EVE: The Plant Incubation and Identification Robot for Household Botanists

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Abstract*—*This paper presents a low cost 'all in one' robotic replica of Disney's EVE from Wall-E which can serve as a household tool for plant enthusiasts. This prototype includes arm actuation, head swivel, and LED screens to evoke a personality for the robot. Further purposed work would be to include plant identification abilities as well as a plant incubator inside the robot to monitor and improve plant health in a plant based optimized environment. This robot would remove nuances from plant care such as required light conditions and hydration to ensure plants can survive alone during long vacations or busy life events.

I. Introduction / Background

Everyone should have the ability to have plants in their homes if they wanted to. However, many people live busy lives, go on vacations, or just forget about their plants. On top of that many plants die due to improper conditions. This prototype solves that issue for household applications, removing the stress of the common gardener or plant lover experiences while also providing possible new information regarding different plants over the course of their lives

This robot prototype features three main electronic components, each serving their own purpose. (1) actuation for robot personability, (2) incubation and care of plant life to ensure adequate water, PH, sunlight, etc., and (3) identification of plant and current health status for research development.

Note that the personability and aesthetic outer shell of this robot was inspired by EVE from Disney's *Wall-E,* this was chosen due to the in-movie personality and function of EVE, that being to find vegetation in hopes to confirm Earth was habitable again for humans to return from space. It was also chosen due to the close relationship I had with the movie throughout my engineering career.

With a robot like this built for the common household, plant ownership could be encouraged without fear of accidental negligence. This robot could also increase the interest and study of botany widely by being introduced in homes or schools. Furthermore, any data collected could be utilized to further the knowledge of houseplants or even garden plants as many people have switched to growing herbs, fruits, or vegetables indoors.

II. Related Work

Many studies and prototypes have been done on similar topics regarding robotic identification and studies into plant phenotyping; however, these all relate to large scale farms, and agriculture based around crop yields. However, these ideas could still relate as this prototype is just a small-scale more educational version.

Reference [1] centers around robotic using touch for identification. The system works by detecting moisture levels within the plant using electrodes that measure electrical resistance, which correlates directly with the moisture level in the plant tissues. The system also uses sensors to evaluate the tactile feel of the leaves and stems. Together this data predicts the plants' identity through machine learning. This removes difficult AI vision-based classification techniques most systems utilize. When it comes to this prototype, this type of system would be useful since there will already be sensors integrated into the robot for care related applications. Secondly, it's implementation into a widely used robot could establish a large database of different species and varieties for later studying. Thirdly, this type of plant evaluation could be interesting to include in classroom units for students to learn how plants differ, or how certain traits change under varying environments.

Reference [2] covers the monitorization of orchards to collect data on plant health and growth to study the efficacy of robotics in agriculture using autonomous ground vehicles (UGVs or AGVs) and autonomous aerial vehicles (UAVs) equipped with advanced sensing technologies. Ultimately, this study found that the usage of these vehicles provided crucial data to improve crop yields and assist in sustainable farming practices. Considering this type of robot could increase large scale agriculture efforts, a small-scale robot such as the one purposed could use this type of data for plant care, ensuring a high survival rate. It is also noted that according to reference [3] plants under incubators tend to have higher survival rates then their potted, or field grown counterparts due to the conditioned environment they are placed in.

III. Exsisting and Future Prototype Ideas

Originally this project started as a simple actuating hobby robot printed from PLA (polylactic acid) filament based on

Disney's EVE but has since advanced into a multiphase project as end of college celebration encompassing everything I have learnt during my education. So far only the aesthetics of the robot including the outer shell of the robot, as well as the arm and head movement has been prototyped as apart of phase 1. Phase 2 includes theorized integration of identification and care of plants with minimal CAD (computer aided design) based adjustments. This phase would push the design from a simple robot to a useful piece of hardware.

