Exploring roads less traveled: eye-tracking in art

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Abstract. Eye-tracking technology provides valuable help to interdisciplinary collaboration between various domains, such as human-computer interaction, digital art and creative media, so as artistic creativity can be expressed and developed. In this paper we present (a) an overview of eye-tracking technology in art and (b) the first results of a digital art research project, entitled DiBaB, which were based on paintings made by vegetal dyes for the creation -via eye tracking technology- of new artworks. The result was experimentations with artworks that have made visible the invisible, becoming a window to artist’s mind.

1 Introduction

The direction of gaze plays an important role from a very early age in communicating with other people: and transmitting information about people emotions and mental state. Furthermore, the ability to see, focus on things and visually perceive them, helped people to understand their surroundings and make sense of the world. Thus, the eye-tracking research can play a very significant role to enhance insights and understanding into human perception and cognition. The first era of eye-tracking research dates back to ca. 1879–1920 and is limited to the recording of the basic eye movements, the second era (ca. 1930–1958) is related to behaviorism in experimental psychology, the third era (ca. 1970–1998) achieved easily obtained eye movement recording and the fourth era there is the appearance of interactive tools and technologies that permit accurate information recording and processing tasks [1]. Eye-movements are closely related to attention imagination [2] and perception [3, 4]. Buswell [5] made a research about how people look at art images and Yarbus [6] studied systematically the eye movement and made some really interesting points about eye fixations to important –according to the viewer- points, the center of the image where usually the eye tends to look and the repeating eye fixations. Eye-movement recordings can provide a path of the direction of a person’s visual attention in relation to visual stimuli. Various studies explored the fixation location and duration [7], visual interest in art [8], symmetry [9], memory [10], level of expertise [11] etc. The use of digital technology in contemporary art creation is often referred to as new media art. In this paper we present and overview the eye tracking applications in contemporary and new media art and the digital art research project “Saccadic Universe” that connects applied contemporary art, such as painting with vegetal dyes, with eye-tracking technology.
2 Eye Tracking Technology

Eye tracking technology uses optical sensors and projection patterns to collect eye movements and gaze direction. Using eye tracking technology the point of gaze and the eye motion can be measured and recorded in real time and in high accuracy. Therefore, it is possible to capture the fixations, pauses over informative regions of interest, and the saccades, quick eye movements usually occurring three to four times every second between fixations that are the basis for calculation of other metrics, such as scanpath measurements.

The usefulness of this technology is important both for designing new ways of interacting and evaluating of user experience by interpreting the results of the detection mechanism, the eye tracker. Eye-tracking technology can provide answers for two basic questions, what one considers interesting and how someone sees it. The last years, eye tracking technology is used by a wide range of disciplines: psychology, medicine, cognitive linguistics, product design, cognitive science, human-computer interaction, usability evaluation, and recently also in the field of culture and art. In the later, eye tracking is used as plethora of research areas in culture, such as museum installations, an alternative interpretation medium of human behavior [12, 13], personalization [14] and learning for virtual museum visits [15], virtual search, art perception [16], guidance of viewer’s eye [17], expertise [18, 19, 20], perception [21], understanding [22] and performance [23].

3 Eye Tracking Experimentations in Art

A number of contemporary artists have experimented with eye tracking technology that can provide a valuable insight to cognitive processes, trigger creativity and get transformed to artworks. Seiko Mikami incorporated eye tracking technology in an interactive media art installation entitled "Molecular Informatics" [24]. In his exhibition the viewer becomes a creator wearing a pair of Virtual Reality (VR) glasses with an eye tracking sensor and creating -via his/her eye movements- new structures in a VR space that consists of molecules and molecular formations (Fig. 1).

![Molecular Informatics](http://www.virtualart.at/database/general/work/molecular-informatics-morphogenic-substance-via-eye-tracking.html) (last accessed 30 June 2013)

This exhibition communicates the relationship between biology and informatics in an attempt to explore the boundaries between art, interaction and transformality. Visitor experience a virtual world that interacts with and get transformed in real-time by his/her eye movements. In his interactive installation entitled "Eye-Tracking Informatics" the artist creates an installation for ‘observing the act of observation’ and ‘consciously and unconsciously established lines of vision’ [25]. The installation has used the ‘EyeWriter ver 2.0’, an open-source eye-tracking apparatus and software initially used by artists with paralysis by Amyotrophic Lateral Sclerosis to draw using only their eyes [26], in order to provide the opportunity to the visitors to utilize eye control technology without wearing any kind of device, and to navigate within the naked eye's field of view. In this installation the artist has visualized visitors’ lines-of-sight -that act as a ‘complex, organic, architectural construct- in 3D space, introducing the concept of bio-architecture.

