Interactive Architecture

State of the Art

Seminar Computer Science

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The RAM House

Figure 1: Ram House Prototype

The future of homes is most often described as being connected to an increasing number of digital devices, rising connectivity and the infamous term of permanent connectedness. Many projects developing the assumed future of the home do not take a basic human requirement into account: privacy. Homes have always been a place of non-digital privacy. You can lock doors, close curtains and become virtually invisible to an outside gaze. The digital age changes these circumstances. Today connected devices "follow" you into your home and keep a connection to the outside.

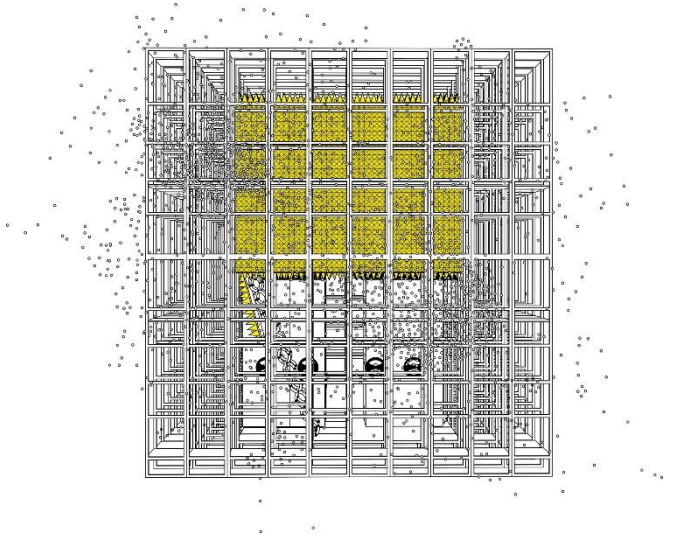

Figure 2: Ram House Schematic showing Faraday Cage

Most designs for future homes strife to increase the amount of connectedness, using smart devices that also communicate with the outside world permanently. The ram house takes our current societal as well as digital development into account and tries to extend the human need for privacy to a digital level. Parts of the house (a prototype) is built using materials capable of absorbing electro- magnetic waves as well as a faraday cage. The absorbing parts can be shifted according to the inhabitant's requirements making it possible to shift

between becoming invisible to the outside digital world and having normal connectivity as in any standard house. The target is described as giving people back their digital autonomy in a future in which the digital gaze into the living place will be much more present and potentially revealing than the conventional one.

The Numi Toilet

Figure 3: Numi Toilet in real Setting

Toilets are often thought of being something simple which do one not too glamorous task: taking away our bodily waste. The future home should improve every aspect of everyday life to benefit the inhabitants. As the main theme of the subnetTalk describes, it is important to go beyond what we currently envision when talking about the home of tomorrow. And when doing so we realise that there is capacity for innovation in areas that do not immediately come to mind. One of these areas are toilets. While smart toilets have already been a huge thing in Japan for quite a long time, the western world has not quite realised their potential. Now as home improvement and optimisation are becoming ubiquitous, many areas are discovered as being worth improving. One of these areas are toilets. One example is the "numi" toilet by Kohler. First of all, this is not the only bathroom component by Kohler. They target a room long neglected by the smart home community. With their "numi" toilet they create a striking example of incorporating functionality that is not apparent in the respective product type. This particular toilet achieves two main objectives. Not only does it improve the product with respect to its original purpose, but also adds functionality not related to this very purpose which improves the experience. First, the toilet integrates components that have been around in Japan for a long time. These include bidet functionality, dryer, a motion-activated-cover as well as a heated seat. Additionally, it includes features for more comfort including a foot warmer and illuminated panels. These panels change colour based on the time of day and personally set options targeting a more relaxed experience. All this functionality is controllable through a touch-remote which also stores presets for several users. Further, more unseen features include speakers to play music and the possibility to connect to Amazon's Alexa, giving the ability to control functionality with

