GROUP REPORT

DCM110

A DESIGNERLY PERSPECTIVE ON IOT: A GROWING SYSTEMS APPROACH

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Introduction

This group report serves as a reflective exploration of growing systems through rich interaction, parameters of use, approaches towards growth, distributed vs. centralized designs, and core/emergent functionalities. We start by discussing the interplay of form, function, and interaction within the concept of rich interaction. Moving on to parameters of use, we delve into the process of translating technology parameters into user-friendly parameters of use in order to enhance usability. Next, we analyse our modular growth approach, including challenges encountered. The fourth concept examined is the shift between distributed and centralized design in our design. This includes a discussion on individual operability, centralized control and the integration of the emergent functionality. In the last section, we reflect on the core and emergent functionalities, showing how these elements contribute to healthy living and convenience. Finally, we reflect on the potential for growing systems using the five elements discussed.

Rich interaction

Introduction to Rich Interaction

Rich interaction is a design methodology "inspired by tangible interaction and the concept of affordances" (Frens, 2006, p.56). This methodology aims to create interactions which are aesthetic by combining the form of products, the interaction possibilities with them, and the functions it has, all whilst respecting and having the human skills in mind.

Form, Interaction and Function

These three properties: form, interaction and function; combined, carry the information-for-use. This allows the user to understand what the product allows him to do and what the potential outcome of use will be. These functions are related to each other as a user is invited to "interact through form and behaviour and thus reaching functionality" (Frens, 2006, p.58).

In the concept of assignment 3, we attempted to integrate these properties. The user could pull the device apart and therefore adjust the temperature of the heated pillows in its vicinity. However, we relied too heavily on metaphors. For example, the holes in the side panels were meant to indicate ventilation that would allow more oxygen to 'fuel the flame'. This, however, was not clear to everyone using the product. Therefore, the information-for-use was not conveyed as the link between the properties was quite vague.

In the first iteration of assignment 4, the properties were in parts integrated better. For example, the lights in the house could be adjusted using a ring on a cylinder. The cylinder afforded pointing which contributed to the core functionality of the concept which was that the ring could be pushed towards a certain lamp to control the brightness. In this concept, the form invited the user to interact and push the ring, which was linked to the function, as the user could see a direct adjustment of brightness in the lamps he was controlling. However, whilst this specific function of adjusting brightness had a clear link between the three properties, it conflicted with the other functionalities of the concept. The cylinder still afforded a pointing interaction even though, when connected to the emergent functionality: 'IoT hub', it did not require pointing at all as it adjusted all lights in a certain range. Therefore, the relation between form-interaction and form-function was broken.

The final concept 'Heat Aura' was meant to address the issue of the relations between the properties breaking up when combining both core functionalities. Firstly, looking at the overall design, both core functionalities were re-designed to be represented as rings which could be adjusted using sliders. By having the same design for both functionalities, the relationship between Form-Interaction is maintained. Whether in centralised or distributed mode, the user can adjust settings the same way, as the general form does not differ. The sliders provide information-for-use that they can be moved around the ring which in combination with the displays on the rings give feed-forward to the user about the settings they are about to change.

Looking at the relationship between Form-Function, in distributed mode, information-for-use is provided to the user as he can increase the height of the rings, which directly relates to an increase of range for the desired settings. In centralised mode, there is also a relationship between Interaction-Function, as the devices are now attached to the wall of a house, and no longer in the palm of the user. Therefore, information-for-use is provided as that one is no longer adjusting only a personal range but settings for the entire house.

Considering the sliders more closely, there is also a relationship between Form-Interaction. By being designed to fit into each other, information-for-use is provided which invites the user to push them together and activate ‘Ambiance Mode’. This also shows the link between Interaction-Function as this merging of sliders directly leads to a new functionality by activating the emergent functionality. Unfortunately, after creating and using the prototype we realised that it's possible to reverse the position of the sliders which eliminates the functionality of perfectly fitting into each other. In case the sliders get reversed, the relationship between Form-Function-Interaction is broken, so a redesign is necessary for which no matter the position this relationship is maintained.

As will be mentioned in the section about parameters of use, the lighting control in the current concept has been overloaded with functions. By having the same slider which controls the colour and brightness of lights, there is no clear relationship between Form-Function-Interaction. The user could only be informed about this using the display on the ring which goes against the principles of Rich interaction.

MR APs and MURPS

Frens (2006, p.87) states that whilst trying to integrate form, interaction and function; he saw reoccurring themes of Mode-relevant action-possibilities (MR APs) and Mode-of-use reflected in physical state (MURPS).

