Spotlight Navigation DPA39

Final Project Report

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Final Bachelor Project

By

Erik Kogler

S061804

Coach: Jun Hu

Clients: Conante

B.J.J. van der Vlist

G. Niezen

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Introduction

The origins of the ‘Spotlight Navigation’ project at the Technical University of Eindhoven lie in the combination of two independently developing projects. The larger of the two projects, the SOFIA project, is an EU funded multi-corporation endeavor to research possible use-cases and applications for the smart environments that will soon be made possible by ever increasing product intelligence. The second project, ‘Spotlight Navigation’, is a project undertaken by a small German company: Conante. Conante is originally a spin-off of Sony Research and focuses on creating an interactive, hand-held projection device which can be used to turn any available surface into an expansion of severely restricted GUIs, such as those on portable media.

Spotlight Navigation at the TU/e can thus be said to arise from SOFIA’s need for interactive controllers for the ubiquitous, invisible technological networks that will surround the user (in this case in the home). When dealing with pervasive technology it is normally assumed that all manner of products will be able to share and collect information, even though they lack an interface capable of creating the connections to make this useful. Conante’s Spotlight Navigation device seems an ideal solution to this lack of interface as it can use any surface to create a vast and entirely flexible user-interface.

Even though they carry the same name, the similarities between Conante’s and the TU/e’s Spotlight Navigation projects end at the fact that they share a technological concept of the interactive device. While Spotlight Navigation has previously focused on expanding existing GUI’s, at the TU/e it is being used as the sole interface and must therefore have its own interface design.

The task of developing such an interface design was given to the author as a Final Bachelor’s Project in the field of Industrial Design in September 2010, and the report that follows describes the progress made by January 2011.

Research

Understanding the Design Task

In order to gain an understanding of the underlying strategies in this project, a study of the secondary client's previous publications was made. In these publications van der Vlist et al. discuss the theoretical basis and approach which lead them to design a physical interface for creating wireless connections.

Aim:

According to van der Vlist et al., their "research is centered around developing visualization and interaction techniques for semantic connections/interaction, to support information presentation and to increase information and service awareness [through the use of] user conceptual models … within the smart home environment."[1]

Consequently, they are developing "mediators between the physical world and the digital, invisible world"[1]. The hope is that by designing physical, interactive products with appropriately designed semantics, the world of ubiquitous and invisible technologies will become more accessible to the average user.

Approach to Semantics:

Van der Vlist et al. Believe that "for users to truly benefit from smart environments it is necessary that users are able to make sense of such an environment"[1]. The proposed method to help users understand the 'internet of things' that surrounds them in the smart home, is to integrate explicit design semantics and abstracted models of connections in the design of interactive objects, through which they may interact with a smart environment.

One of the things to keep in mind, is that the way in which a smart environment functions is beyond most users, and thus a correct understanding should not be a requirement to interact with them. This sentiment is in fact the basis for most user interfaces and can be quite easily demonstrated with the example of a computer. Van der Vlist et al. suggest that it is more important to focus on how users believe a system works to develop models and metaphors for the interaction that is to be designed.

"User Conceptual Models [are] usually an approximation or simplification of reality. This means that these models are often incomplete and different from reality, but as long as they work for users they do not need to be true"[1]. UCMs are thus very similar to metaphors which allow users to "understand and experience one kind of thing in terms of another", in this case an invisible connection and flow of information in terms of physical 'handles'.

Essentially the aim of incorporating semantics and semiotics in the design of an interactive object, is to endow the 'handles' with a high degree of affordance, making them appeal to our sensory-motor skills, and thus intuitive to interact with. The feedback and feedforward inherent in these intuitive interactions should then make the abstract conceptual models understandable for the user.

Important Factors:

Even though the approach to this project claims that the User Conceptual Models used to design the interactions may differ from reality, they must still have a basis in the real system from which to draw their meaning.

The project operates on the assumption that the smart home environment will be based around the outlines defined by the SOFIA project. The approach used in SOFIA is what is known as a blackboard architectural pattern. In this pattern a centralized network is mimicked in that the interconnected devices of a smart environment share information by posting it on a virtual blackboard, rather than communicating peer-to-peer. This means that an industrial standard of communication need not be established, but rather that the blackboard can use its own ontological representation to store the information, thus creating an independent basis through which to focus on the semantics of the information.[2]

Because the information can be said to flow through a central (albeit virtual) blackboard, it would seem instinctive to design the interaction along similar lines. Research done by Kwak, van der Vlist et al. in [3] when comparing centralized and decentralized conceptual models, suggests that "users are better able to project their mental model of how the system works on decentralized representations"[3]. This is most likely due to the fact that in ubiquitous computing the technology is effectively hidden from a user who is likely to rationalize their desires and intentions with the aid of direct connections.[2]

