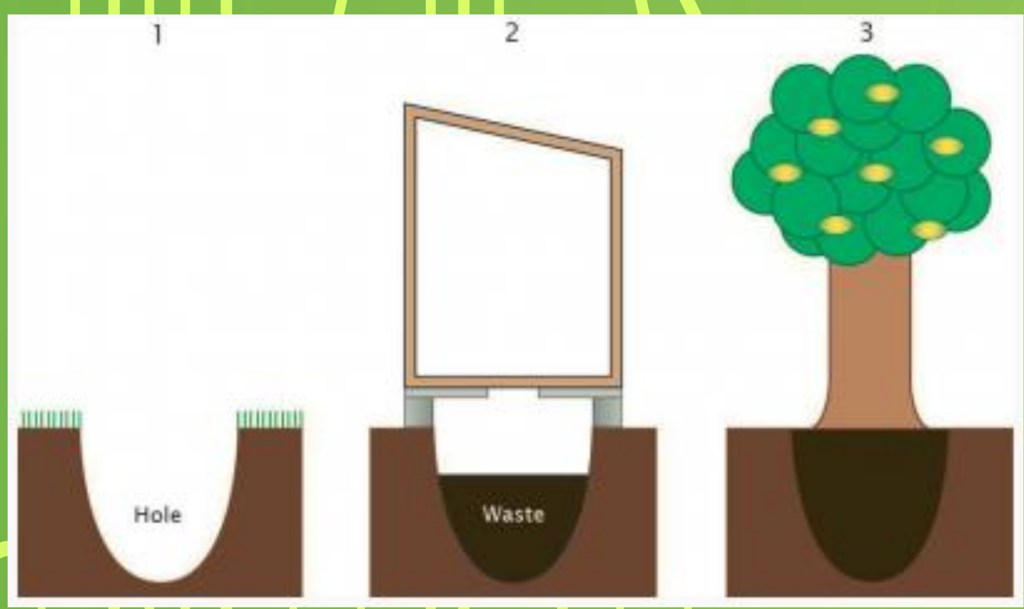
Toilet Use Sensor
Senior Design Project 16414



Arborloo Concept

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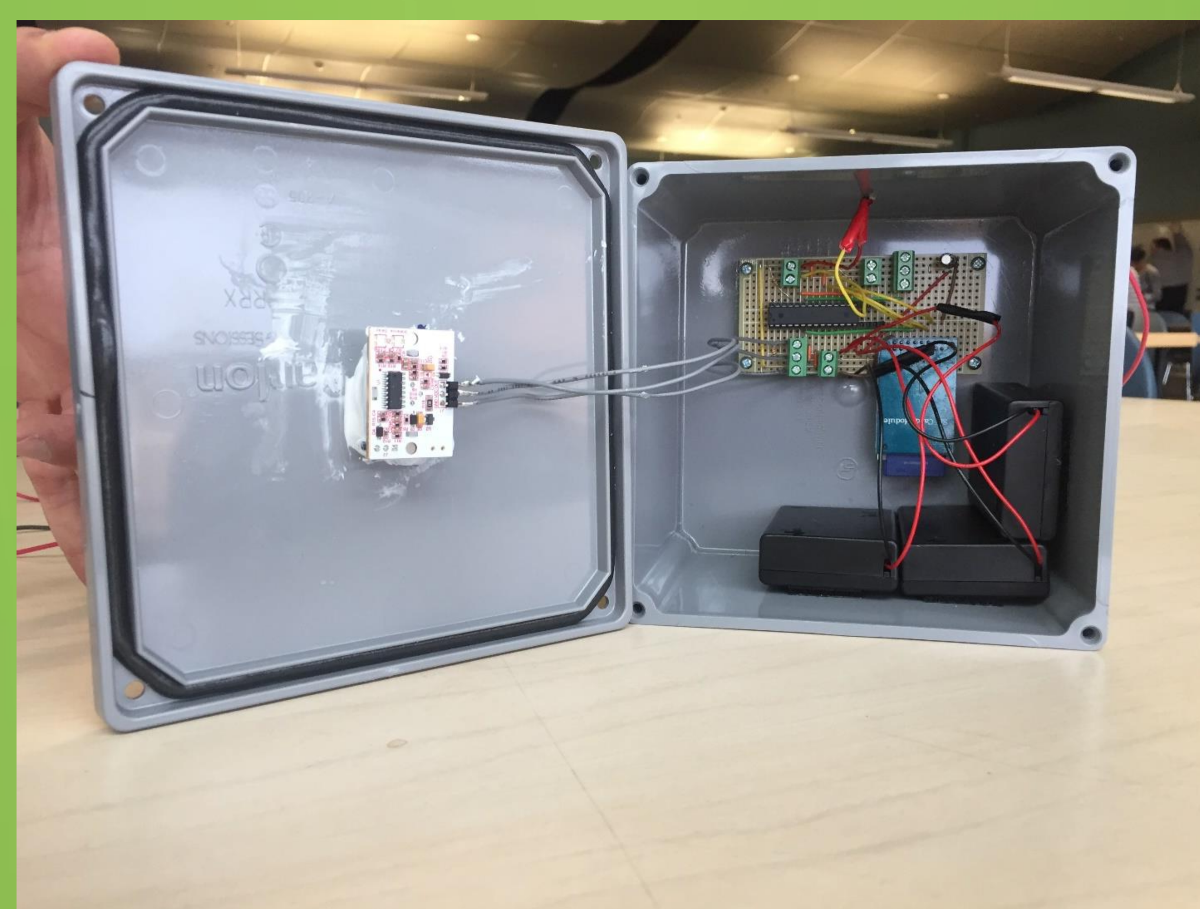
Faculty Guide: Edward Hanzlik

