Project Florence: A Plant to Human Experience

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Abstract
If plants could talk to us, what would they say? Equally important how might they respond to us if we could converse with them? How might these conversations evolve and expand our ability to better relate with the Natural World? Project Florence is an artistic representation of a Plant-Human Interface Experience that is built on top of a scientific analysis of the plant and its environment. Paired with the ability to receive human input, the plant can return a response, thus promoting a two-way conversational experience. Combining Biology, Natural Language Research, Design, and Engineering… we have created an instantiation of a plant to human interface through the power of language. Project Florence enables people to converse with a plant by translating their text sentiment into a light frequency the plant can recognize and respond to.

Author Keywords
Interactive Art; Plant Signals; Natural Language Processing; Interaction Design; Human to Plant.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

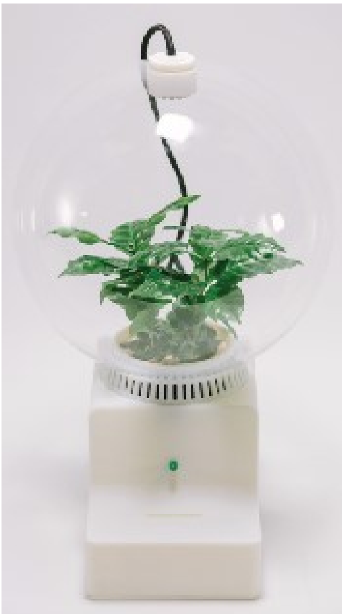

Figure 1: Project Florence Base piece containing a living plant instrumented with a variety of sensors to measure temperature, soil moisture and humidity. Additionally, the LED at the top displays Red or Blue light on to the plant depending on the user's sentiment. The plant will print out a response via a mini printer installed below the plant.

Introduction
It is widely accepted in the Scientific Community that plants communicate to one another [2] and can elicit an electro-chemical response to their environment, this is referred to as Plant Signaling [9] While their reaction and response time may differ from ours, it is not impossible to detect and perhaps even translate these signals through today's technology. While plants do not speak different languages, they do use electro-chemical signals to communicate and activate processes inside themselves. Each species can react differently to stimuli and adapt differently to its own needs. For example, some plants produce bitters to defend themselves against animal attacks. Other plants, such as the Mimosa Pudica shrink away from physical touch [1]. But the research in plant communications is still in an early stage and the sophistication and complexity of different 'languages' in nature still needs to be explored. With the explosion of new sensor technologies, we hope to learn and inspire others to understand these communication patterns, and to use interactive art as a mediator and translator between the natural environment and ourselves to better understand the dynamics of different organisms in our ecosystem.

Today, Internet of Things has become a trend that infers a future in which our lifestyle will be connected to our devices creating an intelligent connected world [4]. Project Florence would like to expand on this concept of connection and transfer this into the natural world by leveraging on the pervasiveness of sensing technology that can help monitor and understand the basic needs of plants including moisture, light, and temperature. This coupled with the science of plant signaling can now deepen our understanding of human to plant interaction.

Related Work
Within the last several years there has been a variety of human to plant hybrid projects that have attempted to explore ways in which Humans and Plants can co-exist and play together through technology. Several of these pieces have leveraged robotics, sensors, electrodes, or a combination of all to infer exaggerated interactions between plants and humans. In the case of movement, the Jurema Action Plant [6] uses electrodes inserted into the plant to measure changes in the electromagnetic fields when a plant is touched. The plant sits on a robotic platform that moves away from the person touching it when those signals are detected. IndaPlant [3] similarly uses motion based on the plants need for water or light that is detected via sensors and not necessarily by human interaction. Both these pieces explore the idea of free roaming plants driven either by human touch or sensors but unlike Florence there is little focus on any kind of interspecies communication.

Closer to Florence in concept, Botanicalls [5] uses common human methods and tools of communication to make a person more aware of the conditions of a plant. The project uses simple soil humidity sensor to predict the optimal condition of the plant soil. When the plant needs water, it will call or text message it's owner with a pre-canned message. Designed with humor in mind, it is a great example of how sensing technologies can help augment our environments. However, it still doesn't enable two-way communication. Others go even further to infer that a network of instrumented plants can become sensors themselves that help monitor our environments [8]. While Florence remains focused on a single plant to human experience, the concept of intelligent and networked plant life is on the rise.

