Ongoing Efforts in Implementing an Educational Intelligent Robotic Gardening System

Elise Araiza, Ryan Integlia
Florida Polytechnic University
Lakeland, Florida 33805, USA

e-mail:- earaiza7061@floridapoly.edu, rinteglia@floridapoly.edu

Abstract—This project will focus on bringing together interactive education, recreation, and gardening to promote education in gardening through robotic and interactive gaming systems. The system would be beneficial in a community environment and will be used as a community resource. By using recycled materials including robotic vacuums and computers as well as new materials, including microcomputers and game interfaces. This system will combine the complexity of machines and the simplicity of nature’s plants. To gain educational human-machine interaction, an open sourced game involving machines and horticulture will be included that is related to the environment. Learning can also be included with the various sensors that the robotic vacuum will have onboard. This project can also have room to be manipulated to fit a certain environment and its surroundings. While this project has these views in mind, it can also be used as a connection to intelligent farming and gardening in urban areas.

Index Terms—Robotics, Education Technology, Gaming, Human Machine Interactions, Horticulture

I. INTRODUCTION

The system that will be used will be an interactive sensor system that will include a series of autonomous robotic machines, a computer gaming interface, various lights, sensors, imagers and it will interact with users. An automated system will also manage the upkeep of the garden, including watering and measuring soil temperatures through the gaming interface. The gaming interface will include questions for users to answer, information about the environment (i.e. fun facts), small open sourced games for users to play regarding the environment, display the information that is measured in the environment and will record/measure the user participation on the device. The system will assist users in learning about the environment, horticulture, and measuring interaction with participants. The completed system will be displayed and will interact with the local community and schools to encourage participation and learning. The system will enhance the park as a community resource. The data collected from the computer on the gaming interface will assist in finding out who is interacting with the system and what changes can be made because of it.

Practitioner interference with the systems and the plants will improve the system by understanding the needs of it in a certain environment.

II. BACKGROUND

This system has correlations between other systems in design and function. The project will be a sort of outreach program that will involve the local communities to learn about horticulture [1] as well as the mechanics behind the system [2,3,4]. By being able to take measurements on the plants, monitoring the readings are important, especially if it can lead to the development of water qualification [5]. Intelligent farming is an idea where systems and machines can keep track of important information relating to crops and could be based on computer vision, or scans of the area [4,6]. This system will be considered a small sustainable garden when in use. These gardens are useful in many communities around the world and this system can improve these gardens [7]. This will include autonomous robotic machines that have been upcycled, like robotic vacuums and computers [8]. The robotic vacuum machines would be equipped with lidar scanners aboard it to assist in maneuvering around the changing environment. A lidar scanner measures an environment by scanning it with reflected pulses that reflect into a sensor [9].

A customizable gaming interface will be used to display questions and monitor participation within the coexisting space [10]. The autonomous robotic machines will be connecting to a base station that houses the computer with the program included on it. The system will need human interaction in order to completely function. For this, the interaction will need to be safe and use energy in a limited fashion [11]. The base will spend information via a transmitter on the machines to make it move. The importance of these systems is that they can be used to show younger generations about the importance of farming and gardening through computer programs, engineering and control systems [2,6,12]. These systems working together can also assist youth with gaining knowledge of robots and their different functions [13]. Many things can be learned from this system about plants, including the circadian rhythms of certain plants and how measurements can take place [14]. Intelligent
farming can lead to sustainable communities and smart city resources [15]. With this system in place, it can collect feedback from consumers, that can assist in developing the system.

III. CURRENT DEVELOPMENT

A. Experimental Setup

A simulation of this system can be done at the Florida Polytechnic University campus in a controlled environment. Multiple trials will take place for the gaming interface as well as the robotic vacuums. An experiment of this system will take place on campus in a controlled environment. An experiment will include a prototype of the gaming interface, with an open-sourced game and a location scanner, along with a modified robotic vacuum. Certain experimental scenarios that could be tested include a wondering child, an immovable object blocking a path, a possible malfunction onboard, transmission trouble, etc. The machines will need to be able to learn to seek someone out to help relieve the problem. These test scenarios will be carried out and tested for each individual environment it is placed in. A possible test environment will include the controlled environment on the Florida Polytechnic University Campus. Locations that can benefit from this system include Bok Towers Gardens, the City of Winter Haven, and Saint Lucie County.

