ARTIFICIAL SYNAESTHESIA: EXPANDING HORIZONS OF HUMAN PERCEPTIONS

ABSTRACT

As French philosopher Roland Barthes said, there is no natural connection between signifier and signified, the existence of an object in the objective world is perceived by our sensory organs, such as shapes, colours and temperature of objects are just our subjective perceptual language in the brain. Hearing colours, tasting alphabets, the fundamental appearance of synaesthesia is based on “non-existent hallucination” in the brain. How to use those hallucinations to represent the information, that unnoticed or cannot be perceived because of limitation of senses in humans, is primary aim of this project. Thus, a novel head-mounted device is presented, the device gathers visual information and represents into pure tactile language, it provides a possibility: haptic as a “low-resolution” perceptual language, can be used as a new channel of senses, by means of machine cognition and artificial intelligence to expand horizons of perception in humans.

INTRODUCTION

Visible light waves (vision), temperature (haptic), chemical molecules (taste) and other phenomena we can see or perceive are actually a tiny part of the real world. In real life, much information goes unnoticed and cannot be perceived because of limitation of senses in humans. To increase the capacity of the human mind has thus been our goal since a long time.

Synaesthesia is a perceptual phenomenon in which the stimulation of one sensory or cognitive pathway leads to automatic, involuntary experiences in a second sensory or cognitive pathway (Cytowic 2002); such as hearing the colours, tasting the shape of alphabets, and seeing colours of music are, that perceptions do not have in the objective world. But synaesthesia provides us a general idea of how a sense can be transferred to other senses. Therefore, “artificial synaesthesia” is designed so that people who do not have synaesthetic experiences can gain the ability to experience joined perception through human intervention. This new perceptual experience allows people to “see” familiar objects in a completely new way and also to expand the abilities of their natural perception to make them feel objects that were ignored or even to discover an unknown world that they had not been able to sense.

Humans’ vision involves more complex neural mechanisms and gathers distinctively more information than the other senses, I attempt to translate visual information into tactile information by artificial means, the aim of this project is to discover the novel perceptual channel of humans, to allow people expanding their perceptual abilities. The fundamental appearance of synaesthesia is based on “non-existent hallucination” in the brain, thus, the reality of the world was never my consideration during this project; the important question is how people use their own imagination to understand the subjective world, and eventually by means of machine cognition and artificial intelligence to enhance sensory abilities.

SENSORY SUBSTITUTION

The first idea of sensory substitution was introduced in the 1960s by Bach-y-Rita. Sensory substitution systems attempt by using artificial means, to help people who have a sensory impairment to restore their ability to perceive a certain sensory modality (Bach-y-Rita 2003). It is a similar concept to artificial synaesthesia, but the two also have significant differences. Sensory substitution has developed over almost half a century, and many products and prototypes are being applied. Brain plasticity is one of the most important theoretical ideas supporting the sensory substitution system. During sensory substitution experiments, scientists have shown how impressively flexible the human nervous system can be when heavily trained (Singh-Curry 2008).

In previous works scientists focused mainly on to convey “real” information from one perceptual modality to another, as shown in Figure 1, although the modality was transferred successfully, the information still retained the shape stimulation (visual information).

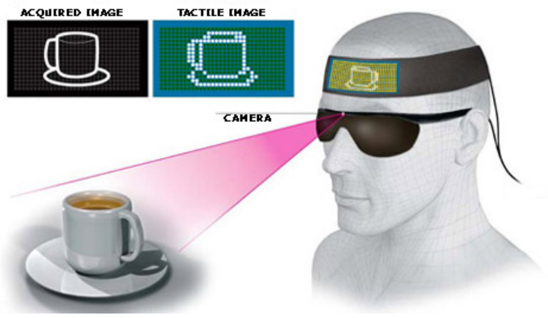

Figure 1: The tactile display unit (Kaczmarek 2011)

In my opinion, the perceptions of humans and the reality of the environment have no direct connection. Perception is likely the brain’s language describing reality, a symbol for the object. What we should be really concentrated on is the translation of the language.

For example, the most successful sensory substitution system to date is braille. The braille system does not simply use an embossed alphabet; instead, the characters have different tiny bumps called “raised bots”. Raised bots are actually the new tactile language describing the alphabets. “Hallucination” is the biggest difference between artificial synaesthesia and sensory substitution. Artificial synaesthesia lets people through technical interference to feel information that should not exist, and after multiple trainings, to manually build a connection with the real feature of an object.