In "Saccadic Sightings" the artist Rune Peitersen collected eye movement data from various environments and created videos as ‘filmic representations of the visual information received by the eyes’ [27]. These videos were used for installations and presentations that intended to incorporate eye movements into video footage in order to ‘create a representation of the input the eye receives from its surroundings – capture the ‘raw’ footage as it were, before the input is processed’ [28]. Nils Völker cooperated with Christien Meindertsma, a designer of we-make-money-not-art, in order to create a robot that replicates the way the visitors look. An eye-tracker has been used to record the movement of visitor’s eyes, while s/he was looking at various images. It has been connected to the Lego robot that made a dot for every point they have just been looking at and painted what the visitors saw in the exhibition (Fig. 2) [29, 30]. One of the project’s intentions was to reveal the different was the same objects have been perceived.
Golan Levin created Eyecode, an interactive installation whose display is wholly generated by the eyes of the people that view it. With the aid of a hidden camera, the installation records brief video clips articulated by the duration between two of the viewer's blinks and replays it. This procedure results to a ‘typographic tapestry of recursive observation’ (Fig.4) [32].

EyeMusic is a project of the Cognitive Modeling and Eye Tracking Lab at the University of Oregon, in which an eye tracker is connected to a multimedia performance environment, in order to perform a musical composition, create computer music and interactive art based on eye movements. In other words, the eye movements are sonified to demonstrate the place the person is looking using sound and how this can create music in real time [33, 34]. Olafur Eliasson designed an installation in the ARKEN art museum of Copenhagen entitled "Din blinde passage" (Your blind passenger), which is a 90-metre-long tunnel [35, 36]. When entering the tunnel, visitor’s body is surrounded by fog with visibility 1.5 meters, white and yellow colour lights and the eye tracker records visitors’ eyes. Thus, the visitors can see the way the eyes behave inside the tunnel when there are no other stimuli.

4 Fruitful intersections

Visual March is a march in successive trails from Florina to Prespes in northern Greece that aims to introduce the artists that participate in contemporary concepts by experiencing the environment of the area of Prespes. Already in its sixth year, in Prespes is a 7 days activity that takes place in Prespes (Florina, Greece). Borders and Beyond (BaB) project is the main theme of Visual March in Prespes and was initiated from the need for an artistic practice that defends art created from the organic relations of culture, place, society and the individual [37, 38, 39, 40, 41]. The BaB project is the culmination of the Visual March process created an international network of artistic and scientific research groups and practices that explore the idea of border in every possible aspect: as borderline, as limit, as frontier etc. The results of BaB are published via a webpage [42]. At a second stage, the process is open to groups that relate their research to social research and cultural intervention of critical artistic and scientific practice.
Digital Borders and Beyond (DiBAB) is an ongoing project in collaboration with the Laboratory of Photogrammetry and Remote Sensing of the Aristotle University of Thessaloniki and aims at expanding human interaction with artworks using ICT. This shift is about involving artists and the viewers and enhancing cultural experience and participation. The project is being conducted by creative researchers with various scientific backgrounds to provide innovative and exciting ways of experiencing art, permit artistic experimentation and artworks re-visit/re-use. In this paper we present the first results from the application of eye tracking technologies to paintings.

4.1 First Phase- Prespes Visual march
The paintings of Leonidas Gelos [43] -selected for experimentation with ICT- were inspired during the Visual march in the lake of Prespa. Visual march provided the means to create a travel in reality, or rather in realities of the landscape, Time and history. The procedure introduced the artistic practice of the artist-thinker-researcher that will focus on the creation of the artistic outcome in itself. This practice is separating itself from the prevailing practice dictated from the predominant Dantonian practice and its local representatives. The Dantonian practice relies itself by stabling the artist as a professional creator of self-referential works. Visual March in Prespes is the predominant request of artistic experience through life itself without the motivation for a professional return. The process is initiated and driven by the need to fulfill artistic goals, or –even better- for the sake of artistic practices itself [44].

An important part of the process is the research on artworks works exclusively created from materials derived from Nature that can also be absorbed to the environment. Along with that there will be a study of the way contemporary technologies can be used in that environment. In their most creative application the trails will explore any techniques that can derive from the experience of the landscape, in an effort of the artist to better understand and effectively communicate with the landscape and the environment [ibid].

4.2 Second Phase- Artworks/ Stimuli
The artworks were created with vegetal dyes from plants collected from the area with water from the lake Prespa and inspired and powered by the beliefs of Zarathustra (630-553 B.C.), Empedocles (circa 400 B.C.) and Aristotle (384-322 B.C.) that life is composed of four elements of nature: earth, air, fire and water. Thus, the artworks depict and were named after these four elements not only representing the balance of the environment, but also proposing a balancing coexistence with the environment (Figures 5, 6, 7, 8). The materials for their creation (herbs, water and soil)

Fig. 5. Earth
Fig. 6. Air
Fig. 7. Fire
Fig. 8. Water

Source: http://leonidasgkelos.com/artworks.htm [last accessed 31 August 2013]
4.3 Third Phase- Eye tracking experimentation

