The Artistic Potential of Tactile Vision Interfaces: A First Look

Antal Ruhl
Avans University of Applied Sciences, Parallelweg 21–24, 5223 AL, Den Bosch, NL
a.ruhl1@avans.nl

Michel van Dartel
Avans University of Applied Sciences, Centre of Expertise for Art, Design and Technology
Beukenlaan 1
4854 TA, Breda, NL
mf.vandartel@avans.nl

Alwin de Rooij
Tilburg University, Tilburg center for Cognition and Communication
Warandelaan 2,
5037 AB, Tilburg, NL
AlwindeRooij@uvt.nl

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Abstract
Interfaces that subvert, substitute, or augment the relationship between acting and sensing make interesting tools for experimentation in artistic research. Amongst them, tactile vision interfaces, which enable people to experience to “see with their skin”, have particular appeal. However, surprisingly few such interfaces are used by artists. In the present work we take a first look at how the artistic potential of tactile vision interfaces could be unlocked. On the basis of related artistic work, we argue that an accessible, generalizable and learnable interface is needed to enable artists to explore the possibilities of tactile vision. Subsequently, we present ongoing research that revolves around the development of such a tactile vision interface. A case study is presented that informs the development of a new prototype of this interface that overcomes two key limitations in its purpose to unlock the artistic potential of tactile vision.

Author Keywords
New Media Art; Sensory Augmentation; Sensory Substitution; Tactile Vision; Cognitive Science.

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H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

Introduction

Developments in cognitive science suggest that people make sense of their environment by exploiting contingencies between their physical actions and the changes in sensory input that these actions bring about [9]. In parallel, recent developments in the domain of art suggest that art is not to look at or listen to passively, but that art should call to action to make sense of something [9]. Therefore, interfaces that subvert, substitute, or augment the relationship between acting and sensing, make interesting tools for both scientific as well as artistic experimentation [2].

Tactile vision interfaces map data from imaging sensors worn on the body to tactile sensory stimulation in real-time [1] and can be used to achieve a wide range of sensory augmentations [6]. Such augmentations enable novel and surprising ways to make sense of our environment, which makes them appealing for artistic experiences that activate and challenge audiences to make sense of something. However, surprisingly few tactile vision interfaces are being used in the domain of art. It seems that the artistic potential of tactile vision interfaces has yet to be unlocked.

In this paper, we present ongoing research on the development of a tactile vision interface that may help to unlock this artistic potential.

Tactile vision interfaces

Counteracting the cold, hard and less human world of screens, the body can be seen as a canvas where interaction takes place to explore the human-technology relationship on a much more personal level [16]. Tactile vision interfaces are designed to substitute or augment the visual sense, by mapping the sensory changes that result from the movement of an image sensor to the sensory changes in the tactile sense [6]. Such sensorimotor mappings can, for instance, enable or support sensemaking in the absence of a sufficiently functioning visual sense, i.e., *sensory substitution* [1], but may also augment sensemaking by pairing vision through the eyes with tactile vision, i.e. *sensory augmentation* [14].

Sensory substitution based on tactile vision was pioneered by Bach-y-Rita, who developed the first tactile vision interface: a chair with a camera placed over the user’s shoulder, and a mapping of the camera image sensor to a grid of solenoids embedded in the backrest of a chair [1]. After training, people used the interface to estimate an object’s spatial orientation and recognize the type of object, sometimes achieving remarkable detail, such as recognizing whether a person in front of them was wearing glasses or not [15]. A noteworthy observation made during these pioneering studies is that for some participants the tactile vision interface enabled the novel subjective experience of *“seeing with the skin”* [15].

Sensory augmentation through tactile vision is achieved by, for instance, making use of the specialized properties of the tactile sense to process visual information (e.g. a higher temporal resolution, cf. [4]), making use of the imaging sensor and processing capabilities that extend the human visual sense (e.g. using an infra-red image sensor [14]), or placing the image sensor on the body in an ‘unnatural’ configuration (e.g. an image sensor on the hands embedded in a glove [7]). These particular uses of tactile vision expand a person’s sensemaking capabilities, and thus their ability to have novel personal and subjective experiences.

While anecdotal subjective experiences, such as “seeing with the skin” [15], are commonly not further explored in scientific research, such novel personal and subjective experiences are a key subject for exploration in artistic research. While anecdotal evidence points towards extremely interesting subjective experiences based on tactile vision [11], our conjecture is that this artistic potential has yet to be realized.

Unlocking artistic potential

An exploration of the artistic potential of sensory augmentation implies that novel experiences are created on the basis of a person’s active contribution to the emergence of that experience. This implication aligns well with a contemporary shift in art theory that considers art a call to action to make sense of something, rather than the passive consumption of some object [9]. In line with this, much artistic work has shifted from making objects to actively intervening, subverting, and augmenting the relationship between humans and their environment [2].