Because of this van der Vlist et al. propose to focus concepts of user interfaces on connections themselves rather than on the transferred information, thus setting their work apart from many previous concepts. They go on to say that "instead of giving digital information physical containers … , we allow for exploration and manipulation of the connections 'carrying' digital information (pipelines instead of buckets)"[1]. In this scenario they do not discriminate between the 'real' connections and those the user 'imagines'. Theoretically the user can thus create the possibility of information flow (pipelines), rather than transferring the information themselves, and thus the true nature of the flow of information is no longer decisive for the path of said connections. Van der Vlist et al. hope that by allowing this, users will be able to "explore and make configurations on a high semantic level without [being bothered by] low-level details". [1]

Spotlight Navigation

At this point it was also necessary to create a standardized definition of the Spotlight Navigation device so that it can be referred to without running the risk of confusion with Conante's developed prototypes. The device consists of a color laser pico-projector, 6-axis accelerometers and gyroscopes and a processor with wireless capabilities. When calibrated, these components allow the device to transform any surface into a GUI by revealing a cut-out, or 'spotlight' of the overall GUI with the projected image. The sensors also help prevent distortion of the projected image if the projector is not being held normal to the plane of the surface. The combined effect of this is that the hand-held device can be used as a display and 'cursor' simultaneously.

ZUIs:

Finally it is worthy to mention the concept of Zooming User-Interfaces, or ZUIs. ZUIs differ from traditional GUIs in that a ZUI only has one layer of infinite resolution, while traditional GUIs consist of several layers containing finite amounts of information each. A simple example of a ZUI would be Google Maps. When the user zooms in towards a location on Google Maps, they do not only enlarge the image, but the amount of detail shown on the map adjusts as well. In a non ZUI version, the user would have to select the detail or scale of the map that they desire, and then the appropriate magnification. It is readily deducible that a high-detail map would be too cluttered when observed from a distance to be decipherable, while a low-detail map magnified strongly would be essentially blank and thus equally useless. Consequently ZUIs are well suited to enabling users to analyze large amounts of data and to narrow these down rapidly to detailed results. Another strong point of ZUIs is that they function on a 3-dimensional basis allowing users to use their sense of spatial awareness to navigate through them rather than having to rely on memorizing a hierarchical or chronological order.

First Idea Generation

In the first idea generation phase the ground principles for the interface design were established.

In the research it was discovered that the approach to the interface design was to be based on information channels rather than the parcels of information themselves. As a result of this “pipelines instead of buckets” [1] became one of the leading themes of the interface design. The continuity of a pipeline also suggested a fluid and uninterrupted interaction style with which to create these pipelines, causing the ‘pipeline’ interface to be coupled with a drag & drop interaction rather than pick & drop or copy/paste.

According to van der Vlist et al. the “context [of a connection] (what things they connect) is pivotal for their meaning” [1]. In [2] it is claimed that “we consider context awareness to be one of the most important features of a smart environment, especially when we consider a user’s interaction with the smart space” as only context can help the user map their interaction in the digital environment to their physical surroundings. The solution used to instill a sense of context in both the user and the system, was to incorporate a set of filters into the design, forcing the user to select which medium or activity they wished to edit connections for. This concept was adapted from another media ZUI [4] in which it had been very successful, as it also helps reduce the amount of unwanted information supplied to the user, thus reducing clutter and making navigation easier. From a technological point of view, this means that the device must be able to recognize the different products in the household so that it knows which category it belongs to. In the SOFIA project this is being solved by adding a camera to the device which can recognize the shape of a product from a database of photos.

If we can assume that virtually all electronic products will be connected to the ‘internet of things’ inherent in a smart home, then for each activity that the user wishes to undertake, there is a plethora of products which are unrelated and thus do not need to be included in the interface. For example when creating connections related to listening to music, the dishwasher is not a product that has any value and can thus be ignored. This concept of setting filters and pre-selecting media is already abundant in today’s interfaces, and has been accepted well.

The fact that the device functions by projecting light, and already relies heavily on the spotlight analogy, suggested the metaphor of a flashlight with different colored filters be used as for this concept. This in itself already suggests a physical interface that imitates the placing of different filters in front of a lens.

Organic Symbolism

After an initial brainstorming phase on the types of symbolisms and metaphors that would be most apt to emphasis the desired continuity and availability of channels for information flow, it was decided to use organic representations of pipelines and connections. This decision was supported by the discovery that users found it easiest to follow a smooth, lightly curved path with a spotlight, rather than angular or direct pipelines (see User Testing I).