Simulate pit setup used to test the counting system

Project Summary

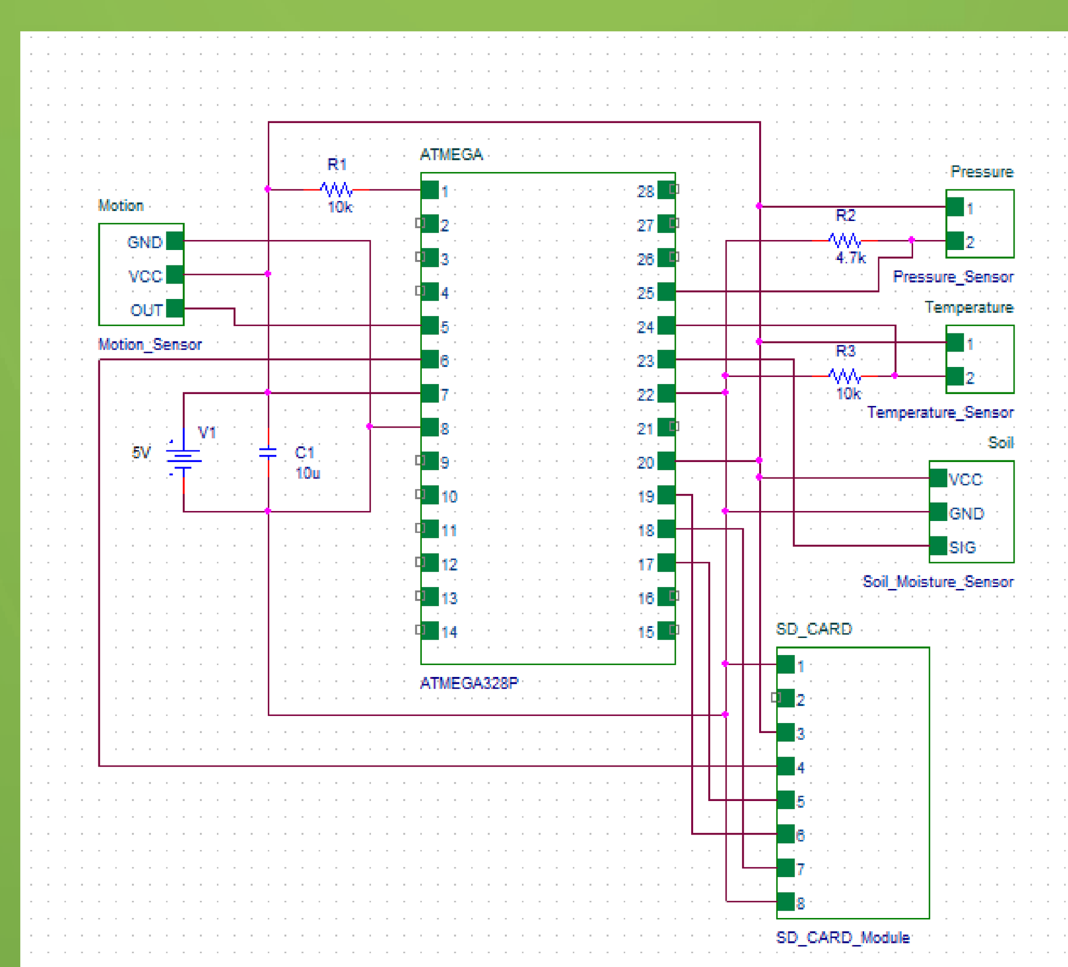
Every year, 760,000 children under the age of five die from diarrheal diseases around the world. An arborloo is a potential solution to this problem. It is a simple movable pit latrine that will compost human waste into nutrients for a fruit tree. An arborloo prototype has been designed and is ready for field testing, but there is currently no good way to count usage and measure the environmental conditions of the composting human waste. Our project is to create an sensor system that can do just that. We are using both a motion and pressure sensor to detect usage and a temperature, soil moisture, and pH sensor to measure the environmental conditions of the pit. Detecting the usage will show researchers if the Haitian families are using the system frequently. The environmental sensors will verify if the pit is composting correctly which will reduce pathogens in the soil.

