Synesthetic Video: Hearing Colors, Seeing Sounds

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ABSTRACT
In this paper we present Synesthetic Video, an interactive video that allows to experience video in cross-sensorial ways, to hear its colors and to influence its visual properties with sound and music, through user interaction or ambient influence. Our main motivations include accessibility, enriching users experiences, stimulating and supporting users creativity, and to learn more about synesthesia and how videos can influence and be influenced by users and the ambient, at the crossroads of art, science and technology.

Categories and Subject Descriptors
H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – Video, Audio input/output.

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – Interaction styles.

General Terms
Design, Experimentation, Human Factors.

Keywords
Synesthesia, Video, Color, Audio, Music, Ambient Media, Immersive Interactive Interfaces, Perception, Neuroscience, Accessibility, Digital Art.

1. INTRODUCTION
Synesthesia is a neurological phenomenon that occurs when a stimulus in one sense modality immediately evokes a sensation in another sense modality. It means to perceive (esthesia) together (syn) [5,22], and was first documented in 1880 by F. Galton, a cousin of Darwin, in a paper in Nature. Examples of synesthesia include to hear music in color, patterns or tastes; to see letters and names in color; or to experience tastes as shapes or textures. Young synesthetes find these relations so obvious that since early age they always think that everyone has it, but later find out that this is not the case. Actually, Cytowic suggests that we might all be synesthetic at a subconscious level of central nervous system functioning - a normal process but one hidden below consciousness in all but a few of us. However, there is becoming clearer evidence of the genetic basis of the phenomenon then the ideas that we all have synesthesia but are unaware of it, or that these are learned associations.

MindTrek 2010, October 6th-October 8th 2010, Tampere, FINLAND.

In synesthetes' brains, regions of the brain that normally do not communicate, such as the visual and auditory cortexes, show signs of what is known as crosstalk, influencing their experience of the world. Some consider it a defect, others as a skill to perceive other dimensions of reality. Often, synesthesia is mentioned in the media as a neurological defect, or by neurologists as a congenital brain defect. But do synesthetes experience their synesthesia as a disability, as something that impairs them in daily lives? Not quite. They often report how useful they find their ability in their daily lives, for example when they remember names or telephone numbers through their perceived colors [2]. Ramachandran [22] addresses the relation between synesthesia and creativity, presenting studies reporting that this condition is seven times more common in creative people than in the general population. Although correlated, there is still a lack of scientific proof of this relation. Cytowic and Watson discuss cooking and how his synesthesia enhances his creativity and enjoyment - he liked to create a dish with an 'interesting shape' [5]. Kandisky is reported to have painted his atypical visual experiences when listening to or reading music [10], and also Paul Klee's painting style is known to be very influenced by music [20].

Cytowic [5,6] suggests synesthetics leads one to consider why sensory experience is always modular, why touch and vision, for instance, or hearing and smell, are kept separate. What makes synesthesia such a fascinating phenomenon is that it raises questions that scientists cannot answer at present. Rarely has scientific inquiry concerned itself with all the senses at the same time. The same can be said of the arts - e.g. the domain of connecting music and the visual arts has been increasingly explored only in recent decades [2,9]. These quests brought van Campen to explore what he called the "hidden sense" [2]. Cytowic, in turn, brought up between the two worlds of his father's medicine and his mother's art, has long been interested in the harmony between science and art, between the slow and frequently tedious deliberations of theory proving and the bold expansive and imaginative brush strokes as paint hits canvas, and has been approaching it with a strong root on neuropsychology.

We became interested and somehow fascinated by synesthesia based on our own experiences and previous works [3,4,16,23]. We have been working on the interactive visualization of video spaces, on creative video editing, on accessibility, in particular, with digital talking books and on ways to teach human-computer interaction, with a strong visual dimension, to blind people. In addition, one of the authors is blind and at least another one is a synesthete. So our main motivations for this work include exploring ways to make video images more accessible to blind people, and possibly video sound more accessible to deaf people, and to explore the creative and artistic dimensions by letting people experience video in synesthetic ways, to let them interactively co-create their own versions of the videos in this way, stimulating and supporting their creativity, and to learn how videos can be influenced by the ambient [13] where they are being played.

Being video a very rich medium, able to present in a rich cultural context a large quantity and diversity of multimedia information, and in a moment when video is becoming a pervasive medium, reaching more people in more contexts, we believe it is relevant to address video in this synesthetic perspective at the crossroads of science, technology and art.

