Shapeshifting Appliance with Morphable Display

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The shapeshifting appliance (SSA) combines the versatility of mobile devices with fit-to-purpose appliances like digital cameras. The key to this is its ability to morph dynamically into a shape that is defined by the current application. The core concept is the ability of the display to morph its surface to the desired form. Apart from the concept and the required technologies, we will also discuss, how present WIMP technology can be adapted for such a device.

1. Motivation

Improvements in display technology enable new kinds of design. Especially striking is the virtualization of input facilities. I.e. input devices like mouse or buttons become simulated by touch sensitive displays. Another development may be that displays dominate the design of appliances. In extreme cases appliances may consist just of displays.

What do we get from those developments? The domination of display technology could help us to fit the design of an appliance more to its current use. E.g. if the user makes a call, the device is turned into a cell phone; if she or he is browsing the internet, the device becomes a browsing device.

Current touch sensitive technology is not sufficient in terms of usability as it is 2D only. Physical 3D input elements deliver a much better look and feel. This means we are looking for a device, which is able to change its form.

In this document we will discuss how such devices are composed and how user interfaces have to be adapted to handle the new capabilities. Additionally, the realization of such devices is investigated. Particularly, the results of a simulation are presented.

A remark to history of this paper: The first ideas for such a device were sketched in 2004. Then, with a view on the PDA technology at that time. The first draft mainly covered the concept and the sections on realization and the user interface. Later (in 2009), the simulator was written. Then, an attempt for an patent application was made (in 2010), which also included the widgets. Due to [1] the plan for it was dismissed. In 2013 the present version was written.

2. Concept

We propose a shapeshifting appliance (SSA) as follows (cf. Figure 2.1):

- the device consists of a skeleton
- the skeleton is covered by surface elements (SE)
- each SE is covered by a display - also called display element (DE).
- each SE can be moved below or above the default level by a certain degree (the difference between the minimum and maximum height of the SE)
- each SE is touch sensitive; additionally it may pressed down somehow - if it is configured to do so. Such a SE will also call an input element (IE).