B. Development and Discussion

For the complete system, multiple parts will communicate and work with each other to create the system. The system would communicate through the Robotic Operating System (ROS), due to its flexible framework for writing the needed software [14]. These parts include the gaming interface, the autonomous robotic machines and the computer that controls the movements for the robotic machines, as shown in Figure One.

![Figure 1](image1.png)

**Figure #1 – Relationship between Gaming Interface and Robotic Machine.**

(This includes is the representation of a fixed environment that the machine(s) and gaming interface will be in. In the controlled environment, which is represented by the oval, a movement breaks the field that the lidar scanner has scanned. Once the scan has detected a break, it will send a signal through the transmitter to the computer and will move to another area.)

A possible user interaction monitoring and analysis framework that could be used is BaranC and it is compatible with smart and digital devices [17]. The computer system and the robotic machines will be a separate system, but the overall system will also include the gaming interface. The gaming interface will bring in guest and user interaction, while the robotic machine will gain user interest in the movable garden and the machine itself. On the autonomous robotic machine, a plant will be placed on them and can move around the environment. Sensors could also be placed on the pot of the plant to measure aeration, via an imager (i.e. Pixie Cam and Pixie Cam 2), water level, soil pH, circadian rhythms [18,19] and the overall health of the plant, as shown below in Figure Two. These sensors will be Arduino-based and will have a personalized library for each sensor. A battery will also be placed with the sensors as a source of power to keep them functional. A water reservoir, with a possible water pump, a reservoir filled with liquid fertilizer and light source could also be added to maintain the wellness of the plant. With these in place, it would be necessary for the practitioners of the facility to accommodate the health of the plant and the data from their sensors.

![Figure 2](image2.png)

**Figure #2 - This is the design of the autonomous robotic machine system. From the top, the water reservoir is in the pot with the plant along with the interface. Under the stand, is the Lidar and a sensor board with various sensors that are controlled and monitored by the computer underneath its base. All of this is situated on top of the autonomous robotic machine.**

![Figure 3](image3.png)

**Figure #3 – This is a CAD design model of the above figure.**

The autonomous robotic machine will move in a controlled environment, which will be made especially for the completed
system. The machine will be coded via Arduino, to know and complete simple tasks including knowing where its location is relative to its environment via GPS, whether it is on the ground or picked up and whether it has bumped into anything using the lidar scanner. It will also recognize various movements made by users and use machine learning [20] to either stay in its current location or move to another one.

**Figure #4 – Robotic Movement**

This figure includes the flowchart of actions that will take place in the autonomous robotic machine when there is movement close by it. The actions will rely on a movement, by the lidar scan being broken or not complete. If the movement is detectable, it will continue to communicate with the coded program on the computer via the transmitter on the autonomous robotic machine. From there it will move to another area in the environment and stay in the new area. If the movement is not detectable, then the machine will ignore it and stay in its current position.

**Figure #5 – Group Movements**

This figure shows a diagram of a group of four robots with plants working together in a group while also protecting their plants' lifestyle. In Figure Five, the robots switch positions to accommodate human-machine interaction and plant health. Plant robot 4 is at a rest area for the robot to charge and for the plant to get shade, water, and other materials. While at the same time, indicating how they could work in groups for their purpose while enhancing how they protect the plants' lifecycle. They will communicate via a ROS network that was previously discussed and a possible mesh network that will be discussed in ‘Future Work’.