Figure 4: Numi Toilet LED Lighting

one's voice making the whole experience hands-free. Of course, one could ask if all this is necessary if it even serves any purpose. According to Kohler their philosophy includes making everyday activities more enjoyable and thus improving the quality of life. A major point in designing and developing smart home appliances and technologies is the focus on energy and resource efficiency. Many smart home solutions try to increase efficiency and optimise power consumption e.g. smart heating controllers. The “numi” toilet includes two flushing modes and uses the reduced mode if not instructed otherwise. This helps cut fresh water consumption. On a global scale reducing the amount of water used by toilets could potentially have a huge impact. At this point the “numi” toilet has to be seen from a different perspective. It is a ridiculously expensive product, which will without any doubt not reach a high enough number of sales, to have a big impact on our lives. This is also not the point. The reason it is included here is to show an approach to the future home, which introduces change and innovation in an area not thought about very often. It demonstrates that improving interactions is not limited to what is apparent, since it introduces features not related in any way to the standard model of toilets.

Figure 3: Numi Toilet in Compact Form

Infrascan Smart Toilet

We now see a different approach to a vital component of our homes or buildings in general. while the “numi” toilet by kohler is an example of how comfort can be improved and optimized in future homes, the infrascan smart toilet shows what future home inventory can do for our health and the planet as a whole. Both are areas in which future "smart" homes and buildings should have an impact. They are not only supposed to increase comfort and connectivity, but also to completely change the way we interact with our home inventory.

Figure 4: Infrascan Smart Toilet

The infrascan smart toilet creates a new means of interaction which is implicit in something we do and actually have to do every day without us having to change anything in our way of life. It just introduces a new method of interaction without humans having to adapt. Now, what does it do? This toilet does two things besides the usual. On one hand it analyses bodily wastes to determine the user's health and on the other it introduces a novel flushing mechanism designed to make the use of water obsolete.

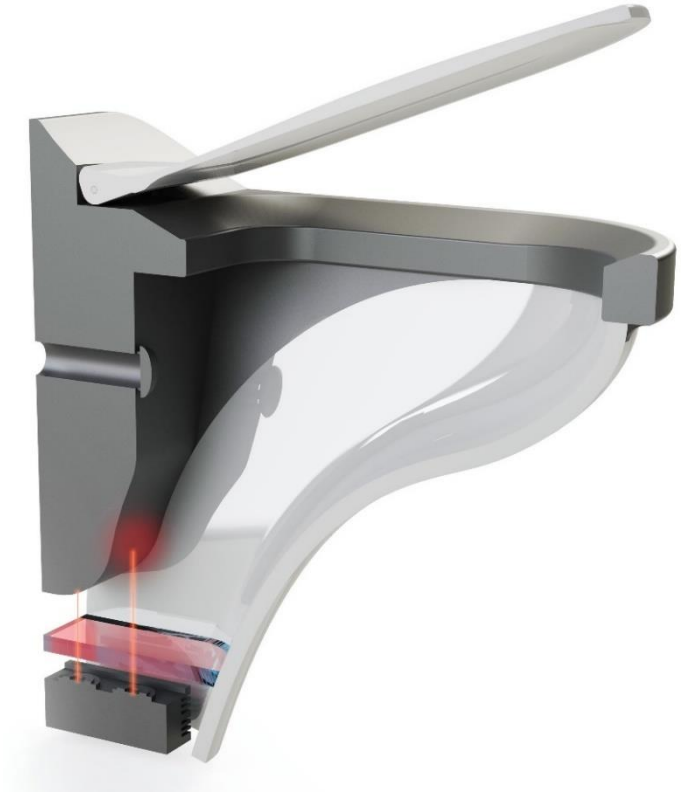

Figure 5: Infrascan Analysis

First of all, flushing is done using supercritical CO_2 which is in between liquid and gas state. The toilet can be sealed by the lid and pressurised to make supercritical CO_2 possible. The benefit being that obviously no water is used. CO_2 has a very low surface tension making it spread out across the toilet surface to clean it. It is then sucked into a chamber, filtered and put back into a gas state for storage. Unfortunately, the designer does not specify how waste is transported from there, but since this is only a concept, we will ignore this lack of explanation for the time being. The other function is analysis of bodily wastes. This follows the trend of analysing human body functions, as already done by "smart wearables", but much more implicit and frequent. Analysis is based on infrared scans and Fourier Transform (FTIR) to get the wavelength spectrum of the waste. This spectrum can then be analysed to find anomalies. What makes this approach special and stand out is the frequency in which samples are taken and analysed, which is basically every time the user goes to the toilet. This approach follows the general approach of collecting large amounts of data. The infrascan smart toilet can also be linked with one's phone to sync and visualise data which can then be accumulated over a long timespan to help show and interpret changes potentially indicating health problems. This toilet shows that the future home can do much more for us than just improving comfort and reducing workload. By introducing a novel, implicit form of interaction it can help us live healthier lives as well as potentially reduce our impact on the environment.