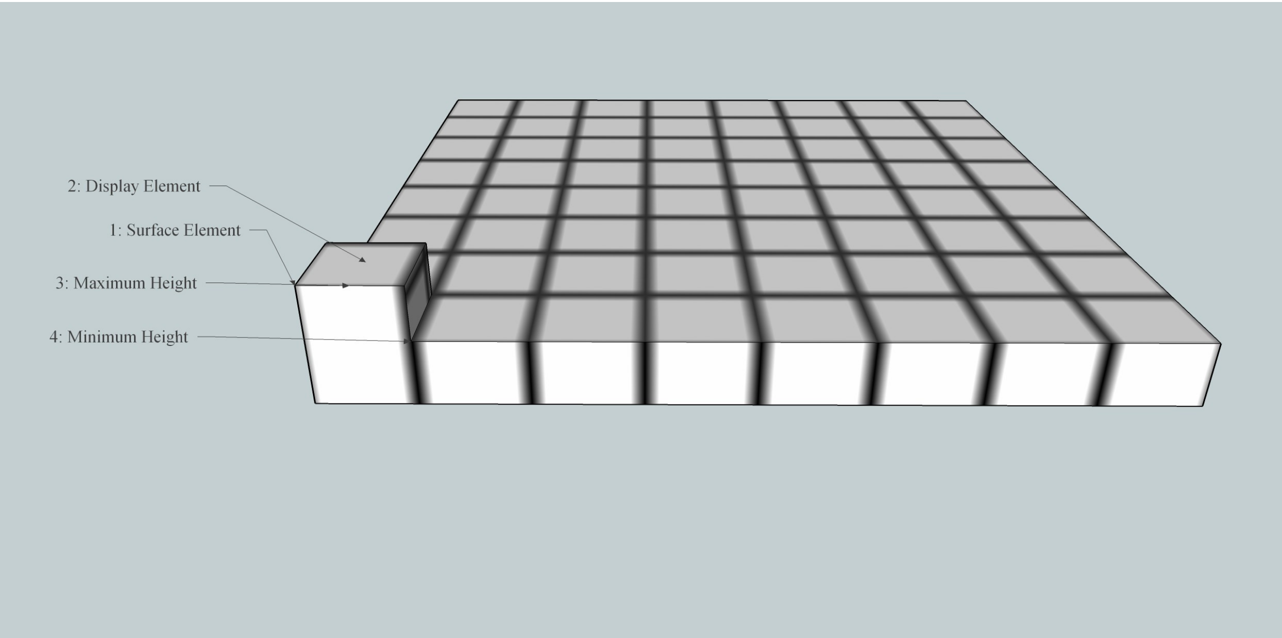

Figure 2.1: A surface of the SSA

This specification gives us an appliance which can be closely shapeshifted to the current use of the device. Since the essential element is the ability modify the surface of the display, we will call it a morphable display or a relief display ([1]).

Note, that the surface may be flexible like a pelvis to keep the surface intact. The device may have additional i/o connectors (e.g. audio i/o, lan, ...).

Now, we will show, how typical widgets of a GUI can be realized. In Figure 2.2 a button is shown. All SEs which are part of the button are raised. If the user presses the button, all those SE are lowered.This means the system is reactive to the user's input.

This even more apparent in the case of a toggle switch (Figure 2.3). when the user presses the two highest areas of the switch, they are lowered. At the same time, the two lowest areas of the switch are raised.

A slider (Figure 2.4) consists of the slider, a raised area, and the sliding area. The movement of the slider is realized by first lowering the raised area and raising the adjacent area in direction of the movement. This is repeated until the user stops or the end of the sliding area is reached. Quite similar is the turning of a control dial (Figure 2.5). Here it is realized by a slider which can be moved in a circle.