Interaction Design

When you visit Project Florence (Fig.2), you begin by typing a message to it on a Microsoft Surface tablet that is connected to the plant ecosystem. What you type is then sent to a cloud service hosted in Azure, which uses Natural Language Processing to examine the sentiment and the sentence structure, and this is then translated into stimuli (in this case: different light frequencies and durations) that the plant can understand and react to. We leverage the plant's ability to respond to different light properties to deliver different sentiment and trigger a plant response. The user can attempt to communicate with or influence the plant through modulated natural language. As they type into the laptop, their inputs are analyzed for sentiment and semantic content. The resulting signals are used to modulate a light source that projects either a red or blue light spectrum based on that sentiment. For positive sentiment, we flash a red-light spectrum that encourages plant cells to grow. For negative, we project a blue-light that in effect turns off the cells ability to expand.

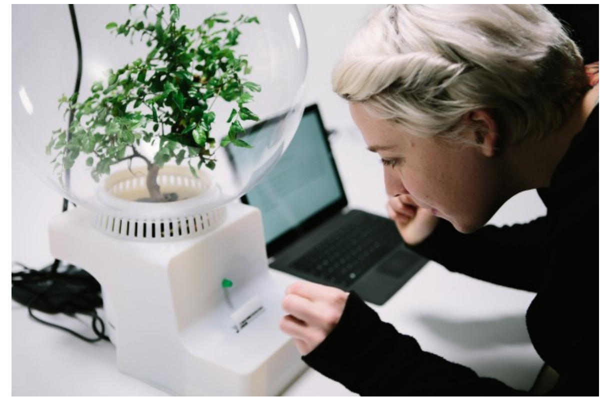

Figure 2: Interacting with Florence

Florence then "replies" to you with a sentence or two provided by the Azure cloud service, using sample words and phrases collected from Twitter that are of a similar context to your message and possibly found in botanical and/or environmental contexts. The sentiment of what Florence replies is affected by its "mood" (based on the sensor readings) as well as the time of day. The reply from Florence is sent to you via a small printer that is connected to the base of the plant (Fig.3). Additionally, the data gathered from the plant including moisture levels, temperature and Carbon Monoxide levels are gathered and infer a state for the plant. The combined input from the user with that of the plant's signals is used to generate a conversational response from the plant that is finally printed out via a micro printer. The resulting responses are transformations of the input, driven by linguistic trees as well as lexical paraphrases.

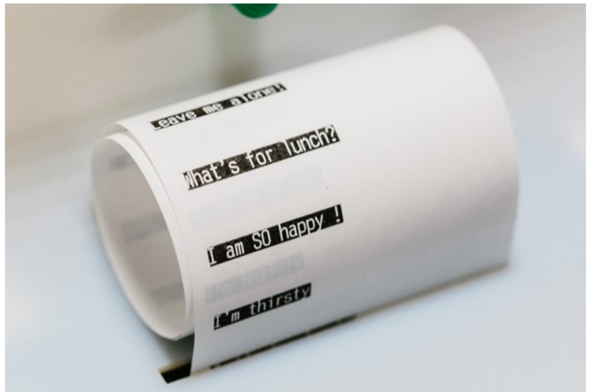

Figure 3: Plant response printed via mini printer.

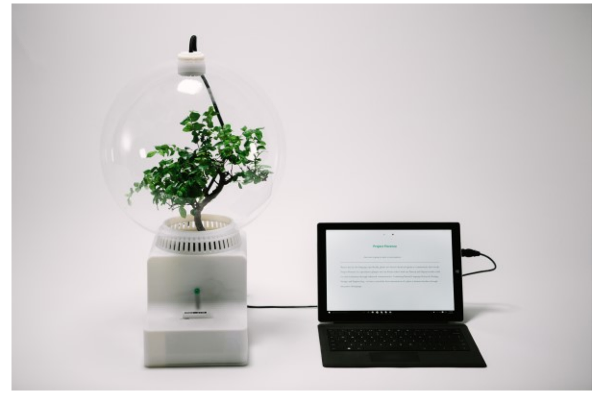

Figure 4: Project Florence Plant Base Unit connected to Surface.

