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MICROGREENS...?

The Good:

+ Low overhead costs

- + Seeds, water, light, soil/grow medium, 1020 trays
- + Fast growing
 - H <u>1-2 weeks</u> from seed to harvest
- + Incredibly healthy!
 - + <u>4-40</u> times the nutrition of adult version (depending on species)
- + Rapidly growing market

The Bad:

- EXPENSIVE!
 - Up to <u>\$80/lb.</u> or more
- Very labor-intensive
 - 5-6 hours per 1020 tray
- Very detail-oriented
 - Humidity, temperature, water, air flow, soil quality, etc.
- Marketability requires consistency!

USE CASES

Reduce labor costs
 Reduce seeding time



- $\circ~$ Entirely remove need to care for crops while growing
- Simplify complex cultivation details
 - Automatically optimise growth conditions to specific plant climate preferences
- Maintain rigorous food safety standards
 - Comply with all recommendations and guidelines in the FDA FSMA Produce Safety Rule (80 FR 74353)

Project Area Coverage: Hardware, Software, Signals

REQUIREMENTS: FEATURES

- Grow at least one "1020" tray of microgreens per cycle
 Dimensions of internal chamber are able to fit a <u>10" x 20" x 2"</u> bin with enough head room for plants to grow and tool equipment
- Automatically seed new trays
 - \circ Capable of accurately dispensing <u>1-2 oz.</u> of seeds
- Maintain optimal growing conditions over the course of a grow cycle
 - Judged as a <u>yield ratio</u> (seed weight:harvest weight)
 - Compared to manually grown control via wage equation (next slide)
- WiFi connection to a custom website interface
 - Latency <1s



REQUIREMENTS: LABOR COSTS

- Target sale price will depend on plant
 - Roughly \$35/lb target sale price
- Compared against manually grown controls
 - \circ $\,$ Control set at same sale price regardless $\,$
- Wage equation will quantify benefits of automation

UNIT PRICE RETAIL PRICE							
S70,84 PER PODNO Arming Turtles Inc DRGANIC BLOOD BEET MICROGREENS		MVP	Target	Target+			
	Hourly Wage	\$7.25/hr. (minimum wage)	\$14/hr. (<u>average hourly farm</u> <u>wage in USA</u>)	\$37/hr. (<u>average USA</u> <u>farmer salary</u>)			

TECHNICAL CHALLENGES

- Coordinating massive number of inputs and outputs
 - Multiple sensor inputs and actuator outputs of varying types need to be made sense of
 - \circ $\,$ Custom circuitry to handle various specifications $\,$
- Environmental safety of electronics (integrity)
- Plant unpredictability
 - MiGroBox is supposed to run unattended what if something goes...grows...wrong?
- Maintaining cleanliness
 - Could create significant additional maintenance labor
 - \circ $\,$ Design must minimise dirt collection and be easy to clean $\,$
- Increasing efficiency to the point where it's worth owning and using a device to farm microgreens
 To what degree do you have to build it for them to come?

SOLUTION APPROACH: HARDWARE

- Create <u>custom main board</u> to house stepper motor drivers, peripheral electronics, and central microcontroller
- Central microcontroller: <u>ESP32</u>
- <u>I2C</u> communication between slave
 <u>ATtiny85</u> nodes
- <u>UV LED</u> and <u>RGB LED</u> grow light strips
- 2 axis CNC using <u>Nema 17</u> stepper motors
- Frame made from <u>80/20</u> aluminum extrusion





SOLUTION APPROACH: SOFTWARE



- ESP32 running <u>RTOS</u> with <u>ported GRBL</u>
 - Likely <u>FreeRTOS</u> but still undecided
 - Programs over top either written in <u>C or CircuitPython</u>
- Website interface built in <u>Django</u>
 - Simple GET and POST HTTP requests
 - Read sensor data and control machine manually for testing
 - Set device to automatic grow mode for final product
 - Store and display information about crops

TESTING, VERIFICATION & METRICS

- Constantly growing microgreens each week
- Compare automated microgreens quality vs. manually grown
 - \circ Yield ratio
 - Shelf life
 - Flavor
 - Color







TESTING, VERIFICATION & METRICS

 $\frac{(Sale Price)(Yield) - (Seed Price)(Seed Weight) - (Other Overhead Costs)}{(Labor Hours)} = Hourly Wage$

- Wage is the core metric driving the project
 - Central goal is to increase value of time spent growing microgreens by reducing hours
- Sale price set to be equal to manually grown control group
 - \circ $\,$ We will attempt to package and sell locally $\,$
 - Price will potentially shift to reflect quality

TASK DIVISION

Greg:

- Website backend
- Website front end
- MiGroBox grow routine software
- Embedded software
- Manual microgreens cultivation

 Access to on-campus facilities

Lucas:

• Hardware design and

implementation
(mechanical and

physical)

- Embedded software
- Microgreens research
- MiGroBox live testing vs. manually grown microgreens



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SCHEDULE

- Core hardware will take a lot of work
- Limited by remote location
- Tight schedule but ample slack time built into tasks