

Applying gestures in domestic appliances

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ABSTRACT

Gestures are not often used to control domestic appliances in a modern household. This paper describes a research project on the current use of gestures in domestic appliances and possible usage in the future. First, a literature survey is done in different gesture input possibilities, also advantages and disadvantages are discussed. After that, a few current domestic appliances with their input possibilities are reviewed. To give an overview in the applied gesture field, a research in domestic appliances with the use of gestures is presented. Using the described input methods, new gesture control methods are introduced in the domestic field. A remote control with touchpad or capacitive field controls came out as an interesting device. A small qualitative user study is done with a concept 2D paper model of a remote control to evaluate its usability. Seven users from different ages executed tasks and a small questionnaire to get their opinions. It is concluded that a remote control with a touch sensitive interface in combination with a displayed remote control screen is preferred above the traditional remote control using push buttons.

Keywords

Gestures, human computer interaction, domestic appliances, remote control, television.

1. INTRODUCTION

Current domestic appliances are using old-fashioned interaction methods, such as buttons and switches to interact with them. Research in Human Computer Interaction (HCI) and electronics offers new methods to interact with machines. Interaction using gestures is a part of the HCI research field and enables remote controlling without using a 'remote control'; it makes controlling at a distance possible without the need of an additional device. Looking at domestic appliances in home electronics shops, relatively fewer new interaction techniques with the use of gestures can be found. For this reason, it is interesting to add interaction methods to the domestic appliances which are using gestures. In this paper the results are presented from a research that focuses at gesture interaction techniques in the domestic appliances field. A user study with a paper concept remote control is done to evaluate gestures using to control a television.

Different categories of gestures can be distinguished: spontaneously made gestures and non-spontaneously made gestures. In the first category different subtypes can be seen [1]. For this research a few types are important to mention. The first type is the iconic gesture. These gestures are made accompanied with speech to communicate in a better way. They match the semantic content of speech. An example of this kind of gestures is a situation when someone is talking about getting a gun and at the same time moving his hand to the place the holster normally should be. The second type is the deictic or pointing gesture. They also accompany speech within inter-human communication. This kind of gesture is made very naturally and does not have to match with real objects. An example is pointing to the left and talking about outside the room. There is also a category which contains the sign language for deaf people, made with a thought purpose. This category is called the non-spontaneous gesture and is able to communicate a complete language, created for inter human communication and have to be learned in advance.

According to Goldin-Meadow, Kim and Singer [2] who researched what spontaneous gestures can do in a math lesson, the use of speech accompanied with gestures let math teachers communicate in a more effective way compared to speech without the use of iconic gestures. Watching the accompanying gesture helps the listener to better understand speech. The iconic type of gestures are maybe interesting to use in communicating with machines because the expected intuitiveness of their use and clearness of their meaning. Maybe using these gestures will replace the normal button interface and improve the usability of domestic devices.

Humans are able to make precise and fast movements with the hand. In normal life they used to make different kinds of actions with the hand, such as pointing actions to locate objects and controlling actions such as steering a car or tuning the radio. There are lots of different methods to let the hand communicate with a device; in the next chapter a couple possibilities are explained. When a gesture is used to control a device, a movement of the hand is coupled to a control statement in such a way that the machine understands the meaning of the movement and is able to interpret it and take actions when applicable.

2. The field of recognizing gestures

Within Human Computer Interaction, has been much research about interpreting gestures. Gesture movements who are connected to a meaning in the system are recognized and interpreted. In the next paragraphs possible ways to interface a gesture into a machine are discussed, and a summarization is written.

2.1 Computer Vision

2.1.1 Introduction

Computer Vision uses techniques to detect the perceptual existence or movements of objects with the use of cameras. It can detect a human body or body parts such as a hand for example by comparing different picture frames and looking for the differences, or looking for skin coloured parts. Also pattern recognition in combination with motion tracking is used to keep track of the human body. This is a technique that searches for a common pattern, such as a head or a hand, and tries to keep track of it. For example if we follow a hand, we are able to see a line or a figure the hand is making. With this information commands could be executed.

A review [3] shows that there are at least two classes of hand recognition; the first class uses a human hand model in a spatial way. This 3D model contains a simplified skeleton of a human hand including joint angles. The second class takes a static image and searches for the appearance of a human hand without the use of hand models. It analyses the hand image property parameters, such as contours and edges [3] and draw conclusions from it.

2.1.2 Computer Vision summary

Computer Vision is usable for remote control, but there is a minimal distance needed between the camera and the user. This distance is approximately 1 meter with a maximum of approximately 6 meters, varying to about 100 meters, depending on the zooming functions of the camera and the detail level needed.

The disadvantages are: It is hard to get a focus for the short distances, caused by to the minimal useable distance of 1 meter.

A processing unit is needed with the computation power to process all the video data, which is often quite a lot.

2.1.3 Future

The development of CPU's and electronics is still making new and faster processing of computer vision data possible. In the Computer Vision field, more processing power and faster recognition of data patterns is definitely going to be possible. In the future, the needed processing power will be available in the electronics of modern households.

2.2 Pen-based input

Pen-based input is often used for applications on palm-computers or Personal Digital Assistants. The movements made with the pen can be read through an interface such as a touch sensitive system. These movements are handwriting or other gestures made with the pen. This category also includes gestures made with the fingertip instead of a pen; this is because the movements are almost the same and therefore the applications are comparable.