Setup

Florence is comprised of several components. The plant sits inside a 3D printed base that contains 2 Arduino boards used to monitor the data coming from the sensors inside the plant ecosystem, as well as control the interactions between the plant and the human (Figs. 1, 4). Additionally, there is a micro printer installed at the front. The setup consists of the following:

- 3D printed base
- A custom cut Glass Bowl
- Sensor kit: Air Temperature, Soil Moisture, Carbon Monoxide Level, Humidity
- Micro Printer
- LED Ring
- 2 Arduino Micros
- Living Plant
- Surface Pro PC (Connected to Azure)

Measuring Bio-Electrical Signals

The opportunity to interact and communicate with our natural environment enables us to look beyond the physical properties of plants and gives us access to look at the processes and functions of plants. Within the Florence ecosystem, there are various sensors measuring environmental factors that define Florence's "mood". These sensors include soil moisture, air humidity, carbon monoxide, and air temperature. These sensor values are collected and streamed to the Azure Cloud service. The Azure service combines this plant-mood-affecting information with the Natural Language Processing of the human conversation as inputs into the formulation of Florence's conversational response.

The 'moods' of Florence are defined by the common knowledge of plant physiology and its reaction to environmental conditions like weather, draught and its internal clock (circadian rhythm). The different conditions are than mapped on common human reactions to thirst or tiredness and to phrases and idioms used in farming and gardening. We also developed a set of tools to help us examine the reactions of plants to different light frequencies and durations as proposed in project Florence. These tools enabled us to measure variation potential changes within the plant by inserting needle electrodes [7] (Fig. 5). The A Micro Spectrometer (C12666MA) from Hamamatsu and a customized plant clip with high-power UV-led enabled us to capture the fluorescence spectra changes within the plant (Fig. 5). The set of boards produced made it possible to reproduce the pattern generated by the plant which leads to eventually using it in an installation like Florence.

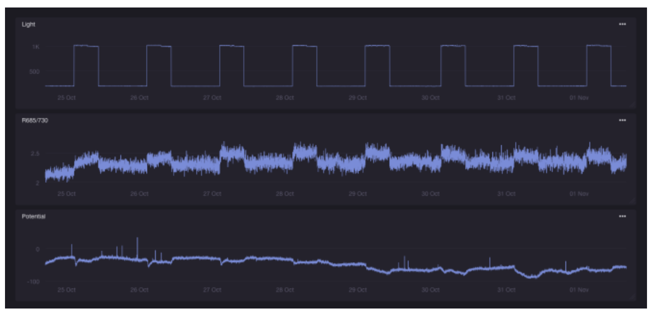

Figure 5: 8 day long experiment with a tomato plant measuring variation potential and fluorescence spectra changes (R685-730Nm) in relationship to a 8h blue and red light cycle

This could lead to novel applications for agriculture to detect things like plant infestation at an earlier stage, requiring less pesticides. This can also expand our ability to monitor our natural environment and crop-fields to better understand the problems we face and to build more sustainable agricultural systems.

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Conclusion
Project Florence is an artistic interpretation of a future world where Nature and Humans can communicate and co-exist in greater harmony. Enabling people to "talk" to a plant and receive a response opens their minds to this concept. Sometimes, Florence can be quite cranky and unpleasant if she is too dry or does not care for your input. This too invokes a sense of personality to the plant that people would not normally consider. The design of Florence has inspired new educational opportunities around Plant Human Interaction specifically towards primary education. Educational researchers are considering incorporating aspects of Project Florence into current curriculum. If students are inspired to monitor and respond to their plants, they can better assess the invisible processes of plants with raised awareness and enthusiasm. It is our hope that we can help equip the next generation with tools and knowledge necessary to help maintain healthy and sustainable practices.

Video Link
Project Florence : https://vimeo.com/158255450

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