UbiWheel: A Simple Context-Aware Universal Control Concept for Smart Home Appliances that encourages Active Living

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***Abstract*— Smart homes contain many useful appliances that can help individuals live independently for longer. A problem with current smart homes prototypes is that each device often has its own remote control or control unit. These control units are often manufactured by different suppliers with totally different and inconsistent user interfaces. This is confusing for most individuals and become a huge barrier for individuals with reduced cognitive function. This paper thus introduces a conceptual sketch of a universal and ubiquitous control wheel, termed UbiWheel that is designed to control most appliances in the home. The user simply moves the controller to the proximity of the device be controlled and adjust parameters by simply twisting the wheel, thereby preventing inactivity as the user need to move around the home. Several cases are explored herein.**

Keywords—universal remote; smart home; context-awareness.

I. INTRODUCTION

Although the idea of smart homes is decades old [1, 2] the interest in smart homes has increased in recent years [3]. On one hand, governments need to cut spending on welfare services as the ratio of old people in society are globally increasing and the current welfare and health services are not sustainable. By empowering older and disabled individuals to live independently for longer without the need of the welfare system, huge savings can be made [4]. Contrary to some users reported perceptions [5], people's ability to live independently and freely is likely to give them a more dignified and happy life which, again, is believed to benefit health.

A smart home is a living space equipped with technology intended to assist inhabitants with daily activities to reduce the need for intervention by healthcare workers. In practice, a smart home, such as the one built in this study, is composed of various technologies from a range of manufacturers. Each particular device usually come with its own remote control or control panel. The design of these controls usually follow different conventions. A common problem in many homes is that there are too many remote controls, for example remotes for the TV, satellite tuner, DVD-player and the radio. Our interviews with smart home users revealed that some had six remotes in the kitchen. It has been reported that users in the target group are skeptical of the usability of remote controls in particular [6]. Although such remotes are similar, they have often certain small unique traits that greatly affect usability. Even to select the right remote can be a challenge, let alone know what buttons to press for a particular function. Again, if one add remotes for the air-conditioning unit, lights, etc., the number of remote controls is unmanageable in practice.

The control of complex appliances with simple remote controls has receive some attention [7]. The problem with many remotes is well-known and several innovative methods have been proposed such as laser pointers [8], gestures [9] and wrist worn controllers [10], in addition to commercial universal remote controls. One key problem with universal controls is that they often rely on mode, where the user needs to select a particular mode to control a particular device. Modes can be challenging for users. Touch based remote controls [11] have become increasingly common yet touch based displays can be difficult to use [12, 13, 14]. Moreover, often obscure icons are used with small writing. Touch devices also have limited tactile feedback. The technical challenges of allowing general devices and controllers to discover each other and work without manual configuration has also received attention [15] and ISO/IEC FDIS 24752 is a standard for remote control user interface interoperability.

More recently, smartphones are increasingly used as universal remote controls [16] as many manufacturers allows their devices to be controlled via smartphone, or even totally rely on smartphones.

This study therefore explores UbiWheel: a universal remote control for controlling smart home devices. However, unlike traditional universal remote controls, UbiWheel is only one control, that is, it can only control one parameter at one time. However, through context awareness and proximity it is possible to control several parameters. The remote control therefore needs to be located close to the device in which it is to control and hence encourage the user to move around the smart home, unlike traditional remote controls that keeps the user passive. The UbiWheel does not rely on selectable modes. It provides direct parameter manipulation with haptic feedback.

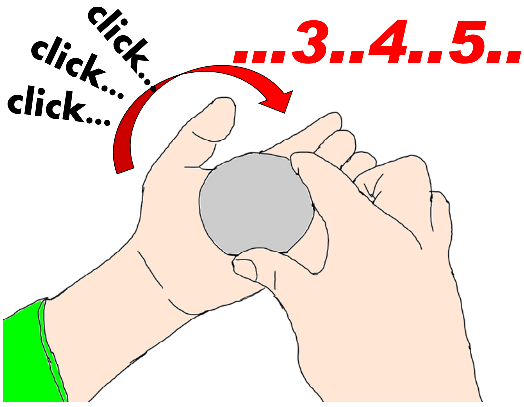

Fig. 1. UbiWheel operation: rotating the wheel

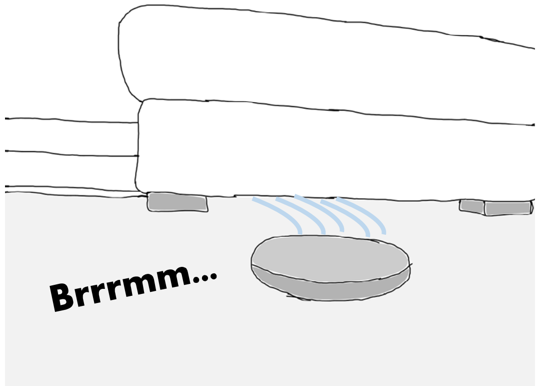

Fig. 2. The controller re-emerges from underneath a sofa after being dropped.

