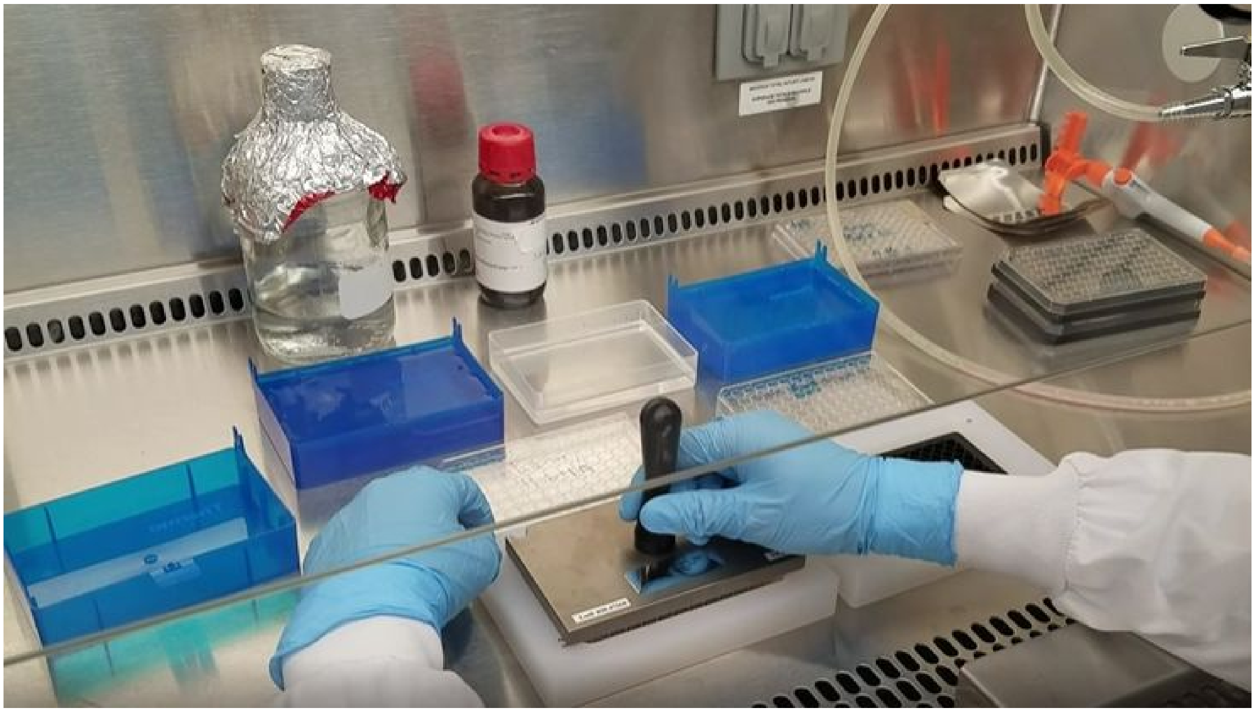
Senior Design 1 Initial Project Design
January 29th, 2020

Pin Transfer Robot for Chemical Screening



Department of Electrical Engineering and Computer Science
University of Central Florida
Dr. Samuel Richie

Group H

Christopher Clifford	Electrical Engineering
Brenden Morton	Computer Engineering
Dominic Simon	Computer Engineering
Yousef Abdelsalam	Computer Engineering

Project Narrative

As an engineering student working in a regenerative medicine laboratory for the past two summers, I thought of many ways to optimize experiments by inventing tools that could automate or assist with parts of the experimental process. Much of my research involved testing an assortment of small molecules and growth factors on differentiating stem cells to determine their influence on the cell's protein expression. This process was normally done by me manually and it is very tedious and any small error or inconsistency can have massive influence on the outcome and repeatability of my experiment. For this reason, I became interested in creating a robot that could carry out the chemical screening process for me so that there would be drastically less inconsistencies and time in my experiments. There are currently robots that do what I am describing but they cost anywhere from tens of thousands to millions of dollars. Some labs are completely dedicated to screening chemicals for toxicity and safety, or to find potential anti-cancer drugs. My goal with this project is to create a small robot that could be used by biology labs whose primary focus is not chemical screening and comprises a small part of what the lab does. The benefit of this is it would increase possibilities for experiments in these labs while not having a monetary barrier to entry. I myself would use a robot like this to conduct my experiments in the future and I can say personally that it would greatly increase my productivity. With this robot I could expect orders of magnitude more discoveries based on the quantity of experiments I could conduct.

