Design Thinking

Throughout this thesis I have been looking for a way to radically change the mobile experience. I have done this by using sensory substitution in a way that may benefit all kinds of people. For this to work, I will propose in this section what I think are the building blocks for a design oriented approach to Digital Synesthesia and Artificial Sensory Experiences.

The first thing to keep in mind is that I am proposing the ability to turn sensory experiences on and off as the user may need. To this end, the user studies have looked into how a user may be able to quickly turn on an artificial sense and get satisfactory results in a short amount of time and in different situations.

1- What is the engulfing activity?
2- What type of sensing do we want to create?
3- What kind of signal are we tracking?
4- What control does the user have over the signal?
5- Are there any redundancies with other senses?
6- What type of actuator can we use?
7- Where are the sensor and actuator located?
8- Can we set up a natural learning environment?

The Main activity

It is important to remember that digital synesthesia is not an end to itself but a means to enhance an experience by creating richer connections between the user and the environment. So the main activity is that in which the user will be taking part in and in which Digital Synesthesia will be a part of. For the designer it will be important to be aware of how much attention does the activity demand of the user because the artificial senses will need to make room in the user's attention span.

Take for example sailing as a main activity. The main experience should remain the same; the user wants to go out sailing in the same manner as before. Digital Synesthesia will offer the ability to feel wind speed, tilt of the boat and direction of north. Depending on the user's experience, sailing can demand different amounts of attention. For the beginner sailor, the artificial senses must be clear and relevant enough for the user to successfully and willingly be aware of them. The experienced sailor might be more relaxed and have the ability to add to the sailing experience other senses that are not as intrusive, as well as less obvious. The experienced sailor will have no need for wind speed or tilt of boat so they can choose to be aware of depth of the water under the boat or distance to other boats if they are in a race.

TYPE OF SENSING

I have recognized two distinct categories of artificial sensing, active and passive sensing. In passive sensing, the user does not need to be constantly aware of the sensory feedback being generated; rather, the user wants to either be aware of big changes or of when a signal passes a set threshold. This is also the case when the sense changes very slowly and the user want to track it during that long period of time. This means that the actuator giving the signal has to be discreet enough to not annoy the user but effective in grabbing the user's attention when a threshold has been reached. Active sensing is when a signal is completely under the user's control, it changes quickly and the user's actions affect the way in which the user feels this signal. The actuator for an active sensing experience can be strong since the attention of the user will be placed on the sense and will last only as much as the activity lasts. It can be turned on and off easily so once the activity is done, the sense disappears.

TYPE OF SIGNAL TO BE TRACKED

The type of signal will determine how we present it to the user and how we do the translation. Is this a signal that changes quickly or slow? What is the range of change? Do we need continuous feel of will checking a value every once in a while be enough? Is it quantifiable as a single value that can be mapped to another sense or will it be more complex? Is there a better metal map of the signal than a simple quantity?

Most signals whether quick or slow are given to be quantifiable and hence are easy to represent in another modality like frequency or temperature. But a signal can be more complicated. Going back to the sailing example, the sense of tilt of boat could be represented as a quantity for angle from horizon, but it might be better represented to the user by two vibrations that move up or down on the sides of the user, like a level (confusing, insert figure), and this might prove to be easier for the user to understand with less training.

WHAT CONTROL DOES THE USER HAVE OVER THE SIGNAL

Our sailor is enhancing its sailing experience with the artificial sensing of wind speed, tilt of boat, north and depth. Some of these senses are completely out of the sailor's control, like wind speed and north. Some are under partial control like depth or tilt of boat, depending on the experience of our sailor. So if a signal is given to change with no action from the user, that sense is said to be completely outside of the user's control. If the signal will never change, but by direct action of the user, then the signal is under control. A signal like tilt of boat changes with the actions of the sailor but also because of environmental factors like wind or waves, so that signal is only under partial control.

In general, most senses that are out of user control are good for a passive experience. Since the user can't control the signal, they can only be aware of the changes. Depending on the importance of this signal to the main experience, the user will want to be constantly aware of minor changes or simply notice big changes as they happen, the actuator should be placed according to these conditions. The actuator must be able to grab the attention of the user at the right moment. A sense like depth or tilt of boat are under the user's control in the sense that the user's actions will immediately change the signal and the artificial sense will help create a close feedback loop that the user will use to successfully navigate the experience. So changes in the depth will inform the sailor on the best direction to steer the boat which will then change the depth as the boat sails to a different location. That makes it an important sense for the experience and the translation of such sense should be clear but since the signal will be under the user's control then the attention of the user will be largely on the signal itself so the actuator does not have to grab the attention, it simply needs to be clear and not intrusive in the active experience.