In the initial concept the pipelines took on the form of creepers or vines that could be 'grown' out of different products in the smart environment. The interaction concept was to have the user grab a short tendril protruding from each product, and pull this to elongate it, creating a long creeper which could be directed towards the desired recipient of information. The creepers should also have a certain elasticity so that when they are no longer part of the interaction, they will shrink back to their original state.

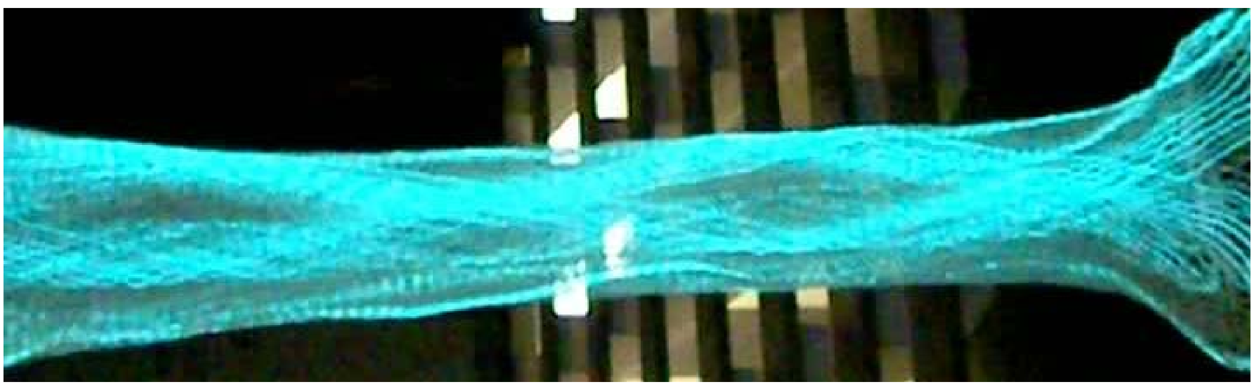
This vine could then be organically 'mated' to the tendril growing out of the recipient product, thus creating a bond completing the connection between the two, by holding them on top of each other for a short time.

This concept of biological mating, coupled with the user's need for information regarding the possibility of a connection, lead to research being done on principles of attraction between the dragged vine and the recipient tendril. It was decided that not only the look of the

tendril and vine should demonstrate willingness, but that the behavior should as well.

Consequently, the recipient tendril grows towards the incoming vine and when they have reached close proximity, they develop their connectors.

Once connected there should be a visible flow of information along the vine mimicking the flow of sap in a tree.



User Testing I:

(for more detail on the procedure see Appendix: User Testing I)

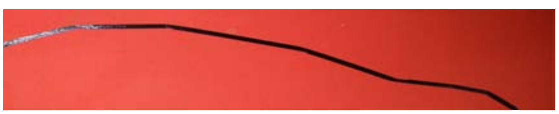
After this initial phase of idea generation, some simple user evaluations were done in order to discern which organic visualizations most appealed to the users and which were most easily understood.

The test subjects were presented with an array of visuals in different categories as well as a short set of questions for each of the following categories:

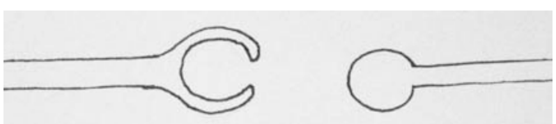
- Pipeline path shape
- Male/Female vs. Unisex connectors
- Ease of connection and disconnection
- Active/Inactive pipeline
- Flow visualization

The respective results of the questionnaire were:

- Smooth curved paths



- Male/Female



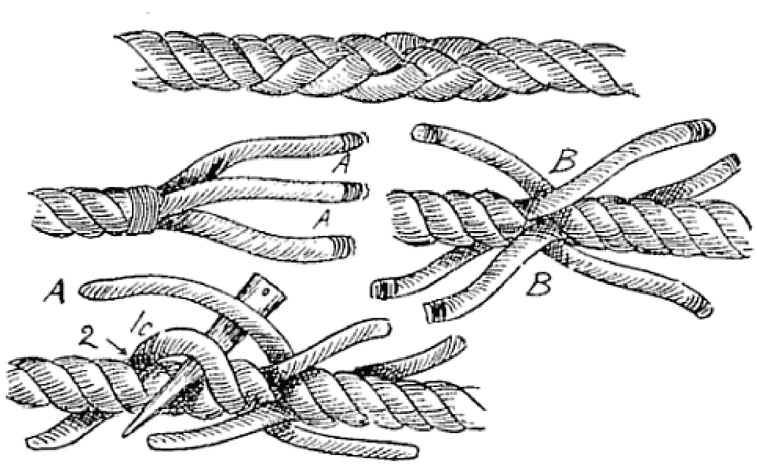
- Organic connections perceived as slow and permanent

- Green=active, solid gray = inactive

- Sine-wave

Although the visual language and symbolism were understood by almost all the users, there were frequent comments about the disconnect between the digital information flowing and the organic visuals, especially as the visuals are created by something as high-tech as a pico-projector.

