

# Invisible Sight: Looking at biodiversity data through an interactive art project

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**Abstract.** This article addresses the development of the project "The Eye of Gaia", an interactive data-art piece about biodiversity (extinction data to be more precise) and the results of the climate crisis we are experiencing. "The Eye of Gaia" is a visual representation of data in the form of a tridimensional "pseudo-eye" made from particle systems, that reacts interactively when observed. This project intends to explore the communicative capability of the data-art medium (over regular information visualization), while it tries to exploit the interactive possibilities of effects like the "uncanny valley" and "direct-gaze", in order to express the inevitability and urgency of the topic as well as motivate the viewer to act on it.

**Keywords:** Computational Design · Data-Art · Climate Crisis · Biodiversity · Extinction · Interaction

## 1 Introduction

Human activity has increasingly been a cause of the environmental instability we are experiencing [24]. The number of natural catastrophes has been increasing [13], along with the average global temperature [25] and the mean sea level [9], at the same time we watch more and more ecosystems being destroyed due to human action [29]. This project appears as a way to give the planet a way to talk back, in a more sensitive, and personal way, while keeping the accuracy of empirical data. "The Eye of Gaia" intends to mediate a dialogue between nature and men, creating an individual connection between the two, in order to motivate and persuade people to pay attention and look beyond the data, finding their real soul.

## 2 Related Work

### 2.1 Between Information Visualization and Data-Art

Information visualization addresses the visual representation of abstract data as a way to increase its perception, in order to facilitate the communication process [8]. Data-art as a medium comes up from the same principle, but it adds an emotional and unifying capability [12] inherited from its artistic component, resulting in complex artifacts that explore the innate beauty of the displayed data sets, surfacing as a way to create understanding [20] and communicate information in a more meaning full and memorable way. Projects that address climate change data from a information visualization point of view, like the work from J.R. Adler [3] and Thomas Nocke [26], sometimes result in direct representations of geographic data, that can lead to less appealing results [20] (from a visual standpoint) as well as a disconnection between the viewer and the information that is displayed. This is something that we want to avoid in the development of the proposed project. Despite that, projects like "Coastline Paradox" (2020) [1], and "Data as Art" (2015-2020) [5], prove that it is possible to explore the data-art medium while keeping some principles of information visualization. Both projects represent climate change related data directly, but take advantage of the digital medium to include an expressive component that contributed to more immersive and memorable experiences as a whole. Data-art projects often make use of climate change related data sets in order to reveal the hidden expressiveness / message found within them [12]. Examples like "MRI of the Earth" (2022) [4], or "Diving into an Acidifying Ocean" (2022) [33], take full advantage of the digital medium, as a means to create immersive experiences, where scientific data is represented in an abstract way (through AI generated imagery representing a future "artificial" nature [4] in the first example, or through the representation of imaginary "anthropocene" animals with particle systems [33] in the second), resulting in persuasive objects, with a heightened aesthetic value, while keeping an informative component without disregarding an easier direct reading of data and giving a memorable experience to each viewer.

### 2.2 Eyes as Visual Representations

In this subsection we present two examples that show the potential of circular / spherical representations in the fields of information visualization and data-art. "Circadian Rhythms" (2022), is a biometrical data visualization project, where the french artist Kirell Benzi represents a data set with more than 2 million entries in a circular way referring to the temporal representation of the circadian rhythm [7]. "Data Eye of Wanjing" (2020), is a "phygital" sculpture where the artists at turkish studio Ouchhh, represent various data-sources all related to aspects of life in Beijing [27], in a circular, ring-like shape resembling, in an abstract way the representation of an eye. Both these projects serve as inspiration to the visualization proposed in this article.