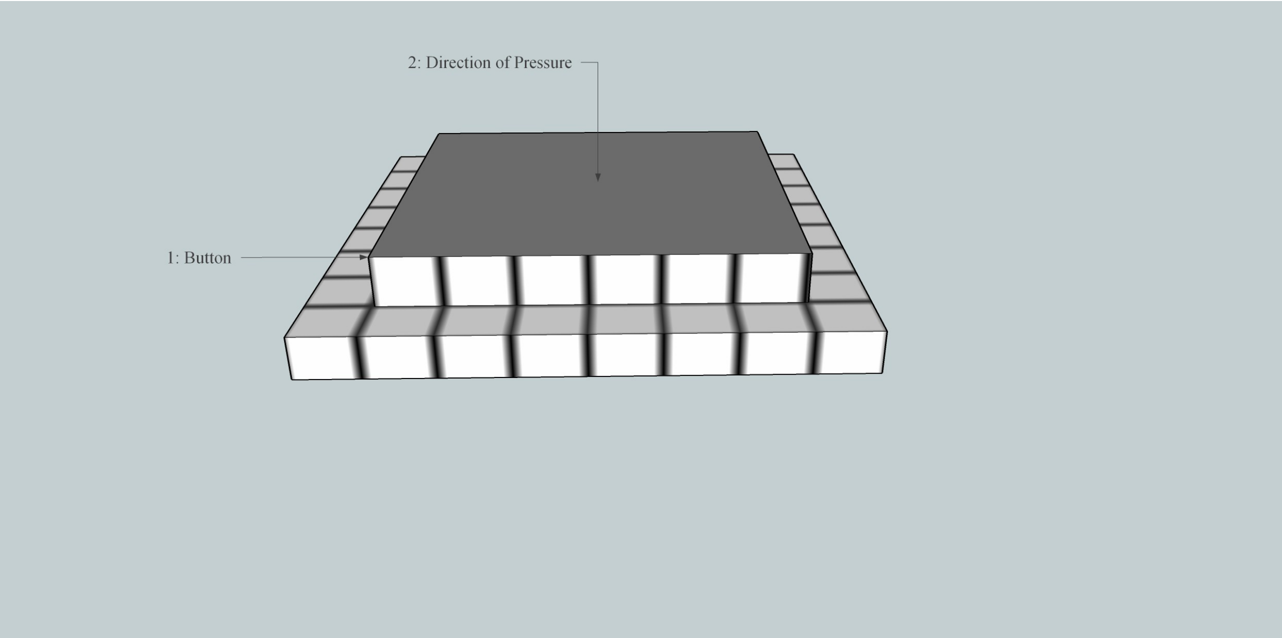

Figure 2.2: A Button

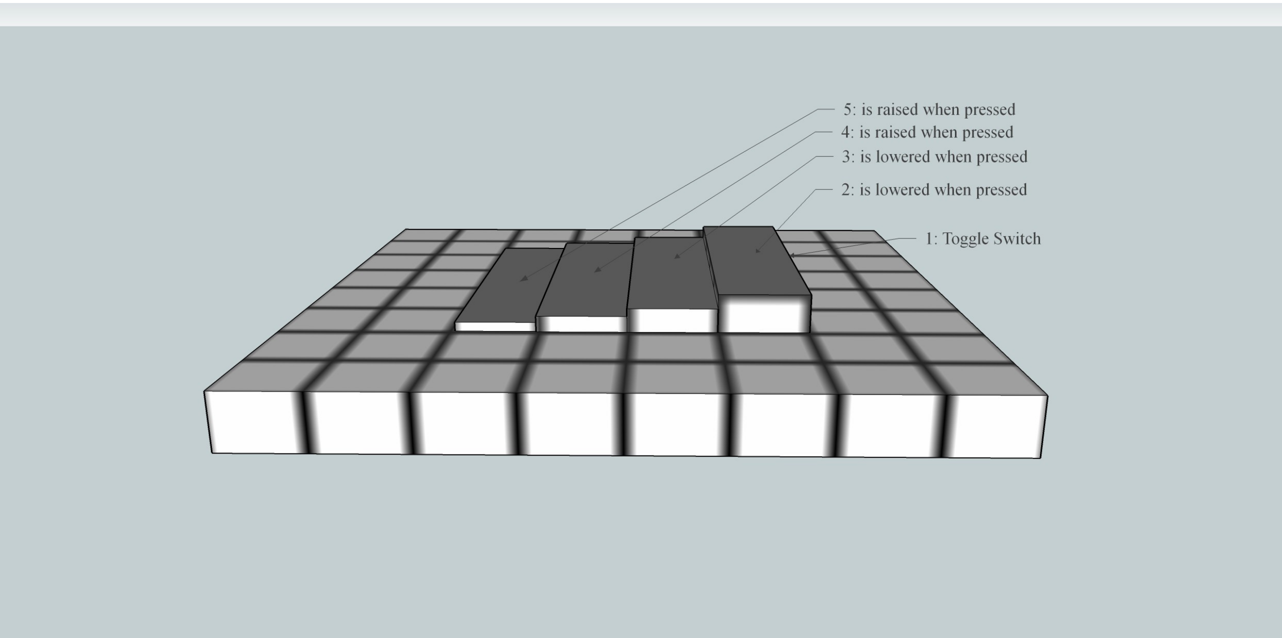

Figure 2.3: A Toggle Switch

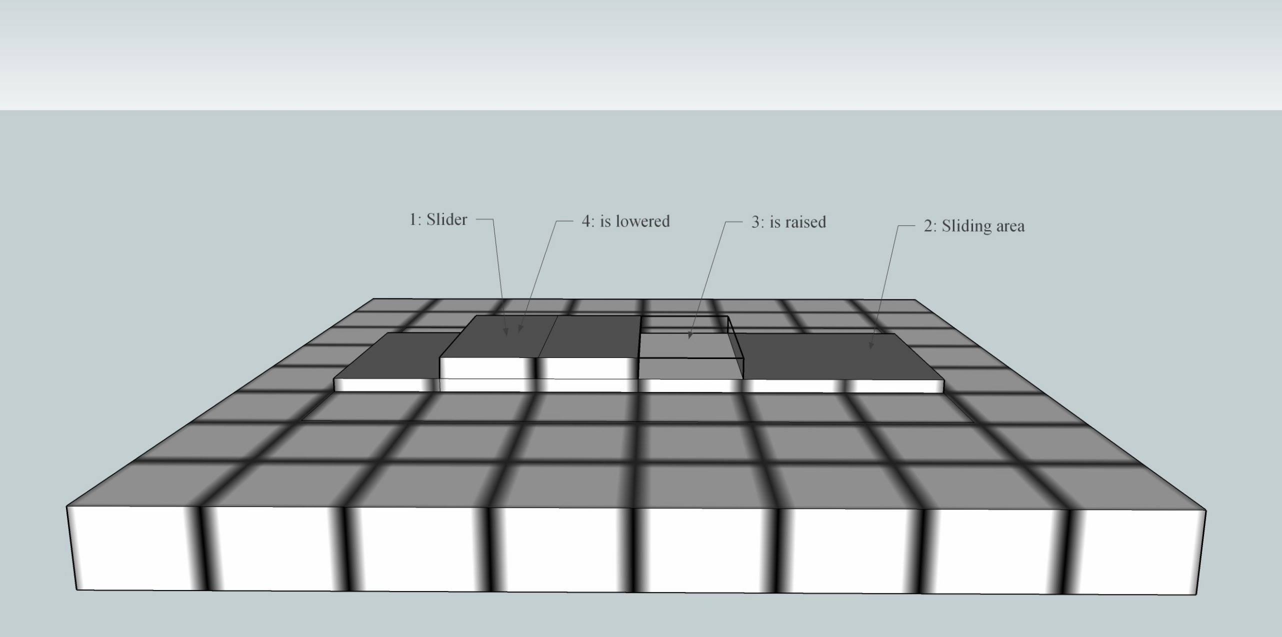

Figure 2.4: A Slider

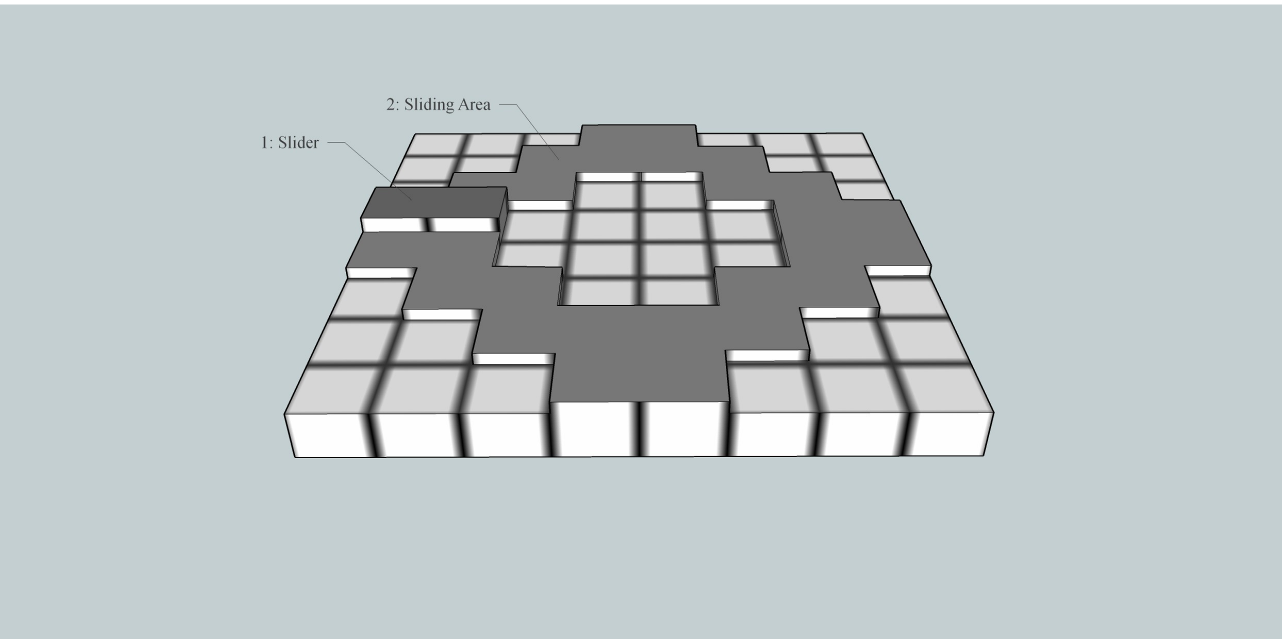

Figure 2.5: A Control Dial

3. State of the Art

3.1 Smartphones

Presently, mobile devices like smartphones or tablets use touch displays. The user interacts with the device using a pen or his or her finger. Touching here means that a place on the screen is pressed and the device then reacts to this action. Present devices typically react to multiple touches at the same time. Also gestures like swiping or pinching are supported, which extend the GUI from desktop computers.

While this approach combines the visual presentation of the user interface with the input facilities, it lacks a dedicated representation of input elements. E.g. buttons just have a visual representation, but do not have a 3D structure. This is similar to arts where sometimes surfaces are just painted to create a 3D effect - instead of shaping the surface.

The main drawback is that such devices lack a decent haptic feedback – even if a rather unspecific vibration is given. A may also be noted that whole display surface is mostly active though no not all applications require the full display.

3.2 Flexible Displays

