ENSC E-123. HW 10: Project Ideas

REV 0; April 23, 2020.

Total points: 16. Due Thursday, April 30, 2020

Contents

1 Your Project Idea

For this week's HW we would like you to propose an idea for a (small) project using the 8051. We'd like you describe in some detail how your project would work, what technical challenges you will need to solve to complete it. We would also like you to propose a brief project plan with some intermediate steps and milestones. Projects shouldn't be massive undertakings – we tend to encourage students to aim for something they think they can do in the equivalent of 1-2 labs.

We want this to be *fun* so we hope this serves as an opportunity to do something interesting with what you've learned!

Mushroom Farming & Photography

Project Background

Mushrooms are cool. They comprise their own biological kingdom, apart from plants and animals. Wow. They require little light to grow, and they're gaining popularity in consumer markets,[1] so lots of farmers are starting to produce and make money from them.[2] The psychedelic kinds of fungi can elicit mystical experiences that have been shown to change people's lives in positive ways. For instance they can help people quit smoking[3] and reduce anxiety.[4] These experiences can have negative impacts as well of course.[5] That can all be discussed in a different class though. Mushrooms are also beautiful and just fun to grow from an aesthetic standpoint.

Growing your own mushrooms is tricky. They require a special kind of environment in order to be properly grown, kind of like plants do. Or dogs. Or most any living organism. Whereas plants need light, water, and nutrient-rich soil to grow, mushrooms thrive in an environment low in CO_2 and high in humidity. I am currently designing a chamber system that simulates this kind of environment. It's been going well so far, but I have found that without a mechanism for exhausting CO_2, the mushrooms tend to suffocate in their own respired carbon. CO_2 is heavier than air, so some way of exhausting CO_2 out of the bottom of the chamber—where the mushrooms are supposed to be growing—turns out to be pretty important. Here is a time lapse I shot showing what it looks like when you don't exhaust that CO_2 properly. Bummer!

Speaking of time lapses, I like shooting time lapses of the things I grow. I find it to be aesthetically compelling and kind of psychedelic in its own right. I've also combined this with my mechanical engineering hobby to produce camera rail actuators, so that I can produce more cinematic time lapses that have elements of motion. I've mostly focused on the mechanical side of these projects, building the hardware, and otherwise have built some

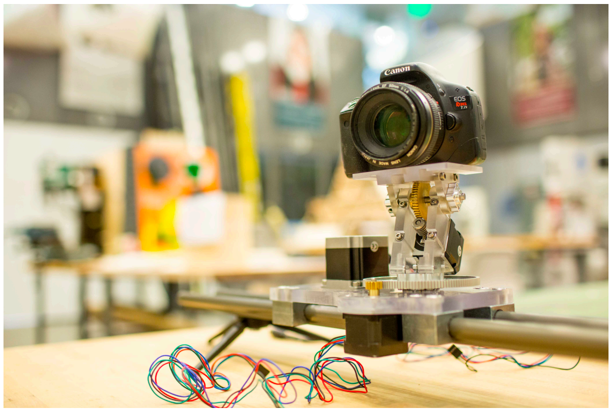
[1] Cartter, Eileen. "Why Not Grow Mushrooms During the Apocalypse?" Garage, 5 Apr. 2020, garage.vice.com/en_us/article/akwxvp/why-not-grow-mushrooms-during-the-apocalypse.

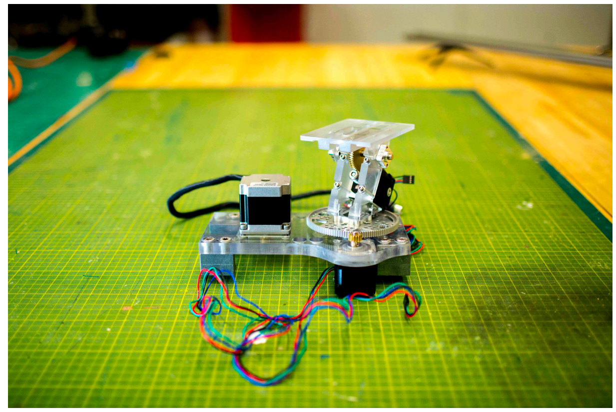
[2] Davis, Eric. "Retail Data Shows Significant Increase in Mushroom Sales." FreshPlaza, 13 Apr. 2020, www.freshplaza.com/article/9207707/retail-data-shows-significant-increase-in-mushroom-sales/.