Fig. 3. Turning on a light.

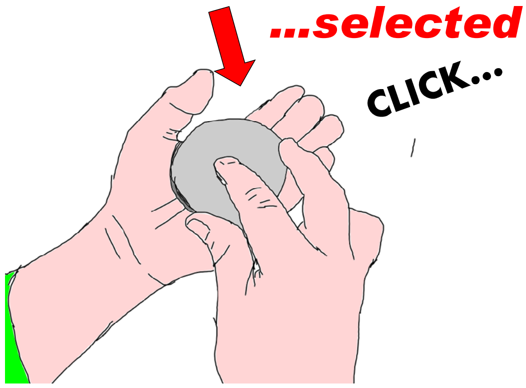

Fig. 4. Making a selection.

II. UBIWHEEL

UbiWheel is a small disk shaped controller (see Fig. 1) with the appearance of an ordinary physical dial [17]. A physical dial is intuitive to use as it is either twisted left or right and the state change is directly observable [18]. It is approximately 5-10 cm in diameter and 1-2 cm thick. Unlike traditional dials that are attached to a specific device for controlling parameters such as the volume of a radio, the UbiWheel is not fixed to any device. Instead, UbiWheel is held closely to various items in the smart home, similar to how RFID can be used to interact directly with services [19, 20, 21]. Depending on which istem is in focus UbiWheel controls parameters for the given context.

UbiWheel has a display in the middle that shows context specific feedback. It also shows what context UbiWheel is in. The display remains upright irrespective of the angle of tilt.

It has been argued that haptic interfaces can benefit universal remote controls [22]. UbiWheel therefore provides tactile and audio feedback, allowing the user to feel the steps as the ubiquitous wheel is turned clockwise or anticlockwise. The tactile feedback [23] is provided vibration and audio.

The controller is also equipped with the ability to move by the means of small wheels. If the user accidentally drops the controller and it falls into a dark and hard to reach place such as beneath furniture, UbiWheel will drive out from beneath the furniture and back to the user (see Fig. 2). The device is thus designed such that it cannot stand on its side, but tip down to one of the flat sides such that it is capable of moving on the floor or other areas.

This study focuses on the concept of UbiWheel, through a series of sketches [24], and not the actual implementation. However, one can imagine UbiWheel to be implemented in several ways. One approach would make UbiWheel communicate directly with devices via wireless network protocols such as ZigBee and hence also allow UbiWheel to detect the devices in its close vicinity. Alternatively, it could be built on top of an existing smart home infrastructure where UbiWheel communicates with a central smart home control unit that relays control signals and feedback states and where some indoor localization strategy is used to determine which device to control. Alternatively, UbiWheel could be implemented as a hybrid mixture of a peer-to-peer and a centralized system.

III. CONTROLLING DEVICES

The basic idea of UbiWheel is to control key characteristics of devices. For instance, to turn a light on, off or set it to a specific dimming level the user walks over to the light to be controlled. This can be considered a form of proxemic interaction [25].

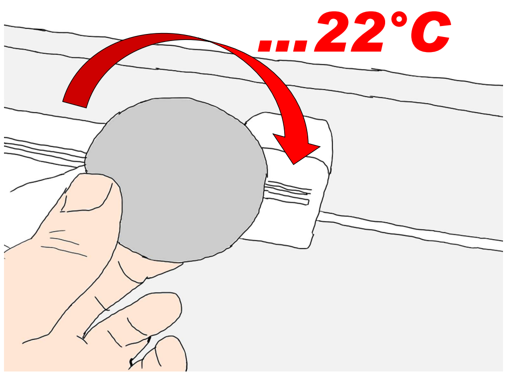

Fig. 5. Controlling a thermostat.

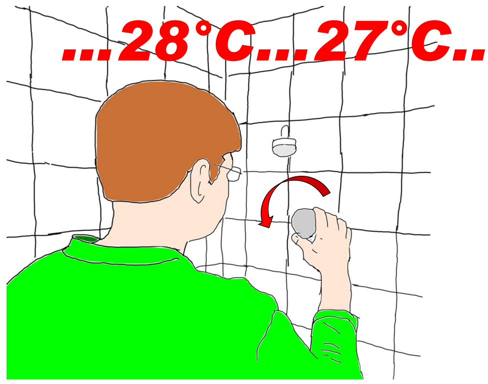

Fig. 6. Controlling the shower temperature.