Pen-based input is often used for textual input. There are two pen-based methods for text input; the first method is writing characters with the pen itself in combination with character recognition; the second pen-based input method is selecting the character from a displayed keyboard. These two methods are not extremely fast; although there are word-predicting techniques available [4] which accelerate the text input process. Research in this field is done but the new techniques are not implemented in practice yet.

With stochastic techniques [5] it is possible to input text at a faster rate compared with only handwriting recognition techniques [4]. Therefore some processing and calculations are needed; also the language model should be the same as the users language.

Not all the pen-based or fingertip-based gestures are easy to learn and remember to users. There are several properties of a gesture in this category that influence the usability. Research in the similarity of pen-based gestures [6] concluded that for example curviness is such a property. If a gesture looks the same as another gesture, it is more difficult to remember and reproduce the gesture. Research shows that there are computable features to measure the similarity between gestures; these features are correlated with (perceptual) similarity. If pen-based or fingertip-based gestures are used, this similarity should be taken in account to achieve better performance on gesture writing. If other kinds of gestures are used, such as hand-based or arm-based gestures, these results can't be used due to the specific area of this research.

2.2.1 Advantages

Pen-based input compared with keyboard input is smaller to use, because of two reasons: the display is used for both visualization and input, and secondly because a keyboard takes a lot of space. A keyboard is not integrated in a display and is therefore an extra device. This also counts for mice.

Pointing, drawing, selecting and signing are easy to do with pen-based methods because everyone has learned this at school with a normal pen and its usage is very similar.

Local operation is possible and obliged due to the physical contact of the pen.

2.2.2 Disadvantages

No remote control is possible due the physical contact with the pen and his sensitive surface. A pen and a sensitive surface are both needed to do pen-based input. For a large amount of text this method is not optimal in use because the relatively slow method of generating characters.

2.3 Glove-based input

A human is able to control his fingers very precise; this makes the hand suitable to control electronic devices. An electronic readable glove is developed to sense the position of the separate fingers; it contains sensors and is able to continuously monitor the glove. To do tracking of the whole hand in its surrounding environment, computer vision is applicable. The glove has sensors in itself to monitor the position of the fingers and therefore doesn't see a movement that the whole hand is making. Besides computer vision, extra sensors are developed [7] to measure 3D movements of the hand with low frequency magnetic fields.

The main advantage of a glove is that it is a precise readable device and has a quick responsiveness. On the other side, the user has a huge device on his hand [7] that could obstruct the user from doing normal hand movements. Also does the user needs visualization of the gloves impact, because there is no spatial feedback and therefore the user won't know what he is operating. This disadvantage is alternatively solvable by other mechanisms such as force feedback techniques.

Maybe in the future the glove-based input is replaceable with computer vision as reading method, focusing at the human hand.

2.4 Capacitive fields

Through capacitive fields it is possible to track and follow the movements of the hand and fingers of a human. A capacitive field is a surface that is sensitive for the electro capacitive changes on its surface and is able to track multiple hand positions and shapes at the same time [8]. This solution is called SmartSkin. It can for example be used to interact with maps or building plans to manipulate them dynamically. The virtual objects that are being manipulated can be projected on the surface, for example from above.

2.4.1 Advantages

Multiple fingers and positions are readable in parallel. Only a sensitive surface is needed and a device to process, no additional extra devices. Usage on flexible surfaces is possible, also applications at non-flat shapes. Multiple user and multiple hand operations are possible; although it is hard to distinguish whose hand it is.

2.4.2 Disadvantages

Advanced electronics and calculations are needed to compute the implications of the interactions; the meaning of a movement has to be assigned. This needs some calculation power. Remote controlling with capacitive fields is not possible due the short operating distance that is required. Very precise operation is not possible due the large grid size and the low sensitivity; they have reached an accuracy of 1 centimetre with a grid cell size of 10 centimetre.

2.4.3 Future

The capacitive fields method has great advantages and opportunities in the interaction field. Maybe after some more research progress, for commonly used domestic devices this method is ready to apply.

3. Domestic appliances

Different kinds of domestic appliances are used in households. These devices are mostly controlled with the human hand with manual switches. In this section an overview of products is given with varying input methods. Also some criteria for the chosen controls are highlighted.

3.1 Current products

There are different sorts of domestic appliances available in the electronics shops. For example refrigerators, deep freezers,

televisions, driers, washing machines, dish washers, stove tops, vacuum cleaners and ovens can be found. In the table a few examples of appliances is written. These are commonly used and well known. There are roughly two button classes separable, the dial switches class and the push buttons class.

Device / function	Refrigerators	Deep freezers	Televisions	Driers / washing machines
Dial switches	Temperature	Temperature	NA	Temperature, program selector
Push buttons	On/off	Fast freezing, making ice	Channel switching, on/off, remote control	Speed
Device / function	Dishwasher	Stove tops	Vacuums cleaners	Ovens
Dial switches	Temperature, program selector	Temperature	Speed	Temperature, program selector
Push buttons	On/off	Ignition	On/off, speed, wire	On/of

3.2 Current input methods

Dial switches are used because of the various options that can be selected, for example 40, 60, 80 or 100 degrees Celsius in controlling temperature settings. This solution is more suitable than multiple push buttons because it is much more simple to control. This also gives an advantage in the intuitiveness because the user has a lot more overview at the controls. Also progress indicators on washing machines or driers are used as dial switches. Push buttons are used for doing binary settings. Turning machines on or off is their mostly used implementation. Also rotation speed settings for washing machines are not uncommonly used as push buttons. In push buttons are two different subclasses visible; the first type is the push button that keeps its state until the user changes it; the second type is the push button that only sends a command once to the machine and immediately returns to its original state. The 'quick washing' or the 'half load' buttons on the washing machine are examples of the first type. The on/off button from the television remote control or the fast freeze buttons on the freezers are good examples of the second type.