In the next section, we present a review of related work. Section 3 presents Synesthetic Video, focusing on the correspondence of colors and sound and the modes of hearing colors and seeing sounds. Section 4 presents some conclusions and perspectives for future work.

2. RELATED WORK

The conception of devices that relate music and colored light is documented since late XVIth century, later explored in the construction and use of color organs since the XVIIIth century [21,18]. These where mechanical devices in the beginning, then electromechanical, built to represent sound or accompany music in a visual medium. Since 1960s and 70s, electronic devices have been used to respond to music with light shows, and the term light organ is increasingly being used for these devices. Gregorio Comanini in the XVIth century, Louis Bertrand Castel in the XVIIIth century, and Rimington in XIXth century are among the authors of this concept and devices. Quite famous was Scriabin synaesthetic symphony, Prometheus: The Poem of Fire, whose premiere in New York was performed in 1915. Since then, other artists have explored this form of art. Scriabin, a Russian composer and pianist, believed to be a synesthete himself, developed a color system, lining up with the circle of fifths based on Newton's optics [7]. He has influenced the work of other artists like Prokofiev and Stravinsky. Stravinsky and Kandinsky [10] used to write each other letters about the relations of music and painting.

ArTbitrating JaVox [19] is an environment for artistic production in visual and sound domains, upgrading aesthetical judgment through interactive evolutionary computation techniques. As a case study, Kandinsky's like objects based on geometric shapes are created and evolved, exploring relationships between visual features of images and sound in the generated music. Margounakis and Politis [15] generate music from the chromaticism of an image. MetaSynth is an electronic music application and sound design environment, featuring the ImageSynth application that transforms user paintings to sound based on color and brightness [17]. The vOICe is a synthetic vision software that helps blind people by transmitting the ambient or recorded video images through sound [26] by increasing awareness of: left and right, through stereo pan; up and down, through sound pitch; and dark and light, through audio loudness. Also with the aim to help blind people, in this case to be able to perceive information organized in tables, [11] describes a non-visual interface, based on the sonification of its values, by line and column, in different levels of detail.

Synchronism between images and sounds is variably known as ocular music, visual music, colourful music or music-to-the-eyes [12]. More aligned with the aims of color organs, some applications transform music into images or colors, being Windows Media Player one of the most popular.

Saenz and Koch [24] reported the existence of visually induced synesthesia, where people hear sound in the presence of visual flashes, helping to understand the frontiers of creativity. With the aim of providing a multi-sensorial experience similar to synesthesia, which the authors believe might improve users' overall perception of the works of art as well as enhance their own creativity, Sense^2 [8] was developed to play music, based on rythms, out of paintings, based on shapes.

3. SYNESTHETIC VIDEO

To explore synesthetic perceptions of video, Synestetic Video was developed with two main modes: one that allows hearing visual information based on the colors in the video frames, and another one that allows influencing the visual dimension of the video through audio.

3.1 Correspondence of Colors and Sound

In synesthesia, an individual experiencing a sensation in one sensory modality also experiences, involuntarily, a sensation in another sensory modality. The most common experience seems to be seeing color when hearing sounds. This crossmodal sensation is reproducible in a given individual during his lifetime, so that a given sound or word always leads to perception of the same color [5], but the associations tend to be different across synesthetic individuals, although some correspondences seam more natural or universal then others. Several proposals of correspondence between color and music have been proposed in the three last centuries, usually based on the western musical scale, possibly because it is composed of seven musical notes, also the number ordinarily conceived for the colors in the rainbow. Scrabin proposed a scale considered as a result of the influence of his synaesthesia. Levin analyzed and listed some of the most relevant attempts throughout history in relating sound and image [12].

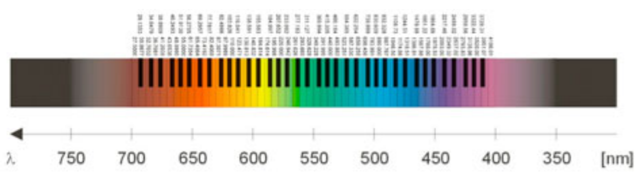

Figure 1. Color-sound correspondence proposed by [14]

In a first phase, we used grayscale images and a mapping based on [26] approach, to increase awareness of left and right, through stereo pan; up and down, through sound pitch; and dark and light, through audio loudness. Then, we started to address color. For this, we are experimenting with: the correspondence between the HSB color dimensions and the sound dimensions: pitch, timbre, and loudness; and the correspondence between light and sound by the juxtaposing of the spectrum of audible frequencies and the spectrum of visible frequencies (Fig.1), by means of a mathematical model based on the cromophonic table of [1], as proposed by [14,25].