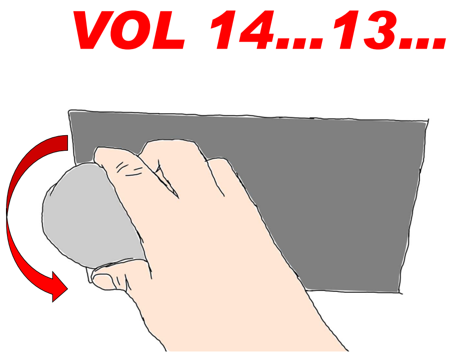

Fig. 7. Controlling the TV volume.

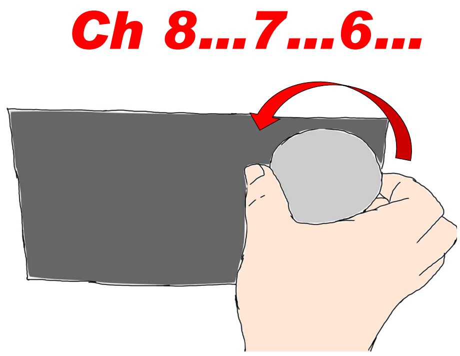

Fig. 8. Controlling the TV channel.

Once the light is in range, the controller makes a sound and provides a tactile cue to signal that the device is in range, in addition to displaying confirmative information about which device is controlled in the given context (see Fig. 3). Next, the user turns the wheel clockwise to turn on the light, or anticlockwise to turn it off. The user can immediately confirm the desired effect by observing the light state change, while additional feedback is displayed on the control. Note that the wheel can be controlled with one hand by holding the wheel in the air with two or three fingers (see Fig. 3), or it can be controlled with two hands where one hand is used for supporting the wheel, while the other is used to turn the wheel (see Fig. 1). To control a different light, the user moves from the current light towards the other light to be controlled.

To make a phone call the user walks to the phone and pick up the handset. Next, the wheel is placed close to the handset, or on the handset, and the wheel is rotated to scroll through the list of contacts. Once the name and picture of the desired contact is displayed, a call is placed by pressing the center of the wheel (see Fig. 4).

In a similar manner, the user control the thermostat by moving to the heater or the air-conditioning unit (see Fig. 5). Once the unit is in range, the wheel is turned clockwise or anti-clockwise to adjust the temperature. The given temperature is displayed on the device as the wheel is turned.

The watertight wheel can also be taken into the shower and used for controlling the water temperature (see Fig. 6). Once controller is in range of the shower, it is started by pressing the display and the temperature is adjusted by turning the wheel. Once the user leaves the shower or drops the device, the water is switched off automatically or the water is stopped by pressing the display on the wheel.

Certain devices have several controllable parameters. For example, the two most commonly accessed parameters on televisions and radios are the volume and channel. One approach for distinguishing between volume and channel is to control the volume by holding the wheel on the left side of the screen (see Fig. 6) and control the channel by holding the wheel on the right side of the screen (see Fig. 7). This convention would match that found on several remote controls.

Another example is to use UbiWheel for cooking. To start a cooking top, the device is placed on its surface close to the cooking pot (see Fig. 9) and the desired setting is selected by turning the wheel (see Fig. 10). This is similar to the Neff twist pad (see http://www.neff.de/twistpad%C2%AE.html). To adjust the cooking temperature of a different pan, the controller is simply moved close to a different cooking zone (see Fig. 11) using direct mapping [26]. If the user picks up the wheel from the cooking top, the cooking top is automatically switched off. Users with cognitive problems such as concentration difficulties or reduced memory will thus not be able to leave the cooker in a dangerous situation. Personal safety is of utmost importance in a smart home.

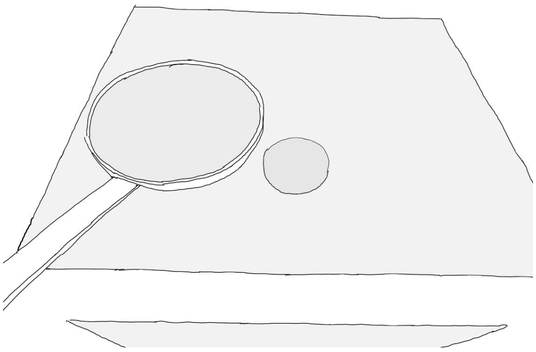

Fig. 9. Selecting a cooking zone.

