DIGITAL SYNESTHESIA: USING MOBILE TECHNOLOGY TO INTERACT WITH OUR WORLD

BY

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Executive Summary

Humans have dreamt for many years to go beyond our physical capabilities. We have dreamt about flying, breathing underwater, exploring space or simply moving as fast as possible. All these dreams have been managed through our use of technology and our understanding of the physical world around us. Another vein of human-augmenting dreams deals with our senses. Popular culture has long put forth the value of characters being able to see through walls, feel the presence of danger, use echolocation or sense the emotional state of others. The technology to sense information from the world is being created constantly and mobile technology has made it possible for humans to use these sensors as a ubiquitous just-in-time source of information. This ability to access digital information from anywhere at any time, is the main user experience and the great value of mobile devices. But the interaction with mobile devices heavily relies on transmitting information visually while at the same time demanding a high level of attention from the user.

This thesis explores a way of using sensor and mobile technology to create a superhuman sensory experience that feels as natural as possible to the user. In doing so, I will develop a new paradigm of interaction between a user and the mobile device. One in which the device acts mainly as the “translator” of information while the users’ interaction will be directly with the world they are trying to explore. The basis of the idea is to use a sensory channel, other than vision, to relay the information detected by external sensors.

Digital Synesthesia refers to the ability to use mobile technology as the conduit between the body and aspects of the world that the body is not able to sense. The value of this approach is that the users will be able to explore their immediate environment in a way that is closer to how the original five senses are used to explore and learn. This will allow each user to find a personal meaning to the new information that they are experiencing and interpret it in a unique way. It will provide an experience that uses a greater variety of sensory channels creating a richer more immersive experience. In addition, by avoiding the visual sense, the users can more easily divide their attention between concurrent tasks.

The related work falls mostly into two categories, those that replace a non-working sense with another and those that give the user a completely new sense. The results of these projects have proved that there is a great opportunity in using senses other than vision or hearing. Also they have demonstrated the plasticity of the brain in interpreting information when received through different senses. This thesis will go further by building on top of these findings and asking how we can use Digital Synesthesia to create a new interface paradigm, one that will allow the user to interact directly with the world and not with the mobile device. This will grant the users a richer understanding of the world as they set to explore their new sensory capabilities.

The evaluation of this work will be done by conducting a series of activities where users will wear devices that will generate additional sensory feedback loops. These activities will be analyzed by comparing results with and without the devices and by testing users that may be familiar and un-familiar with the task to be performed. A qualitative result will be obtained from discussion with the subjects about the wearable technology in general and a quantitative result will be obtained from the data collected during the tasks.

With this dissertation I look to understand and help map a new direction for the future of Human-Mobile Device interaction.

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ABSTRACT

Digital Synesthesia is the concept of using sensors and mobile technology to create a user experience that mimics the way people use their senses and enables the perception of information that the body is not capable of sensing. For this to work, the system must not only collect data through sensors but find the best way to pass the information to the body while staying away from visual and auditory channels. This way the brain will be able to accept the new information without shifting or dividing attention from the current task.

One of the key questions of this research is how capable is our brain in mapping new inputs that could be turned on and off and what are the best sensory channels to convey different types of information. This thesis will also shed light on what kind of activities will find this interaction valuable, by creating scenarios where users will be able to use their mobile devices as an additional sense.

BACKGROUND

Many projects and research have been trying to understand the feasibility of using touch, thermal, vibration and haptics to create experiences. I'll present here the research and projects that best support the basis of Digital Synesthesia.

THERMAL INTERFACING

Studies on the person's ability to discern between two materials using only thermal cues have been conducted. They show how such perception is possible when there is a large difference between the thermal capacity and conductivity of the materials[1]. Similar results have been used to present thermal cues to the users in virtual environments and teleoperated systems [2][3].