Another significant problem was that the users rated the organic connections as being permanent rather than easy to undo. When questioned about this, it was often noted that organic connections are not man-made, so people do not feel acquainted with manipulating them. Particularly disconnecting organic connections worries most users as they are afraid of causing damage, and the connection points are too complex.

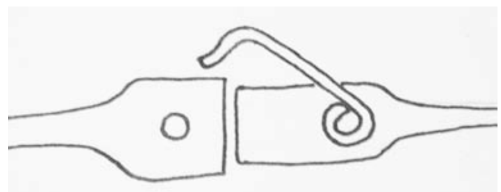


Second Idea Generation

Because the mentioned issues with the organic symbolism effectively crippled the interaction design, a new direction was explored and decided upon, namely mechanical symbolisms.

The entire concept was not lost however, as many of the strong points, such as the path form, active/inactive signatures and male-female attraction principles, could be inherited. In the organic concept, the main issue lay with the connectors of the pipelines themselves, so this was the main point of focus for redesign.

The design explorations for the mechanical connections had to account for the possibility of temporary and permanent connections. This mean that the user would have to be able to manipulate the connection in some way after it was made.



In effect this meant that a widget or tool had to be added to the interface with which to manipulate the mechanical coupling. Fortunately the existence of a tool made grabbing the tendril more intuitive, and giving the tool itself high affordance meant that the interaction was also more understandable.

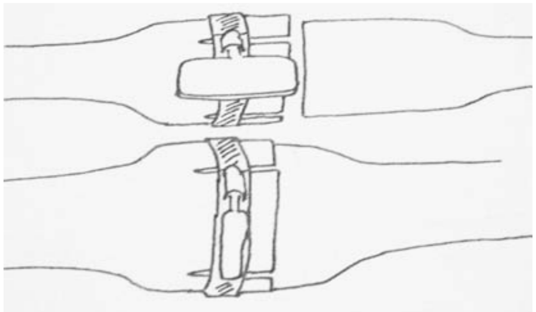
The most important features of the mechanical connection had to be that the fastening system did not interfere with the continuity of the pipeline, and that interacting with this system would be simple and quick without disturbing the previously outlined interaction too much.

After some research was done into possible methods of manipulating such a mechanical connection, it was found that instead of adding another physical interface, the rotation around the longitudinal axis of the projector could be used to manipulate a connection system using a rotating mechanism, as long as it was perpendicular to the pipeline. This is the only option available, as the pitch and yaw of the device alter the position and content of the projected image.

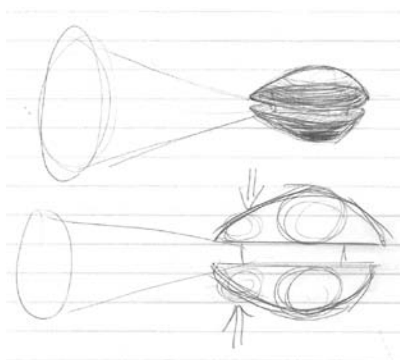
As the continuity of the pipeline was not to be disturbed, the rotating mechanism could not be located centrally on the pipeline. Another reason for it not being located centrally is that it should not be confused with a valve that can be opened and closed.

After some research a special type of hose clamp was found that uses a thumb-screw rather than a normal screwdriver bit to tighten. The advantages of this thumbscrew are that the mechanism can be placed above the pipeline, and that two settings (vertical and horizontal thumb-screw) can clearly be identified.

Using this concept of the thumb-screw hose clamp, a mechanical connection was designed that could be connected temporarily by letting the approaching pipeline slide over the receiving 'tendril'. In order to tighten the clamp, and make the connection more permanent, the entire device need only be given a twisting motion in the longitudinal axis.



Now that the manipulation of the connector was clear, a tool had to be designed to interact with it. Essentially all the tool had to do was pinch the thumb-screw and be twistable. As the tool needed to pinch, it could also be used as a grabber for the pipelines. In order to make the tool as intuitive as possible, a pair of tongs was used as a widget as these conveyed a simple pinching motion made by a hand as simply as possible. In addition to this, a pinching motion could also be effectively used on a physical interface.



