have to be made so that the system allows certain margin of error.

Feedback is an area which can be developed further. As the watch itself is unimodal, the only feedback is the vibrations, it is somewhat limited in its ability to convey what action it preforms. The limited feedback is a bottleneck when it comes to program movements recognized by the watch. By only recognizing a few patterns and have different feedback for each preformed action it is easier to understand how the watch works. In this way the watch remains simple and intuitive to use. The feedback now is somewhat lacking and would benefit from another channel e.g. a LED on the watch. This would allow for more function to be programmed into the watch. The technology is not the limit. The limit instead lies with the users ability and willingness to learn what the technology can do.

The mapping between movements and actions is a complex task to solve. Todays interaction with technology consist mostly of pressing buttons, turning knobs, and in some cases moving sliders. Turning a knob is easily translated into turning your wrist. This is helpful in cases like changing the volume or changing the intensity of a lamp because this is normally how we interact with devices off that sort . As it comes to different kinds of action to be preformed e.g. on and off, play and pause, or open and close there is no clear and intuitive way of how that move would look. Recent technologies like the touch pad has made us more physical active when it comes to interaction, and maybe as drawing patterns to preform tasks becomes more familiar. These new patterns can be used in our kind of setup.

8. CONCLUSION

We had to re-evaluate our feedback model. Haptic feedback is very important in interfaces which otherwise lacks the graphical way of showing user where he/she is, but all feedback is not good feedback. Without thorough thought and implementation faulty feedback is worse than no feedback since it is both misleading and adding mental friction.

9. REFERENCES

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