4. Current research

Domestic appliances using gesture interaction are being researched for different kind of applications. For example smart home projects are developed to devise intelligent home appliances [9]. Different appliances can be made more intelligent and aware of their context and user. For example the following devices are invented: a smart-pen to search word definitions, a smart-pillow to monitor the person who is sleeping, a gate-reminder to help taking everything with you when leaving the house, a picture management component to view all your photos in one album (see also section 4.3), a smart wardrobe to look up the weather forecasts, a smart dressing table for women who like to put make-up on more easily, a smart table to interact with several communication components in the house. But not all devices are developed yet; sometimes it is in a working-prototype implementation or only an on-screen virtual prototype implementation. In the next paragraph a real example is given that uses hand gestures to control a television. After that, the following paragraphs contain more futuristic or uncommon appliances.

4.1 Television control using gestures

A relative old example is the television control by hand gestures [10]. This research made it possible to switch channel, change the volume, and turn on or off the television with the use of hand gestures. Computer Vision was used to detect the open hand and follow its movements and obey its commands. The visual feedback to the user is given by overlaying the controls at the television screen and displaying the position of the users hand through a hand icon. A disadvantage of this system is that with intensive use, the user gets tired using his hand keeping it in the air to control the television. Different algorithms do hand tracking; first background removal is done to avoid analyzing the furniture. To achieve this, they combined the current image with the running average image to adapt to changes, such as movements of furniture. To avoid changes in lighting conditions, the next algorithm uses normalized vectors to track the hand movements. Also a few hand templates are used to avoid analyzing the whole picture for many templates, because that is too costly. After a global analysis is done, a found local area is searched for more hand patterns. This research was done in 1995 and less computing power was available compared with the current computers. Unfortunately, they don't report about an user study; their research focus lays on the technical part to make it possible to control a television using gestures.

4.2 Domestic robots

More recent research shows mainly theoretical results in the HCI field; the applied research is maybe kept secret by research departments from large companies or are not placed in scientific sources. Due to the few results found that directly match the domestic appliances area, the next paragraphs are a little less related to normal households, but still interesting because of the techniques being used.

The first example is a household robot. Stereovision and a 3D map of the surrounding makes it possible for a service household robot [9] to orientate in his environment and to communicate with a human. Comparing the static pre-made model of the environment with the current environmental model gives information to the robot that helps him to know what has to be cleaned or to know where the user is pointing. The interpretation of gestures is dependent on the place where the user and robot are, so pointing in the kitchen will be different interpreted then pointing in the living room. After a decision is made, the domestic robot is going to clean the area or take an object and move it.

Another example is a domestic robot that is developed with the use of a combination of speech and gestures [10]. It uses image based hand tracking to detect gestures. Vocal commands are interpreted and converted depending on the context of the user. A domain specific speech vocabulary is used to extract the commands and these are converted into events. Because of the multimodal input, all the events from the different inputs have to be processed instead of taking decisions directly.

4.3 Digital photo album

Another example is a concept digital photo album called GIA; it uses gestures to interact [11] with the user. The fingertip is used to make gestures on a touch sensitive screen and the photo album manipulation is enabled through basic gestures. Commands such as 'copy, next, slide, new, cancel, print, edit' are available. The user interface is designed with parallels to a real world photo album so that novice users are able to understand it. For example, pictures can be moved in and out of the photo album in the same manner as with a plastic photo album: putting photos into the album with sliding it from above to the bottom.

5. New input method possibilities

New input possibilities in domestic appliances can be found if the gesture input methods from section 2 and the interaction methods showed in section 4 are combined with current domestic products. Due to the unexplored research area and the little empirical research results found, we couldn't use real prototypes of the domestic appliances for doing tests. Instead new combinations have to be made theoretically and characterized using text and graphics. Using this approach has the disadvantage that technical or practical problems can happen in the real but not on paper and remain hidden. To avoid these problems as much as possible, the knowledge from the gesture input methods from section 2 is used, especially the known disadvantages. Also more issues that could lead to practical impossibilities such as: the increase of power usage, the low space available, a great decrease in ease of use, or safety measures should be taken into account.

5.1 Domestic appliances and gesture

In the following paragraphs different kinds of domestic appliances from the table in section 3.1 are being discussed and new gesture interaction ideas are proposed. Not all the devices are discussed because of the functional similarity.

5.1.1 Refrigerator

The refrigerator or fridge is mostly placed in the kitchen and also usable for other purposes such as placing notes on its surface with magnets [12]. Interactive interfaces with possibilities to keep track of the amounts of food and expiry date in combination with digital notes are already invented [13]. Pen or finger based input is often used as an input method and enables writing messages. Due to the small usage distance, a remote control is less appropriate; Computer Vision is therefore not usable. To change temperature of the fridge, the use of capacitive fields is possible, but has low advantages compared with normal buttons because this setting is not often changed. Another improvement can be found in making it easier to open the door of the refrigerator; for example a touch sensitive area can be made that pushes the door open.