MR APs

Looking at MR APs, they are “action-possibilities that are only offered when they are relevant for the mode-of-use” (Frens, p.87). Our final concept ‘Heat Aura’ has some integrated MR APs. For example, if the users do not want to adjust the temperature or lights for the entire house, they can take individual rings off the hub. In case they simply want to adjust the temperature in their vicinity, by taking the ring it switches the mode automatically and the MR APs become available. The user can now adjust the height of the ring to adjust the range and use the knob on the ring to adjust the temperature. As the user opted for individual control, other, now irrelevant APs such as the adjustment of lights, are no longer available.

Another MR AP is that when the user switches into ambience mode by pushing the two knobs together, it is no longer possible to adjust individual settings. Hence, by switching mode, the action possibility of individual control is removed unless the ambience mode is disengaged.

MURPS

Looking at the MURPS, in his exploration, Frens (2006, p.88) found that “in each mode-of-use the form [of the product] is different”. Depending on the mode the products are in, the physical shape differs. He states that if this is integrated properly when switching mode, it should directly relate to a change of form, instead of leaving it up to the user to change the form after switching mode (Frens, 2006, p.89). The ‘Heat Aura’ concept showcases different MURPS. Firstly, there is a clear physical difference between the centralised mode and the distributed mode. As the mode change is properly integrated, when switched by taking a ring off, the physical state adapts. This same also goes for the ambience mode when pushing together the two knobs.

Another MURPS is turning the ‘Heat Aura’ on and off. When in the hub, the knobs clearly indicate whether lighting or temperature is currently controlled. If this is not the case, they rest in the central position, whilst if turned on, they are somewhere on the rings. This change of form informs the user what the current mode of use is.

Parameters of use

Designing function involves translating complex system parameters into user-friendly parameters for use. This process ensures that users can interact effortlessly with the technology, enhancing the overall user experience and making the functionality more accessible and meaningful (Frens, 2006, p. 62). In this project, a similar framework is utilized, where system parameters are referred to as parameters of technology.

The first two parameters of technology are IoT house control and IoT control range. Both parameters of technology have a parameter of use based on location. When using the product at the hub location, users gain full control over their home. However, once they take a ring and move away from the hub, control is limited to IoT-connected products within range. Expanding on the IoT range, the third parameter of technology is IoT range control. Users can increase the range by pulling the bottom and top of the ring apart. A larger product result in a bigger IoT range. In terms of usability, allowing users to physically expand the range by pulling the bottom and top of the ring apart directly affects their control and interaction with the system. A larger physical product results in a bigger IoT range, translating the technical parameter into meaningful interaction by means of form.

Figure 1 parameters of technology linked to parameters of use for the concept 'Heat Aura'.

The parameters of technology for turning heating and light on/off have similar parameters of use. For both, one needs to slide the slider from the center to the desired ring. For ambiance control specifically, users can activate it only when both light and heating functions are on. Connecting the sliders between the lighting and temperature rings initiates the ambiance setting mode, allowing users to select their preferred ambiance by adjusting the sliders accordingly. Disconnecting the sliders restores individual control for light and temperature settings. While the repeated form of the sliders and rings of our design may reduce the richness of individual function interactions, it does support a growing systems approach.

On the topic of nuanced controls, such as heating intensity, light color, light intensity, and ambiance settings, a common parameter of use is rotating the slider around the specific ring. However, an issue arises with light color and intensity sharing the same parameter of use. The rationale behind this design decision comes down to two things: smooth user experience and supporting a growing system approach. The process involves initially selecting the desired color, followed by a 2-second delay during which the screen transitions to intensity settings, enabling users to adjust the intensity as desired. This approach aimed to create a seamless transition that users would not notice, allowing them to focus on the product during color selection and on the environment when adjusting intensity. In theory, this is a fault in the design because the parameters of use are overloaded with different parameters of use.

Approaches to growth

In 1991, a thought-provoking argument, or claim, was proposed that people cease to be aware of the most profound technologies since they become an integral part of everyday life(Weiser, n.d.). This not only refers to how designers combine core functions into a product, but also implies how a growing design or system allows people to quickly accept changes when the parameters of the technology grow. This chapter will focus on the approach used to design and grow the two core functions in our design (temperature control and light control) together, what challenges we faced in this process and the potential for growth of our design in stage 3(Frens, 2017) in the future.

