Lucid Dream: Sensing and Artistic Representation of Plant-Nature Interaction Based on Plants Biosignals

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Abstract

The recent progress of modern science has enabled us to detect the physiological status of organisms through their bioelectric activity; this technique has been constantly applied to contemporary media art. However, exploring plants as a subject and allowing them to interpolate and hence perform art through biosignals remains to be further explored. Lucid Dream is an artwork in which inspection, displacement, and engagement of plant communities take place, shedding light on the subjective perception of plants, a peripheral subject that rarely comes to people's attention. To achieve this, we entered a forest and applied an artificial intelligence-based learning system capable of interpreting the local plants' responses to wind and rain stimuli via their biosignals. Subsequently, we established an environmentally controlled space within the art museum. Here, we simulated and artistically represented the natural elements as perceived by the plants, using artificial machines driven by the plant-nature interaction model. As viewers enter this space, they can experience the plant-perceived natural environment, gaining a non-human perspective through direct engagement with plant life. Lucid Dream not only leverages intelligent computational technologies to comprehend the perceptual system of plants but also fosters cross-species sensory experiences, enhancing our understanding and expanding our perspective on the natural environment.

Keywords

plant-nature interaction, biosignals, artificial intelligence, perception, natural environment

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Introduction

In recent years, as we close the gap between technology and biological systems, artworks utilizing living and semi-living organisms have become increasingly vigorous in contemporary media art. These artworks have presented us with another perspective to understand different life forms. With the era of pan-biological materials of bio art unfolding, artists and scientists who carried multiple identities began to displace the technique of biosignal detection in art creations. A characteristic of displacement, which is Recontextualization, has provided a propelling force for Lucid Dream is divided into the working phases of inspecting, displacing, and engaging with plant communities. We first developed a bio-amplifier to collect biosignals from multiple plants in a forest, we then the dialectic between artists acting due to their thought or their biological reactions to stimulus[1], [2]. Afterward, with the exploration method of using biosignals to construct a new logic for subjects or environments, people have further paid attention to other living organisms, especially algae and microbes[3], [4], [5].

In these artworks, non-human lives are presented as lively, having their own "umwelts"[6]. However, to answer the upcoming question of whether living organisms have a more complex subjective activity and how to represent it to viewers with more direct and persuasive evidence, we believe that plants can be an answer. Due to their natural ability to perceive, adapt, and even evolve a particular method to respond to climate change, plants demonstrate high sensitivity and easily observed feedback to the environment[7]. As a result, it is of great potential for us to utilize intelligent computational technologies to create systems that interface with the "umwelts" of plants in nature in such a way as to extend our understanding and broaden our horizons regarding the natural environment.

1. Environmental-controlled space in the art museum where natural elements perceived by the plants are simulated and artistically represented. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi

Lucid Dream is divided into the working phases of inspecting, displacing, and engaging with plant communities. We first developed a bio-amplifier to collect biosignals from multiple plants in a forest, we then applied an artificial intelligence-based learning system that can interpret the plants' perception of the wind and rain stimuli through their biosignals. The natural environment sensed by plants is displaced to the environmental-controlled space in another realm to be artistically represented. After being "Recontextualized," the environmental data originally subject to scientific methods have been transformed and enabled a new meaning. When viewers walk into this space, they can experience the natural environment that plants perceive through their engagement with plants' life from a non-human perspective. Extending from art to science, breaking the existing framework of scientific research, and connecting trans-species sensory experiences to provide a new possible way to respond to the question of representing the subjective activity of living organisms to viewers.