5.1.2 Television

The television is a device that allows remote control without direct disadvantages, the user doesn't have to be near, or doesn't have to touch it or get something out or put something in it. In section 4.1 television control by gestures [14] with Computer Vision is mentioned; this idea has possibilities. Another approach is a remote control with only a capacitive field at the surface that makes it possible to control the television with finger gestures, for example to change channels and volume. A background display on the remote control gives possibilities to more advanced control because the display can be adapted dynamically. The capacitive field replaces the normal buttons and has the advantage that the input can be experienced to the user as analogue; this can be approached with the use of a digital slider interface and by measuring the speed of movement or acceleration of the finger and use this information to faster switch channels or change volume. The fingers are not limited to touch only the small buttons, because buttons can be created and modified on the fly; e.g. button size can be adapted to the frequency of use and displayed while it is in use. Another adaptation option is to easily change the language of the remote control. This enables easier understanding and interpretation for non-English speaking persons.

5.1.3 Washing machine

The washing machine has various options that have to be set when used; for example: temperature, rotation speed, and different washing programs. To operate the machine, the user has to be near the washing machine to put the clothes or soap in

it; this makes remote control superfluous. Capacitive field-based controls and finger-based controls are applicable to change or make settings. Washing machines with advanced options such as timers, already have displays integrated in it. When larger touch sensitive displays are used, more functions can be accessed using the display.

5.1.4 Vacuum cleaner

The vacuum cleaner is not extensively changed over the last years. Roughly spoken, the same components are there where they were a few years ago. Improvements of interaction can maybe made on the switches that normally are placed on the cleaners' body, for example to adjust the suction power or to power it on or off by placing these on the hand grip of the telescopic tube.

5.1.5 Stove top

The stove top for kitchen cooking usage is using dial switches to change the amount of heat. Sometimes in the models who are using gas, the ignition mechanisms are included in the dial switch and activated when pushed unto it. More interaction with the user and stove does not happen. Replacing the dial switch with other input methods can maybe do improvements. An example of this can be found in using digital sliders that are sensitive for the human finger. Finger-based input or capacitive fields based input can be used to make this possible.

5.2 Summarization

In the previous sections a few domestic appliances are described with new interaction methods using gestures. Different ideas are discussed: the refrigerator with using gesture to open; the television with a gesture touchpad on the remote control; the vacuum cleaner with suction power control on the tube's handgrip; the stove top with slider control. Not all these ideas are very innovative. We choose one idea to work out in a model and evaluate this idea with users.

6. User study

New input methods ideas such as explained in section 5, should be tested on users to know if the new ideas are making any sense; a user study is therefore needed. In this section is written how the small user study and the questionnaire is set up. We also present the results in the next paragraph.

6.1 Remote control using gestures

The user study we executed could not test all the ideas mentioned in section 5 due to the shortage in time. Only the best idea should be tested. We choose the remote control using a sensitive surface as the best idea to evaluate in practice, using a paper model. In the next paragraph we explained why and details are given.

The idea of a remote control using a touch sensitive surface with capacitive fields is very different compared to the normal remote control. A normal remote control has push buttons with the binary on and off capabilities. No variable or semi-analog input is possible. This new remote control makes it possible to use sliders and therefore makes near analog input possible. The displayed screen of the remote makes it also possible to change buttons and language of the buttons without the costs of making localized hardware. The dynamic placement capability enables personalization and multi-displays are possible. Separate controls for different machines, such as a television and a DVD player can be combined in one remote, without overloading it with buttons.

Our experiment setup only used concepts paper models of a remote control. Due to this method, real models have to be used to draw actual testing results. Using this method, we presented results from unskilled users using a new method of controlling a television. No learning time or instructions were given. Our

gestures to use the remote control where very limited. Only sliding up and down is possible, an one degrees of freedom measurement.

6.2 Hypotheses

The remote control with the capacitive field is interesting to look at. Compared to the normal remote control, it has advantages, as we assume, and therefore it will be necessary to verify this on users. A user study is initiated to achieve practical usability results of the new approach. The hypotheses are:

1. A remote control with touch sensitive sliders will be easier to use compared to the normal remote control.
2. A remote control with variable placements of buttons will be preferred above a remote control with fixed buttons.

6.3 Research setup

The kind of user study we needed is called a 'technology push', that stands for introducing more than one new concept at a time. The new design concept model with its possibilities is showed to the user and tasks are given to evaluate its general usage. After the tasks were done, a questionnaire is held and the users were able to give input to improve the remote. The focus is at the slider use and the usability of the varying buttons. In paragraph 6.7 the user tasks are explained in detail.

6.4 Participants

Domestic appliances users are almost everyone who lives in a house and owns domestic devices. Users from different age groups are interviewed to get an opinion that is a reflection of the contemporary society. The user group consists of 4 women and 3 men. The participants age are between 20 and 67 years old; 4 of them are students from different study areas.

6.5 Prototypes

To achieve a good prototype evaluation, interaction faults and design lacks need to be avoided. Therefore the user evaluation took place in two steps. The first step consisted of an evaluation with a person who is an expert in user interface designing and usability studies. Then the paper model was improved to avoid major problems with the bigger user study group. In the second step, the designs were evaluated by seven participants.

6.6 Remote control layout

In this paper, only the improved concept remote control is displayed. The improvements made after the first evaluation steps were: larger fonts on the display buttons, larger channel sliders on the display, an order change in the questionnaire.