[3] Johnson, Matthew W, et al. "Pilot Study of the 5-HT2AR Agonist Psilocybin in the Treatment of Tobacco Addiction." Journal of Psychopharmacology, vol. 28, no. 11, 2014, pp. 983–992., doi:10.1177/0269881114548296.

[4] Grob, Charles S. "Psilocybin Treatment in Advanced-Stage Cancer Patients With Anxiety." PsycEXTRA Dataset, 2010, doi: 10.1037/e609412010-001.

[5] Johnson, Matthew W., et al. "The Abuse Potential of Medical Psilocybin According to the 8 Factors of the Controlled Substances Act." Neuropharmacology, vol. 142, 2018, pp. 143–166., doi:10.1016/j.neuropharm.2018.05.012.





rudimentary controllers with Javascript to actuate the camera and motor. My main impetus for taking this course was to become more literate and capable on the electronics side of this hobby, e.g. controlling their stepper motors and firing the camera shutter.

Project Description

CO_2 Mushroom Control

I'd like to use the 8051 to solve the CO_2 mushroom chamber problem. This will involve connecting a CO_2 sensor and an exhaust fan to the 8051, and writing a program so they speak to one another. If the CO_2 concentration gets too high inside of the chamber, the fan will fire on and exhaust it, preventing mushroom mortality!

Data Logging

But how do I know what the optimal CO_2 environment is? One way would be to run some tests in the chamber with different set points and see which turns out the best mushrooms. I don't plan to do that in the timeframe of the course, but hypothetically speaking. For that I would need to log data. Here I'll try to store readings from the CO_2 sensor onto the 8051's internal memory, and then see if I read it out somehow. This would be a bonus step for my project. Really I'd like to focus on the CO_2 loop and a time lapse, and everything after that is bonus for the summer with my new Physics 123 skills [karate chops cinder block in half].

Other Loops

I mentioned humidity is important for growing mushrooms, too. If I can control the CO_2 sensor-actuator loop, why not try the same for humidity? For this I'll see if I can get these two to shake hands and produce some optimal high-humidity environment inside of the chamber. Again I consider this to be a bonus step for the timeframe of the project, but I do intend to pursue it later this summer on my own.

Photograph Across Time & Space

Considering I have previously been running my camera time lapse systems off of the Arduino microcontroller platform, no reason why not to try to adapt one of them to the 8051. From here I will try to shoot a time lapse of one of my mushrooms growing in its new low-CO_2 environment.[6]

Future

I intend for this project to continue into my summer. It combines a lot of my current hobbies like mycology, photography, and engineering. This project will live on and continue to be worked on after our course ends.

Bill of Materials

Here are the components I have specified so far for the project.

Part	Vendor Part Number	Manufacturer's Part Number	Source	Vendor
CO2 MODULE 2000PPM DIFFUSION	235-1373-ND	T6713	link	Digikey
SENSOR HUMI/TEMP 3V I2C 1.8% SMD	1649-1008-1-ND	SHT25	link	Digikey
FAN AXIAL 40X10MM 12VDC WIRE	603-1724-ND	ASB0412VHA-AF00	link	Digikey
FAN BLOWER 30X10MM 12VDC WIRE	603-1839-ND	BFB0312HA-A116	link	Digikey
YEMIUGO 2PCS 20mm Ultrasonic Mist Maker Transducer	B081T25VW1	B081T25VW1	link	Amazon

[6] Note that I have taken a good amount of time lapses with living organisms like plants, and there is a high rate of failure. Camera batteries die, memory cards fill up, tripods get bumped, mushrooms die, or just don't grow. I'll just see what I can do with a prototype of this. Still I would love to submit a time lapse as one of my main deliverables for my project.

Process & Challenges

Here are the steps I intend take to execute this project.