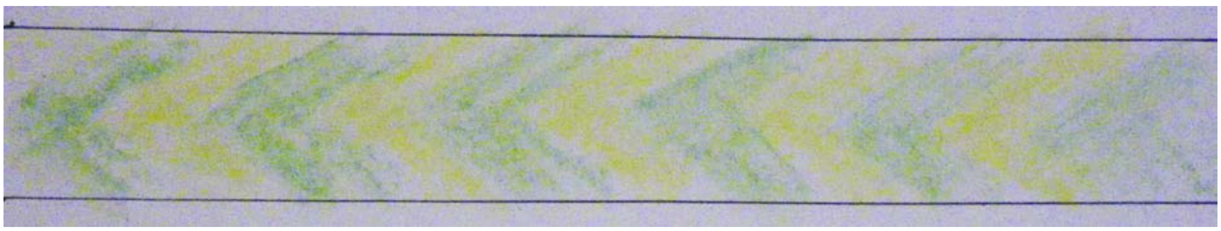
The design of this mechanical fastener, lead to the idea of using a garden-hose metaphor for the interface. The beauty of the garden-hose metaphor is that the garden hose is something that is commonplace to most people, and the ability to make quick and easy connections with them is well known. Not only is a garden hose an actual pipe-line, but it is also known to lead a life of its own from time to time, which allows for the behavioral aspects that were inherited from the organic concepts.

The garden-hose metaphor was extended by adding a frame around those products which are relevant to the selected context. In other words, setting the context filter causes only those products that are relevant to that context to acquire frames. As the frame must be projected onto a surface, it can only be there where a product touches a surface.

As a camera is already involved in the recognition of a product (using its shape), the outline of the product and the surfaces it touches can be established also. This frame represents a ‘tank’ of information which can be passed on through a pipe-line to another tank. On the side of the tank closest to the projection, there is a small reel with an end of hose hanging from it to indicate that the hose can be pulled, and will unwind, to replace the growth symbolism of the organic concept.

At this phase of the design, it was also decided that in order to strengthen the ‘flashlight filter’ metaphor for setting contexts was to be strengthened with the use of color coding. The filter interface would display a series of colored icons indicating the different contexts, and these colors would be mirrored in the color of the pipelines.

Coupling this idea with the active/inactive symbolism of pipelines from the organic concept was possible because in User Testing I it was found that the grey tone of the pipeline denoted inactive, while the form language of the active pipelines was seen to be more important than the color itself. The symbolism of information flow was also adapted somewhat to make it match the mechanical symbolism more. In the organic phase, the indication of information flow had been a sine wave, and this was now replaced by a series of pulses. This imagery was already very popular in User Testing I and mimicked the PC-style loading bars, thus being seen as a more mechanical/technological symbol.



Final Concept:

Graphical User Interface

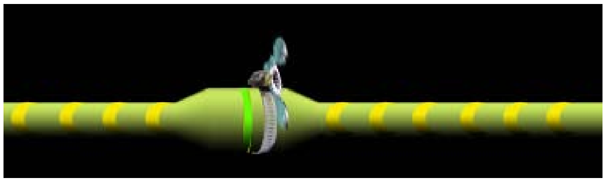
The final concept of the 'Garden-Hose' metaphor as described in 'Second Idea Generation' effectively integrated some of the principles from the organic designs into a more mechanically influenced concept.

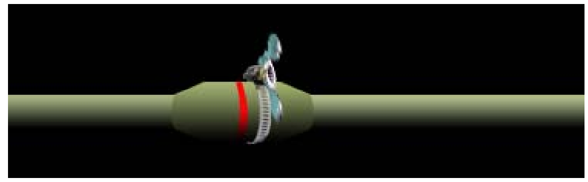
The main concept of the symbolism is that each product in the network is represented as a 'tank of information'. A tank is represented by a frame of the context color being projected around the base of the physical product. These tanks can be connected to each other by pulling a hose from one tank to the other.

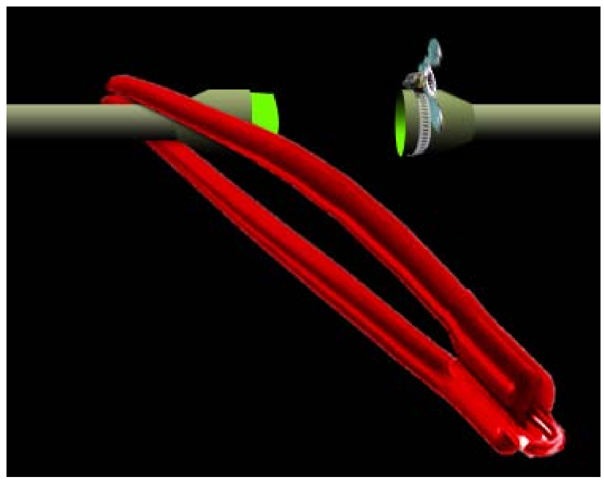
Each tank has its own hose reel, and using the grab tool, it is possible to pull the hose on this reel to unwind it. Once the user has grabbed the hose and is dragging it to the other object, they are effectively drawing a pipeline on the surface that the projector shines on.