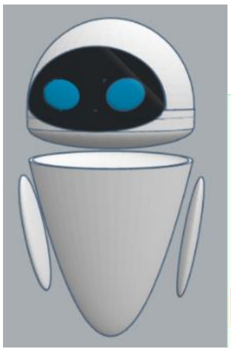
It is also good to note that this robot had a list of needs decided during brainstorming that are as follows:

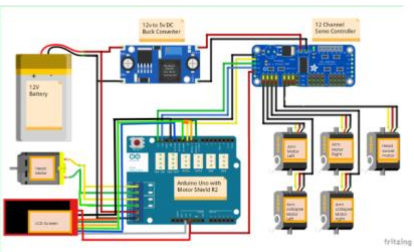
(1) Robot's arms and head must be able to fully collapse into body and have a smooth sleek design.

(2) Robot must be able to fully articulate. This includes 360 degrees of motion in both arms, as well as 360-degree head swivel abilities.

(3) There must be sufficient room inside the body cavity for a medium sized plant to be placed, therefore the electrical and Arduino components must be small. Furthermore, the robot needs to be large enough to fit a plant, but small enough for an average room.

For physical design the robot has been mostly modeled in SolidWorks, with the proposed design shown in figure 1. The overall electronics of the simplified model without plant identification and incubation was also drafted (Figure 2).





(Left) Fig.1. Proposed outer shell design 3D printed from PLA.

(Right)Fig.2. Proposed Arduino electronic configuration for OLED screens and overall body movement.

A. Phase 1: Electronic Componets for Actuation and Personality

This section includes some of the overall external functionality that was based on core needs defined above.

To be able to accurately test all functions, they were split into multiple projects such as arm movement, head movement, eyes. These projects are currently at varying degrees of completion and thus have not yet been integrated into one prototype.

For the initial prototype of the arm movement cardboard and toothpicks were used to create a cheap, proof of concept design. This featured a 3-link mechanism, with a DC motor controlling one link, that would then spin and push the last link in a horizontal movement (Figure 3).

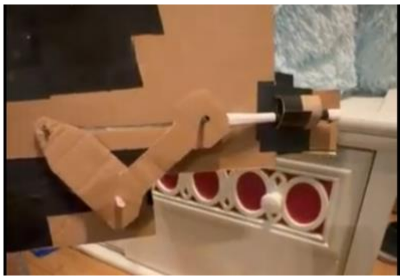


Fig.3. First cardboard prototype of arm retraction method made from cardboard.

After this, I realized the arm needed a more precise motion and was too large, which would then fault need 3. A second cardboard prototype was then created which was much smaller and featured a micro servo motor in place of the DC motor. This prototype included a second micro servo motor to fulfill need 2 and introduced an Arduino button pad that could push/pull the arm and rotate the arm in both directions (Figure 4).

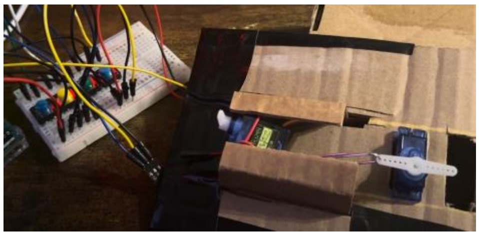


Fig.4. Second cardboard prototype of arm retraction method and 360-degree arm swivel, including Arduino electronics.

Due to the space restrictions in the head, a 82x17mm rail stepper motor is used in place of the prototyped system made for the arms. A micro servo motor is then placed on the top of the stepper motor to satisfy need 2 by making sure the head rotates 360 degrees.

For the eyes, two 128x64 OLED screens in blue were used along with RoboEye code created by Flux Garage [4]. This gave expressive eyes that could be later linked to plant conditions providing the necessary plant health information from just a glance.

B. Phase 2: Plant Identification and Incubation

This section is more theoretical compared to phase 1, so the following ideas may change as the prototyping process proceeds. Material wise, plant identification and incubation would require a wide variety of sensors such as a humidity sensor to monitor moisture levels, photoresistors that monitor light levels, and a soil thermometer to track soil temperature. All of these sensors work in tandem to provide information for identification and what the plant needs for care. Note that there are multi-functional sensors that track all these values and more such as pH and salinity in one device, but these tend to be more expensive. To keep the device more hobby based and low income available this project will use the sensors individual counterparts.