3.2 Hearing Colors

Synesthetic Video translates video frames into sound, based on brightness, and based on colors, as explained in section 3.1. Users can get an audible perception of the images presented in the video as a complement to the video, or to make for the absence of the visual perception.

The translation can be done from real-time video, in slow motion, or frame by frame with the video paused, if the user wants some time to explore individual images. The default is to scan the frames from left to right and top down, using stereo balance to provide awareness about the horizontal position and pitch to provide awareness about vertical position of the current pixel being heard. Users can, however, interact with the video to change this default scanning, in order to change its direction or speed. In addition, instead of hearing the translation of the whole images, users may interactively select regions to be translated, in a more exploratory mode. The audio produced in these interactions can be recorded for future replay.

Figure 2. Interacting with a flashlight

Interaction devices include: arrow keys on a keyboard, a mouse, or a touch screen, in more classic desktop or mobile devices interactions, or the use of a lighter or a flashlight in an installation (Fig.2), identifying the pointer as the most bright pixels detected with a webcam facing the users while they point at the video. Users can also control the breath of the pointers (like brush strokes in an image editor) and the loudness of the sounds.

3.3 Seeing Sounds

In the opposite direction, Synestethic Video allows to filter, change, or paint video images based on sound, as music, whistles, or even speech. These visual transformations or effects can be made in the whole frames along time, in a uniform way or taking sound source positioning to select the different positions of the image to be affected, or in selected regions, by using the interactive pointer devices described in section 3.2. The resulting video can also be recorded for future replay.

Color and sound correspondences defined in section 3.1 are used in these image transformations as filters, i.e. by making transformations towards the color corresponding to the current sound, but also taking into account the previous color of the pixels. The level of influence can be configured and is also related with the sound loudness. The louder, the more influence sound will have in the resulting image.

In the current version, we wanted to explore the influence of sound in the video image. The more straightforward conversion of the video sound to images, based on colors, independently of the video frames is a particular case of our approach, when the sound source is the video sound, and the level of sound influence in the image is 100%.

Figure 3. Painting a video (on the left) with colored brush strokes, using a flashlight as the brush and sound as the ink.

With this interactive video, we wanted to explore how a video can be influenced by the user or the ambient where it is being played: calm, busy, noisy, or in the presence of different kinds of music, heavy metal, calm, sad, merry, etc. For example, how differently would a certain video be influenced by the Bethoven's 9^{th} Symphony or Michael Jackson's Billy Jean? And what kind of video would be more influenced? Synesthetic video also allows users to paint videos in a synesthetic way, by using, for example, music, voice or whistles as paint, and a flashlight as the brush, producing visual effects like those presented in Fig.3.

4. CONCLUSIONS AND FUTURE WORK

We designed and developed Synesthetic Video to explore synesthetic perceptions of videos based on their visual and audible dimensions, mainly through color and sound correspondences. Our main motivations include making video more accessible, to stimulate and support users creativity through the experience and interaction with video in synesthetic ways, and to learn more about synesthesia and how videos can influence and be influenced by users and the ambient when they are being played. Through interactivity, the spectators, individually or as part of the audience in different ambient scenarios, become co-authors of a live piece of art. There is an accessibility dimension and also a more creative and artistic dimension that may help to learn more about synesthesia, in its different facets, contributing to the interactions and transformations of art, science and technology.

The results we are having so far are promising, but we plan to conduct more thorough usability tests to refine our approaches. In particular, we want to refine the mapping we make between colors and sounds, to learn how natural or creative they are to blind people, synesthetes and the general public, and explore how the influence of the ambient can be captured by these mappings. In terms of interaction modalities, we intend to make more refinements to make them as natural as possible. Although the use of multiple media accounts for a certain level of immersion, we want to further explore immersive environments, especially for installations, and possibly with 3D video.

5. ACKNOWLEDGMENTS

This work was partially supported by FCT through LaSIGE Multiannual Funding.

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