Some alternatives to our project in the marketplace currently include full scale lab implementation, liquid handling robot adapted to handle pin transfer, and manual pin transfer. Full scale lab implementation takes up an entire building with incubation chambers, imagers and robotics. The entire chemical treatment, cell culture, and imaging process is automated. For reference I have included two videos of a full scale lab implementation here: Environmental Protection Agency Broad Institute. The first real possibility for a smaller lab that wants to get started in chemical screening would be purchasing an adaptor for a liquid handling robot. Liquid handling robots are used to dispense and sample liquids from wells or microplates. Some companies such as V&P scientific sell adaptors that can be mounted to the head of liquid handling robots so that a pin transfer tool can be fitted to the robot. This effectively creates a pin transfer robot with some major drawbacks. The biggest problem is that liquid handling robots are designed to only handle one plate at a time so if you would like to treat duplicate plates or many different cell plates you would need to manually move the plates in and out of the workspace after each program execution. Ideally our project will handle the plate management by placing the plate in and out of the work space. This would strongly differentiate our project from available options on the market today.

Design Considerations

In the field, smaller research labs tend to have to use some form of pipetting/pin-transferring tool that needs to be properly handled and operated. As stated before, not only can this process be tedious, but it also entails room for human error and cross-contamination. In order to alleviate this, we will implement a pin transfer tool that will be mounted onto a robot in such a way so as to automate the pin transfer operation. There would also be a drying fan that would be activated after the pin transfer operation has been completed. There must also be a mechanism for aligning the pin transfer head with the 96 well plate, which must involve the head moving up and down for the pin transfer motion at least. Ideally, there would also be a mechanism for moving the plates into position from an existing stack or repository of plates.

There are many possible implementations from there. One way to implement a head that moves in such a fashion would be to use a sixaxis robotic arm of some kind to take plates from a particular reservoir, perform the pin transfer, and then move them to a stack of some kind. However, this is an industrial-sized solution that is quite costly and would perform the stacking process one at a time as opposed to doing it in bulk. The main advantage to this approach would be the range of motion that it provides within the lab.

Another possible implementation would be to have a robot that can take well plates that are arranged in some kind of queue that would be moved through a conveyor belt. From there, the pin transfer operation would simply involve moving the well plate underneath the head for pin transfer.

Lastly, there is the possibility of using a gantry robot that can move anywhere within the XYZ coordinate plane provided for it in order to perform the pin transfer operation on well plates that are provided within a grid-like area.

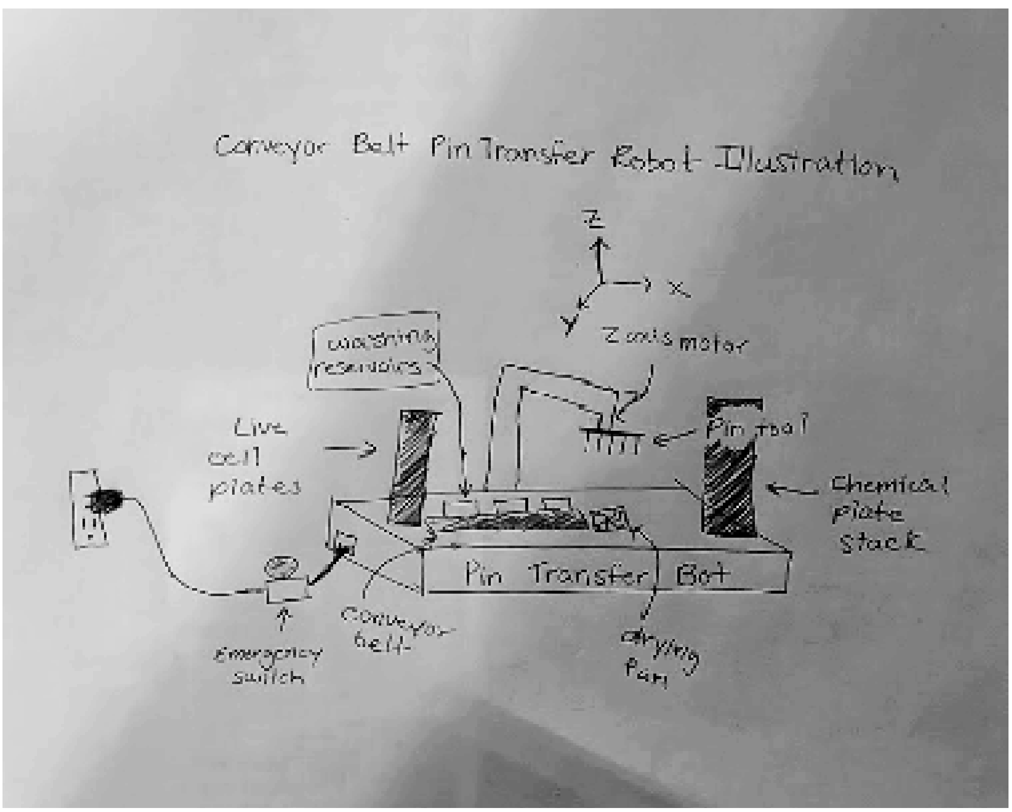
Some nice-to-have ideas that could be implemented would be some kind of barcode scanner that can read information about the time in which the pin transfer operation was implemented along with the cells and chemicals that were used to be read into a database.