The new concept remote control is based on the layout of the usual remotes. It has a normal width (5cm) and height (18cm) so it fits well into the users hand. The upper part contains a function block to switch between the main devices, such as the television and DVD player; this block is fixed. The middle part is for various usages, depending on the needs of the controlled device. The lower part is used for channel control for the television mode, page control at teletext mode and finally volume control in every mode. They are displayed as a very large button and are actually sliders. The user can slide over the button with his finger from the upper part to the bottom while changing channels. The behavior of the slider button is in a way that when the user touches the button in the upper part, he will faster switch channel then if he puts his finger in the lower part. The faster part is marked with a double plus sign. The volume sliders have the same behavior as the channel sliders.

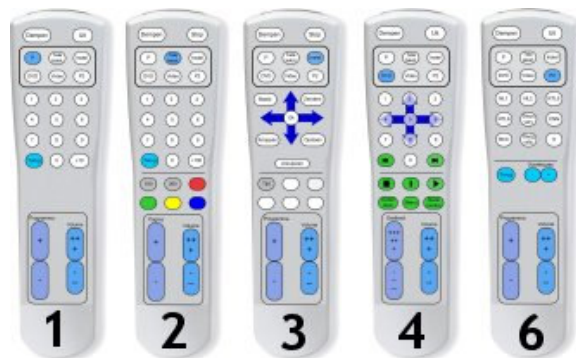


Figure 1

There are various fronts designed for the remote control with each its functions. Figure 1 above shows the concept designs in a small version. The larger versions of the concept designs are presented in the appendix chapter 'Concept remote control layouts', number 8.3. The numbers on the layouts who are added in black do not exist at the concepts; they exist to refer more easily in this paper. The front designs are:

1. Number one is called 'P', because of the abbreviation of the word 'program' and it is more often used in the same way. It stands for normal usage to control the television channels. It contains the preset channel numbers 0-9, a back button, volume control, power control, channel up and down control, and the default function block. The channel and volume controls are designed with sliders.
2. Number two is called 'Teletekst', as a Dutch equivalent of teletext. It has the normal 0 – 9 buttons for page control, a back button to return to the previous page and teletext coloured buttons for using presets, displayed at the screen. The page and volume buttons are designed with sliders.
3. Number three is called 'Instel', as a Dutch equivalent of setup. It has four buttons located at the middle part combined with arrow buttons for menu usage. This four buttons are accessing the properties: view, channels, buttons and save. The button beneath the arrow buttons is to cancel the made changes. There are some buttons available free to program. The sliders do not have a special usage here. We choose to give it channel and volume properties.
4. Number four is called 'DVD'. Nowadays everyone has a DVD player and the assumption is that this will be useful. The middle part contains scene or chapter control buttons, combined with arrow control printed beneath it. Using the DVD menu on the television screen, the arrows are useful. The green buttons are to control the DVD player. Functions as next scene, previous scene, stop, pause, play, subtitles, menu and playing mode are accessible. The playing speed and volume control are accessible with the sliders in the lower part.
5. Number five is called Video. This layout is not designed because it does not add much functionality and has common properties as the DVD player.
6. Number six is called 'P2'. Its functions are similar to number one, but it number six can be used to free program the channel buttons. Buttons can be renamed to match the channel name. It has also a previous and next button to change the channel pre selects; also a back button is added. The sliders are used to change channel and volume.

Some usability results from other researches show that it has advantages to keep an important design stable when using different functions. The designs we use change the middle part of the remote control the most. The function block in the upper part of the remote is the most stable; only the colors change to make clear what device the user is controlling. The buttons

above this block are sometimes alternating between power and stop, depending on the needs of the device. Next to this stop or power button a mute function is placed. The lower block of the remote is fixed, they contain the sliders. The changes in this part of the remote control are the different functions with the buttons: page control, channel control, speed control; depending on the teletext, television or DVD function.

6.7 User tasks

The users were given tasks to evaluate the usability of the remote control. In the appendix chapter 8.1.3 'Scenario' the precise and literal words used are given. In this paragraph a summary is given. Important to mention is that concept layouts number five and six were not tested at all. These are variations on the same idea and therefore do not add possible new important information to the user study.

In the introduction the user is explained the situation and background of this research project, without mentioning the new functions of the remote control.

The first scenario tasks are about controlling the television and trying to look at a teletext page without explaining how this should work. Also the user should mute the sound because the phone is ringing; this is to test if the mute button can be found easily and if the use of the volume sliders is intuitive. A subtask is to increase the teletext page number; the user can choose how to achieve this, typing the new number or using the page '+' button at the slider section are the two options.

The second scenario tasks are about changing the brightness of the television screen. The user should go to the setup section, front number 3, and use the proper button.

The third scenario tasks are about the DVD player, the user likes to see a movie that is already loaded. He should start the disk and after this has been done, the user has to go to chapter 7 of the DVD. Changing the subtitle and forward and reverse winding should be done. This is to test if the speed button in the slider section can be found.

The fourth scenario tasks are to stop watching DVD and program a button on the remote control, and a new channel on the television. After this is achieved, the tasks are completed and the questionnaire is done.

6.8 User questionnaire

The user questionnaire is used to make the ease of use explicit and to ask more ideas or improvements to the interface. This paragraph explains what the users were asked.

The first part of the questionnaire is to know the background of the user; the age, sex, education level and the frequency of watching television were asked. Also the ease of use of the remote control is asked, using a semantic differential scale.

The second part consists of an explanation of the intended usage. The slider buttons in the lower part and the variable placements of the buttons are explained. The questions that follow are to evaluate the functional differences, compared to a normal remote control the user often uses. Users were asked to give advantages of the remote control and why they use or did not use the slider buttons.

