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$15,000 Lemelson-MIT "Eat it!" Graduate Winner
Better Connections between Humans and Plants on Earth and in Space

SmartPot and AgQ: Improving Health by Creating Better Connections between Humans and Plants on Earth and in Space

The Challenge: Many scientists believe the next progression for the evolution of the human species is to move off of Earth and into the solar system. Eating is the most fundamental human function after breathing. It is vital to create sustainable nutritious food in order to meet the larger challenge of creating sustainable living solutions throughout the solar system.

Additionally, the current food options available to astronauts do not provide the enrichment and sensory input humans can get from food. In fact, a common issue for astronauts is that they do not eat enough and food options currently available for astronauts in space are not as appetizing as meals on Earth. When combined with the reduced appetite they experience from physiological changes due to a zero gravity environment, high workload leaving little time to eat, and a lack of variety and fresh food in their diets, these issues can lead to major health impacts.

The Solution: Producing robots that can garden in space. Heather has developed two primary inventions, which together can be used to grow fruits and vegetables in any environment. **SmartPot (SPOT)** is a smart growth chamber that can work semi-autonomously to grow food. It's small and compact, so it can easily be moved anywhere in a space habitat. The chamber itself is an enclosure that acts as a microclimate for the plant with everything from temperature, humidity, lighting and ventilation specifically controlled for the optimal conditions for the individual plant. The base of SPOT is a water reservoir which has all of the nutrients for the plants. The water is recycled in the chamber by pumping it up through the chamber, where it drips onto the plant's root zone and eventually flows back into the reservoir. On the outside of SPOT, a screen displays the health data of the plant to the astronaut caretakers. That data is simultaneously being sent back to a teleoperations center on Earth where an operator can monitor all the systems for the plant – helping to reduce the workload for astronauts. The second invention is **AgQ**, an A.I. platform for agriculture that uses plant health data from sensors in SPOT and wearable human physiological sensors to monitor, alert, diagnose and predict issues with both the plants and their human caretakers. AgQ employs a data processing pipeline and machine learning techniques to improve crop yields through early warning systems that educate its users about the health of their crop and provide suggestions for corrective actions when a problem is identified.

Photo courtesy of CU Media.

Heather also worked with the XHab team to develop the concept and prototype for a Remotely Operated Gardening Rover (ROGR), which was designed to work with SPOT and AgQ, moving via remote control about a spacecraft to care for and harvest the plants. ROGR can move SPOT from one surface to another with several cameras that allow it to drive and inspect plants to determine if the fruits or vegetables are ready for harvest. The teleoperator can use the arm to harvest the food and bring it to the preparation area on the spacecraft. Each SPOT has the ability to call for a care task, such as refilling the water reservoir to be performed either by ROGR or the astronaut caretaker, which receives alerts via a mobile app.

Together, these inventions can provide the necessary nutrients for astronauts' survival and will enhance the psychological well-being of the crew by providing familiarity and contact with nature in a hostile and unfamiliar environment such as Mars. The inventions also allow astronauts to be able to interact with the plants which may reduce their stress levels and improve their general well-being. With minimal additional workloads, astronauts have access to nature and fresh food with SPOT on board.

Application and Commercialization: The need for space habitats is a future growth area in the new space economy. However, the technologies needed to sustain life on other celestial bodies have current practical Earth applications for developed and developing communities. The current market has a distinct void between basic hobby grow systems (anywhere from $300 up to a few thousand dollars) and highly expensive research growth chambers and commercial control systems (starting at $25,000-$50,000 and ranging upwards of $100,000). Heather's SPOT and AgQ technologies fill the gap between these options.

Heather has also patented a geodesic dome structure that provides sustainable food production systems for use on Earth and in space exploration. This dome structure can be used for horticulture applications, in disaster relief and sustainable housing (with integrated food production options), among other applications. The technology from SPOT and AgQ can be scaled up for integration into this dome, making the commercialization of SPOT and AgQ more attainable on Earth.

Heather firmly believes that her inventions have current applications on Earth, including applications with small scale growers, educational instructors, horticulture therapists and researchers. Paired with the NASA and larger research applications; they will allow her to pursue robust opportunities within the academic and commercial arenas.

Heather and her team are planning to test SPOTs at a Mars analog habitat such as Antarctica or the Mars Desert Research Station (MDRS), both of which have similar environments to a Mars mission and the inhabitants live a similar life to those on a long duration space mission. To further refine these inventions, Heather and her team will receive data on how the crews in the analog habitat interact with the plants, what improvements are made to their stress levels and cognitive performance and generally how the living plants in their habitat improves their daily lives.