In the recent years new kind of displays are developed which are thinner and much more flexible than conventional displays (particularly OLED displays). Additional, they possess also the ability to keep the displayed content.

While these kind of displays could be basis for the SSA, they still lack the ability to extend the display. Maybe the displays can be adapted to the requirements needed for the SSA.

3.3 Multiple Displays

Workstations and PCs support multiple displays for quite some time. A typical configuration is the placement of the display areas on a 2D surface. But, virtual reality installations also use 3D structures (e.g. The user is placed inside a cube where the walls show the various displays [4]).

In the area of mobile devices, also approaches exist to use multiple displays for a mobile device (e.g. [6] and [3]).

The SSA shares the idea of considering the topology of the devices for the user interface itself. The core of the SSA is the morphable display. There is no need to have multiple displays provides its peculiar functionality. Still, it has to be validated that a device, where all its surfaces are displays, is really useful.

3.4 Morphable Robots

For quite a number of years robots are discussed, which are able to assemble themselves or to reconfigure themselves in terms of their shape (e.g. [5]).

These robots could not really serve as a basis for the SSA as they not designed to serve as a visual input system. But, they are interesting with respect to the aspect on how to represent shape and to how organize a shapeshitfing process.

3.5 3D Printing

Another technology which is on the rise is 3D printing. The analogy to SSA is that you can create any physical form much more rapidly than with conventional forms of engineering. Currently, 3D printing is limited to producing shapes. And the result is fix: it is not able to change its form again.

3.6 Morhpable Displays

The most similar approach known to the author is described in [1]. They call the display a relief display, which has like the morphable display in this paper the ability to raise and lower a display surface with haptic abilities.

[2] claims to have realized a touch sensitive display, which has the ability to raise its surface using fluids.

4. Applications

Next, typical use cases for mobile devices are discussed. The list is not exhaustive. It shall only demonstrate how the SSA can be used.

4.1 Communication

When a user does a call, we can distinguish between the following (simplified) states:

1. The number of the called person is entered.
2. The callee accepts the call.
3. A dialogue is performed.
4. The call is terminated.

In this case nearly no DE are needed - except some status data. This means nearly all DE should be turned off to save energy. Additionally, IE are mostly needed to dial the number. Special IE may be used for often called numbers. During the dialog, only an IE to finish the call is needed.