All of the implementations described above would ideally have to have some kind of sanitization method as well. This can be achieved by combining a cleaning chemical solution of some kind of drying mechanism. A pin transfer machine that was used at the Harvard Medical School used compressed air for their drying mechanism to great success, drying the pin transfer tool within 10 seconds and thus achieving an overall pin transfer throughput of one 384-well plate per minute. Other possible implementations include a form of suction or a drying fan. All in all, this part should be fast enough and good enough to be able to handle as many plates as a small research lab can handle without leaving any well plates to go bad. It should also either have a reasonable throughput by either being fast enough if it's operating only through the day or it should at least have enough time to operate on all of the necessary well plates by operating within the night(preferably both).

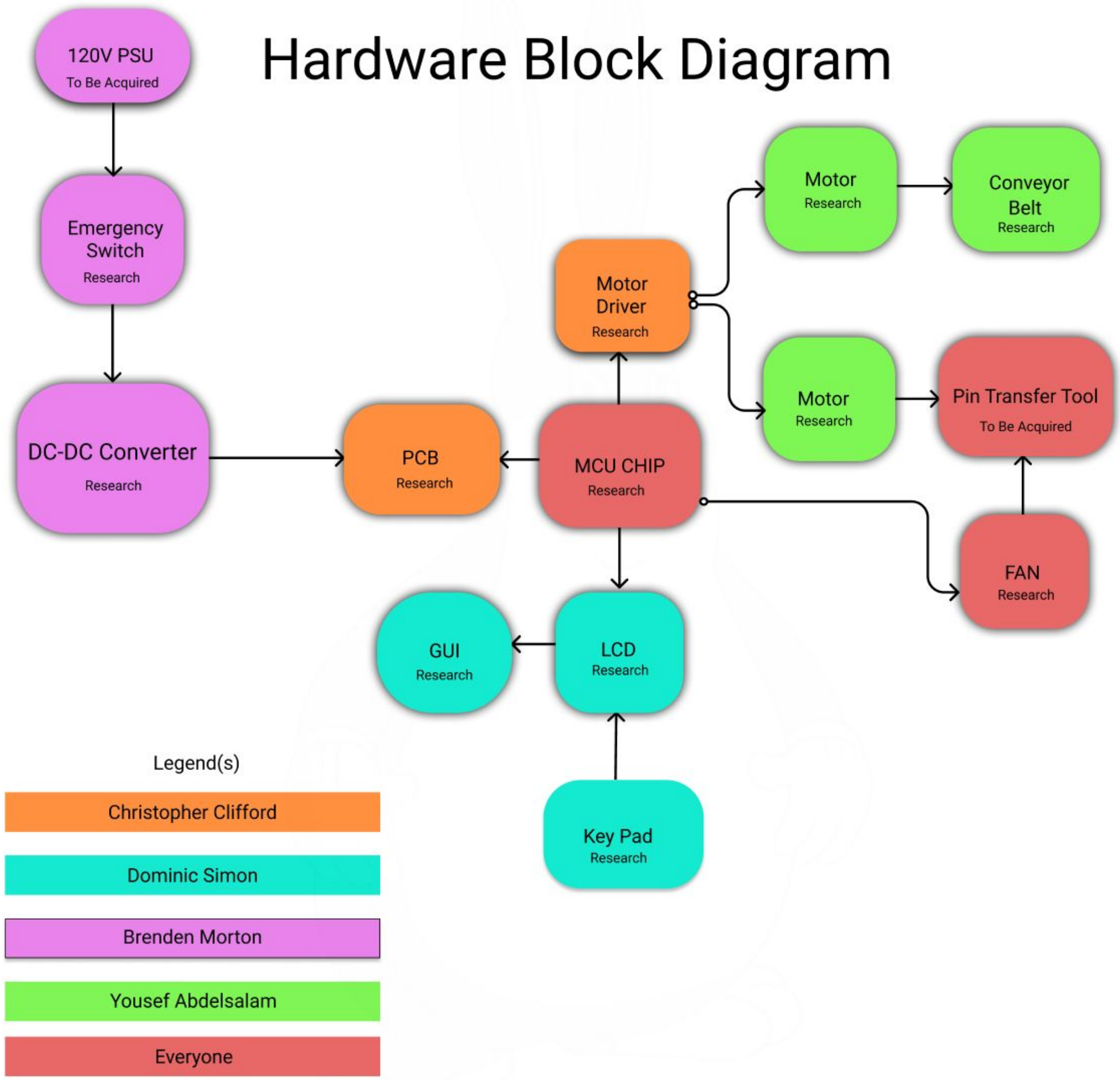
Requirements and Specifications

- GUI supported by an LED screen
  - Asks for Number of Well Plates
  - Allows user to tell how deep to put the pins in the solution
  - Allows user to tell how long to leave the pins in the solution
  - Alerts User When Completed
- 120V PSU
- Standard Pin Transfer Tool
- Able to handle a maximum of (16) Perkin Elmer 96 well plates (could be extended to include 384 well plates) at a time.
- At most 48 inches in width and 18inches in length
- 200 ml refillable solution reservoir
- Embedded fan for drying the well plates
- Able to be sterilized using 70% ethanol to be in a biosafety cabinet.
- Robot should be plug and play. Configure number of plates and washing steps and then the cycle can begin without interaction with a lab technician until completion of the task.