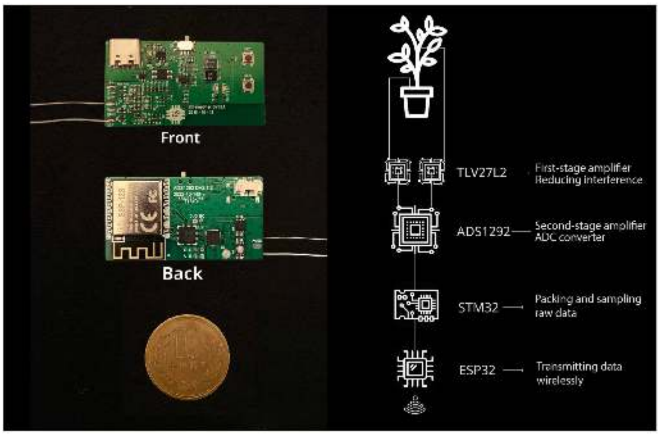
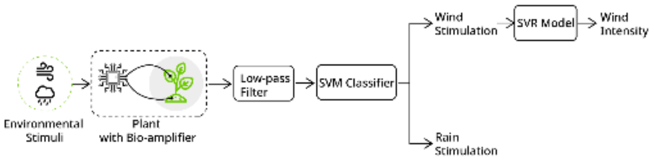


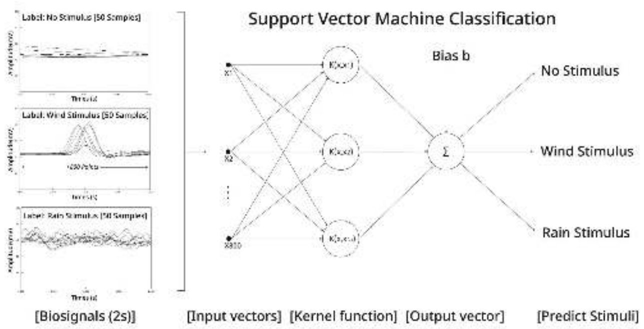
Figure 2. Bio-amplifier design. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi

Biosignals Detection and Analysis

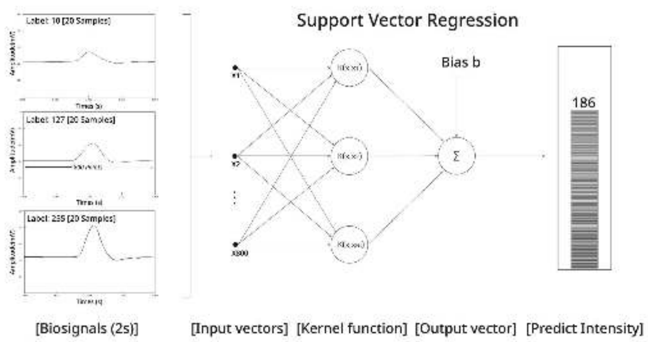
In this project, we focus on the Mimosa in the forest, known for its high sensitivity to environmental stimuli and commonly used in bioelectric signaling research[8]. We developed a miniature bio-amplifier to detect its biosignals in response to environmental stimuli. It detects the difference in electric potential between the substrate and the leaf petiole. As shown in Figure 2, it consists of two integrated amplifiers (TLV27L2 and ADS1292). Due to the uncertainty of plant resistance value and the electromagnetic interference caused by other equipment, most of the plant signaling tasks are carried out in the Faraday cage. We overcame this constraint by using two high input impedance operational amplifiers (TLV27L2) to get less interference and enable detecting the biosignals from plants in the natural environment. To reduce the size and power consumption of the circuit, we utilize the ADS1292 which integrated high-resolution analog-to-digital converter (ADC) with a built-in programmable gain amplifier. We used an STM32 microprocessor to pack the raw data and an ESP32 to transmit the data to the computer wirelessly based on TCP protocol. On the computer side, there is a program developed in openFrameworks that receives and processes the biosignals.



3. System workflow. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi



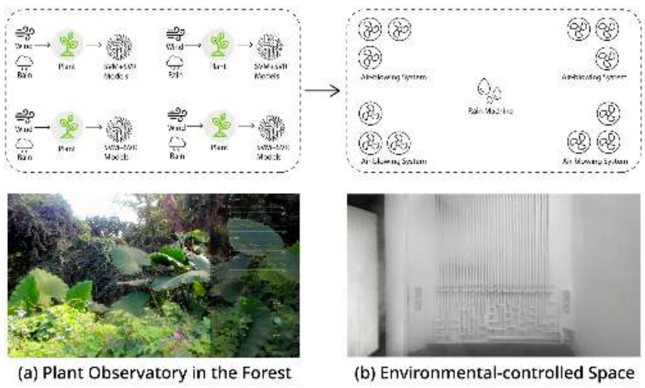
4. Support vector machine configuration. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi



5. Support vector regression configuration. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi

We next applied two supervised learning algorithms to conduct a time-domain analysis of the biosignals to get the Mimosa's status under different environmental stimuli. Figure 3 shows the workflow of this system, A support vector machine(SVM) classifier was applied to discriminate between wind versus rain-stimulated biosignal activity. A support vector regression(SVR) model was then used to predict the wind intensity sensed by the plant. We first reduced the noise of raw signals by a low-pass filter (second-order Butterworth filter) and then collected the biosignals as 800 dimension vectors detected under two environmental stimuli. As shown in Figure 4, for each stimulus, 50 samples were collected and they were labeled "Wind stimulus" and "Rain stimulus." We also collected 50 samples that the plant was under no stimulus. We then trained the SVM model that can classify the status of plants under two environmental stimuli. We also collected the biosignals under three intensities of wind stimulus. As shown in Figure 5, for each stimulus, 20 samples were collected and they were labeled with integer values of 10, 127, and 255. We then trained the SVR model that can predict the wind intensity as an integer value between 0 and 255 that the plants perceived in response to wind stimuli with different intensities.

In this project, we have developed a plant-based system for environmental state sensing. Despite its inherent biological variability, which can result in less precision compared to silicon-based sensors, this system holds significant potential for future bio-hybrid sensing technology. Additionally, we are exploring its creative applications in the realm of artistic practice, aiming to provide audiences with a novel perspective on their interaction with the natural environment.



6. The system configuration of Lucid Dream © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi

System Implementation and Artistic Representation

Based on our research in biosignals detection and analysis, we created an artwork that artistically represents the natural environment perceived by plants in an artificial space. As shown in Figure 6, the artwork consists of a plant observatory in the forest and an environmental-controlled space in the art museum. There are four Mimosas equipped with bio-amplifiers in the plant observatory. The perceived state of each Mimosa in response to environmental wind and rain stimuli will be analyzed by our artificial intelligence-based learning system and remotely simulated in the environment-controlled space. The space is equipped with four sets of air-blowing systems, each with three fans driven by the SVR models. The input is the biosignals of four Mimosas. The intensity of the wind perceived by each Mimosa corresponds to the number of active fans in each air-blowing system. A rain machine is installed in this space, which synchronizes the rain stimuli perceived by Mimosas based on the SVM model. It consists of a water pipe running along the wall to the ceiling and a pumping motor. When the system detects that Mimosas senses rain, it will trigger the rain machine to simulate the outdoor rain environment in this space.

Figure 5 shows the exhibition site in the art museum, with a monitor real-time streaming the environmental conditions in the forest and the biological state of the four mimosas. The natural environment sensed by plants is displaced to the environmental-controlled space in another realm to be artistically represented. After being “Recontextualized,” the environmental data originally subject to scientific methods have been transformed and enabled a new meaning. When viewers walk into this space, they can experience the natural environment that plants perceive through their engagement with plants’ life from a non-human perspective.

7. The exhibition site of Lucid Dream. © Youyang Hu, Chiaochi Chou, Yasuaki Kakehi

Conclusion

This paper introduces the artwork Lucid Dream, which uses plants as perceptual subjects to gain insight into and artistically portray natural elements to viewers. To accomplish this, we have devised a bio-amplifier for detecting plant biosignals in response to environmental stimuli. Subsequently, within a forest environment, we have employed an artificial intelligence-based learning system capable of interpreting local plants' responses to wind and rain stimuli through their biosignals. Additionally, we have established an environmentally controlled setting to simulate and artistically represent the natural environmental elements as perceived by these local plants to viewers. Lucid Dream not only delves into the utilization of advanced computational technologies for understanding plant perceptual systems but also endeavors to create cross-species sensory experiences, expanding our comprehension and perspective on the natural environment.

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