### 2.3 Interaction, Communication and Eye Contact

From the interactivity standpoint, projects from american new-media artist Golan Levin (for example "Eyecode" [16] (2007), "Opto-Isolator" [18] (2007), and "Double-Taker (Snout)" [19] (2008) - all part of the collection "Art that looks back at you" [17] (2009)), represent the full expressive potential of human-computer interaction, in a "direct-gaze" context between viewer and art piece, resulting in a more effective memorization of the experience [37]. All the examples mentioned in this subsection react when observed by a spectator, taking full advantage of the *gazing* stand-off as a way of familiarization with the projects [17], creating once more a deep relation between spectator and art piece. Furthermore, this examples not only explore the phenomena of "direct-gaze" and "eye-contact" as a way to establish connection (due to the non-verbal communication potential of the eyes [32]), but they also address the "Uncanny Valley" effect (a non-linear relation between the resemblance of humanoid robots to human beings, and the affinity of humans when in contact with them [35], mostly due to the insufficient similarity present in their eyes [30] - crucial element in the human process of natural face recognition [31]), as a way to trigger action / reaction on a first contact between artwork and viewer. In "The Eye of Gaia" it is intended to explore both these effects as a way to create discomfort and unavoidability, serving as a metaphor for the urgency of the portrayed topic as well as a way to engage the viewer in a connection / communication they can't abstain from.

## 3 Approach

### 3.1 Conceptual Proposal

As mentioned previously, "The Eye of Gaia" proposes a visualization of biodiversity and climatic crisis effects, through the translation of an extinction mapping data set [14] into a digital and interactive tridimensional eye. With this project, the aim is to create an attention grabber art piece, through discomfort and strangeness (referring to the exploration of the "uncanny valley" [35] and "direct-gaze" [21] effects), implying directly the user's presence as part of the exhibition and hopefully creating a motivation factor that increases the communication effectiveness. From a visual standpoint, we will resort to particle systems (where each particle will move independently) in order to represent data occurrences across a spherical shape, analysing what are the fundamental needs for what constitutes an eye. With the intention to take the connection between artwork and observer even further, the eye movement will be dependent on the viewers position creating a "following" effect that will simulate gazing / eye contact.

### 3.2 Technical Implementation Proposal

For the purpose of keeping a consistent aesthetic with the one adopted in other projects of the data-art medium, as well as attaining the proposed goals, "The Eye of Gaia" will be represented visually through various particle systems (correlated to the selected data-sources - where each particle corresponds to a number of living beings and the chose color represents their taxonomic group). Initially, there was an intention to have all particles behave as *random walkers* [36] [28], moving across a spherical surface while leaving a path of color as a way to simulate a living being's movement and give the piece a more organic fell as shown in the prototypes presented in Fig. 1.



**Fig. 1.** Early prototypes of "The Eye of Gaia" - 2D and 3D

Later on the development process this pattern was altered due to performance restrictions, being adopted a system where the particles move according to a tridimensional noise pattern (adapted from Guillaume Mourier's "Fields" [22]), maintaining the organic feel but resulting in a better performing system with a smoother animation. This method ended up being used as a foundation for every organic movement seen on the project, being later applied to the deformation of the "Pupil" geometry (initially intended to be represented as another particle system). As it was set initially the "Pupil" will behave dynamically as a whole, moving slightly (deforming) according to the noise pattern created, in order to create some strangeness and adding a surrealist character to the piece, while also referring to the different pupil shapes found in the animal kingdom. On the other hand, each particle of the "Iris" will behave individually, being that every one will represent 100 species of living beings. The material applied to each particle will also refer to the data-source selected [14], where every color group is related to one of four major group of organisms (*Vertebrates* = blue, *Invertebrates* = yellow, *Plants* = green and *Fungi & Protists* = purple) and where *hue* and *saturation* variations correspond to smaller taxonomic group within those first ones.

### 3.3 Interaction Proposal

The interactive aspect of the artwork will also be noticeable in two different fractions of the piece (refer to Fig. 2 for further analysis). Firstly the presence of a viewer will determine the assembly of the eye (from a random "tunnel" of particles), as the same time as it trigger the begging of the interaction stopwatch, starting the conversation between the artwork and the observer. When the duration of a single interaction (*continuous presence of a person before the artwork*) reaches 25 seconds, the message will intensify, implying the viewer as a responsible for the change occurring in the artwork (as well as in the environment), by the revelation of the camera view inside the pupil (serving as a distorted mirror for the viewer). Secondly, the movement of the viewer will determine the behaviour (rotation) of the eye, resulting in a following effect that will entice the user to search for meaning within the artwork, or at least recognize its existence. Viewer interaction will also influence the textual component of the piece as well as the composition of the particle system, so that the viewer is set accountable for their effect on the planet. In order to solidify this metaphor, every user interaction will have a direct impact on the Eye's composition, being that every second they step under the artwork field of view, they will be responsible for the "extinction" of two particles, that are equivalent to approximately 170 species, the number that The United Nations' Convention on Biological Diversity estimates becomes extinct every day [11].