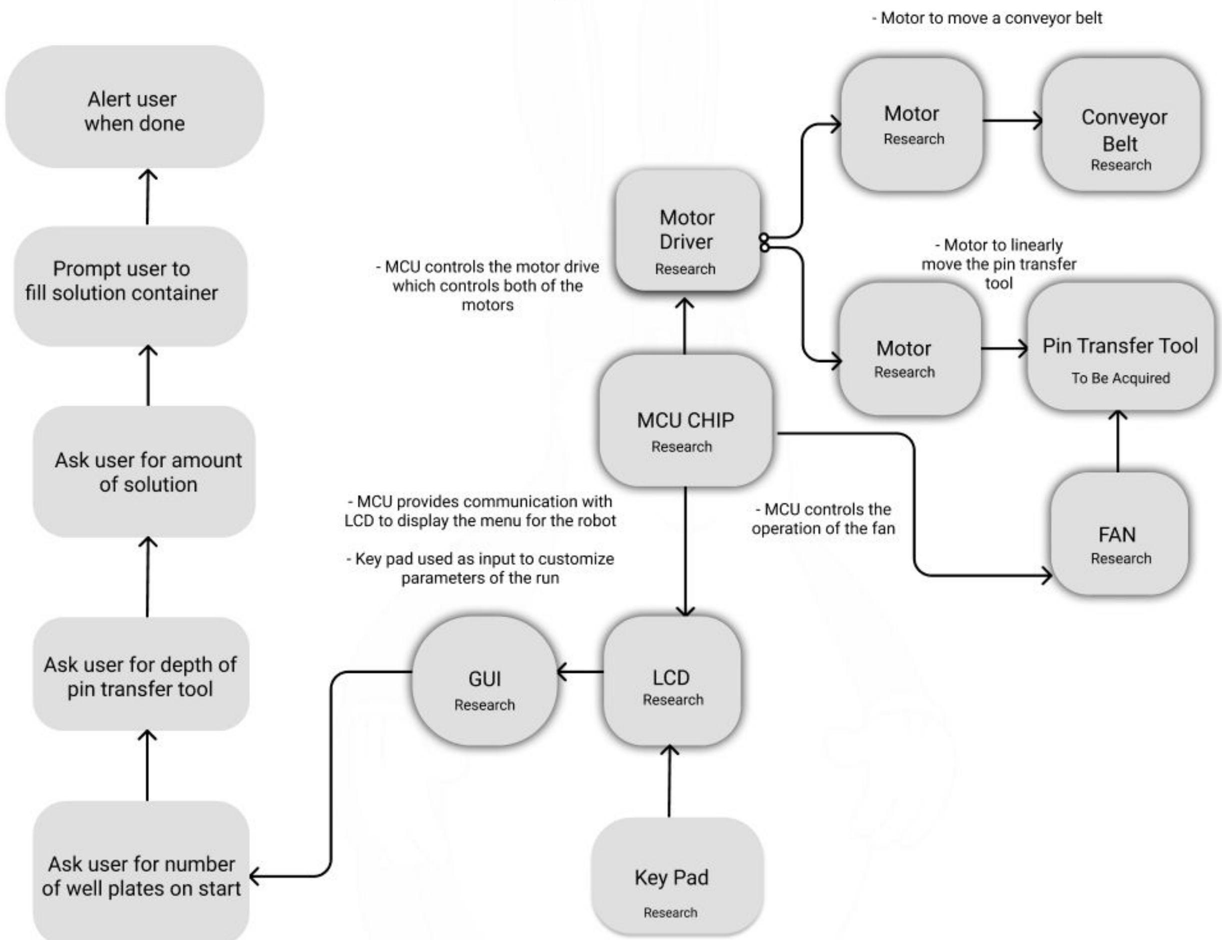
Illustration



Block Diagrams



Software Block Diagram



Estimated Budgeting and Finance

Though it is anticipated that there would be a number of moving parts to this project that would be decided on at later stages of the design phase of SD1, one can expect that

Part Number	Description	Quantity	Unit Cost	Total Cost
xxx-xxxx	Pin Transfer tool	1	In research of part	In research of part
xxx-xxxx	MCU	1	In research of part	In research of part
xxx-xxxx	Conveyor Belts	1	In research of part	In research of part
xxx-xxxx	Fan	1	In research of part	In research of part
xxx-xxxx	Power Supply Unit	1	In research of part	In research of part
xxx-xxxx	DC-DC Converter	1	In research of part	In research of part
xxx-xxxx	PCB	5	In research of part	In research of part
xxx-xxxx	Power Switch	1	In research of part	In research of part
xxx-xxxx	Motor Driver	1	In research of part	In research of part
xxx-xxxx	Motor	2	In research of part	In research of part
xxx-xxxx	LCD (16x4)	1	In research of part	In research of part
xxx-xxxx	Key pad	1	In research of part	In research of part

Number of Team Members	4
Sponsor Contribution	Unknown
Total Cost of Project	To be determined
Contribution per team member	To be determined

Decision Matrix

Ideas/ Nice-to-haves	Difficulty(higher is easier)	Time (higher is less time)	Space (higher is less space)	Quality	Practicality	Cost (higher is cheaper)	Totals
3 Axis Gantry Robot	6.0	6.5	6.0	8.5	7.5	6.0	40.5