Modular approach

There are four approaches and design cases been shown: hybrid approach, modular approach, shape changing approach and service approach (Frens, 2017). When designing a complex product or system, the term Modular Design is considered as a design technique that uses similar components to combine design elements (Shirley, 1992). In assignment 4b, two iterations of our design both use the modular approach to grow light and temperature systems together. More specifically, in the first version of the solution, the light module which is shaped like a wand can be connected or added to the temperature module by users according to their needs. In the second version, two rings that can fit each other are designed then leads to the emergent functionality.

The challenge of designing a growing system in a modular approach

One of the challenges that arose during the design process is that in the first iteration of the design, the two core functions were still working separately and the parameters of use were not in good cooperation, therefore the emergent functionality was not clearly designed. This is also mentioned in (Frens, 2017) that by using a modular approach, the emergent functionality can be difficult to grasp because the emergent function does not stay in two components. When exploring the solution, besides considering how to combine two components physically, it is also crucial to think about how to weave two core functions together on the parameter of use level and make it possible for the IoT system to grow based on a similar pattern. In the second iteration, the prototype 'Heat Aura' aligns the interaction pattern by switching a slide on each ring to adjust the heat and light. When the emergent functionality, ambience, is designed, users can still use the sliders in combination to achieve a transition from using separate core functions to using the emergent function. This solution is more suitable for the design with core functionalities that have no obvious logic behind the working order but function separately or in parallel according to the needs of the user.

The evaluation of growth in our design

A growing system needs to be proven as rational over time in the context of use (J. W. Frens & Overbeeke, 2009). When displaying and evaluating the final prototype in context, it is clear to see how other possible modules, such as the sound module and air purifier controller module, can be added to this prototype with a similar shape to the ring. In an ideal state, these core functionalities can be physically combined, giving room to the new emergent functionalities through a unified form of interaction thus growing in this way. However, when determining a unified operating paradigm, here refers to the sliders on the rings provided to users to control the system, designers should consider the rationality and specific application in areas of rich interaction and continue to examine it after the system grows and new emergent function shows up in the future.

The core and emergent functionality

The Core functionality

Initially, our core functionality aimed at the distributed control of heating and lighting systems. Building upon the design for controlling the heating system in Assignment 3b, we introduced a new core functionality, controlling the lighting system with a stick with a ring, as it is a crucial component of smart home interactions. Users frequently interact with lighting systems, hence, in an IoT environment, our focus was to provide convenient interaction methods for users to control both lighting and heating systems.

However, during the reflection and review process, we realized that defining both heating and lighting control as separate core functionalities would introduce a significant inconsistency in user interaction methods. This discrepancy might confuse users and impose unnecessary learning costs, which contradicts our goal of convenience.

Therefore, we ultimately refined our core functionality to encompass centralized and distributed control over both heating and lighting systems. When both rings are installed on the base, they can control the heating and lighting systems of the household. The outer ring controls the brightness and colour of the lights, allowing users to select specific lighting colours, and specific brightness on the same ring after a two-second wait. The inner ring controls the power and temperature of the heating system, enabling users to select specific temperatures within the range of 14-26 degrees Celsius.

When the rings are removed from the base for portability, the control range for lighting and heating is pre-set to a radius of two meters from the centre of the ring. The interaction methods for power, brightness, colour of lighting, and temperature of the heating system remain consistent with centralized control, providing system coherence. Additionally, users can expand the control range of lighting and heating by stretching the rings, and a transitional effect is presented when there is an overlap in the settings for lighting or heating within a range.

This change not only satisfies users' needs for unified control of aggregated devices when returning home or going out, eliminating the need to individually adjust each light device or each room's heating settings but also meets users' demand for point control of single or multiple devices in scenarios such as reading or relaxing. It also allows users to conveniently adjust the range without moving around, accommodating multi-person scenarios.

The emergent functionality

Initially, our emergent functionality was the coordinated range control of heating and lighting systems, achieved by connecting and combining the two knobs to unify control range. However, upon further reflection and review, we realized that rather than being an emergent functionality, it was more akin to piecing together two core functionalities.

Therefore, we ultimately defined the emergent functionality as setting the ambiance in the home. When both rings are installed on the base, connecting and combining the two knobs activate ambiance mode. Ambiance mode supports five different modes: sunrise, sun, rain, sunset, and twilight. Users can select different modes to activate different lighting and heating pre-sets in coordination. Light colour temperature and intensity can influence human circadian rhythms and mood states. Additionally, the heating system can adjust indoor temperature according to changes in lighting to meet users' comfort needs, providing a more comfortable environment. This functionality helps regulate residents' circadian rhythms, promoting overall health. For example, simulating the natural light cycle by adjusting lighting can improve sleep quality and enhance work efficiency.