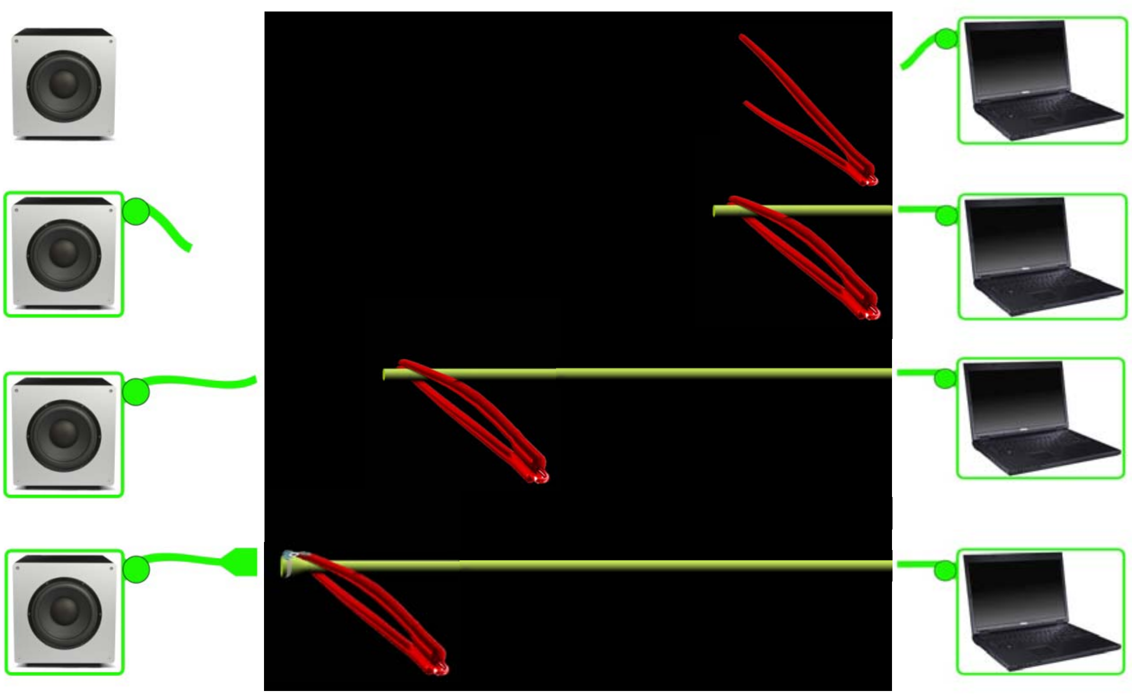
The dragged hose can then be connected to the short piece of hose hanging from other objects' hose reels. The connector on the receiving hose is simply a widening of the hose, the last segment of which is bright green. The connector on the approaching side is also a wider section of hose, but slightly larger than on the receiving end, as has the same color as the hose. The approaching end will have the hose clamp on it in the loose setting, and situated close to the end of the wider section. To connect two hoses, the approaching hose (which has a larger diameter) slides onto the receiving hose. On an established connection, the hose-clamp can either be horizontal (loose) or turned vertical (tight) to indicate temporary and permanent (repeated use) connections respectively.

Once a connection has been made, its equal will appear on the other end of the hose. This means that there is a central piece of hose, connected to the information tanks on either side. A connected pipeline will have the color of its context, and when information is flowing through the pipeline, this will be represented by lighter colored 'pulse waves'. Should the situation change (for example one of the products is switched off or is not working) the pipeline is considered inactive and will become predominantly grey with a slight color tone depending on its context. The length of the wider section on the approaching end is slightly shorter than on the receiving end, so that when connected a band of the receiving sides colored end is still visible as the status band. This band is either green (for an active connection) or red (for an inactive connection).









Behavioral Aspects

The tank's reel can slide along the tank outline, allowing it to always be positioned as close to the grab tool as possible.

The short piece of hose coming from the reel is dangling freely. When the grab tool grabs the hose, it will be held by the tool and thus be straight from the centre point of the reel, rotating around this when the tool moves. The user can then drag the hose away, and will appear to be drawing it onto the surface. This allows the user to define roughly the path the hose should take. This is necessary because there may be obstacles between two objects that are not suited to projection (e.g. a window) that need to be circumnavigated.

There will always be an imaginary tension on the hose created by the hose-reel. This means that if the hose is released by the grab tool, it will slowly be pulled back into its original reel. When a connection has been established, this behavior manifests itself by smoothing out the path drawn by the user to an extent where it becomes easy to navigate with a spotlight, while still staying true to the general path to avoid objects.