ARE THERE ANY REDUNDANCIES WITH OTHER SENSES?

Digital Synesthesia can be used to create sensory experiences that are completely outside of the sensory capabilities of our bodies, but also to enhance a sensory experience that might be sensed by the body in other ways. These sensory redundancies have resulted useful in different ways and the designer should be aware of the opportunities that these redundancies might present.

If what is happening is a simple enhancement of an existing sense, the artificial sensory experience is acting in a similar way to a natural experience that the user is used to. An example of this can be a pressure sensor on the tip of a finger. Even though the finger can feel pressure, the artificial sense can be dialed to be more sensitive than the natural counterpart. These redundancies allow the user to quickly understand and make sense of the new sensory experience.

The artificial sense can also be a substitution of an existing sense, so like in the case of the first user study, the sensory experience was used to determine information that was readily attainable through the visual sense. This creates a very close feedback loop that will have important effects on the acceptance of the information through the artificial sense, learning will be quick and when time comes that the user can't use the redundant natural sense, then the artificial sense will suffice. If we think back to our sailing experience, wind speed is something we can naturally feel through our skin and hair but our brain is not used to paying too much attention to these signals, so the artificial sense can be a way of helping the brain

create an understandable experience of the natural sense until time comes that the artificial sense is no longer needed.

Lastly, the user might be using an artificial sense of a signal completely foreign to our five senses. As in the second user study, training is the hardest because there is no real feedback loop except trusting that they are correct in their assessment of the artificial sense. In these cases, extra care must be put into the learning process. The second study even though it showed that there was no difference between the times when the users had a visual feedback and when they didn't, it was clear that in every case, having the visual feedback made the learning experience more enjoyable and the results were more encouraging.

WHAT TYPE OF ACTUATOR CAN WE USE?

In this project I centered in two types of actuators that created three kinds of feeling. The peltier devices would generate temperature through the skin while the transducer could be used to create either vibration on the skin or sound through bone conduction.

I have shown how a peltier device giving temperature signals will be better suited for a passive sensing experience where the user does not want to be aware of small changes but instead wishes to feel significant changes through long time periods. It might be possible to increase the opportunities for using temperature as a sense by using other devices than the peltiers given that some of the problems I had were because of physical constraints of the device and not of the experience.

The transducer, whether used for vibration or bone conduction, was very well suited for active sensing and quick changing signals. On the other hand, the transducer proves to be not adequate for passive sensing because the users reported not wanting to have that signal constantly during longer periods of time. I did not test for the advantages of bone conduction over vibration and this would be interesting to dive into. But for bone conduction to work, the transducer must be places close to the head and/or bone, and as we will see there are other constraints when it comes to the location of the actuator.

WHERE ARE THE SENSOR AND ACTUATOR LOCATED?

Where to locate the sensor and the actuator is a key question to be considered by the designer. All of the previous points I have discussed will have a direct effect on this step. There are basic design issues like not allowing the sensor or actuator to hinder the user's natural ability to physically perform the main activity. So if the main activity requires the user to grip a controller then nor the sensor or actuator should be in the palm of the hand where they would not allow the user to properly grip the control.

The research has uncovered a more nuanced approach to the consideration of sensor and actuator placement. When the experience is of passive sensing, the sensor can be anywhere, either on the user's garments or on the mobile device, since the user will mostly not be aware of the sensing experience until a big change happens, the location of the sensor is irrelevant. The location of the actuator is concerned only with the ability of this actuator to grab the attention of the user at the given time and depending on how much attention is already being used by the main activity, the actuator will have to be in more sensitive parts of the body. A good cold feeling down the neck and back should be able to give a good jolt of urgency to the user.

For active sensing, there are two situations to be examined. The users can have control of the sensor or not. When a user has no control over the sensor, it means that either they are not wearing the sensor or the sensor is tracking signals that have no influence by the users' body movements. In these cases, the actuator can be anywhere on the body as long as it still obeys the rules previously discussed.