4.2 Writing a Message

When the user is writing a message (e-mail, SMS or instant message) a rather large display and also a high number of input elements are needed.

But, it is possible to make an optimization – as it is already done in smartphones. During writing more IE are needed; the display can be reduced as the user focuses on a small area. When he or she is browsing the written text, the number of input elements can be reduced and the display area be increased.

4.3 Playing

For games a large display is important. Usually, only a small number of IE is configured. Note, that the IEs may be mode dependent.

4.4 Browsing

Again a large display is needed. The IEs can be integrated in the displayed HTML page (links and navigation buttons). The flip side of the device may be used to show a second page.

4.5 Listening of Music

For listening music no display is needed - except some status information. Some fix IEs are needed to control the application.

4.6 Watching a Video

For watching a video a large display is essential. Some IEs may be used to control the application.

4.7 Navigation

For showing a map the full display is needed. Additionally, a small number of IEs help to control the application.

4.8 Discussion

The non-exhaustive examples above showed, that there the following types of applications:

Application Type	DE	IE
Presenter (e.g. video player)	Many	Few
Non-visual (e.g. music player)	Few	Few
Highly-interactive (e.g. browser)	Many including several screens	Few to many

This means, the configuration has to consider application type:

- Device Layout: The device layout is about how to set up a SE. For this, we have to specify the configuration of its IEs and its DEs. The IE can be disabled, can act as a touch screen or can act as a button. A DE can be switched off, set to some static content (if useful for display type) or be dynamic. A combination of DEs and IEs makes sense (e.g. the IE can be set to the label of a button).

- Energy Consumption: As especially DEs consume a significant amount of energy, the designer should switch off all elements that are not needed - even dynamically. Additionally DEs should be switched to the static mode - if this has an advantage because of the display technology.

5 Implications for the GUI

5.1 WIMP

If we want to reuse the WIMP model, the WIMP configuration has to be mapped to the display configuration.

The WIMP model is based on the desktop metaphor. It uses a rectangular desktop on which windows as representations of applications are placed. Basically all graphical elements have rectangular shape, which also simplifies the rendering of them.

Regarding the SSA, 2D shapes, but also 3D can be considered. We will restrict the possible shapes to forms which can be easily mapped to the WIMP model. I.e. We will discuss rectangle, loop, cuboid, cylinder, and torus.

Rectangle
The mapping is straight-forward. It is only necessary to specify an order of the DE so that form a rectangle. (Basically, this is already done by current WIMP systems to support multiple displays).

Loop
This is like the rectangle only that two sides are joined together. There are two kind of joins: regular join and moebius join (a moebius loop is formed). In the first case the coordinates of the axis which is orthogonal to the join are kept constant when passing it. In the second case they become mirrowed. For handling the passing of the joint support by the WIMP system is needed.

Cuboid
Here we have six different surfaces, which have to be treated as six different displays. It might be useful though to specify the topology of the displays. Each surface is a rectangle which can be treated as discussed above.

Cylinder
As we decided to restrict the shapes which consist of rectangular surfaces, only the main body of the cylinder is available for display. This main body can be considered as a loop with a width that corresponds to the length of the cylinder.

Torus
In a torus all sides are joined together in a regular manner. We need support from the WIMP system for passing the joints. Nevertheless, the basic form is a rectangle.

While a shape like rectangle or cuboid currently seems more likely for an SSA, also the other shapes are interesting when mobile devices move to new areas like clothing, furniture or buildings.

5.2 3D WIMP

Described above was an approach that is based on WIMP. This has the big advantage, that current applications could be run on the SSA without significant changes. We will discuss now a model that fits better to the 3D nature of the SSA. For the sake of simplicity, we will assume that the SSA has the shape of a cuboid.

A 3D version of WIMP could simply mean that the shape of the SSA is taken as the basis, i.e. the desktop becomes a box into which the user is looking.

