ArchaeaBot: A Post Singularity and Post Climate Change Life-form

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Abstract

This extended abstract introduces "ArchaeaBot: A Post Singularity and Post Climate Change Life-form" an underwater biomimetic robotic artwork that explores what 'life' might mean in a post singularity, post climate change future, by artists Anna Dumitriu and Alex May. The project is based on new research about archaea (a group of unicellular micro-organisms believed to be the oldest form of life on earth adapted to life in extreme conditions) combined with robotics, 3D modelling and printing, artificial intelligence and machine learning. The artwork embodies a speculative future life-form which suggests what might be the 'ultimate' species for the end of the world. The robotic installation has become a means of reflection on both the development of new technologies and the impact of climate change for significant artistic audiences around the world.

Introduction

Figure 1 "ArchaeaBot: A Post Singularity and Post Climate Change Life-form" installation view at Ars Electronica Festival 2018. Photo credit Vanessa Graf/Ars Electronica

"ArchaeaBot: A Post Singularity and Post Climate Change Life-form" [fig. 1] takes the form of an underwater biomimetic robotic installation that explores what 'life' might mean in a post singularity, post climate change future. The project is based on new research about the structure of archaea (a group of unicellular micro-organisms believed to be the oldest form of life on earth adapted to life in extreme conditions) combined with robotics, 3D modelling and printing, artificial intelligence and machine learning, to create what the artists describe as "the 'ultimate' species for the end of the world as we know it".

"ArchaeaBot: A Post Singularity and Post Climate Change Life-form" was created by artists Anna Dumitriu and Alex May. They have an extensive track record of creating robotic artworks in a range of forms, including humanoid robots and animal-like robots, and using a range of technologies including evolutionary computing. Anna Dumitriu was formerly artist in residence in the Centre for Computational Neuroscience and Robotics at the University of Sussex and both artists are now artists in residence in the School of Engineering and Computer Science at the University of Hertfordshire and members of the Biocomputation research group. The work also builds on Dumitriu's extensive research around microbiology in the field of BioArt and is the first work that brings her interests in robotics and microbiology together.

Collaborators and Supporters

The project is the result of collaboration with researcher/cryomicroscopist Amanda Wilson at Imperial College within the framework of the EU MARA project, based at Imperial College. Additionally, the artists collaborated with Daniel Polani, Professor of Artificial Intelligence in the School of Computer Science at the University of Hertfordshire. The piece was developed through an artistic residency at LABoral (part of the first edition of the European Media Art Platform (EMAP), a Creative Europe funded programme aimed at European artists working with new technologies) as well as funding from Arts Council England.

The Art-Science Collaboration Process

The project originated from discussions between Amanda Wilson and Anna Dumitriu which explored Wilson's research as part of the EU FET Open project called MARA (Molecular Analytical Robotics Assays). The ultimate aim of MARA is to build functional DNA nanorobots that locate bacterial pathogens or tumour cells before destroying them by drilling through their cell walls. In order to do this the scientists were

studying a species of archaea called *Sulfolobus acidocaldarius* using electron cryomicroscopy techniques to reveal the mechanisms by which they can move about to seek nutrients using tails known as archaella. *Sulfolobus acidocaldarius* are bulbous microscopic prokaryotes that are able to take up nutrients from their environment. When nutrients are scarce, archaella pop out from inside the cell and enable it to tumble in an uncontrolled way until they locate more nutrients, at which point the tails fall off. In *Sulfolobus acidocaldarius* the archaella take the form of cogwheel-like 'motors', far simpler than those observed in other micro-organisms such as the flagella of *E. coli* bacteria. The aim of Wilson's electron cryomicroscopy research was to understand the structure of archaella in *Sulfolobus acidocaldarius* and then verify colleagues attempts to build their own versions using a technique called DNA origami, which allows you to fold DNA into 3D forms. The idea being that these DNA origami rotors, powered by adenosine triphosphate would be able to drive drills made from DNA targeted on bad cells using chemically modified aptamers.

Dumitriu shadowed Wilson in the lab to learn the methodologies for studying the archaeon *Sulfolobus acidocaldarius* and learned how to culture the organisms which grow optimally between 75 and 80 °C. She learned how they were first discovered in extreme environments of the acidic hot springs of Yellowstone Park in the United States of America and how these organisms may be some of the most ancient life on the planet.

The way that the MARA project scientists talked about creating biological molecular robots inspired the artists to discuss ideas around the future of robotics and artificial intelligence. The ability of the acidophilic and thermophilic archaea to withstand extreme conditions suggested that these ancient life-forms might be far better than humans at withstanding possible future environmental conditions such as acid rain pollution, rising seawaters, or higher temperatures potentially caused by unchecked carbon emissions through the greenhouse effect. This gave rise to the idea of creating an artwork that would bring these concepts together in order to create an object that enables our audiences to imagine these existential risks and it shocks them into reflection.

The Production Process

The piece was made using 3D modelling in Blender to design a 'body' for the robot and the separate archaella parts based on 3D models produced by Wilson's cryomicroscopy. The textured sphere-like body contains a fully waterproofed Raspberry Pi Zero, a motor controller shield, three DC motors with gears and an accelerometer, magnetometer, and temperature sensor. Following extensive experiments about the best materials for the most life-like 'tails' we settled on silicone tubing threaded tightly over the outer plastic covering of electrical wire with the copper stripped out. Waterproofing of the electrical parts was achieved by filling the motor gears with Vaseline and coating all the components with liquid electrical tape. For the gallery installation an external power source was used, however plans are underway to incorporate a battery inside the robot body to enable use in open water environments.

The Raspberry Pi Zero collected data from the sensors and was used to train a back-propagation neural network which was responsible for the robot's control system. The aim of the control system was to produce fluid life-like behaviour by altering the speeds and rotation of the motors.

The use of the neural network was a conceptual choice rather than an engineering one. The aim was to enable the artists to explore ideas around evolution and the future of AI, as well as speculating about the concept of the technological singularity, especially in the context of the existential threats. The neural network alluded to notions of consciousness, such as transhumanist notions of 'uploading' human 'minds' to live on in silica in an uninhabitable post climate change world. The aim is to shock audiences into reflection on about the future we might be creating, and raise these societal issues in an engaging way.

Exhibiting the ArchaeaBot

Audiences of at least half a million people around the world have experienced the artwork to date at venues including Ars Electronica, The Science Gallery Bengaluru and the ZHI Art Museum in Chengdu. The work is shown in a dark space where visitors can watch the 3D printed robot swimming and moving in an aquarium as it collects data. The aquarium has a turquoise light in it that highlights the robot and movement as well as the bubbles that rise up from the volcanic gravel at the bottom. The robot's 'tails' reach out of the tank or move the gravel around. The work has proved popular with audiences around the world. Gallery visitor comments indicate that audiences find the work both beautiful and disturbing, with a spiritual quality. As higher mammals face potential extinction ArchaeaBot warns society about the hubris of technology elites and speculates on a dystopian solution for humanity to live on by uploading our consciousnesses to neural networks located inside water based robotic archaea.

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