In summary, through iteration, we have ultimately aligned Heat Aura's functionality to meet users' multiple and single convenient control needs for lighting and heating systems while providing benefits for users' healthy living through coordinated control of lighting and heating.

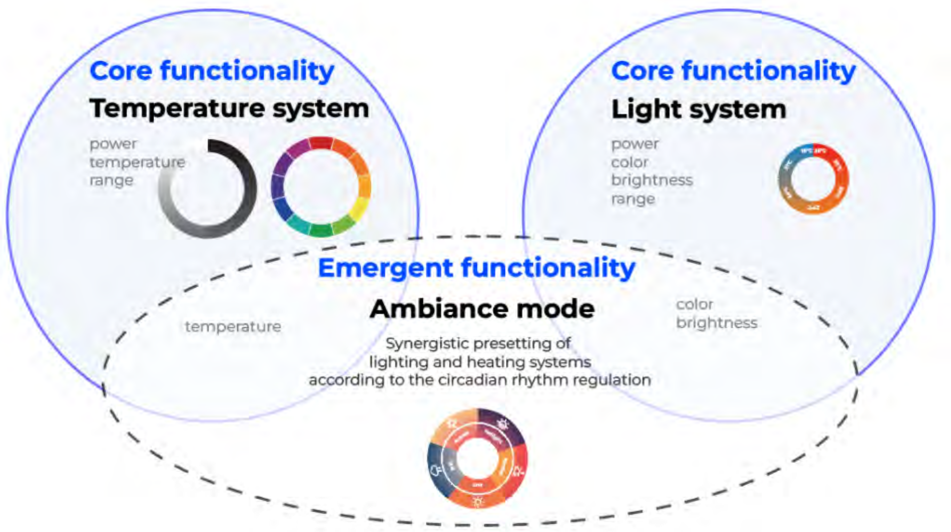

Figure 2 Overview core and emergent functionality for 'Heat Aura'

Distributed vs. centralized design

As stated in (Kopetz, H., & Steiner, W. 2022) designing in a distributed way is becoming the emerging paradigm. IoT devices communicate with each other in a household and exchange data, creating a network of connected devices. In this design the distribution is between the lighting and the temperature, both separately operatable with a ring controller. To be able to manage the distribution, the ring can be pulled up and down by a second ring around it. While adjusting the lighting or temperature, a cylinder shape around the device will increase or decrease, depending on movement. This is not physically shown, but by indication of the lights starting to glow if the place it hit by this invisible cylinder. Where (Yaliang, C. 2020) shows that light indication can help the user understand the shifts of usage.

The design changes when it combines in the hub on the wall. Where it is still possible to operate the temperature and lights separately, it will now do it for the whole household. Changing it to a centralized design. With the addition of an emerging functionality, a new centralized function is added to the system and is only usable in a centralized setting.

When developing the prototype for assignment 4 the issue of the unbalance in the design about this topic was noticeable. The design should not be confusing when it is emerged or used individually. To create a framework with less confusion, both rings are using the same controls. And if they are emerged, they work together to shift between the circadian rhythm.

Conclusion

In conclusion, we believe that there is room for growing systems using rich interaction, parameters of use, approaches to growth, distributed vs. centralized designs, and core/emergent functionalities. However, there are also many challenges.

Rich interaction allows for intuitive experiences but requires creativity to manage emerging functionalities. Our experience with the "magic wand" feature is an example. Initially, it led to a different type of interaction than anticipated, causing us to design a more generalizable interface, like a ring, to accommodate various functions. Parameters of use require careful consideration, as compromises may be needed to support system scalability, as seen in our struggle with overloading parameters due to our approach for scalability and unity. A mixed approach is preferable for accommodating diverse interactions and multiple parameters, particularly with the addition of new core functions and emergent features. However, integrating screens requires a hybrid approach to prevent interface overload. Our approach to centralized vs. distributed highlighted challenges with potential user overwhelm and increased options. To address this, we adjusted affordances and integrated multiple rings with the centralized hub for smoother interaction, especially in multi-user settings.

Regarding state 3 in our design, the current concept of the ambiance mode combines only heating and lighting to create an atmosphere. However, in a growing system, different modules such as sound systems could be added to incorporate sounds fitting the ambiance setting. Similarly, adding a humidifier could adjust moisture levels to fit the ambiance. These could be incorporated by adding an extra ring around the existing rings.

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