6.9 User tasks results

As presented in section 6.7, the user executed tasks. The buttons the user pressed on the concept remote control are written down to analyse the usage. In this paragraph an evaluation of the used buttons is presented. Seven users executed the tasks and filled in the questionnaire.

The subdue button in the upper part of the remote control was not always used when the user was told the telephone is ringing. Four users used this mute button and the other three pushed on the '--' area from the volume section. The 'terug' (or 'back') button usage is comparable with the mute button. Only two

users pushed that button, the others preferred pushing the channel number again.

The task to view teletext was no problem to any of the users. Even the users who never used teletext executed this task well and reached the proper page. When the next task was to go to the next page, only three persons used the '+' button at the slider section. The other four users typed again the three buttons to reach the next page.

The task to quit teletext was executed differently. Three users pushed the teletext button to exit the teletext section; two users pressed the stop button and two users used the P button. Sometimes a user needed some searching time to find the television mode again. When they made a guess, 'P' was used.

The task to change the brightness of the television executed well, all users pushed the expected buttons: first go to the setup mode and then press the 'view' button.

Viewing the DVD was no problem, the DVD button was found almost immediately after the task was given. Only one elder user pushed the 'power' and 'menu' button after the DVD. The next task was to look at chapter seven from the DVD; they could use different buttons for that task. Two users used the next chapter button ('>>|'), two used the menu button in combination with the arrow keys, two used the '7' button and one the speed button '++'. Forward winding of the DVD was done with the '>>>|' button by four users. Only two used the speed button at the slider section; and one user pressed the play button.

Switching between the DVD player mode and the television mode sometimes confused a bit, users were looking for a TV button, but only the P button exists. Six from the seven users executed this task without a problem; only one user did not know how to reach the television mode.

Powering the DVD player off caused some confusing also. One user wondered if the power button shut the whole system down or only the DVD player. Only two users pushed the stop button and switched to television, without powering it off.

When the user should program a channel on television, six from the seven users reached the setup mode and pushed the channel button also.

6.10 User questionnaire results

After the tasks were done, the users were asked some questions and their background information is written down. The first question is about the usability of television in general. This is important to interpret the feedback they give about our remote control. Six users judge the usability positive, one user neutral. The majority gave as reason the intuitiveness of the remote control, but not all the buttons are known, that is a drawback. For some icons the functions wasn't clear to the users.

Without explaining the meaning of the new buttons and functions, they answered the question how they judge this new remote control. Five users answered positive, one neutral and one very positive.

After the explanation was given about the full meaning of the buttons they were asked if they prefer this new remote control or their remote control they are already using. Except one person, six persons liked this new idea. The user who doesn't like this new remote control argued that he is not able to change channels without watching the remote control. In the future this could be solved using little edges around the three function blocks. The reasons from the users to use this new remote control are: using fewer separate remote controls, one instead of three or four; the functions of all the buttons are clear; the view on the buttons is easier, it is easy to find a function; it is easy to understand the buttons function because it is written on it in clear text; clear function separation, e.g. at the DVD front, all the functions are to control the DVD player, the same for teletext; faster to control the functions; more personalized to the

users needs or more customizable; infinite functions possible due to a dynamic layout; more devices controllable with one device.

Asking if they intuitively understood the function and usage of the slider section, they answered no. For the volume sliders, the most users thought that it is one button or one button with two press sections.

The users judged the change of buttons sections positive, for example when you change from television to DVD mode. It was more easy to understand and you see what you need. Changing the color within the different functions was experienced positive; the color was changed to green and therefore it is very clear what buttons you need when controlling the DVD.

The upper part of the remote control with the main control function were judged four times positive and two times very positive and one neutral. It is easy to find your way back and it is easy to switch between the devices. Two users doesn't understand the name 'P' on the upper left part. Replacing that name with 'TV' would make that a bit more intuitive, one user said.

An important part of the research is the evaluation of the slider buttons and how users judge this part. Three female users said no to this new function. They said that the speed of the sliders can be too fast, one of them doesn't need more speed and preferred one speed. Some comments about the slider is not needed for volume adjustments, but could be useful for channel changing or winding the DVD. They sometimes said to test the speed of the slider buttons first, before knowing to like it or not. Four users would like to use the slider buttons because of the speed.

They were asked for hints about the layout. One user said that he likes controlling the devices without looking at the remote control. If this remote is flat, this can be an disadvantage. Making a border from a few millimeters high could solve this. This could be done between the different functional areas so that the border could be used in different functional modes of the remote control. The other users did not mention this potential problem, but they also couldn't try the remote control as a working model, because it is a paper model.

6.11 Discussion of User Study

Overall, the user tasks were executed well. The users could find all the functions needed for the tasks on the remote control. The positive evaluation of the new remote control design is caused by a few main changes.

6.11.1 Fronts

The first change is about the different fronts used. Changing the display and button functions made it very clear what the buttons should do and what their functions are; no misunderstanding about buttons and their usage were experienced. Almost without any search delays, the DVD function and teletext function were executed. This is a major improvement compared to the normal remote controls. Due to the different and variable fronts, one remote control can replace different remote controls in a house, this is seen as an advantage also.

6.11.2 Textual buttons

The second change is about using text on the buttons instead of icons. The users explained that the icons are not always understood and this text placed on the buttons at the concept model is very easy to interpret compared to the normal used icons. The learning ability would improve using this text approach, because there is less to learn.