MIT CityHome Project

Figure 6: CitiHome Gesture Control

The following project is no longer active but contains many concepts potentially important for future homes. The CityHome project introduces an approach to the future of small homes. This concept contains several modes of interaction as well as the ability to maximise available living space. In a world in which city populations rise, available living space becomes scarce and prices skyrocket (e.g. New York, London or Vienna), maximising available and affordable living space is definitely an important step towards the future home. The city home project offers a solution to this space-funds-problem. Their design promises to potentially triple living space in small (even one room) apartments by eliminating the premise of having different rooms for different activities. The CityHome project turns a single room into multi-purpose living space. This is achieved by a specially designed "wall". This wall contains different components required in a home e.g. bed, table, seating etc. which can be stored and extended depending on the current requirements. In addition, the wall itself is movable making it possible to change the size of parts of the room (e.g. enlarging seating area and reducing the size of the bathroom). Changing the room's layout also enables the occupant to change if the kitchen is embedded in the room or separated again based on the current requirements. The wall features many more options for customisation. It can for example retract all deployed accessories and move itself into a corner maximising the space available. This space can then be used as personal workspace, for working out or even throwing a party. Besides managing available space CityHome does even more: it also sports lighting which can be adapted to the current situation (party vs. work). All the aforementioned features including transformations, retractions, changes of lighting can be accomplished using hand gestures.

Figure 7: CityHome Example Configuration

Intellithings Roomme

Now we discover a project which completely changes the way we interact with our homes. Smart appliances can do many things for us, including playing music, adjusting temperature, or lighting mood. Originally all these

Figure 10: One Sensor per Room

components had to be addressed separately via some interface. In recent years we saw the rise of assistant devices like Amazon's Alexa or Google Home which are able to interact with all these different smart home appliances consolidating control into a central device the user can interact with. In addition since the main benefits of these smart home assistants are their voice recognition capabilities users can use them to control their home environment. This is of course fine, but still not seamless; the user still needs to interact with the controller. Intellithings' roomme follows a different approach in which interactions become implicit. Abstractly talking a room becomes aware of the person inside and automatically sets the environment to the specific person's preset. This seems to be the logical next step to smart homes. Explicit interactions with homes or rooms become obsolete. Rooms automatically adjust to occupants. The question remains: How does this work? According to Intellithings a single sensor is placed in any room to be controlled. There is no face recognition involved. Actually, the sensors do not identify people at all but rather their phones' Bluetooth signature. Every sensor builds a Bluetooth fence at the room entrance and monitors incoming and outgoing Bluetooth enabled devices. Should an incoming device match a stored signature, the corresponding person's settings are applied. The sensors come with a smartphone app in which behaviour can be configured. These settings can be quite specific e.g. "When I enter between 5pm and 9pm, set temperature to a certain value".

Figure 11: RoomMe Sensor

Any supporting device could then be set to a certain state when the user enters. This cold also include a coffee machine e.g. some people like black coffee, some prefer cappuccino. Roomme could potentially turn on the coffee-machine when the user enters the room at breakfast time and apply the stored settings. Roomme also includes some artificial intelligence. According to Intellithings settings can not only be set by users, but also

learned over time. There is no explanation to be found on how this actually works, but an intuitive solution would be sensors monitoring their connected devices and learning settings from patterns in which users adjust them. These settings can then be set automatically for the user. So potentially roomme could completely automate home automation requiring only installation of sensors and one-time pairing of phones and devices to control. The sensors would then learn and at some point, no further user interaction with any controlled appliance would be necessary. Roomme also fulfils a different requirement. As awareness of the importance of protecting personal data increases, we do not want to share our room-preferences with others. Roomme stores everything locally. There is no communication with the outside world at all, except for updates of course.