VIBROTACTILE INTERFACING

LA Jones et al have tested a tactile display mounted in the user's arm and back[4]. Simple commands and instructions were communicated through a vibration pattern and tested for accuracy and efficiency. SenseableRays[5] from Rekimoto Labs uses a small finger-mounted module that detects a structured light signal and emits a vibratory pulse giving the sense of feeling the projected light.

MOBILE COMMUNICATION

Rekimoto lab has presented AffectPhone[6] a system that gives a handset the ability to detect a user's arousal level through GSR sensors and transmit it to another user as hot or cold sensations in the hand. Similarly Pressages[7] is a system that translates the pressure with which one user squeezes the sides of the mobile phone into vibration on the receiving phone. Both these projects are looking to create a better communication by using sensory feedback of the user's state. Connexus[8] was an ambitious project that attempted to detect several signals of the users in order to recreate an image of the non-verbal cues that were being lost in non-co-located communication.

SENSORY SUBSTITUTION

Either because a person may be lacking one of the five senses or because a different sensory input may offer other benefits like greater detail, sensory substitution has been seen in several fields. Most sensors are a translation, temperature, wind speed, distance or the passing of time; are all things our bodies can perceive but by using a sensor and translating the information to a coded visual form we add the ability of greater accuracy and universal understanding. Brainport[9] is a system that captures images through a camera and translates it into electrical signals that are felt on the tongue. The artist Neil Harbisson and his team have developed Eyeborg[10] so that Neil, who is completely color-blind, can use this device to capture color information through a camera on his forehead and translate it to sound he hears through bone conduction.

New Senses

Another big area in this field is creating completely new senses. Mostly out of curiosity, adding a new sense to our repertoire changes the way we understand and interact with the world. If the Umwelt[11] theory shows how every creature can only understand the world through the affordances of its senses, then creating new senses should open up completely new world perspectives for humans. The FeelSpace[12] belt was a device with vibrators that could be worn around the waist. The vibrator closest to geographical north would constantly vibrate, giving the user a sense of direction. Another take on navigation is Momo[13] a egg-like device that leans towards the direction the traveler needs to go so the change in the center of gravity of the device is perceptible in the hands of the user. Dan Berg, a writer and technology advisor implanted a small magnet into the little finger of his right hand[14]. One of the reported effects was the ability to sense electrical flow by disruptions on the magnetic field. Disney research has developed Aireal[15] to use air vortices to create a tactile sensation of virtual images or images projected on the body.

Situational Awareness

Situational Awareness is the ability to extract information from our environment and integrate it with previous knowledge in order to form a coherent mental picture[16]. The military has done extensive research on Situational Awareness both learning the limits of the brain when forced to work in an environment with many attention cues as well as the different strategies for reducing the cognitive load while conveying information to the brain through channels other than sight or sound.

Other than many studies in how to measure Situational Awareness in various users and situations, there are some papers on actual devices being tested that use Vibrotactile Displays[17] and Tactile Navigation Cueing[18].

RESEARCH QUESTIONS

The questions that will be answered with this project are related to the success of Digital Synesthesia as an interaction paradigm in different scenarios. The studies and scenarios will be broad enough to be generalized in other situations. Another line of questions will look at the relation between type of data and the mode of transmitting this data to the body. One important objective is to generate a design guideline for future synesthetic interfaces. This guideline would allow future research to understand what feedback modalities are better suited to the synesthetic translation of which new sense. So that temperature might be better for binary or yes/no/neutral situations while vibration might be better at sensations that imply different degrees of intensity.

DISCREET AND CONTINUOUS DATA

1. Will a discreet signal that just turns on and off to get the users attention be more effective than a continuous signal that needs for the user's interpretation of changing data?

2. Is there a better or worse pairing between the input channel and the type of data to be analyzed?

SENSORY SUBSTITUTION

3. In a situation where vision is the sense used to make a quick decision, will Digital Synesthesia prove to be an alternate way of accomplishing the same task or part of that task?