6.11.3 Slider usage

The third change is about the slider usage. The users did not automatically find out that the slider buttons used a semi-analog input method. They thought that every textual object is a button;

e.g. that the '+++' is a very fast forward button and '++' fast forward button, even when this functions are in the same border and color. After explaining the this new function, four of the seven users liked this feature. The three users who did not like it do not need the speed or were afraid it is going too fast. Probably previous experiences with such speed buttons result in such a presumption. How the users would appreciate this feature on a real remote control would depend on the implementation of the speed used.

7. Conclusions

Domestic appliances using gestures are not mainstream; household robots or a digital photo album are in the laboratorial state and currently in development. In section 5 we showed some ideas to control some appliances using gestures, but interfacing gestures into the machine is mainly achieved by touch sensitive surfaces, instead of controlling appliances at a distance. Due to the need of being close to a device this can't be avoided. The concept remote control for television and DVD player doesn't have this disadvantages. In this field the improvements can be achieved using gestures. The new remote control concept showed some advantages compared to the current remote controls available. Also this brings us to new ideas on improving the remote control and its usability.

In section 6.2 three different hypotheses were drawn up. We evaluate the hypothesis's here.

1. "A remote control with touch sensitive sliders will be easier to use compared to the normal remote control." About this hypothesis, we could conclude that it is not automatically easier to use, compared to the normal remote control. Users have to get used to the new way of using a remote control. Also more testing has to be done with working prototypes to get an impression of the usability in real. We used paper models only to get an impression of the expected ease of use.
2. "A remote control with variable placements of buttons will be preferred above a remote control with fixed buttons." It came out that the variable placement and the including advantages (e.g. localization of language) gives a great improvement on the clearness of the remote control and helps to separate the different functions. Users almost never made mistakes or have to search long for a function they needed. However, we didn't measure these search times and therefore more research has to be done.

Our user study compared concept remote controls only. New ideas were evaluated with the users opinion. Therefore user studies have to be done with working remote controls to achieve more reliable data.

7.1 Future work

The users evaluated the slider buttons with a comment about the speed of control. They mentioned to tune the speed control of the slider buttons very carefully to meet users wishes. If the sliders are controlling the speed too fast, it will be very annoying. More user studies should be done on the optimal speed of such sliders.

The stop and power buttons are unclear or confusing to some users. They don't know exactly what device they are controlling because the power button suggests to control the whole system, including the television. This thought did raise some questions about pressing the power button when the DVD player should be turned off. Future work could be done to investigate the consequent use of the power buttons.

More finger gestures could be integrated into the remote control. For example gestures to the right and the left side of the remote control could be added with new functionality. Pilots should be done to verify if the added functionality really increases the usability.

Better results could be accomplished if different remote controls are compared after a certain learning period. The normal push button remote control is integrated in normal life and often used. Therefore better comparable results could be expected after giving instructions about the new concept remote control.

It could be interesting for users to enable gesture controlling with the remote control as a whole. For example moving the remote control to the left or right while keeping it targeted to the TV. Other sensors and techniques are needed to convert movements into commands.

Despite of a search in the scientific resources, after this research was finished, more remote controls were found using touch sensitiveness. For example Philips ProntoPro NG TSU7000 [15] was found with a LCD touch screen interface. These remote controls could be used for more ideas or user studies in the future. They are not using the same ideas as the remote control in this research. Some differences are that our remote control only works with touch sensitiveness and also is it using the layout used from the regular remote controls, except the changing main group of buttons.

More user studies could be done to achieve more reliable data and conclusions. We only used concept remote controls and therefore we can only use the results to get an idea of the expected usability. We would prefer to do a controlled user study with working remote controls for a follow up.

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8. Appendix

8.1 User study tasks

Gebruikersonderzoek afstandsbediening

8.1.1 Inleiding

Ik heb een nieuw soort afstandsbediening gemaakt die ik wil testen op een aantal gebruikers. Het doel hiervan is het product en idee te evalueren, uw commentaar en tips worden op prijs gesteld, ofwel gewaardeerd met dank. Het product heb ik niet uitgewerkt in elektronica, maar in een papieren model. Dit model functioneert natuurlijk niet echt, maar ik kan wel vertellen wat de reacties zijn en u sommige gevolgen laten zien. Ik schrijf af en toe op wat ik zie in het gebruik van de afstandsbediening. Wat u nog moet weten over de afstandsbediening is dat de knoppen op het echte model ook plat zijn, ze zijn namelijk 'aanraak gevoelig' in plaats van 'druk gevoelig'. Soms geef ik u een nieuw frontje van de afstandsbediening, deze horen allemaal bij dezelfde afstandbediening. Het echte model kan dat zelf veranderen, nu doe ik dat. U test steeds dezelfde afstandsbediening. Ik geef u af en toe opdrachten wat u zou willen of kunnen doen, zodat de belangrijkste functies getest worden. U merkt het wel. Achteraf bespreken we hoe het gegaan is. U kunt verder niets fout doen, ik test het product, en niet u.