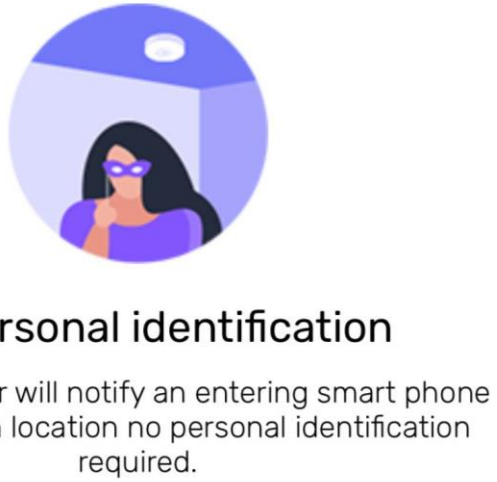

Figure 12: Commitment to Privacy

There is one negative aspect which cannot be ignored: Roomme does not identify people which is good concerning privacy, but it also requires everyone to carry their phone around permanently in order to be recognised. Summarising, roomme incorporates many innovations in home automation into one product introducing implicit interaction without human actions, utilising artificial intelligence and respecting the user's privacy by keeping data local.

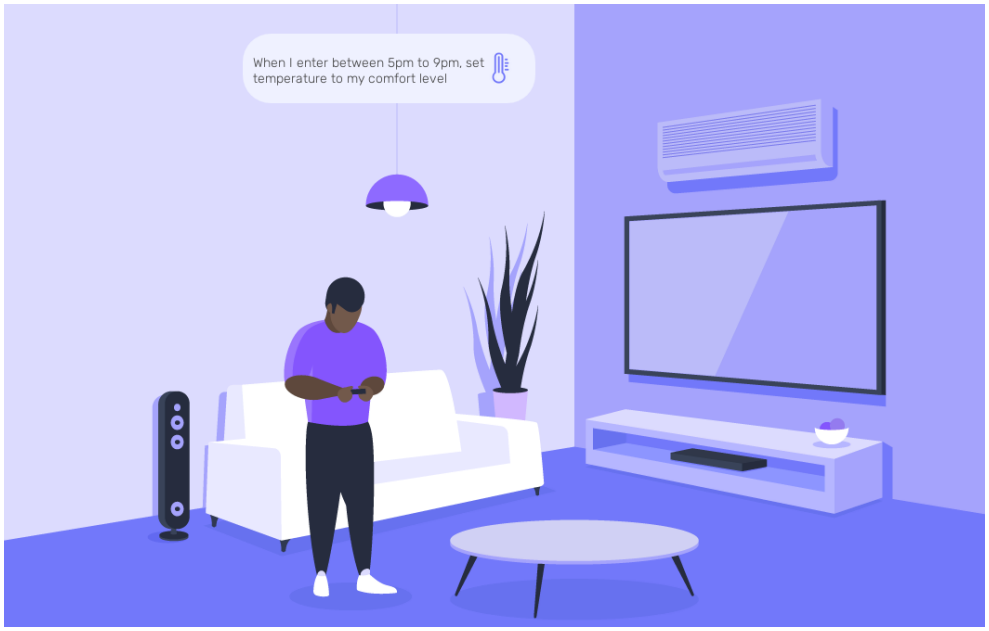

Figure 13: Example Scenario

Interactive Floors

Figure 14: A Game Application

The idea behind this is to project texture on a floor indoors, capture people's actions and react to them. This section is not about a specific project, but rather the whole array of available products in this area. This approach covers something we use all the time: floors in our homes or offices. Now why should these surfaces not be used in a smart way. This is probably also what creators of many of these projects thought. So how can projections on floors be useful? Of course, projections can be used to create all kinds of games or fun interactions with natural materials like water or grass. But apart from applications used in leisure activities there are also many professional uses for this technology. An example would be physiotherapy. Patients are often reluctant to engage in physio due to it on the one hand being a slow process and on the other hand because of the pain sometimes related to it. Floor projections could be used to simulate water or some other material which reacts to their movements for example immediately giving feedback and motivating patients to strengthen their efforts thus increasing the rate of recovery. One different application we do not want to get into extensively are advertisements. Interactive advertising could be unbelievably effective since (we are no psychologists, but) consciously interacting with something for example by walking over it makes it a lot more rememberable than just viewing it.

