Using a microcontroller to control water delivery in a farm setting

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Introduction

Being able to control water flow in a farm setting is a huge necessity in farming. The goal of this project was to create an automated watering system using Arduino, the open-source coding software and microcontroller. The project was powered by using an Arduino uno, a type of microcontroller, and a circuit board which was used to connect and control various components. The microcontroller was fitted with a servo and thermal probe. The servo was used to actuate the handle on the ball valve depending on the time and temperature. The goal was then to have an automatically refilling watering bucket that can be moved anywhere on the farm. The applications of Arduino controlled valves are especially applicable to agriculture (Nu et al., 2019). Arduino is used as an economical alternative to lots of purchased automatic farming equipment, it is especially prevalent in developing countries where the resources to invest in expensive farming equipment is not available. In this specific case it is used for sheep watering, but it can easily be fitted for crop irrigation, or any type of water transfer. As well it creates portability in these systems, as tutorials can be easily shared and re-created.

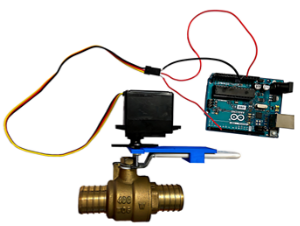
Materials and Methods

The microcontroller used was an Arduino Uno because of their compactness and easy accessibility to be prototyped. The power came from a 5-volt power supply in testing. If implemented on the farm a rechargeable 12-volt battery pack connected by male-to-male Molex connectors would be used. As well, a Hi-tec™ HS-785HB servo was used to actuate the valve. The water was supplied from the ground water pump located in Dr. Kinzinger's house, and a ¾ " ball valve with the servo was attached to this pump. A specialized servo horn was designed and printed to fit around the handle of the ball valve and to be press-fitted onto the typical Parallax servo horn (Figure 2). Press fitting was used because it relies on the normal force of the materials to hold them together, instead of external hardware, and that allowed the materials to be easily replaceable. The servo was wired to a breadboard that was wired to the microcontroller, along with the temperature probe (Figure 3). The temperature probe was set to have a true range of 34 degrees Fahrenheit and higher, and a false range of less than 34 degrees Fahrenheit. The true statement allows the main code to function while the false statement stops

Materials and Methods (continued)

the running of code. The main portion of the code was the commands for the servos. The servos turn from 0 to 90 degrees, with 0 being closed and 90 being completely open. When the servo goes from closed to open there is a 3-minute delay allowing the water to flow enough to fill the water bucket. Then the valves close for 8 hours until they start again. Lastly is the water bucket for the sheep. The bucket was a 5-gallon bucket, commonly found on farms for yard working, fitted with a waste valve bolted to the bottom. The waste valve handle was fitted with a rack and pinion, that had a servo attached to the gear of the rack and pinion (Figure 1). When the 8-hour cycle begins again the servo rotates the gear that pushes open the pinion attached to the waste valve. This allows all the water to drain from the bottom for 30 seconds, then the servo returns to the original position, closing the waste valve. Each item was bolted with 4-40 stainless steel bolts to prevent rusting that came with being in a farm setting. As well it is important to note the ball valve was not connected to a water source during testing, this would greatly increase the torque required to turn the handle and drastically alter the results of the testing.

Figure 1 (right): A render of the rack and pinion with the servo attached to the gear. The rack and pinion was connected to the waste valve to open and close the waste valve.



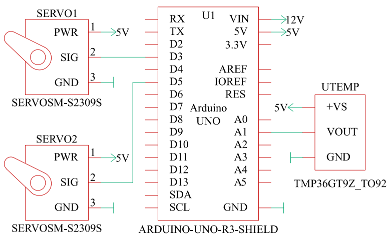
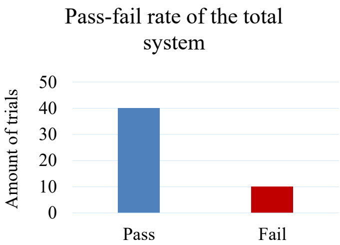


Figure 2 (above): A reference picture of the ball valve with the attached servo wired to the microcontroller. Note that the microcontroller is currently powered by the 5-volt source not the 12-volt battery.

Figure 3 (above): A schematic of the microcontroller connected to two servos and the temperature probe. The 12-volt battery supply was used in this schematic. An ideal schematic would include capacitors to regulate spikes in the current output.

Results

Out of the 50 trials ran 40 of them saw all components work correctly and reset correctly as shown in Graph 1 and Table 1 (below). The servo on the valve (Servo) would fail when it did not fully reset to 0 degrees, allowing water to flow through. The temperature probe (Temp) would struggle to identify borderline temperatures, for example at 33 degrees it would open the ball valve when that temperature is in the false range. Lastly, the rack and pinion (Rack) would jam and not fully open the waste valve on multiple trials. The rack and pinion had the highest fail rate at 20% and was the only component to cause a failed trial without another component failing.



Graph 1 (above): Pass-fail data for every combination of components over 50 trials.

Component	Number of failures
Rack	10
Servo	5
Temp	2

Table 1 (above): The table above shows that there were 17 times a component failed. Those failures overlapped to create 10 total failed trials.

Conclusions

The project was a success as a proof of concept. A total success rate of 80% shows there is still room for improvement. The continuance of this project would be refining the existing components to test above 98% success. Microcontrollers allows the user to add components easily and re-purpose the existing design. A continuation of this project would use a more powerful servo on the ball valve so that the system could work under the pressure created by water flowing through it, as well as an investigation into the failures of certain components to improve future performance of the system.

Reference

Nu, Y. Y., Lwin, S. S., & Maw, W. W. (2019a). Automatic plant watering system using Arduino Uno for University Park. *International Journal of Trend in Scientific Research and Development, 3*(4), 902–906. https://doi.org/10.31142/ijtsrd23714