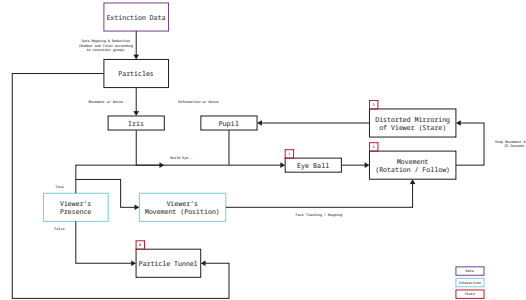


Fig. 2. Interaction Pipeline for "The Eye of Gaia"

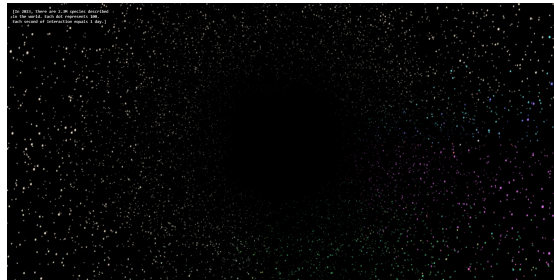
### 3.4 Technical Approach

**Performance Issues** One of the recurring problems that surface in the data-art medium is the insufficiency of computing power allied to absence of tools that are capable of handling large data sets. That same problem emerged in the development of "The Eye of Gaia", due to the need to represent individually millions of objects. This was a focus from the starting point of the implementation process,

and a fundamental point in the selection of the development framework. After testing tools like *cables.gl* [34], *p5.js* [15], or *Processing* [6], *three.js* [23], was the one that allowed for the most freedom while being capable of handling large amounts of particles. Another difficulty that surfaced in the technical development of the project was the ability to simultaneously run the face recognition system from the input camera, as well as the *three.js* [23] sketch, which was solved with an approach taking advantage of the "FaceAPI" from *ML5.js* [2]. In order to further reduce the chance of recurring system limitations (having in account the Web-based version of the project), it was decided to map the input data set onto the final visual representation, reducing the number of elements which would result in a equally interesting artwork, but without the need of elevated computing power to run smoothly.

**Narrative** As a means to explore the communicative potential of the art piece, in a way that it would serve as a representation of the message we were trying to convey, it was adopted a sequential narrative-like structure where the progression was determined by the time of a single continuous interaction as well as the number of detected viewers. For this, it was implemented a state-based system, with the system having different behaviours depending on which state it was on. The different stages of the narrative as well as the transitions between them are presented below.

**State 0: Particle Tunnel** For the first stage of interaction the artwork adopts an idle behaviour, being triggered by the absence of viewers, as seen in Fig. 3. In this state it is shown an abstract field / tunnel constituted by a particle system, where each particle, a representation of 100 species (with corresponding taxonomic categorization), moves independently according to a noise-guided vectorial displacement. This state serves as a "landing-page" as a viewer approaches the artwork, as it generates curiosity without revealing the true meaning of the piece.



**Fig. 3.** State 0: Particle Tunnel

**State 1: Transition** The second stage serves as a *tweening* state, a transitional moment where the particles that shape the initial abstract field, organize into place in order to build the "pseudo-eye" that represents "The Eye of Gaia" (illustrated in Fig. 4). In this stage the particles stop their displacing movement in order to take position on the sphere-like object that is the "Eye", at the same time as the camera shifts position to allow the viewer to observe the totality of the artwork. This state serves as a passage point for the narrative, allowing the observer to connect the initial particles to the ones that shape the "Eye". Finally, this transition terminates with a simple reaction from the "Eye" signaling its emergence to the viewer with a light greeting recognizing the viewer as a part of the environment. All these alterations are implemented using basic tridimensional trigonometry calculation.