Figure 15: Application with Interactive Water

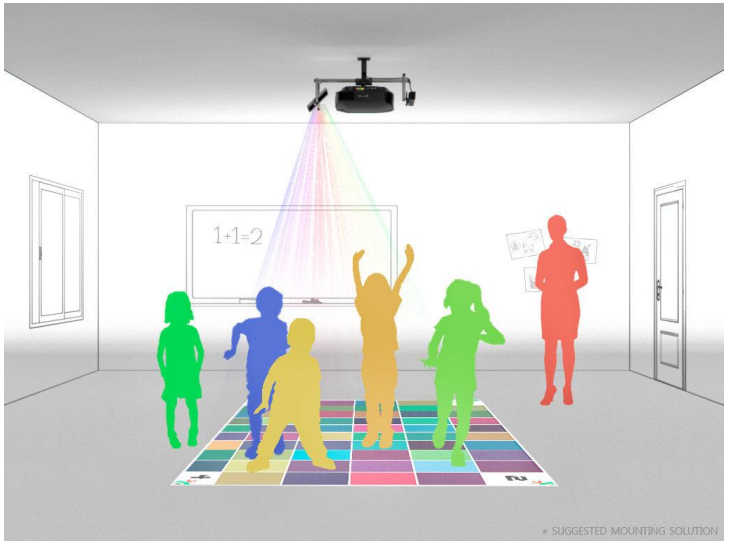

Figure 16: Schematic Description

Sources

Ram house:

- http://www.spacecaviar.net/ram-house/

Numi Toilet by Kohler:

- http://www.kohler.com/numi/
- https://www.architecturaldigest.com/story/kohler-numi-smart-toilet-amazon-alexa-craziest-launch-at-ces

Infrascan smart toilet

- https://www.jamesdysonaward.org/2018/project/infrascan-smart-toilet/

MIT CityHome project:

- https://www.media.mit.edu/projects/OLD_cityhome2/overview/
- https://www.fastcompany.com/3030991/mits-cityhome-is-a-house-in-a-box-you-control-by-waving-your-hand

Intellithings roomme:

- https://www.intellithings.net
- https://www.tomsguide.com/us/intellithings-roomme,review-6069.html

Interactive floors:

- https://lumointeractive.com/interactive-floor-projection-display/
- https://marialorenalehman.com/post/creative-interactive-floor-projection-brings-nature-indoors-in-new-ways

Figures

1. http://www.spacecaviar.net/wp/wp-content/uploads/2015/04/D_SL_4446-Modifica.jpg
2. http://www.spacecaviar.net/wp/wp-content/uploads/2015/04/RAMHouse.jpg
3. https://media.architecturaldigest.com/photos/5a57cbfe2eccdd317055f3b4/4:3/w_600/Numi%2520Black%25202.jpg
4. http://www.kohler.com/numi/images/features/numi_lighting.jpg
5. https://www.residentialproductsonline.com/sites/rpo/files/styles/large_content_image/public/field/image/Kohler-Numi-toilet.jpg?itok=wy5Bvc_P
6. https://www.jamesdysonaward.org/Document/f33a3e65-4246-4400-8363-d08234825a38/iso.jpg
7. https://www.jamesdysonaward.org/Document/f2108879-1fcf-4488-816a-a5964b04ad2f/untitled-1.jpg
8. https://www.youtube.com/watch?v=f8giE7i7CAE
9. https://www.youtube.com/watch?v=f8giE7i7CAE
10. https://c1.iggcdn.com/indiegogo-media-prod-cld/image/upload/c_limit,w_695/v1500803613/cgvq5b7kxqzgrytxwsez.png
11. https://pbs.twimg.com/media/DutSkQFXcAoQLRo.png:large
12. https://pbs.twimg.com/media/DuyjSzgWkAEbSV6.jpg:large
13. https://www.intellithings.net/
14. https://www.vertigo-systems.de/fileadmin/_processed_/6/2/csm_bodenprojektion_01_09eb71583d.jpg
15. http://oceanzacoustics.com/wp-content/uploads/2016/10/image4.png
16. https://fluurmat.com/wp-content/uploads/2017/10/fluurmat-interactive-floors-for-education.jpg