8.1.2 Context

De omgeving waar u bent is thuis in de woonkamer. Ik veronderstel dat daar een televisie staat met een DVD speler erop aangesloten. Als dit niet het geval is, mag u doen alsof dit wel zo is. We zijn nu thuis in de woonkamer en ik geef u de afstandsbediening. [papieren model overhandigen]

8.1.3 Scenario

1. De televisie en DVD speler staan uit. We beginnen met televisie kijken. U wilt de televisie op zender of kanaal 1 doen. Ga uw gang. [welke knop?]
2. Na een tijdje gekeken te hebben gaat de telefoon, u wilt daarom het geluid tijdelijk zacht of uitzetten, gaat uw gang. [welke knop?]
3. Na het telefoongesprek moet het geluid weer harder. [welke knop?]
4. We gaan nu naar zender 8. Nu willen we weer terug, hoe doet u dat? [welke knop?]
5. Nu kijken we naar NL1, het is handig om even het weer te bekijken. U weet dat dit kan op pagina 704 van Teletekst op de publieke omroepen. Hoe doet u dit? [welke knop? + wisselen afstandsbediening front]
6. Nu willen naar de volgende pagina gaan, dat is dus pagina 705. Hoe doet u dat? [welke knop?]
7. We hebben genoeg teletekst gezien voor nu. U wilt teletekst weer uit doen. Hoe doet u dat? [welke knop?]
8. We zien dat de beeldkwaliteit niet alles is, hij staat namelijk veel te donker. U wilt het beeld dus van helderheid veranderen. Hoe doet u dat? [welke knop?]
9. Nu gaan we DVD kijken. Er zit gelukkig al een toffe film in. U wilt de DVD aanzetten. Hoe doet u dat? [welke knoppen + volgorde?]
10. We zien nu dat u 1 maand geleden al de eerste 6 hoofdstukken of gedeeltes (scènes) van de film hebben gezien, u wilt naar hoofdstuk 7 springen. Hoe doet u dat? [welke knop?]
11. De ondertitels moeten ook nog aan. Hoe doet u dat? [welke knop?]
12. Dat is gelukt, nu moeten we weer verder kijken naar de DVD. Bovendien wilt u dan een stukje (1 minuut) verder spoelen. Hoe doet u dat? [welke knop? + letten op de sliders]
13. Nu willen we 10 minuten terugspoelen omdat we dat een mooi stuk vonden. Hoe doet u dat? [welke knop?]

14. We willen snel even kijken of het journaal al is begonnen op NL2 en daarna weer DVD kijken. [welke knop?]
15. De DVD mag nu uit, we gaan nu weer TV kijken. Hoe doet u dat? [welke knop? Uit of niet?]
16. We willen nu iets gaan kijken op de zender Talpa, die hadden we nog niet geprogrammeerd. Hoe doet u dat? [welke knop?]
17. Nu willen we ook een knop van de afstandsbediening veranderen. Hoe doet u dat? [welke knop?]
18. Daarna is het goed, we willen weer verder TV kijken. Hoe doet u dat? [welke knop?]
19. Het is mooi geweest. De TV mag uit. Hoe doet u dat? [welke knop?]

Bedankt voor het gebruik. Nu wil ik graag nog een paar vragen stellen hierover. Uw gegevens worden vertrouwelijk behandeld.

8.2 User study questionnaire

8.2.1 Vragenlijst

1. Naam:
2. Leeftijd in jaren:
3. Hoogst genoten opleiding:
4. Hoe staat u tegenover de gebruikersvriendelijkheid van de televisie in het algemeen?
 - a. **(erg negatief) -2, (negatief) -1, 0 (neutraal), 1 (positief), 2 (erg positief).**
 - b. Waarom?
5. Hoeveel uren kijkt u ongeveer naar de televisie?
 - a. elke dag
 - b. meerdere keren per week
 - c. 1x keer per week
 - d. 1x keer per 3 week
 - e. nooit
6. Vond u deze nieuwe afstandsbediening gemakkelijk werken?
 - a. **(erg negatief) -2, (negatief) -1, 0 (neutraal), 1 (positief), 2 (erg positief).**

8.2.2 Uitleg werking

Zoals u gemerkt hebt, kan deze afstandsbediening zijn eigen knoppen veranderen. Nu hebben we dat met papier gedaan. Ook is de werking van de volume en de programma knoppen veranderd. Hij kan namelijk langzaam of snel een functie vervullen, afhankelijk van de positie waar u uw vingers plaatst. De 'plus plus' locatie is sneller dan de enkele 'plus' locatie.

7. Als deze nieuwe afstandsbediening compleet zou werken, gebruikt u dan liever deze nieuwe afstandsbediening of uw oude? Waarom?
8. Had u begrepen dat de volume en programma knoppen om kunnen gaan met variabele snelheid? Ja / nee. Waardoor of waarom?
9. Toen u bijvoorbeeld van televisiekijken naar DVD ging, werden er grote groepen knoppen vervangen. Er kwamen bijvoorbeeld ineens pijltjes bij en nieuwe functies. Vindt u deze functiewijzigingen handig in gebruik?
 - a. **(erg negatief) -2, (negatief) -1, 0 (neutraal), 1 (positief), 2 (erg positief).**
 - b. Waarom?
10. Vindt u het bovenste blok met hoofdfuncties handig in gebruik?
 - a. **(erg negatief) -2, (negatief) -1, 0 (neutraal), 1 (positief), 2 (erg positief).**
 - b. Waarom?
11. Denkt u dat u de knoppen met variabele snelheid zou willen gebruiken? Waarom wel of niet?
12. Wat zijn de voordelen van deze afstandsbediening ten opzichte van uw standaard afstandsbedieningen voor uw TV of DVD speler?

13. Hebt u nog tips voor de nieuwe afstandsbediening, zo ja welke?
14. Als u één ding mocht veranderen aan deze afstandsbediening, wat zou u dan veranderen?

Dank u.

8.3 Concept remote control layouts

8.3.1 Layout 'P'



8.3.2 Layout 'teletext'



8.3.3 Layout 'setup'



8.3.4 Layout 'DVD'



8.3.5 Layout 'P2'