Most modules will only contain the count system, referred to as low tech modules, while a select percentage will contain the environmental sensors, referred to as high tech modules.



Above: The interior of the box for the low tech module

Below: Electrical schematic for the high tech module showing the ATMega328 chip and the connections to the sensors and SD card module

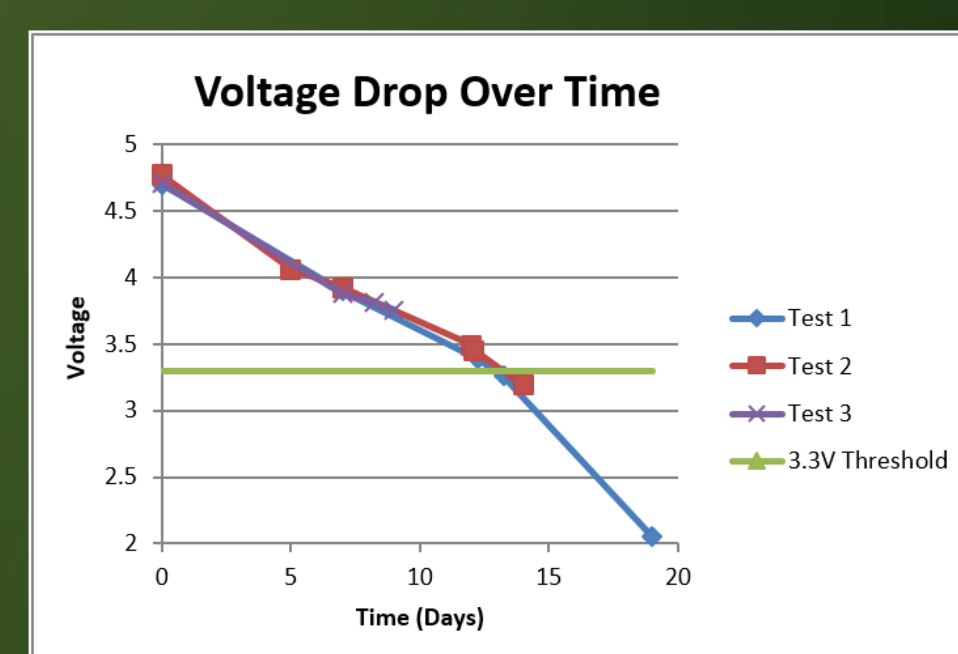


Critical Engineering Requirements

- System requires no grid electricity
- Detects use of system with >90% accuracy rate
- System can be used for 45 days without interruption
- Detects temperature within ±1°C, detecting up to 80°C
- Detects moisture within ±0.1%, detecting 0%-100% moisture
- Measures pH within ±0.1, reading values from 2-10