RE: VISION

The imagination of human being can be used not only in the creative artistic works, it offers pragmatic applications, too. In my conception, the most important point that I focus on, will be to invent a tactile “language,” to represent our visual perception in a completely different way.

FIRST PROTOTYPE

As an initial point, the system based on a Kinect camera for gathering the visual data is presented (Figure 2). The camera emitted thousands of invisible infrared rays, to calculate the area of objects in a certain distance, and the environment towards camera has diverted into multiple sections in the monitor. The collision of infrared rays in different section would be activating different LED, depends on the number of collision the intensities of LEDs can also change autonomously. In this respect, the intensity of signals was connected the area of objects in the sections directly, with more collisions responses the LED higher Luminance.

Figure 2: Visualisation of visual data

INPUT

The second step that was taken into consideration, was how to translate the information and to receive those data through suitable tactile signals. Compared to haptic devices of previous works, conveying unnecessary information about the environment can lead to a risk of sensory overload. The translation of tactile signals should be as simply and as distinct as possible. The first proposal of application was to use mini vibrators instead of the LEDs (Figure 3 left). But it does not fully meet our expectation because of the lack of sensitive receptor. The second proposal was designed to simulate the press stimuli by using hub magnet (Figure 3 right), which was more accurate and similar stimulus of electrical stimulation.

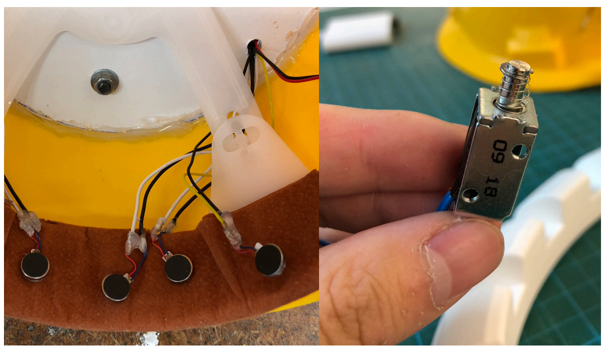

Figure 3: The proposals of input simulation

The final stage of this prototype integrated the Kinect motion sensor and the input simulation, that can be attached to the head; the hub magnets, which are with annular housing mounted, can generate the stimuli, and be convey to the forehead (Figure 4).

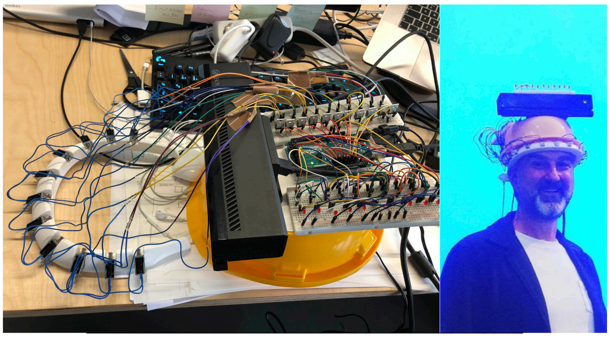

Figure 4: Final stage of the prototype

REPRESENTATION

How can the spatial position and the shape of objects be represented like our visual perception with only a few stimuli in one row taking into account the limited change in the magnitude? For accomplishments of representing such quantity of visual data, three distinct factors have to be condition and notice:

- The changes of direction, that what are user facing (head rotation).
- The changes of position, that where is user standing.
- The changes of each signal intensity in certain moment

To more clarify describing the way, how to represent visual data using tactile language, the fundamental functions were be illustrated (see Figure 5 and 6). The grid shapes express the sections toward camera system, each section connect with each stimulus in the round shape.

As a head-mounted device, the reception of environmental information is based on the rotation of the head, when the head is no longer towards the target, the stimuli will also be transferred from centre of forehead to the side. The advantage of this change is, when user is moving, the feedback of target changes constantly, unless the head is always towards the target during the movement. Therefore, when user moves, the change of feedback can intuitively indicate the spatial position of target (Figure 5).