Artist Carsten Höller, for instance, aims to elicit experiences that are “like an expedition, a conscious decision to get confused, to end up somewhere else”, which contrasts with viewing the artist as a kind of “visionary who says ‘This way, follow me!’” [13]. Such artistic work enables its audience to have novel personal and subjective experiences, based on their own active contributions. Experiences based on sensory augmentation do exactly that, which means they have substantial potential for artistic work. Although artists do incorporate sensory augmentation in their work (see [11] for examples), tactile vision is generally not the preferred means to achieve it.

We identify three potential reasons for this:

Accessibility. A noteworthy artistic achievement that involves tactile vision is *Invisible Labyrinth* by artist Jeppe Hein. In this work, Hein applies a head-band equipped with location sensors and small vibrators to indicate distance to invisible barriers, forming a labyrinth that challenges visitors to find their way out of [10]. Although the work has been widely reviewed (see, e.g., [5]), these reviews do generally not acknowledge the technological challenges involved in achieving a convincing tactile vision experience of this scale. The expertise and financial means required to implement tactile vision on such a scale lays well beyond the reach of most artists. Therefore, increased *accessibility* to tactile vision technology, e.g. by creating more affordable solutions that are ‘plug-and-play’, could open its potential to a wider use by artists.

Generalizability. As every artwork aims to achieve a different experience, an interface will only be widely used by artists if it allows for the exploration of diverse experiences; i.e. it should be general in its purpose by, for example, having interchangeable input sensors and output actuators to enable a wide variety of sensorimotor mappings. Similarly, *multiple* inputs and outputs could aid experimentation on new combinations of mappings, without the need to redesign the interface or reprogram the software. Therefore, *generalisability* based on modularity and multiplicity seems key for an interface to unlock the artistic potential of haptic vision.

Figure 1: Front of the haptic vision interface, with camera.

Figure 2: Back of the haptic vision interface, with solenoids.

[1] See github.com/antalruhl/Tactile-Vision for files and code.

Learnability. If conscious experience relies on the capacity to exploit contingencies between physical actions and the changes in sensory input that result from these actions, then having rich sensory experiences requires *learning* to understand these contingencies [15]. Not surprisingly, it has been proven that haptic vision based on high resolution tactile stimulation requires more practice (e.g., 20-40 hours with Bach-y-Rita's 20x20 solenoid grid [15]), than haptic vision based on a low-resolution output (e.g., one vibrating actuator on the skin connected to a distance sensor can instantly be used [3]). Therefore, a tactile vision interface should have a relatively low resolution to meet the amount of time an audience is likely to invest in an artistic experience, or should be adjustable to the preferred duration of an experience.

Prototyping a tactile vision interface

To mitigate these three reasons that may prevent artists from widely using tactile vision in their work, we are developing an interface based on accessibility, generalizability, and learnability. To have a first look at how such an interface may support the unlocking of the artistic potential of tactile vision, we created and tested a rudimentary interface that maps image sensor data to a tactile actuator in a modular way.

The input module is a 3x3 grid of motorized pixels in a lightweight wooden casing (Figure 1). A camera can be mounted on top of the casing, in which case a custom software program translates the camera's feed into a 3x3 pixel feed. The grey value of each pixel is continuously filtered, using a threshold that categorizes the input as either 'black' or 'white'. When an input is classified as 'black', the corresponding motorized pixel is activated; when an input is classified as 'white', the pixel is not activated.

Another wooden box holds an Arduino board, to which a desired mapping between the input and output can be uploaded, as well as a custom-build electrical circuit to interface the input and output (Figure 1).

The output module consists of a 3x3 grid of solenoids (Figure 2). The linear motors driving these solenoids administer local pressure on the skin when the Arduino board transmits an electrical pulse because one of the motorized pixel is activated. Together, these nine solenoids function as binary pixels, i.e., each of them either pushes against the skin or remains passive[1].

A first look at the artistic potential

To explore how such an interface may support the unlocking of the artistic potential of tactile vision, we conducted a small case study in the form of a masterclass which consisted of six parts: 1.) an introduction to the art and science of sensory augmentation, 2.) introductions to a range of sensory augmentation interfaces (including the tactile vision interface introduced above), 3.) hands-on exploration of these interfaces, 4.) the forming of subgroups around each of the interfaces, 5.) discussions within each subgroup moderated by experts instructed to steer their discussion towards possible uses of the interface, and 6.) presentations of discussion outcomes to the whole group.

The participants (n=13) consisted of a mix of students and young professionals with backgrounds in art, design and science. The masterclass was held as part of the *STRP Biennial* on March 28, 2017 [12].

Figure 3: A rudimentary test to measure in how far haptic vision is of aid to people with impaired vision.

During the masterclass, participants focusing on inversion goggles (i.e. goggles that reverse vision, e.g., up and down), decided to work together with the subgroup that explored the tactile vision interface. This unscripted merge led the group discussion to gravitate towards the potential of combining *'inverted vision'* with *'tactile vision'*. This sparked a surprising number of ideas in which the tactile vision interface could be used to substitute inverted vision; e.g., to compensate for the difficulty of coordinating limbs while vision is inverted, or to aid the learning of new sensorimotor contingencies that result from reversing vision.