Step	Description
Sensor-Actuator Handshaking	
Spec a CO2 sensor	Specify a CO2 sensor that will interface well with the 8051. Something that uses UART or I2C, and is low power is ideal.
Spec a fan	Specify a low power miniature blower fan to act as an actuator to respond to the sensor, i.e. exhaust the chamber when it reaches a particular CO2 concentration.
Power up the sensor	Simply unpackage the sensor, power it, and see if it "lights up."
Read the sensor	Connect the sensor to the 8051 and write a program to get it to show some data in the console. Start with UART and try I2C if ambitious, per Oliver's recommendation. Troubleshoot this with the lab book section on communication protocols. If stuck, just get to know the sensor first through Arduino. Once the communication protocol is validated, then take it over to the 8051 and some Assembly language. Also per Oliver's recommendation, use the handy Application Note for the sensor if it has helpful walkthroughs.
Move the sensor's value with assembly code	Write a proof of concept program that just grabs the sensor's value in some fashion, e.g. just move the value into a spare register. Figure whatever weird things out here, like does the value need to be multiplied or scaled in some way as it comes off of the sensor?
Turn the fan on	Open the fan out of the box and get it to power up with a power supply. Oliver also advised some miscellaneous hardware and schematic that will include a diode and MOSFET. Connect these up on the breadboard and get the fan working.
Turn the fan on with Assembly code, pushbutton	Write some Assembly code that assigns the fan to a hardware interrupt pin and get it to turn on with a push button.
Turn the fan on with Assembly code, timer	Write some Assembly code that assigns the fan to one of those internal "C-out" pins and code it to turn on, say, every five seconds.
Link the fan and the sensor	Now combine the sensor and actuator through the 8051! Write some code that links the sensor with the fan. Tell the fan to turn on if the sensor is reading anything above ambient CO2, then exhale onto the sensor to spike it and test the fan's actuation.
Data logging	
Store a reading internally	Write a program that grabs a sensor value and stores into the 8051's internal memory.
Store a reading at an interval, internally	Do the same thing, storing a CO2 value in memory, but do it at a regular interval of time. Practice some tricks from lecture 09 like using the @ symbol for setting the storage location in the loop, and DJNZ to prevent going beyond the memory's capacity.
Timestamp the data, internally	Along with telling the 8051 to capture a reading from the sensor, instruct the 8051 to also capture some timestamp or any other metadata available like day of year, and see if it can be associated with the the sensor reading for later parsing.

Step	Description
Store data onto external memory	Buy some external memory, link it to the 8051, and do the same data storage exercise but this time moving the data into external memory.
Parse and read the data	Take the new, raw dataset and see if it can be extracted into something like a CSV file, or at least get it off of the 8051 in a way where something can be done with it.
Visualize the data	Take the new raw data file and simply plot it as a visualization, e.g. concentration over time.
A Second Sensor-Actuator Loop	
Repeat these steps for another sensor actuator loop	I have also acquired a humidity sensor and a piezoelectric water ionizer, for producing humidity. I would like to repeat the above steps for this other sensor-actuator pair.
Build an Intervalometer	
Trigger a DSLR camera with the 8051, pushbutton	Split open a DSLR remote shutter cable. Combine it with the Bitflip lab exercise and actuate the camera shutter with the pushbutton.
Trigger a DSLR camera with the 8051, timer	Connect the DSLR remote shutter cable to one of the 8051's timer interrupts and write some code that fires the camera off at a set time interval. Use one of those handy timer-based interrupt pins that we explored at the end of Lecture 09, and a corresponding lab if necessary.
Move a Stepper Motor	
Spec a stepper motor and driver	Specify a stepper motor and stepper motor driver that can be used with the 8051. Scott has made an excellent tutorial for this so I will follow that.
Trigger a stepper motor with the 8051, pushbutton	Connect the motor and driver to the board according to the tutorial and get it to move according to a button push.
Trigger a DSLR camera with the 8051, timer	Do the same thing as above but trigger the motor according to a timer. Use one of those handy timer-based interrupt pins that we explored at the end of Lecture 09, and a corresponding lab if necessary.
Link the motor to a camera rail	I have built several camera rail mechanisms with stepper motors, so the mechanical part of this "connection" step is complete. However here I will still need to run some conversions and create variables in my code that translate arbitrary steps into "rotations."
Create Motion-Based Intervalometer	
Link the motor and the camera	Merge the intervalometer program with the stepper motor program such that it produces a "step, shoot, step" sequence.
Program a sequence for a photo shoot	Modify the time and turn variables in the program according to time lapse I would like to capture. For instance, if I would like to shoot a mushroom growing for one day while turning on a table, write a program that shoots and steps the camera once every three minutes.
Stage the time lapse	Setup is the most important part of a time lapse in my experience. All potential points of failure must be accounted for in the setup. Here I will establish memory storage to the SD card, tripod positioning and anchoring, lighting, light leakage from the external environment, battery power to the camera, and other items.
Shoot the time lapse	Shoot a time lapse of a mushroom spawning from mycelium with the camera rotating around it over the course of one day.
Post-process	Offload the images and post-process into a final video.