SENSORY AUGMENTATION

4. In a situation where the user already bases a decision on information from a sense other than vision or audio, is there an advantage to being able to interpret that same data through a different sense and in greater detail?

NEW SENSES

5. How does a user perform in a specific task when using new information that could not previously be sensed, compared to the same activity with no sensory enhancement?

THE USER AND THE NEW STIMULI

6. How accurate is the interpretation of the data when experienced in this new way?

7. Will there be feelings of "phantom input" where the user will feel the effects of a stimulation that is not present.

8. How valuable is the device when used towards the completion of a task when the user is first learning this task? When used by someone who is experienced in the given task?

Escaping the visual user interface

We know there are other senses but our understanding of visual user interfaces makes us think of the interface with these new senses in visual terms, where input signal is translated to numeric data and transmitted to the eyes.

9. Can we find the new usage paradigms for senses other than sight?

10. Can this research start to uncover the particular ways in which information should be understood and interpreted when transmitted to the skin (or other senses) than to the eyes? Perhaps the idea of "value" is mostly a visual construct.

Design Thinking

11. Can a pattern be observed such that we can use the findings of this thesis to create a guideline of sensory mapping?

12. Could this research pave the way for a new "Mixed-Sensory Interface" field in the user interface world?

Research Plan

The first step is to design simple input-output systems where sensor data will be sent to the mobile device and the device will translate and send the information to an output modality. Currently I have built a temperature to vibration head-band, a location to temperature system that currently is worn on the back of the neck and a warning system that takes an online prompt like email and gives a scent as a signal. In addition I plan to build a pressure sensing system to be used between fingers and an ultrasonic system to be used between the hands. For each of these systems there will be a usage scenario designed to test the value of the translation.

Different scenarios will be designed in order to test a Digital Synesthesia interface. The design of the scenario will aim to answer some of the research questions outlined. Each scenario will allow for pairing different output modalities to a single input sensor in order to compare the efficacy of each output. Each test will be performed with vibration, thermal and bone conducted sound in order to decide which type of feedback better fits each particular data type.

Proposed Scenarios

In order to test a situation of sense augmentation a wearable pressure sensor will be placed at the user's fingertips. Pressure information will be translated to the body while adjusting the sensitivity level. This will allow me to compare the hand's natural pressure sensitivity to the sensor's performance and by adjusting the sensitivity of the sensor I can test if this sense augmentation strategy is in any way advantageous.

For testing a new sense, the users will wear a head band that can detect the facial temperatures of a person standing in front of the user. With accurate temperature measurements, the user should be able to detect the level of stress of the other person[19]. This might be useful in a gaming scenario, like a poker game, where knowing the stress level of the other players can be of use to the user.

Another new sense test will be a location awareness scenario where a user can receive feedback depending on their location around the lab. This test will be used to look at the user's response to an alert that they might not be constantly looking for, un-like the poker game where the user will want to be constantly paying attention to the signal.

As the project advances and I am able to test new circuits and scenarios, I expect to be able to propose more input-output systems to be tested.

Timeline

Phase One (January)

This stage is dealing with the final contexts that will be developed to prove my thesis as well as getting the proposal submitted and approved by MASCOM and defended.

Phase Two (February - March)

This is the development stage. Fabrication and initial testing will be made of each of the systems for the contexts chosen. Extra attention will be put on the mobility of the system and its future deployment outside the lab.

Phase Three (April - May)

User Testing will be done with the systems in a controlled environment.

Phase Four (June - July)

Thesis writing and defense

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Bio

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Santiago received a B. in Industrial Design from Universidad Jorge Tadeo Lozano y Bogotá, Colombia (2003), a Master in Industrial Design from the Rhode Island School of Design (2007) and a S.M. in Media Technology from MIT in 2010. During his time before MIT Santiago worked in areas as varied as Media Broadcasting, Architecture and Education. During his master at the Media Lab, he started to look into the interfaces between users and objects with an emphasis on mobile devices and video storytelling. He has also taught courses on fabrication and design.