**State 2: Follow** For the third stage of interaction the "Eye" starts a following action, rotating according to the viewers position, implicating its presence as part of the artwork, resulting in a mixture of curiosity and strangeness, as well as in a questioning reaction from the viewer, who wonders if its proximity is welcome or not. In this state, the user starts to affect the composition of the "Eye" being "responsible" for the extinction of the species that shape it, referring to the injurious impact of human beings on the environment, and how their action (interaction) may shape the world in a negative manner. This "extinction" leads to the disappearance of particles from the surface of the "Eye" in a rate of two per second, serving as a representation to the predictions mentioned in section 3.3, where it is mentioned the extinction of 170 species daily. In order to maintain a dynamic and surreal aesthetic the individual particles also adopt a noise-guided movement in this state (similar to the one adopted in state 0), only less evident, in order to keep a visible and evident representation of the "Eye's" geometry. For this reason also, in this state it is added an informational caption signaling the number of species extinct on the present iteration of the artwork, so that every viewer knows they are part of a bigger community where everyone has an influence on the environment, being that the cumulative effect has a larger impact than the individual one, as well as to keep track of their influence on the artwork on a more figurative representation.

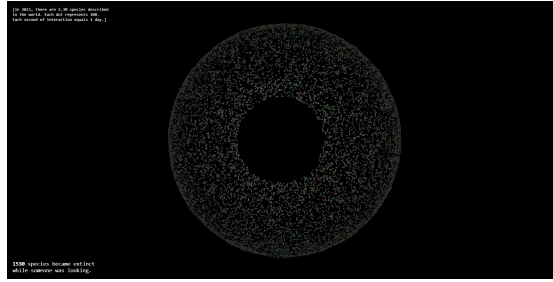


Fig. 4. State 2: Follow

**State 3: Stare** On the final state of interaction, the viewer is confronted with their impact on a individual scale, being implicated in the artwork through their distorted reflection on the "Pupil", as seen of Fig. 5, leading to an increasing feeling of discomfort and uneasiness, due to the confrontation with the fact that they are being observed. Adding to this fact, another caption appears signaling the individual influence of the viewer since they first interacted with the eye, calculating the number of species that have gone extinct in the current interaction.

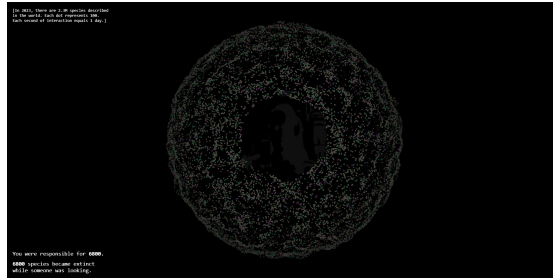


Fig. 5. State 3: Stare

**State Transitions** As mentioned before, the state transitions react to the number of detected faces in the field of view of the artwork, being that the detection of zero viewers will result in state 0 (3.4). When one or more viewers approach the piece, it transitions to state 1 (3.4) briefly, moving after to state 2 (3.4). After being in this state for 25 seconds, the system will recognize a lasting interaction, meaning that the viewer is deeply invested in the artwork, and it will transition to state 3 (3.4), the final stage of interaction. The system will reset upon recognition of no faces in it's field of view, or upon the surpassing of the extinction limit, when the "Eye" disappears in it's totality due to the removal of all particles by the interaction of one or more observers.



**Data Mapping** Like it was previously alluded in the beginning of this subsection, performance was largely a restricting factor on the development of the project. To tackle that issue, it was adopted a reduction strategy in order to handle all the data sources intended for this task, being reduces the number of entities from 2 million to 20 thousand, resulting in a better performing system. This reduction causes some difficulties when it came to the mapping of the extinction rates, since it was needed, in order to propagate the message in an effective manner, for the viewer to detect the changes occurring in the "Eye" particle system. For this, it was adopted another mapping system, this time related to the interaction time, where 1 second equals 1 day, in order to better handle the visualization of the effects of the viewer's presence. This effect was further reinforced by the textual competent of the piece, where the viewer could actually account for the continuous decrease of the represented particles.

**Species: Visual Representation** Investigation over the theme of the climate crisis we are currently facing, led to multiple possible paths to exploration, when it came to data sets available and the related message to convey with this project. After analysing natural catastrophe and biodiversity related statistics, it was concluded that the adoption of extinction data as input was the most effective way to tackle the proposed approach, as well as to communicate in a most simplified way the message, of human derived environmental repercussions. Accordingly, it was selected the 2023' IUCN Red List [14] as an input data set, due to it's simplicity, currency and relevance. This decision allowed for a simple mapping choice, where each taxonomic group corresponded to a color group and, a certain hue and saturation variation, obtained through basic visual tests grounded on graphic design's color theory principles. Still regarding the particles' visual representation, and in order to maintain the organic and surreal aesthetic of the project, it was adopted an irregular static shape as a base material, giving the system some consistency between the two fundamental elements: the "Pupil" and the "Iris" that now would reminisce similar shapes.

**Soundscape** Initially, sound was an integral part of the project, but with the advancement of the development process it was increasingly disregarded as a secondary dimension to the artwork, mostly due to the much more significant role the visual aspect took in the communicative role of the experience. Nevertheless, the sonic dimension of this project was accounted in a more simplified manner, with the adoption of a static soundscape that would still contribute to the immersive and expressive capability of the art piece, as it gave it a more uncanny / unearthly ambience, that would emphasize the strangeness and discomforting feeling the artwork is intended to provoke. Take in consideration that this is only a provisional measure that will be further developed in the section 4.1: Future Work.

### 3.5 Ideal Support

Ideally, "The Eye of Gaia" will take the form of a large scale digital installation (like the ones that take part of the project feedNplay [10] - represented on the mockup of Fig. 6), exploiting the capabilities of the supported medium, allowing for interactivity, as well as an immersive experience while revealing the detail of the artwork. In that respect, the project will be developed using WebGL (with *three.js* [23]), what will also allow a future publication of a web version, allowing anyone to explore the proposed project on their own devices.



**Fig. 6.** 3D Mockup of the Installation

## 4 Testing & Discussion

Most of the hypothesis formulated over this article, were only confirmed or denied on a testing phase, were it was evaluated if the system could or not effectively communicate what was initially intended at the same time it conveyed the proposed emotional experience, leading to the desired effect of raised awareness and increasing motivation to act over the addressed topic. For this, the test subjects were presented with the Web-version of the project, being later questioned informally about their experience, what led us to further conclude that the project attained successful results, leading to a more intimate and meaningful connection between viewer and artwork what culminates in a more memorable experience, as well as in a lasting effect in the observers, one of the main goals of the project, as it was searching for a way to emphasize a message, leaving a lasting effect, that can lead to further reflection or even better, further action.

### 4.1 Future Work

For future development of this project it is intended to add a signification layer to the experience, recurring to procedural generated ambient music fueled by data, replacing the static soundscape mentioned previously in section 3.4. It is also

intended, in a later stage of the project, to add informational layers to the particle system, representing in a more direct manner, the species they correspond to, allowing the viewer to get a more detailed look at the data set when observing the artwork. Associated with this, it is also intended to explore the concept of filtering associated with dynamic information visualization, where the viewer is allowed to explore in a more dynamic way, the full capacity of the data set resulting in a more complete experience from an educational stand point.

## 5 Conclusion

The development of this project allowed for the conclusion that the data art medium can be a fruitful path in the future evolution of digital art, allowing for a direct communication between data (and the intrinsic message it conveys), and people, allowing for a more synthetic way to express meaning, without compromising the room for interpretation that is present in the abstraction of art. "The Eye of Gaia" also allowed to deduce that effects like "uncanny valley" [35] and "direct-gaze" [37] can be a powerful mean to generate strangeness and discomfort in an artwork, what can result in a more effective communication of its inner meaning. With this we can claim this project as successful, leaving room for further development in an area that still has much to explore.

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