The only force that can overcome the reel (apart from the grab tool) is the mutual attraction between hoses. When a dragged hose comes within range of a contextually relevant product, that products hose will begin to unwind and approach the incoming hose.

When the two ends of the hose are in close proximity, they will develop their connectors to indicate 'willingness' i.e. the possibility of creating a connection. Once a connection has been made, the strength of the connections prevents the hoses from returning to their reels until the connection is broken by the user or, for in a temporary connection, one product is switched off or used for another purpose.

A connected hose acts as an object on its entire length and can thus be grabbed, moved and manipulated.

Interaction and Physical Interface

According to the designed GUI, the necessary user interactions are quite few and very simple.

All of the navigational tasks are completed by simply moving the spotlight navigation device like a flashlight. This means any sort of movement, whether it is rotational or linear will change the position of the projected image and as it is mapped to the real world, its content as well.

Setting the context filters should comply with the flashlight filter analogy. A ring selector around the lens (like the focus on a camera lens) was chosen above filters that could be slid in from one side (like a slide-projector) because it had more of a direct reference to the projection axis and because it only needed one action (turning from one to the other) rather than two (removing one and sliding in another).

As the navigation and movement interactions all occur by moving the handheld device, it was desirable to also be able to manipulate the main interactions with the hand that is holding the device.

The manipulation of the grab tool should be as intuitive as possible and thus have a strong correlation to the GUI. In the GUI the tool is represented by a pair of tongs or tweezers, as the normal interaction with these is to apply pressure on the top with the thumb and the bottom with the fingers, this could be implemented analogously on the handheld device.

When making connections, the attraction between the ends of the hose means that they are already perfectly aligned, so all that remains for the user to do is move the approaching connector onto the receiving end, and release the grab tool.

As described before, the interaction with the hose-clamp’s thumbscrew could be solved by combining the grab tool with a twisting motion of the user’s wrist when holding the device. In order to simplify the interaction and make it more efficient, it was decided that it would suffice to grab the connection rather than the thumbscrew itself, and then twist the device by 90 degrees.

In order to break a connection, the user would only have to grab the connection, or a part of the hose close to the connection, and shake the device thus dislocation the connectors. If the hose-clamp has been tightened, it must first be loosened again. As previously described, the hose will then slowly retract into its reel, giving the user time to find it and pull it back should they have erroneously disconnected it.

As the user's distance to the projected image is constantly varying (especially when moving over several surfaces) and is also unknown to the device, the user's proximity to the projection cannot be used as a measure for the amount to detail that they wish to see. When the user is very close to the projection surface, the amount of visible detail becomes irrelevant as the area of the projection becomes very small and thus it is unlikely that more than one pipeline will be seen at a time. When the user is further away however, they may wish to see an overview of the network (i.e. zoomed out) or be able to accurately follow a single pipeline. To solve this, a zoom interaction was added to the concept. As described in Research, the zooming user interface allows the user to adjust the amount of information visible. Consequently the zoom interaction is also used to enter a menu structure for the connections. These menus will help the user adjust certain settings for a connection. This may become necessary in scenarios where a device could send different types of media in the same context (e.g. when listening to music, a laptop could send the sound to a television, but could also send the song's video clip etc.). In this case the grab widget is exchanged for a cursor.

Physical Model

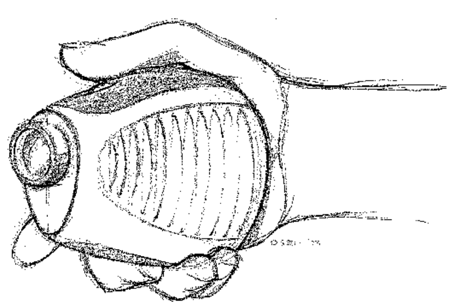
The physical model was created to demonstrate the physical interface, as well as to suggest the form and size of a prototype to the client.

As the model is a suggested prototype, it is modeled around the components (such as the pico-projector) which are to be used in the prototype. At the same time it should fit the user's hand well and not be too cumbersome to interact with.

The device should be something that the user is not afraid of using due to difficulty or complexity so that they can get the most out of their smart home environment by interacting with it frequently and flexibly. Because of this the interfaces and interactions have been designed to be intuitive and understandable.

The physical model has a slightly different visual language, as it has been designed to be more playful and to instigate the user to interact with it. Additionally, the device is something that has to fit to the user's home as it is constantly there, where as the GUI is only a projection that will disappear when not in use.