Battery Life

Battery life was one of the major difficulties of this project. Most microcontrollers will only run a few days off of a single battery pack. We needed a much longer battery life for our system. To lengthen the battery life of our system, we decided to use just an ATMega328 chip instead of the full Arduino microcontroller. An Arduino microcontroller constantly regulates the input voltage between 3.3V and 5V. This uses a lot of the power. With the ATMega328 chip, we can run the system at a constant 5V using 3 AA batteries in series. We then can add more 3 AA battery packs in parallel to extend the life of our system. After all of the adjustments were made, our system is able to run over 35 days using 3 sets of 3 AA batteries. Every month a field worker will change out the 9 batteries for new a new set. We hope that the battery life of the system can be further reduced in the future. Below is a graph of voltage drop over time for the battery life tests performed, including the 3.3V threshold of the sensors.



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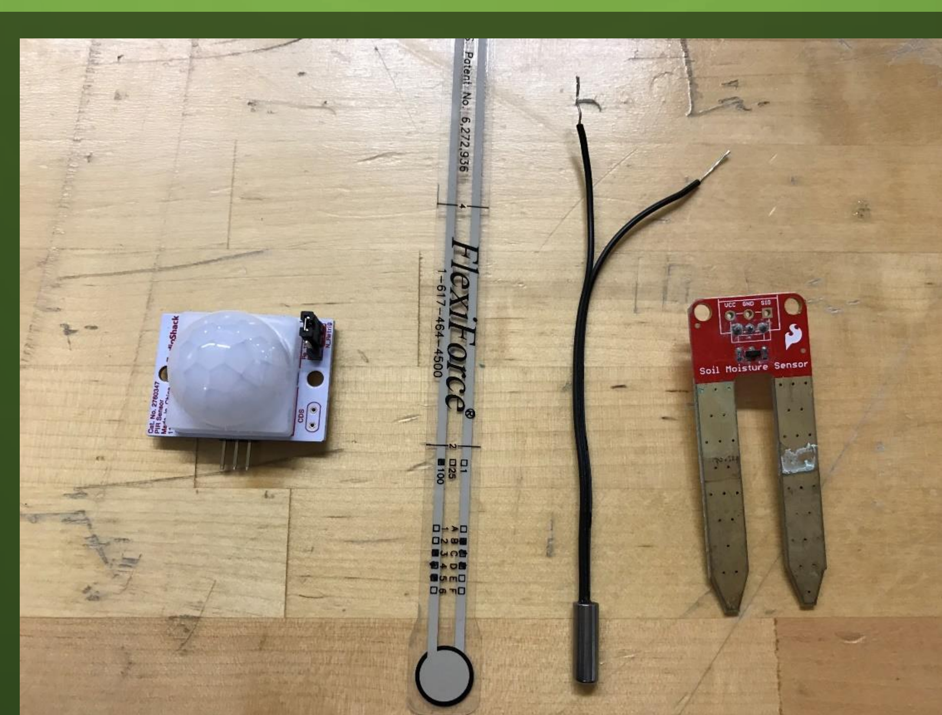
Item	Price ($)	Cost for Low Tech	Cost for High Tech	Total Cost
Arduino ATMega Chip	1	80	20	100
600 Pack AA Batteries	89.88	1168.44	269.64	1438.08
Battery Connectors	2	160	40	200
SD Card and Connector	7	560	140	700
Enclosure	12	960	240	1200
Motion Sensor	9.99	799.2	199.8	999
Pressure Sensor	19.95	1596	399	1995
Temperature Sensor	10	0	200	200
Sparkfun Moisture Sensor	4.7	0	94	94
pH Meter	12	0	144	144
Sample Retrieval Device	10	0	10	10
Cups with Lid	0.22	0	2.2	2.2
Conduit	1.92	0	38.4	38.4
Total		5323.64	1797.04	**7120.68**
Per Unit		66.5455	89.852	