In a similar fashion also windows become threedimensional. They can be mapped to boxes, where each surface provides a different view on the application. Other graphical elements can still retain their 2d nature.

Pointing may be surface based. This means for each surface a different pointing state is maintained.

In this approach the perspective is as it is in WIMP. Also a perspective with a central projection can be used, but would mean bigger changes to the GUI. Especially, pointing is a problem in such an approach.

5.3 Physical WIMP

An essential part of the SSA is its ability to change its shape especially regarding the input functionality. How do we add this ability to the WIMP model?

In general, the SSA could adapt to the GUI. This means the surface could be changed to imitate for instance a form. Additionally input elements like buttons can become physical.

Current applications could easily take advantage of the physical GUI as the underlying WIMP system would be responsible for the configuration.

Even better are custom input elements which are optimized for some particular input.

A simple example could we would like to optimize the use of the SSA as a camera. If we would like to take a picture, the SSA would take a form so that we can hold it firmly on our hands. A preview area would be shown where we put the eye. Additional,some IEs would be needed for controlling the zooming, taking a picture or modifying the camera settings. In the viewing mode, the SSA would be flat with maximum display size. Finally, in the transfer mode only a small area is needed to indicate the transfer status.

6. Realization

Regarding the required technologies the realization of an SSA is still a research issue. [2] seems to have realized a relief display. The author has realized a simulator of an cuboid SSA, which demonstrates the interaction but also the implications for the software.

6.1 Dessa – A Simulator of the SSA

Dessa is a simulator of the SSA, which was developed by the author. It consists of the following elements:

- Model: The model consists of the basic shape of the appliance (its skeletion), the specification of the SE (size and distribution) and state of each SE. The state of a SE

consists of the configuration of the DE and the IE. Both parts are of course dynamic.
- Viewer: The viewer renders the device based on the given model. A particular issue is how the UI is mapped to the SE (cf. above).
- Control: Finally, the user is able to manipulate the viewpoint. This includes a free rotation in all three direction, movement and zooming. Additionally, the IEs of the device may be utilized.

The demonstration implemented a cube and a number of simple applications, which are shown in Figures 6.1 – 6.3.

The demonstrator showed that the GUI of applications can be extended with minor efforts to the new kind of GUI (actually with no extra effort if standard widgets are used) . The actual look and feel could only be partly evaluated since the simulator is rather limited in the simulation of a touch (the simulator is operated with a mouse).

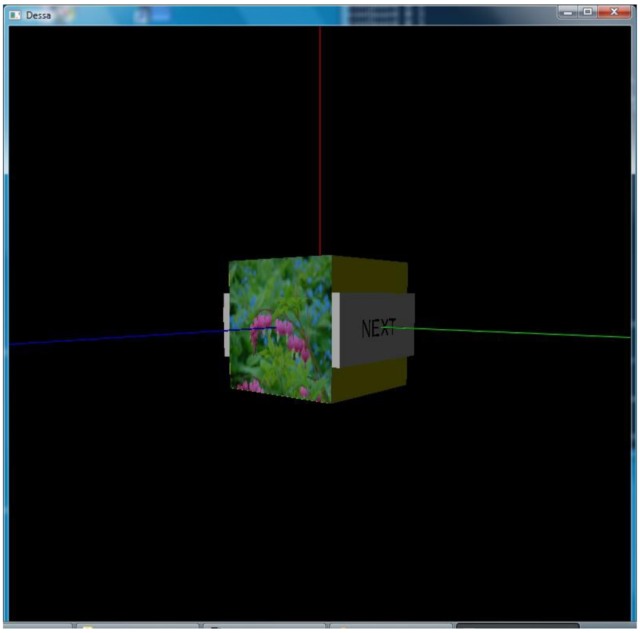

Figure 6.1: A picture is shown together with two buttons; all displayed on different surfaces