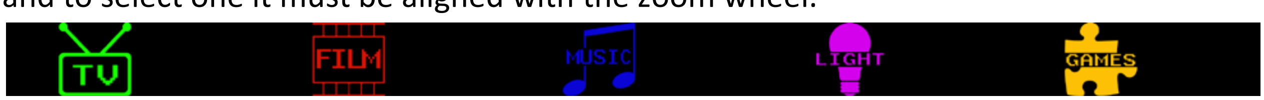
The overall length of the model is 13 cm allowing the projector to just fit in. The front end (i.e. the lens side) is circular with an 8cm diameter. The overall shape is vaguely conical. As the cross section of the housing approaches the cross section of the projector towards the back, the end of the model is oval with a width of 6.5cm and a height of 5cm. This means the shape is more horizontally spread than Conante's first prototype [5] and the new shape allows the device to sit comfortably and safely in the user's hand, while leaving plenty of space for the necessary components within the casing.



[5]

The tong squeezing interface is on the top of the device in reach of the thumb, but is not clearly marked. Instead the difference in material at the top of the device (more malleable and rubbery) indicates that it can be depressed. To squeeze the tongs, the user effectively squeezes the device as if they were holding tongs causing the surface to be pressed in with a stiff click. This interaction is also used in combination with the cursor when adjusting settings, thus imitating a computer mouse. In theory the same interface could be mirrored on the bottom of the casing to make the feel more realistic, but there was no possibility of making the 'click' feedback of both simultaneous in the model.

The first 1.5cm of the model are cylindrical. On this cylinder sits a movable ring which is used to set the context. The ring displays the different icons for the different contexts, and to select one it must be aligned with the zoom wheel.



The zoom wheel is also mounted on the top of the device between the context ring and the squeeze interface. Originally a second ring like the context ring was designed, but decided against to avoid confusion, and to facilitate zooming with one hand. Consequently the zoom wheel is also within easy reach of the holding hand's thumb.

As the shape's only stable position is when it stands on its front, and the device already contains the position sensing technology, this is used as an off switch for the device. If the device is pointed directly downward (i.e. standing on a surface) for a given time it will turn off. The advantage to this is that the device does not need another input, as well as avoiding the projector shining onto someone's eyes when it is put down. It is also easy to see if the device is on or off as the projector would create a halo of light on the surface around the edge when it is on. Because of the lack of a power button, the device is turned on by lifting it up and turning the context wheel. The use of the wheel was added to ensure that it would not turn on when moving the device from place to place.

Because of the sensitivity of the front end of the device due to the camera and projector lens, it is closed off with a clear disk to protect it from the user's fingers when changing context and scratches when putting it down. The back end of the device is left open however, so that the heat created by the projector can dissipate as it stands on the front.

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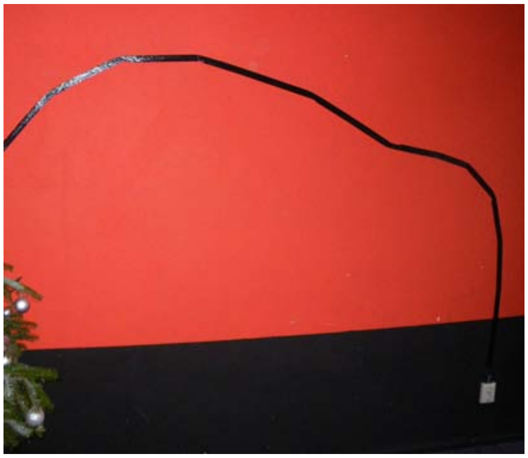
Appendix

User Testing I

Pipeline form



The users were placed in a dark room and given a small flashlight. They were then asked to follow the different paths mapped out on the walls and comment upon how easily and efficiently they were able to follow the paths from start to finish. The reason that a straight line simply connecting the two items would not work is that the line might pass through another object and thus cause not only confusion about which product is connected, but also distort the projected image severely making the line harder to follow.

Male/Female vs. Unisex connectors

After contemplating a set of male/female connectors and a set of unisex connectors, the users were asked to decide which group indicates the possibility of a connection.

Ease of connection and disconnection

After having been shown a series of organic connections, the users were asked whether they believe that these connections could be made and disconnected with ease

Pipeline symbolism

The users were now shown a set of 9 different pipeline visualizations and asked:

Which looks most like an active connection?

Which looks most like an inactive connection?

Which looks most like information is flowing?

Questionnaire:

Which of the pipelines was easiest to follow with the spotlight?

a) The smooth curves
b) The angles
c) The direct line

Which of the images groups indicate the possibility of a connection?

A B Both

Why?

……

Can the connections in croup C be easily made and disconnected?

Yes No

Comments:…….

Which of the images looks most like an active connection?

Which of the images looks most like an inactive connection?

Which of the images looks most like information is flowing?

Images: