

Proteus 3.0 - Interacting with the cloud

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Abstract

This paper presents the *Proteus 3.0* project as an interactive and generative video installation, which tries to remain in conversation with its audience and learns from its engagement to produce new and potentially meaningful sequences of images. This particular version of a series is focused on digitized material as ferrofluid and its digital surrogate generated with a reaction-diffusion algorithm, projected onto a room-scale oval oculus allowing for a collective/immersive interaction. By employing state-of-the-art custom reinforcement learning models coupled with human intelligence in a symbiotic fashion, it aims to make the interaction more meaningful by understanding better human behaviour during an interaction. Additionally, it intends to maintain the interaction as conversations, rather than playful attractions.

Keywords

Interactive art, generative art, reinforcement learning, computer vision, conversational interaction, mixed-media installation.

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Introduction

This paper presents the *Proteus 3.0* project as an interactive and generative video installation, which tries to remain in conversation with its audience and learns from its engagement to produce new and potentially meaningful sequences of images. Proteus, as a series (Figure 1), has systematically evolved with its ferrofluid displays and modes of magnetic activation at multiple resolution ranges, particular sequences of digital and analogue layers as well as types of interaction. This version is particularly focused on moving the ferromaterial to the digital realm with its digital surrogate generated from a reaction-diffusion algorithm, scaling up from an object-size analogue display to an architectural oculus of oval shape at room scale, and which, at the same time allows to shift from an intimate interaction to a collective/immersive one. By employing state-of-the-art reinforcement learning models coupled with human intelligence in a symbiotic fashion, it also intends to build an interaction that is based on conversations, rather than playful attractions. Most frequent and straightforward approaches towards interaction design are based on implicit principles and clear instructions built in a closed loop to promote immediate engagement. These oversimplified views on interaction neglect its long-term impact¹ or the ones stemming from more traditional discourses, and which define any interaction with an artwork purely as a *mental act*.² In that lens, the project revisits the *Conversation Theory* of Gordon Pask³ in its scope of human-machine interaction as a form of open and emulative conversation. A dynamic process in which both ends learn and adapt from each other. As such, the project aims to construct an interaction that goes beyond the boundaries of predefined scenarios that follow the strict categories of an audience's behavioral patterns and tends towards individualized and dynamic responses.



1. The evolution of the Proteus series between 2018 and 2022.
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Background Conversational interaction

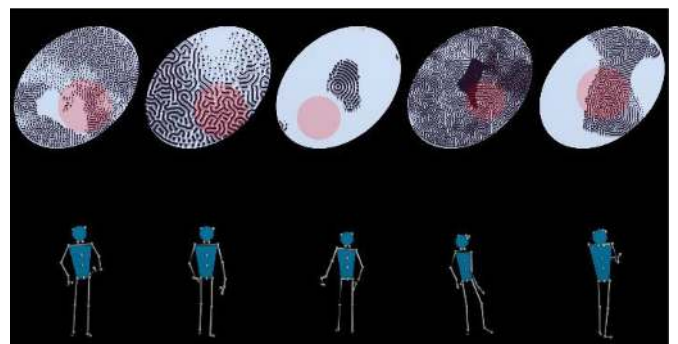
What most generally describes successfully an interaction is the degrees of responsiveness and control an artwork and an audience are communicating to each other. An interactive artwork is essentially a composite made of an artificial component (the artwork itself as an object) and a human component (the audience) that both define its nature and behavior⁴. These degrees of communication are then located somewhat between total randomness and total predictability, without reaching any of these extremums. A total random response could only qualify as part of a reactive process, and a totally predictable one as part of a controlled manipulation. This does not necessarily involve a stable exchange and most frequently concurrent dynamics are at play from both ends as human intentions and artificially designed systems may have different and evolving goals over time. While this constitutes a great challenge for an artist to frame and produce such ideas, it also represents the richness and openness that an interaction may provide in qualifying an object. Interactivity is, by design, the relational property of an object and not an intrinsic one. It results that the value of such artwork is consequently constantly in a state of volatility and becoming, evolving throughout interactions. One might argue that this is necessarily the fate of every artwork, and more generally every object. But this becomes fundamental when interaction becomes itself an object of design in the artwork. Although, the most frequent and straightforward approaches towards interaction design are based on implicit principles and clear instructions built in a closed loop to promote immediate engagement

and playful attractions. Similarly, most theoretical intent to define interactivity in art has been partially treating aspects of interactions that revolve around the topic of controllability. In general, the ability to improve control makes novelty the source of most types of interactivity⁵. In the general perspective of control, interaction can be seen as a learning stage in order to reach control. Once sufficient learning is achieved, interaction becomes redundant. Interaction becomes endowed with the feature of being instructional. However, even during the early stages of cybernetics, the theory of control was seen as only a chapter in the theory of messages⁶. Interactive art must be dissociated from the grasp of control theory [ref] in order to avoid any pessimistic perspectives⁷ or shortcomings in the envisioned artistic power of such artistic interventions. On the same level, Input/Output theory of interaction with computers⁸ simply defines interactions as a unilateral transactional process of information and therefore fall short on creative content. On another aspect, when interactivity is defined as procedural and participatory⁹, the definition lacks enough abstraction and generalisation to talk about the systemic design of an interaction and the informational novelty that go beyond the sole responsiveness of participations to an artwork. On another end, the evolution of machine perception in human computer interaction can be seen as trivialising the term of interactivity in new media arts, and eventually rendering the sum of its tentative description as too loose to be useful to qualify an artwork¹⁰. This oversimplified views on the interaction neglects its long-term impact¹¹ or the one stemming from traditional art, which defines interaction with art purely as a “mental act”¹². It also resonates with the cognitive approach of the power of an artwork being located in the *beholder's response*¹³.

Proteus 3.0 within the series of Protei

Proteus is a series developed as a duo since 2018 driven by the curiosity in exploring aspects of interacting with matter, tensions between analogue and digital, as well as relations between human and machine intelligences¹⁴. The series evolves through the continuous visual and material reference of a colloid compound called ‘ferrofluid’ as a main character¹⁵. When exposed to magnetic fields and interacting with another liquid carrier, it reveals its intricate and lively nature by presenting strongly contrasted and ever-changing complex patterns ranging from discrete patches of dots, meandering streams, to larger coagulated blobs. The

volatility and organicity of this material behaviour in the series is used as an allegory of the Greek mythology of a deity called *Prōteus* and his ability to assume many forms and provoke uncanny encounters¹⁶ that remain evasive to the rational mind but open-ended to the visual imagination. Over the course of its serial declination, *Proteus* has iteratively evolved with varied organic and deep black patterns to serve as an emulator for visual human intelligence. That of seeking meaning in a constantly changing flow of images and unpredictable symbolic relations which can only be found in the human mind, just like gazing at a cloud. But the historical problem in such a romantic contemplation is often emphasized through the notion of distance and the lack of direct communication between a cloud and its beholders. If the cloud could talk back in response to one’s efforts to find visual meaning, would the conversation stabilize to a consensus, or would it constantly move to explore and seek novelty? This problem of distance and communication reveals itself when reframed in the artwork as a generative/interactive installation and its architectural embodiment.

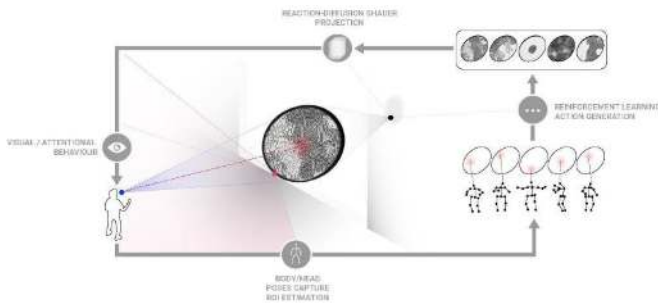


2. Proteus 3.0 installation during BioMedia exhibition at the ZKM Karlsruhe, 2022. © Photo: Thierry Serbeto.



3. 5 predefined interaction scenarios comprising of generative material visuals and behavioural patterns.

Methods



3. Diagram of the interactive loop. ©Image: CompMonks

Proteus 3.0 is an interactive generative 4K video installation, rear-projected onto a black screen of oval shape. The screen, of dimensions approximating 3.5 x 2.5 meters, is rotated 45 degrees and integrates an HD wide angle and infrared camera to estimate body and head poses from the audience and to detect regions of visual interest located on the screen. This information is continuously tracked and serves to build markers of attention to modify the generated visual frames (Figure 3).