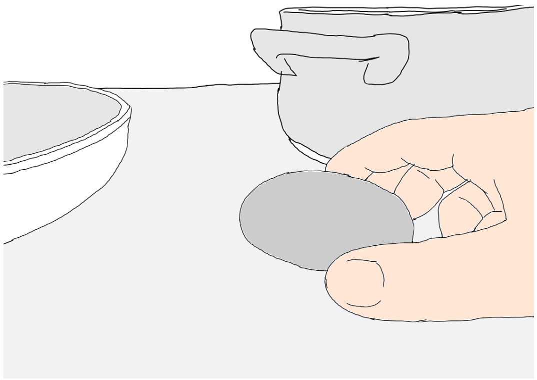

Fig. 10. Adjusting the cooking temperature.

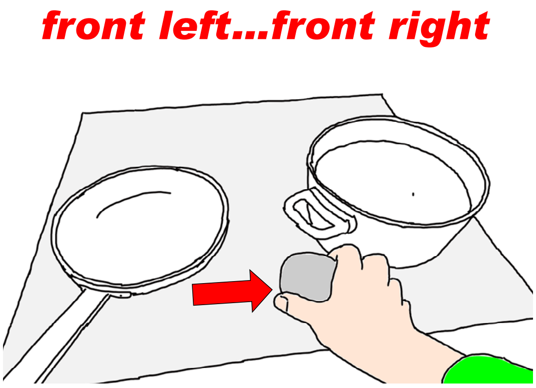

Fig. 11. Controlling different cooking zones by moving the controller.

IV. Persuading Activity, Promoting Health

Unlike remote controls used for controlling devices from one location, the UbiWheel only works if the user moves to the vicinity of the device to be controlled. One may claim that this is a disadvantage for individuals with reduced mobility. However, it is argued herein that technology that encourages and persuades users to be physically active promotes health, which is one of the goals of persuasive technologies [27, 28]. For instance, when turning on a specific lamp, the user must move over to the lamp and hence getting out of his or her chair and thus gets a small bit of exercise.

When summed up during the day, the UbiWheel is intended to lead to more activity than a traditional remote control. Still, UbiWheel eliminates the problem of accessing controls and switches located in awkward-to-reach places and reduces the cognitive load [29, 30, 31, 32, 33] associated with knowing several interfaces. One may hold the position that learning different interfaces trains a user's cognition. Exercising one's cognitive abilities is indeed very important, however, there are probably better ways of achieving this goal [34] such as memory games, practicing foreign languages, listening to music and watching photographs.

It may also be possible to introduce gamification into the smart home [35, 36, 37] using the UbiWheel with the objective of increasing the users' physical activity. A game can be set up for the entire smart home comprising an array of smart devices. This could for instance be achieved through a type of treasure hunt, where the user is given various hints by the smart devices in the home and led from one device to another in order to solve the mystery. This allows the physical activity of the user to be controlled and thus increased, while the user has fun and is activated.

V. Discussion

This paper has presented a concept for universal control of devices in a smart home. The focus is on the user and the interaction and it is not the intention of the authors to focus on the actual technological implementation. The main purpose is to raise a debate on what type of interaction one actually wants in smart homes. Future design decisions should not be affected by current technological hurdles and limitations.

The notion of a wheel that can be rotated is attractive compared to button or key-based interfaces where a user may have to repeatedly press a set of keys to activate the desired function [38] by scrolling through menus [39]. The continuous hitting of keys can be strenuous and a particular challenge for individuals with reduced motor function. Moreover, the tactile feedback and the turning motion means that UbiWheel may hold potential for individuals with low vision [40] or no vision [41] as it does not directly rely on visual feedback which is essential in interaction designed for individuals with reduced vision [42, 43, 44, 45]. This is especially relevant as individuals vision typically degrade with age. Challenges related to text color contrast [46, 47, 48, 49] and reading and interpreting text [50, 51, 52] is also eliminated when reducing the reliance on the visual channel.

The next step in this work is to set up an experiment to assess whether users in the target group are actually able to control appliances with such an interaction style and how they respond to the idea in terms of comfort and preference. Such experimentation can be achieved by creating a concept prototype that gives the user the perceived experience of a working system. It is thus not necessary to implement a fully working system to gain such insights about how users will take to this form of interaction.

Clearly, there are many unresolved technical issues that needs to be resolved in order to make a fully working prototype. For example, should one put wheels on both sides of the controller, or somehow use a shape that ensure it always falls on the right side? How will the controller know which direction to drive when it has fallen below furniture? How does a device know it is on the right or the left side of a TV set? How should one overcome device interoperability and lack of common interfacing standards? These and other issues need engineering solution which is outside the scope of this work.

VI. Conclusions

The UbiWheel universal remote control concept was presented. The device comprises a mobile user interface control, namely the wheel that the user carries around the smart home to control various devices depending on the context given by the users' proximity to the various devices. Future work involves creating a concept prototype and perform evaluations with users to verify if UbiWheel is as practical as theory suggests.

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