**C. Analysis**

For the gaming interface, a separate coded system will be needed to program it and monitor its actions. The interactive gaming interface will include questions guests can answer in response to the garden and include an open-sourced game related to the environment. The open-sourced game will include a positive relationship between plant and machine interaction. It will show that by working together, new ideas can be discovered and explored. The open-sourced game will compare to the Plants vs Zombies game but will show the advantages of robots and plants working together [21].

The interface itself will also monitor human participation by creating a personal anonymous profile of the user to collect data that will be used to analyze the current system, to make improvements and gather user basics. The data will be gathered through surveys and gameplay to decide the effectiveness of the gaming interface. The interface will also monitor the communication between the robots and itself if there is going to be any. As human-machine interaction can also take place through the gaming interface as shown below in Figure Four. Another factor that could be added to the interface would include creating user profiles to see how each person interacts with the interface. By doing this, data can be collected and analyzed on the actions of the users. Human-machine interaction can also take place by creating user profiles for the practitioner(s) that take care of the environment. These profiles could better help the development of the overall system. Presenting surveys and reviews about the environment in the main menu area of the interface would help with the development as well. These surveys and reviews could be generated from a pi games interface.

**Figure #6 – User Interaction**

This figure includes the flowchart of immediate actions that will take place in the gaming interface when it has human interaction. The gaming interface will depend solely on the user. Figure Four shows how the gaming interface will react with continuous interaction, touching the interface, with the user.
Figure #7 -

This diagram explains the actions of the gaming interface from the main menu. There are two options, one to ignore and one to continue. The one to continue will need further interaction to open either the game or information about the environment. The information could include anything related to the present horticulture or a survey/review to collect data.

IV. APPLICATIONS AND IMPACTS ON AN ENVIRONMENTAL AND SOCIAL CONTEXT

The environmental impacts that this system will make include caring for various plants in the garden where the system will be located and collecting information on the various aspects of the plant. The social impacts include assisting users in learning about the environment, measuring interaction with participants an enhance the park as a community resource. Various applications will include an introduction to horticulture via technology and engineering. As well as interacting with autonomous robotic machines and observing how they work and move with plants on them. Educational impacts include peoples of various ages to enhance their knowledge of horticulture, robotics and the connection that can be maintained through both.

V. FUTURE WORK

Any future work will include a possible expansion in the number of autonomous robotic machines and a bigger environment. Future work will focus on the aspects of balance, optimization, and community. To better connect the network of the gaming interface, machines, and human interaction, a mesh network could be added. Possible updates will be affected by the wellness and protection of plants, wellness of interaction and overall system-user connectivity. This will include possible sharing of materials between plants and trade out of various sensors to collect more data. For example, a different type of imager could be added to the autonomous robotic machine to determine the various types of circadian rhythms in the potted plants [22]. The systems can be improved by scraping the internet. Educational outcomes are a major factor in any updates done to the system. After having the initial systems running for a period, updates will be made based on the necessary and available resources, as well as the areas that gathered the top interaction and educational results. As participation grows, guest and user interactions will change to include sound via a microphone, light and other interesting functional features that the user population can have an influence on. Interaction with the system is highly encouraged and due to this, changes will be made to the selected plant, in case of participant allergies. Another aspect that could be included in the future is adding insects into the garden system. The insects, i.e. bees, could be used to transmit data via radio waves and detect the various sensors within the plant robot [23].

VI. CONCLUSION

Bringing machine intelligence into a biological system will spark the minds of young learners and urge them to continue to learn through this interesting interactive learning system. The system itself will depend on guest interaction to function and bring in more guest participation because of it. This project will enhance the social aspect of learning about and gaining interest in horticulture and machines in the community. Hopefully, this will drive people who encounter the autonomous robotic machine, the plants, and the gaming interface they will see the importance of preserving nature and advancing technology. The project will be used by organizations who see the importance in the environment and how it can assist us in expanding our knowledge into the future of gardening, farming, and technology. The current work on the system is still experimental and is needed to be worked on to be complete. Current work includes finding a way to keep the plants monitored and healthy.

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