GROWBOT: A Robotic System to Help Children Grow Plants

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Abstract
Growbot and Growall comprise an interactive robotic system that helps teach a child to care for a plant. While some children learn caregiving skills from pets, many children live in areas where pet ownership is impractical or not permitted. Plants are more accessible and can teach a similar skillset. But, unlike pets, plants are unable to draw attention themselves to get the care they need. Growbot, a mobile robot capable of moving a plant, enables plants to move in goal-directed ways to gain attention and communicate needs to a child caregiver. As the plant grows with the child's long-term care, the child is rewarded with Growall, an interactive, flowering, wall-mounted surface. As the plant grows, Growall becomes increasingly active to further motivate the child's caregiving. In this demonstration, we will show how Growbot interacts with a plant and communicates its needs to a caregiver.

Author Keywords
Child-Robot Interaction; Interaction Design; Scenario Design; Prototype

CCS Concepts
•**Human-centered computing** → **Scenario-based design;** Activity centered design;

Figure 1: Growbot's lid open to provide light to a plant

Figure 2: A child waters a plant after prompting from Growbot

Introduction

As predominantly social beings, the opportunity to provide care for other living things is a basic human need [10]. Caregiving opportunities offer several developmental benefits to young children. Children who care for pets are more empathetic and prosocial than children who do not have pets [2, 9]. In addition, caregiving offers educational benefits. By providing care to a dependent, children enter into a meaningful relationship that provides the social context and motivation for learning [8]. One study [4] found that children who took care of pet goldfish learned significantly more about the unobservable biology of fish than those who did not have goldfish. Further, they were able to generalize this knowledge to other animal species [4].

In our research, we plan to increase accessibility to these skills and learning opportunities by focusing on caregiving for plants. Unlike pets, plants are accessible for almost any lifestyle and housing situation. One main challenge of this approach is that children struggle to understand plants as living things unless they are taught that plants exhibit goal-directed motion, like turning towards the sun for nutrients [7]. In our research, we expand on person to plant interfaces [3], augmented reality plants [1, 6] and caregiving for robots [5] through the use of a robotic platform, Growbot, that solicits the help of a child caregiver for a real life plant. In this way, the plant-robot system can communicate and exhibit goal-directed motion, helping the child identify it as a living thing.

Design

The robotic system is composed of two main elements: Growbot and Growall. Growbot is responsible for day-to-day plant activities, while Growall responds to long-term plant growth and care. Neither element directly cares for the plant, but communicates the plant state to the child caregiver. For example, Growbot can prompt the child to care for the plant by indicating when the plant needs water or sunlight. If the child successfully helps the plant grow, they are rewarded with activity from Growall. As the plant grows (from successful caregiving) Growall's mechanical "flowers" will "bloom" and move in novel patterns. As Growall is still an early prototype, we will focus primarily on the design of Growbot.

Growbot has two main elements: the Growbot robot itself (referred to as Growbot) and one or more "follower" planters (referred to as the plant). The bulk of the hardware lies within the shell of the Growbot, while the plant is equipped only with plant health sensors (e.g. soil moisture, UV sensing). Growbot has four primary actions: driving around, attaching/detaching from the plant, glowing different colors, and opening/closing its lid. When Growbot's lid is raised, it reveals a grow light bulb which can provide light to the plant if it does not have enough natural light. Growbot is unable to turn on the light on its own; rather, it depends on getting the child's attention and getting the child to turn the light on with the power switch. This communication between the plant, Growbot, and the child is facilitated via different light signals emitted by Growbot. Three options are available to communicate: blue (needs water), yellow (needs light), or green (plant is satisfied with care). The way Growbot implements these behaviors depends on the care provided by the child, as illustrated in the following scenarios.