If the users have full control over the sensor, it means that they are wearing it and that their body movements have a direct effect on how and what the sensor detects. Think of this as the way we use our nose to find a smell by moving it around looking for the strongest scent, or how we move our hands in front of our bodies in the temporary absence of vision. Here I have found some interesting situations, mainly having to do with whether the user can visually confirm the precise location of the sensor in the body. If the user can see the actual sensor, the brain can create a very tight feedback loop with the movements of the sensor, the object or direction being sensed and the feeling of the actuator. This is a perfect situation for quick learning of the artificial sense and the most effective and accurate use of it. Also, in this situation, the location of the actuator in relation to the sensor is not very important and some freedom can be taken in were to locate it.

In the case that the user has no visual confirmation of the sensor's precise position, like in the second study when the sensor was in the forehead, the accuracy of the experience goes down because of a low sense of proprioception of the user. The user might have an idea of where the sensor is by touching it but when it comes time to aim the sensor towards a particular direction I noticed that the users would not be accurate in where the sensor was or where it was pointed. In these cases, an effort must be made to locate the actuator exactly behind the sensor, the actuator becomes the only clue the user has to the location of the sensor and so they will attempt to line up their sensor with the object or direction they are interested in by assuming the sensor is where they feel the actuator.

CAN WE SET UP A NATURAL LEARNING ENVIRONMENT?

An important element for the success of an artificial sensory experience is the training and learning phase. Some sensory experiences will be easier to learn than others. If there is a redundancy between the artificial sense and a natural sense then an activity should be created so that the users can get accustomed to the overlapping feelings between the artificial and natural senses, then the activity should change so that only the artificial sense is felt with the possibility of checking the users' performance by confirming from time to time with the natural sense. This will not only generate valuable practice but also eventually will re-enforce the users' confidence in their artificial sense.

When users can visually confirm the location of the sensor and actuators on their bodies, the learning process will be faster. This applies to active sensing when the accuracy of the artificial sense is related to the user's control of their body. Proprioception and Kinesthesis are senses that vary wildly from person to person and some users will only be able to master an artificial sense by being able to see how their movements affect the experience.

My results have shown that having confirmation of whether the users' response is correct or not has no significant effect on learning, it does however, have an important effect on the experience of learning, making it more enjoyable and interesting and hence making it a better learning experience.

EXAMPLES

Given this guideline I'll attempt to propose artificial sensory experiences for three main activities.

1- What is the engulfing activity?

   Sailing

2- What type of sensing do we want to create?

   Both active and passive

3- What kind of signal are we tracking?

   Wind speed – quick changes, passive

   North – slow gradual change, passive

   Tilt of boat – quick changing, active

   Depth – slow gradual change, passive

4- What control does the user have over the signal?

Partial control over Depth and Tilt of boat

5- Are there any redundancies with other senses?

Wind speed and tilt of boat have redundancies

North and depth don't have redundancies.

6- What type of actuator can we use?

For North and Depth we can use temperature. Depth can be a passive sense that is activated once the depth becomes shallower than a specified value. North will be a slow changing signal and can be represented by more than one peltier device.

For wind speed and tilt, vibration will work.

7- Where are the sensor and actuator located?

Because of the main activity, hands are out of the question.

The sense of North can be with a belt of peltier devices, it is not intrusive and the body will assimilate the temperature under a particular peltier and when direction changes the body will feel a signal from the newly activate peltier as well as from the de-activated peltier.

Depth must be place in a sensitive area and hopefully away from the North signal. The back of the neck would work.

For winds speed I would choose the forearm, it is close to the hands which the brain will already be paying attention to since they will be controlling the main line and tiller but in the forearm it will be out of the way.

Tilt of boat I would try an approach of three or four vibrators along the side of each thigh that would work in tandem, if the boat inclines towards the left, the bottom left and the top right vibrators would be on.

8- Can we set up a natural learning environment?

Training for north and winds peed would be easy to set up as it might simply be wearing the actuators at any moment when walking outside.

Tilt of boat, if we want to put in the effort, could be trained by creating a surface that tilts under the users weight and then the user can get used to the new sense.

Depth, being a passive sense that will only respond to a limit value does not need training, we simply need to make sure that the user can feel it at any moment.