Ever since Renaissance the body of the artist was placed against the object that was observed. The way the body perceives reality—such as the artworks in our case—and the way it shapes these stimuli into visual artworks is one of the on-going quests of art. The artist was calculating the distances, the angles. The experience of that result created space, as the artist perceived it. In contemporary art the body of the artist has become by itself the observer and observant as well. The body of the artist in contemporary art moves inside space and experiences the impressions of reality. ICT and more specifically eye tracking technologies provide the opportunity to externalize and materialize what is hidden and unrevealed, the reception of art as an active and continuously updated procedure. “Visual experience is dynamic” [3, p. 11]. Even, in Plato, Timaeus states that the eyes give ‘gentle’ light, “they formed into a substance akin to the light of every-day life; and the pure fire which is within us and related thereto they made to flow through the eyes in a stream smooth and dense, compressing the whole eye, and especially the centre part, so that it kept out everything of a coarser nature, and allowed to pass only this pure element” [45]. Thus, he considers that the fire, which burns inside the human beings, comes out of eyes as a smooth and dense stream of light. Via eye-tracking this ‘stream of light’ was visualized and recorded on the paintings. A S2 mirametrix eye tracker [46] has been used for the project in the premises of the company MindsSearch in Athens. The aims was to visualize the mental activity and learn how the artist look at his artworks, where do the artist look first, what is the path artist’s eyes follow, how the eyes receive the visual stimuli, and share the same visual reality with him. This is important, because the artist creates the artwork, but the experience of art itself is personal, unique and—most of the times—not easily recognizable by the artwork viewers, it leaves ‘an ambiguous territory for the viewer to inhabit’ [47]. The four paintings created have investigated the territory of artists’ mind by means of eye tracking technologies (Fig. 9, 10, 11, 12). This kind of interactive art can visualize mental activity, thoughts and perceptions can provide the artist the opportunity to interact with the artworks and create new ones. “Vision is not a mechanical recording of elements but rather the apprehension of significant structural patterns” [3, p. 6]. Synergistically with nature and technology the new project cartography stimuli generated by thoughts and travels of artist’s eyes, in order to construct rebuild images. It is possible to see what the eyes see, what information has been selected and the focus is directed, before any further mental processing, before the input to be interpreted by his brain.

Fig. 9. Earth

Fig. 10. Air

Fig. 11. Fire

Fig. 12. Water

Source: http://leonidasgkelos.com/artworks.htm [last accessed 31 August 2013]
The four eyelines have been merged and ‘mapped’ on the landscape from which the materials for the artworks have been collected into a cultural topography. Since abstract expressionism the body seems to be more and more present in the construction of the artwork. It is not accidental that Allan Kaprow considered Pollock to be his immediate forunner. For Pollock visual image is created from the movement on the surface of the painting/field. From then on, the idea of perceiving painting and visual surface is not considered as a screen of projection, but rather as an arena of gestures that has deeply influenced visual arts. The art since Pollock and the Abstract expressionists become bodycentric; the body is characterizing the image and not vice versa. Visual Arts are transformed from image-centric to body-centric.

Saccadic approach lies in that fine succession of artistic processes since 1950 that have placed their body in the center of their visual activity. Saccadic process offers a way to measure that approach. In this case the aim was to reconstruct the materiality of the perceived object. However, in the saccadic process the accuracy of the recording is dematerializing the stimuli and what remains is the recording of the energy of observation. The most recent approaches of critical thinking are introducing ways to understand and shape visual image in their socio-historical content. Critical thinking is an effort to move beyond subjectivity and shape an understanding where reason becomes important in the analysis of visual artwork. The understanding that art is bodycentric and the use of saccadic processes as a method to objectify perception is adding further to critical thinking and allows in the broadening of methodology. Saccadic view is the very fine moment when human ability transforms the perception of something material to something that is the ideogramatic transformation of it. The artwork with the gigantic ideogram in the slope of the hill (Fig. 13) exemplifies that approach. At the same time he makes a very clear contrast between the concreteness and reality of the actual stimulus (landscape) to the way the saccadic process transforms it into something non-material. Somehow it is an immediate result of Aristotles’ thinking: the interplay between the materiality of what is there to the way senses are shaping into a non-material outcome: the way we sense it.

Fig. 13. Mapping the eyelines, Source: http://leonidasgkelos.com/installations.htm [last accessed 31 August 2013]

5 Conclusions and Future Research
In this paper the first results of DiBaB digital art research project were presented. ICT are used to trigger artistic and cultural expression as a basis for creating innovative forms of contemporary art, connecting applied art, such as painting with vegetal dyes with new media and eye-tracking technologies and acting as a source of inspiration in artistic explorations. It is also suggested that hybrid environments can permit a new perception of the physical space and materiality and get merged, transformed and reconstructed by digitality and new technologies, leading to a whole new understanding of art.

A continuation of the project has been scheduled, in order to test the scanpaths of various visitors groups, which is planned to be students from the Visual and Applied Arts Department, simple end-users and historians of art. The goal is to compare the similarities and differences. It is planned to create 3D models of trees -with the help of a laser scanner- from the landscape in Prespes that will be projected on the artworks. Furthermore, we aim to experiment with Kinect, a motion sensing input device and permit the movement of the 3D models of the trees on the artworks according to the viewers’ movements.
Acknowledgment

This research has been funded by the Greek State Scholarships Foundation. The authors would like to thank the company MindSearch (http://www.mindsearch.gr/) for providing access to their eye tracker and Agnes Mariakaki and Charis Komninou for their support and assistance to this project.

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