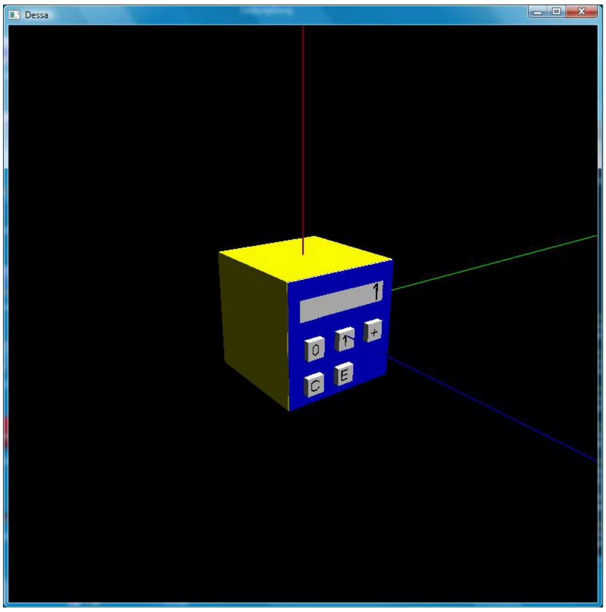

Figure 6.2: A simple calculator

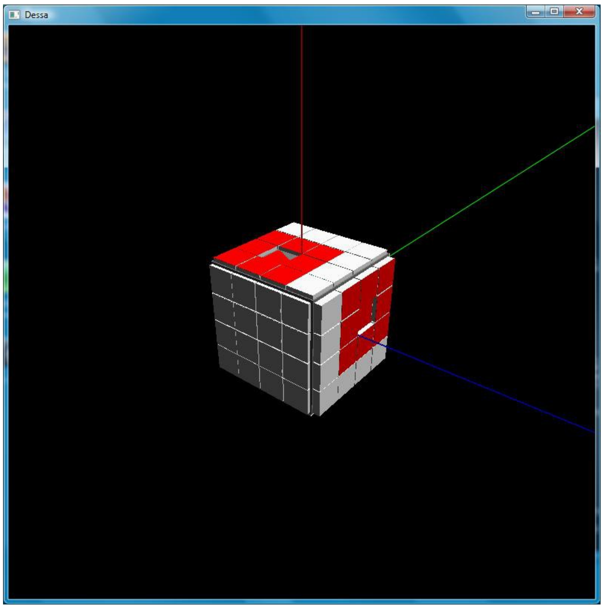

Figure 6.3: A game which covers the surfaces of the cube with buttons

7. Conclusion

In this paper we discussed a device which uses recent developments in display technology to provide more adaptive input and output capabilities. It achieves this by reconfiguring its input and output capabilities and its shape. It is noteworthy, that particularly the combination of those qualities gives the device its flexibility. This has big advantages in usability and energy efficiency. But, this device is currently not easily achievable because of technological limitations.

Also the configuration of the device is still an issue. Current WIMP may be reused. Still other appraches which are more adequate for 3D displays shall be investigated.

Regarding the technology for the SE, it is currently unclear, whether those SE need to be very fine grained with lots of SE or if a coarse grained approach is sufficient, where only a few SE are needed. Clearly, the critical part are the shape-shifting abilities of each SE. Also alternatives to touch-sensitive input may be considered (e.g. how can be joystick realized with such IEs?).

Apart from using the SSA for mobile appliances, the technology can easily be adapted to other areas. For instance, it may also control the use of display technology for cloth or walls. In the first area, it is assumed that display technology will be used for enhance clothes (decoration and body climate control). The other area is interior design. Large scale displays would cover walls. This would improve decoration and light control.

The SSA is clearly a new kind of computing device, which demonstrates how computing can be become more physical.

8. References

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[3] K. Lyons, D.H. Nguyen, D. Ashbrook, S. White. “Facet: A Multi-Segment Wrist Worn System.” Proceedings of UIST 2012. Cambridge, MA. October 2012.

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