These sensors would be located inside of the robot as spikes on the base plate where the plant goes. This makes it so that when a plant is placed inside, the spikes can pierce through the soil for accurate measurements. The data collected would be available for export for personal experiments, and would also get sent to a wide database for plant identification and studies on species and varieties of houseplants. The data would also change the expressions for the OLED eyes mentioned in phase 1, so owners know the state of their plants. There also may be a camera on the interior of the robot to monitor leaf health and wellbeing similarly to reference [2].

The robot would also have functionality to help the plant as much as possible so that busy individuals could still own plants. For instance the base plate that the plant sits will be a lazy Susan where, based on light, the plate can rotate. This would also remove the possibility of more delicate plants like lucky bamboo being burnt from the sun. Then during night the robot can turn on LED lights above the plants that can provide sufficient light for the varying stages of the plant life cycle. The robot would also include a water cycling system where the user can put a small amount of water into the robot. The robot would then systematically water the plant based on the moisture levels received from the humidity sensor, indicating low water life through the OLED eyes. Overall this would produce a household based robot perfect for identification and care of plants.

IV. Responsible innovation

I believe all projects should not only serve a purpose but also put more good into the environment then bad. So, during the brainstorming phase of this replica, it was imperative to ensure this project not only was more than an object on a shelf but could use as many sustainable materials as possible.

Regarding purpose, being able to collect data from the plants during identification and observation of its conditions can be used in a variety of ways. For instance the data could be evaluated during in home experiments as a learning tool for botanists, or maybe with an agreement from the participants, the data can be placed into a larger database of plant traits so we can learn more about common houseplants (or even crops if the users choose to place one inside the robot). Furthermore, a device such as this could be used in classroom long-term experiments, where kids can watch plants grow, learn about different properties and more.

Regarding sustainability, this prototype is considered various materials during its inception. Ideas of creating a paper or cardboard based design with seeds inside so the robot shells could be turned into plants was thought about. Unfortunately, that design seemed too weak, so instead this robot's shell uses PLA, a 3D printable and recyclable material. This would make it more sustainable then the average plastic as well as easily accessible to low-income areas.

V. Author bio(s) / experiences

My name is Kaitlyne Spring. I am an undergraduate studying mechanical engineering at Northeastern University with a minor in math and robotics.

had always been creative and hands on, even going as far as to make a model violin out of pipe cleaners, but I felt stuck thinking about future careers since I wanted to do something that benefited people while also keeping that joy I had when designing. When I saw movies like Wall-E or Dolphin Tale, I realized engineering was that middle ground. So started developing CADing skills during my free time, I went to a vocational school where I learnt how to machine metal, I became captain of a robotics team to grow my robotics skills, and I took every opportunity I saw to grow further.

One of those opportunities was EVE. For context, I had already made a Wall-E replica using my school resources during high school but, considering that was mostly following a procedure of what to print and what to solder I felt slightly unfulfilled. So, I started personally designing an EVE to accompany my Wall-E. Originally this project started as a simplistic robot that could encompass my electrical, mechanical, systems testing, and coding skills. However, I started thinking about useful ways to incorporate a task. Then while looking at my wilting plant, it clicked. A plant incubation and identification-based robot would be perfect for EVE due to her role in the movie, as well as she could then serve a purpose as a 'one size fits all' robot for plant lovers who may have busy schedules, or be away for a time unable to take care of their plants, or not know the proper care for their plant due to not knowing what plant it is.

Since the projects full scope was determined I have made great strides towards prototyping the actuation, the eyes, and the aesthetics of the robot. All in the hope of completing this project before my graduation in 2027.

VI. Acknowledgements

This project is dedicated to the young engineers breaking their way into a huge field, and the plant lovers who are sick of accidentally killing their plants. I also wish to acknowledge my sister who provided reassurance throughout this projects life.

VII. Refernces

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