Material surrogate

Because to this day, no digital model has been able to accurately simulate the physical behaviour of ferrofluid material in real time¹⁷, a specific GLSL shader has been developed for the procedural generation of a digital surrogate. Based on a Gray-Scott reaction-diffusion model between two substances, a series of image filters have been designed as an overlay to mimic the dynamics of the ferrofluid and its pattern formations.

Our experiment was conducted in two following steps: (1) initiate predefined interaction scenarios run in the exhibition context to collect the visitors' data, (2) building adaptive and evolving interaction models with reinforcement learning. The details of those two phases are described below.

Predefined interaction scenarios

At the first launch, the initial interaction consisted of 5 predefined interaction scenarios running in the 80 seconds loop. Interaction scenarios consisted of generative visuals coupled with the most common human behavioural patterns. The visitors' data

responding to these scenarios were collected during eight months of the BioMedia exhibition at ZKM Karlsruhe, starting in December 2021.

In order to build Regions of Interests (ROI) of each interaction, skeleton data of max 6 visitors simultaneously were captured with a Kinect 2 camera to extract their torso and face orientation projected back on the oculus canvas. Each interaction has been recorded into a large dataset organized by timestamp with raw numerical information (visitors' ROI, skeleton data, location in relation to the screen) as well as low-resolution images (like RD noise map and visitors' ROI) for further training. The construction of datasets considers that any relevant personal information is decoupled from the recorded data.

Generative interaction scenarios with reinforcement learning (RL)

The scenarios further evolved into generative characters with the support of a machine learning model programmed in Python, specifically a *reinforcement learning model*, to learn from collected data and extracted markers of attention. It is being trained discretely offline and concurrently for a real-time generation to support the progressive evolution of the artwork that can adapt to different exhibition contexts and visitors' behaviours. The custom model has been developed in python with a PyTorch library.

The real-time performance of the work and the offline training are orchestrated by two combined processes. For real-time performance, a TouchDesigner file manages both visual inputs coming from the camera and generated outputs going to the display. The generated images are sent to two video projectors, mapped and blended for a smooth projection onto the screen. Daily, the recorded data is updated to a remote server and feeds new offline training sessions for the reinforcement learning model. The updated model is then sent back to the local computer controlling the installation to update Proteus' behaviour.

Engagement

Engagement can be measured with simple metrics like the amount of time spent looking at art¹⁸ or more complex summative indexes, like Sweep Rate (SRI) and Diligent Visitors (DV) representing exhibitions "Thorough

Use¹⁹ to improve audience engagement in museums at large. However, those *static* metrics allow us to look at visitors' response only through a pinhole and we do not know the exact impact of the interaction on the visitor (long-term, imaginary, etc). Therefore, we need more data collected during the interaction itself and more sophisticated tools to analyze them. "The Plant" project²⁰ proves that **reinforcement learning** can improve some of measures of engagement, like visitors touch count during interaction, but not average duration of the interaction. This project allows us to draw a hypothesis that AI-based tools combined with generative models can increase the quality of engagement and not just its quantitative factors like duration.

In the next developmental step of Proteus project, we aim to utilize the developed RL model in the future exhibition and conduct comparative studies to evaluate this hypothesis.

Conclusions

Proteus 3.0 is an interactive and generative video installation, which, once in place within the walls of its exhibition and switched on, tries to remain in conversation with its audience and learns from the visitors' engagement to produce new and potentially meaningful sequences of images (Figure 2). Until the end of its exhibition, when it is switched off and set frozen in time. By then, its last learned state is saved and becomes the new generative beginning for its next exhibition. The learning and interactive process continues endlessly during the artwork's lifetime for each exhibition and conditions its existence. Its generative imagery remains open-ended and its content to be modulated by its beholders. This project is an attempt to utilize AI-supported generative systems, which facilitate an interaction that goes beyond predefined behavioral models directly controlled by a few, easily comprehensible parameters and therefore might increase the engagement in the audience.

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Authors' Biographies

Maria Smigielska is an architect and researcher based in Zurich, currently working at DBT, ETH. She is interested in enhancement of potentials for creation of architectural elements, design objects and mixed media installations, by using digital and interactive technologies for encoding and modulating materials properties, custom design and fabrication methods.
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Compmnks (PhD) is an architect and a researcher in technology for architecture based in Switzerland. He currently leads research on interactive and generative design with brain-computer interfaces at ETH Zürich. His artistic work follows a series of design objects and mixed-media installations focused on the power of combining humans with computers.

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