Counting System

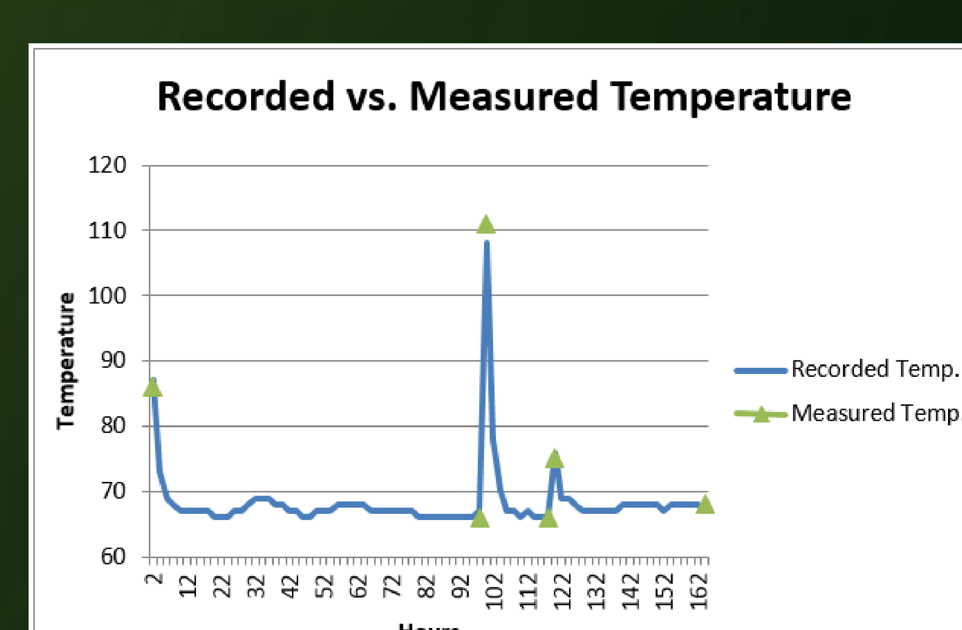
For our design, we decided to use both a motion sensor and a pressure sensor. The combination of these two sensors will allow for more accurate readings. The system will not register a count unless both the motion sensor and the pressure sensor are activated. The pressure sensor will be activated when someone sits on the Arborloo seat. The motion sensor will then also be activated when something is excreted into the Arborloo. Using both sensors together will eliminate false positives due to insects, rodents, rain, or the cleaning of the Arborloo.



From left to right: motion sensor, pressure sensor, temperature sensor, soil moisture sensor

Temperature Sensor

An accurate temperature sensor reading the temperature of the pit contents will indicate whether the contents are composting so that they may be used for nutrients for a tree, as well as giving some indication as to whether the pathogens will be deactivated. The worst error obtained from testing the sensor was a difference of 3°F, or 1.6°C, from the control. This narrowly misses the target ER of 1°C but is well within the marginal ER of 3°C. Below is a graph of the temperature readings when left in hot water with points indicating the control measurements, which were taken when possible.



Soil Moisture Sensor

A moisture sensor was desired to provide further information regarding the potential in activation of the pathogens that will be present in the human waste. The Sparkfun Soil Moisture Sensor was purchased and tested for this. It was placed in completely dry dirt and water, as well as being used in the summer feasibility test. The sensor read 0% and 100% for the first two, and gave a range from 69% to 85% for the latter. However, with any values other than 0% or 100%, there was no simple way found to confirm the moisture of the soil used. As such, the accuracy of the sensor remains unconfirmed.

pH Meter

In order to deactivate the pathogens in the pit and make it safe for plants the pH level needs to be determined. Knowing the pH value will enable the users to add cover material to the pit's contents if needed. Materials such as ash are known to increase the pH to alkaline levels and make it safe for plant life. It was determined after research that having a pH sensor that is part of the system that would be kept inside the pit would be too costly as pH sensors that are durable are expensive and mostly not even capable of being run without being calibrated before readings. Therefore the team recommended using a pH sensor that could be used by a field worker on samples that are to be retrieved from the pit. This will reduce the cost significantly as one sensor can be used for many pits. The Rapitest Digital pH sensor is mobile and has the capability to measure pH values in the range of 2.0 - 9.9. This range is satisfactory as the pit pH is expected to be between 5 and 7.

Future Recommendations

As a major concern of this project is the length of the time the system may be used without interruption, the team recommends looking further into methods of powering the system, including such methods as solar. Furthermore, the accuracy of the sensor used to measure the moisture in the pit should be known; a method to ascertain the measurements from the sensor should be found, or several moisture sensors tested against each other. Finally, the original customer requirements including an oxygen sensor for the pit contents, but that was found to be too costly and unfeasible. Looking further into such sensors, or whether something could provide similar information at less cost should be done

Acknowledgments

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