Scenario 1: Attentive Child, Learned Caregiver
Ruth is a nine year old who has experience taking care of her younger sibling and their cat. She has not owned her own plant before, but knows they need water and sunlight, and checks on the plant regularly. Most of the time, Growbot does not need to do anything and stays dormant in the corner of her room. However, when she forgets to check

Growall
Growall's "flowers" are made from laser cut mylar, and the flowers are mounted on an acrylic sheet softly backlit by LEDs. By controlling how open each flower is, Growall can slowly "bloom" or "wilt" as the plant grows or withers.

Figure 3: Section of the Growall module

Figure 4: Future vision of Growbot accompanied by a train of plants

on the plant, Growbot helps remind her by moving over to her and glowing a blue or yellow light, respectively, for water or sunlight. When Ruth provides for the plant correctly, Growbot pulses green and moves back to its resting place.

Scenario 2: Forgetful Child, Inexperienced Caregiver
Bobby is a five year old who lives in an apartment that does not allow pets. His parents just got him his first plant, and want him to learn to take care of it on his own. Bobby does not know much about plants, but is learning. Every other day, Growbot goes over to the plant, attaches to it, and brings it over to Bobby while glowing blue for water. Bobby waters the plant, and Growbot glows green. That night, Growbot nudges Bobby while he is playing, glowing yellow. This reminds Bobby that the plant needs sunlight, and Bobby is relieved when Growbot lifts its lid to show the light inside. Bobby moves the plant over to Growbot and turns the light on.

In both of these scenarios, Growbot is dormant unless the plant needs care that the child is not providing. This is to help cultivate the relationship between the plant and the child, rather than between the child and the robot. Children who are attached to the robot, as well as the plant, are rewarded for their long term progress by Growall, rather than Growbot. In this way, there is still a robotic incentive to help the plant, rather than trying to be a poor caregiver to make Growbot more active.

Technology and Materials

Growbot was designed with a spherical shell that was 3D printed in a neutral white plastic, so it would be unobtrusive when not in use. The only divergence from this white exterior is the translucent plastic LED strip covering, which allows for communication. The planter has a similar 3D printed appearance (Figure 2). Growbot is powered by two motors and an Arduino, both of which are battery powered. A bluetooth shield allows for wireless communication, and a servo controls the lid-lifting mechanism. Growbot attaches to the planter with magnets, and disconnects by spinning, which shears the magnetic link. The lid is mounted on a four-bar linkage and lifts upward to reveal the grow light.

Future Work

In the future, Growbot's design will be expanded to include wireless communication directly to the plant (which currently requires a bluetooth app). Additional sensors will be added to help it navigate semi-autonomously, so that it can find the plant and the child in a room. In addition, Growall will be developed to include electronic control of the flowers and petals (which are currently manually operated) and this control will be wirelessly paired with a weight sensor on the plant, which gauges its growth over time. The Growall design will be made modular, so it can be adapted to different size spaces.

Conclusion

The Growbot and Growall system has the ability to increase caregiving opportunities for children who are not able to have pets, and provides an avenue for consistent caregiving opportunities as children grow up. Growbot and Growall have a low cost, open source design which could further allow them to be accessible to different populations. In addition, Growbot can operate without the Growall if necessary, and could be implemented in schools, offering young students exposure to both robotics and caregiving in the classroom. Further, once the Growbot module has been set up, it can be paired with multiple planters to allow children, families, or classrooms to create their own indoor garden, and learn about the needs of different types of plants. In this way, Growbot and Growall can be customized based on the child's interests, abilities, and motivational goals.

Figure 5: Growbot project logo

Figure 6: A child enjoys a cookie with her Growbot

Expected Demonstration Experience

Our demonstration will present the Growbot prototype, and will show the modes of interaction between the robot, plant, and participant. Interaction with conference participants will include Growbot magnetically connecting to a plant and bringing it to a participant, where it will light up blue, to indicate that the plant needs water. Upon the participant's successful response it will glow green, disconnect, and drive away. This interaction will be repeated with the plant needing sunlight, showcasing the lid mechanism and grow light. A video of our working prototype: https://www.youtube.com/watch?v=OZlwJtiouN4

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