One of these ideas was a rudimentary test for the extent to which haptic vision can be of aid to people with impaired vision (Figure 3). For the demonstration of this concept, two participants were asked to wear a pair of inverted goggles; one of them was subsequently also equipped with the tactile vision interface, which was attached to the palm of his/her dominant hand. Both participants were then instructed to follow a jagged line on the wall, with one hand and starting at the same time. As both participants struggled to follow the jagged line with their hand, because their vision was inverted, it became apparent that the participant equipped *with* haptic vision interface had a significant advantage opposed to the participant who followed the line with his/her bare hand.

Due to popular demand amongst the participants, based on the competitive element of the concept, the test was performed many times with different participants. Repeating the demonstration resulted in a range of interesting descriptions of the subjective experiences that participants had while performing the test. One participant, for instance, remarked *"I had the feeling that I could feel the line"*, which suggests that the interface could unlock the potential to make 2D visual information tangible.

In summary, our case study resulted in the observation that the haptic vision interface (i) provides useful additional information when vision is impaired (ii) can be engaging and fun, and (iii) is useful in gaining insight into the subjective experience of haptic vision.

Implications for the prototype

These preliminary findings suggest that, on the basis of our rudimentary interface, (i) tactile vision can be made accessible, as it allowed novices to work with and experience haptic vision; (ii) different types of applications can be conceived, as illustrated by the diversity of ideas and experiences obtained; and (iii) the learning required can be scaled to an amount suited for art experiences, as at least one of the demonstrations was considered engaging. The case study, however, also uncovered some shortcomings of the interface.

Firstly, our findings suggest that the generalizability of the rudimentary prototype is limited: Although it prompted the exploration of different ways to map the image data to the tactile grid, and facilitated experiences of these mappings, these explorations and experiences were limited to the fixed configuration of the actuators in a grid and to the positions on the body where these actuators could be placed (cf. [7]). More flexibility in the configuration and placing of the actuators is required to generalize the purpose of the interface to a wider range of potential experiences.

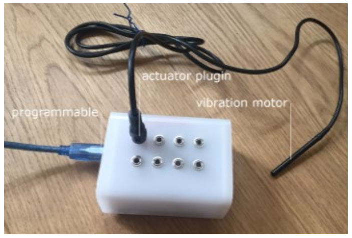

Figure 4: A new version of the tactile vision interface, with vibration motors

Secondly, our case study suggests that exploration with the interface does not automatically elicit artistic exploration, even when the exploration is conducted in the context of an art festival and participants are first introduced to related artistic work. This could be partly attributed to the set up of the masterclass (e.g., as not all participants were artists and participants were allowed to explore in any direction), yet could also be attributed to the interface itself: The binary output signal, for instance, may force participants to reason from this technological limitation (e.g., an exploration mainly targeting meaningful mappings that can be made given on/off output) rather than from the wider possibilities of haptic vision (e.g., an exploration of interesting artistic concepts that the interface may be able to facilitate). The case study therefore suggests that the masterclass, but possibly also the prototype itself, requires further work.

Work in progress

The preliminary findings above suggest that a redesign of the prototype is needed to unlock the artistic potential of haptic vision interfaces. To this end, we are currently developing a new version of the interface (Figure 4), which explicitly addresses the need for more generalizability and for better support in the elicitation of artistic concepts.

This version[2] consists of 8 vibration motors, each of which can be individually connected to the body using *velcro* straps. This design allows for a lot of freedom in the spatial configuration of the actuators and how they are placed on the body. The vibration motors can be connected to a custom-made plastic plug-and-play box, through which they can connect to a computer or to analog input sensors. The number of actuators can be varied easily this way. Also, although the actuators can still be placed in a grid on one body part, they can now also be spread over the body in different configurations. This improvement may overcome the first shortcoming that our findings suggested, as the higher flexibility in the configuration and placing of the actuators on the body generalizes the purpose of the interface to a wider range of potential experiences.

In the light of the second shortcoming suggested by our case study, the upgrade from solenoids to vibrating actuators should be noted. As vibrators allow for binary as well as nonbinary mapping, this improvement allows for the exploration of all scenarios that could be conceived on the basis of the previous version of the interface, but also opens up the possibility to explore scenarios that require more subtle mappings. For instance, the vibrating motors may allow for seeing grey scales or signal strengths "through the skin", and henceforth may better support the elicitation of artistic concepts.

Demonstration at TEI'18

TEI '18 makes for an ideal time and place to combine a discussion of our progress with the premiere demonstration of our new prototype. The demonstration will allow visitors and participants of TEI'18 to experience tactile vision and to explore potential applications on the basis of live experimentation. We expect that this will generate feedback from experts in the field of tangible interfaces, which will help us to evaluate the new prototype and to gain technical insight into the accessible, generalizable and learnable tactile vision solutions that will ultimately unlock its artistic potential.

[2] See github.com/antalruhl/Modular_Tactile_Interface for files and code.

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