Single axis Conveyor belt Robot	7.5	7.5	6.5	8.5	6.5	7.0	43.5
Refrigerator Component	5.0	5.0	3.5	8.0	4.0	4.0	29.5
Barcode Reader	9.0	8.0	8.0	5.0	7.0	9.5	46.5
Requiring stack to take from	3.0	3.0	8.0	9.0	9.0	6.0	38.0
Requiring stack to put on	3.0	3.0	8.0	9.0	9.0	6.0	38.0
Cleaning solution quantity detector	9.0	7.5	7.0	2.0	4.5	8.0	38.0

Milestone Timeline

Milestone Number	Milestone Description	Start Date	End Date
	Senior Design I		
1	Attempt to get a sponsor	1/11/2021	4/27/2021
2	Team Formation	1/11/2021	1/15/2021
3	Discuss Ideas / Project Selection	1/11/2021	1/15/2021
4	Bootcamp	1/21/2021	1/21/2021
5	Divide and Conquer V1	1/27/2021	1/29/2021
6	Decide between Gantry(3-axis) vs Conveyor belt operation	2/1/2020	4/27/2021
7	Select Pin Transfer Tool	2/1/2021	2/12/2021
8	Divide and Conquer V2	2/15/2021	4/27/2021
9	Design power supply(AC->DC Full Bridge Rectifier)	2/15/2021	4/27/2021
10	Design PCB	2/15/2021	4/27/2021
11	Select MCU	2/15/2021	4/27/2021
12	Write Pseudocode for MCU	2/15/2021	4/27/2021
13	60 Page Draft	2/15/2021	4/2/2021
14	100 Page Draft	4/2/2021	4/16/2021
15	Final Report	4/16/2021	4/27/2021
	Summer Break		
16	Acquire Parts	5/3/2021	8/23/2021
17	Design enclosure for Electronics	5/3/2021	8/23/2021
18	Write and Implement Code for MCU	5/3/2021	8/23/2021
	Senior Design II		
19	Assemble Project	TBD	TBD
20	Testing	TBD	TBD
21	Finalize PowerPoint presentation	TBD	TBD
22	Final Testing	TBD	TBD
23	Final Presentation	TBD	TBD