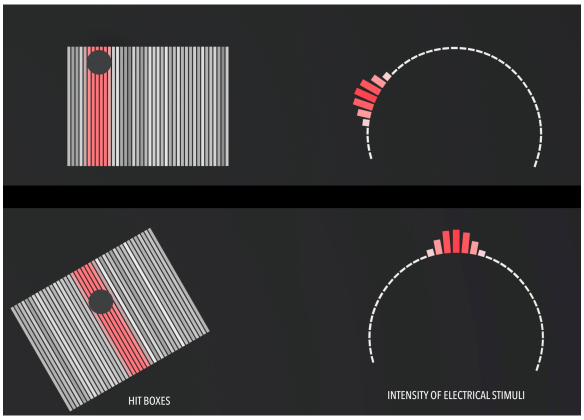

Figure 5: The changes of signals during head rotation

After long-term training, subtle variations of signal intensity can even indicate differences in the shape of different objects. At the moment of contact between the target and the perceivable range of the prototype, the change of signal intensity and the velocity of change in each point can discern the difference from shapes of target (Figure 6). According to this feature, the height and size of the target can be also identified by different variations of signals intensities.

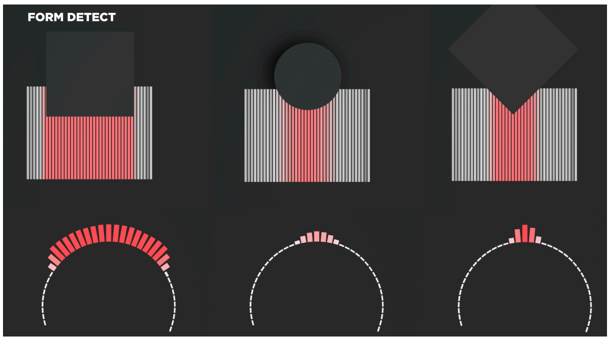

Figure 6: Form detection

Thus, in this prototype, with the help of physical movements such as head rotation, user's movement, the visual description like such shape has fully replaced into the variations of tactile signals. When the signs are accepted and understood in the brain, then the purpose of artificial synaesthesia has been completed.

SECOND PROTOTYPE

Evidence from neuroimaging and transcranial magnetic stimulation (TMS) highlights the general point that different senses do not operate in isolation (Pasqualotto 2012). There are many examples of how information transfer from one modality influences, or even alters, our perception of stimuli in another modality; this also shows how important the integration of different sensory modalities can be. Therefore, based on the first prototype, an auditory sensory modality has considered as an additional perceptual channel in the new prototype. For extending human perception our primary condition is that, sensory substitution should not heavily interfere with other important senses, especially hearing. So the auditory stimulator would be applied only as supplementary input for this prototype.

for practical usage, a head-mounted, lightweight device was designed after comparisons of a variety of shapes and ergonomic considerations (Figure 7).

Figure 7: Appearance of prototype

The final product consisted of three parts (Figure 8): 1. Visual information collector. 2. A row of tactile signal generators. 3. Auditory signal generator.

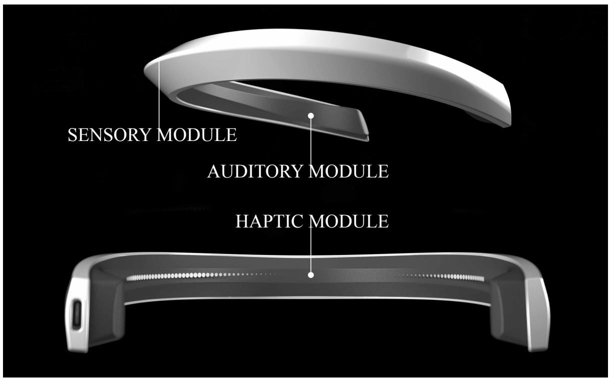

Figure 8: Consist of prototype

According to previous experiments of sensory substitution, using haptics to convey visual information is strongly constrained by the intricacies of haptic representation, although some highly trained observers are able to notice remarkable details. Sensory overload and heavy learning process are inevitable conditions in this project.

CONCLUSSION

Such as shapes, colours, and etc., the subjective description of objects, are actually a perceptual language of our brain. Inspired by that this paper designs a prototype, that represents visual information into tactile language. The successful visual substitution proves, that the information, which received by the natural sensory organs, can be perceived in another form through manual intervention.

Machine cognition, artificial intelligence, the common research topics in recent years, show us how in the future people's daily life would be like, the interaction between people and machine, and also external world become more complex. The aim of this project is to propose a possibility: haptic as a kind of "low-resolution" perceptual language (Gallace 2006), can be described such quantity of information like vision; it can be used also as a new channel of the senses, by means of machine cognition, and artificial intelligence to expand perception in humans.

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