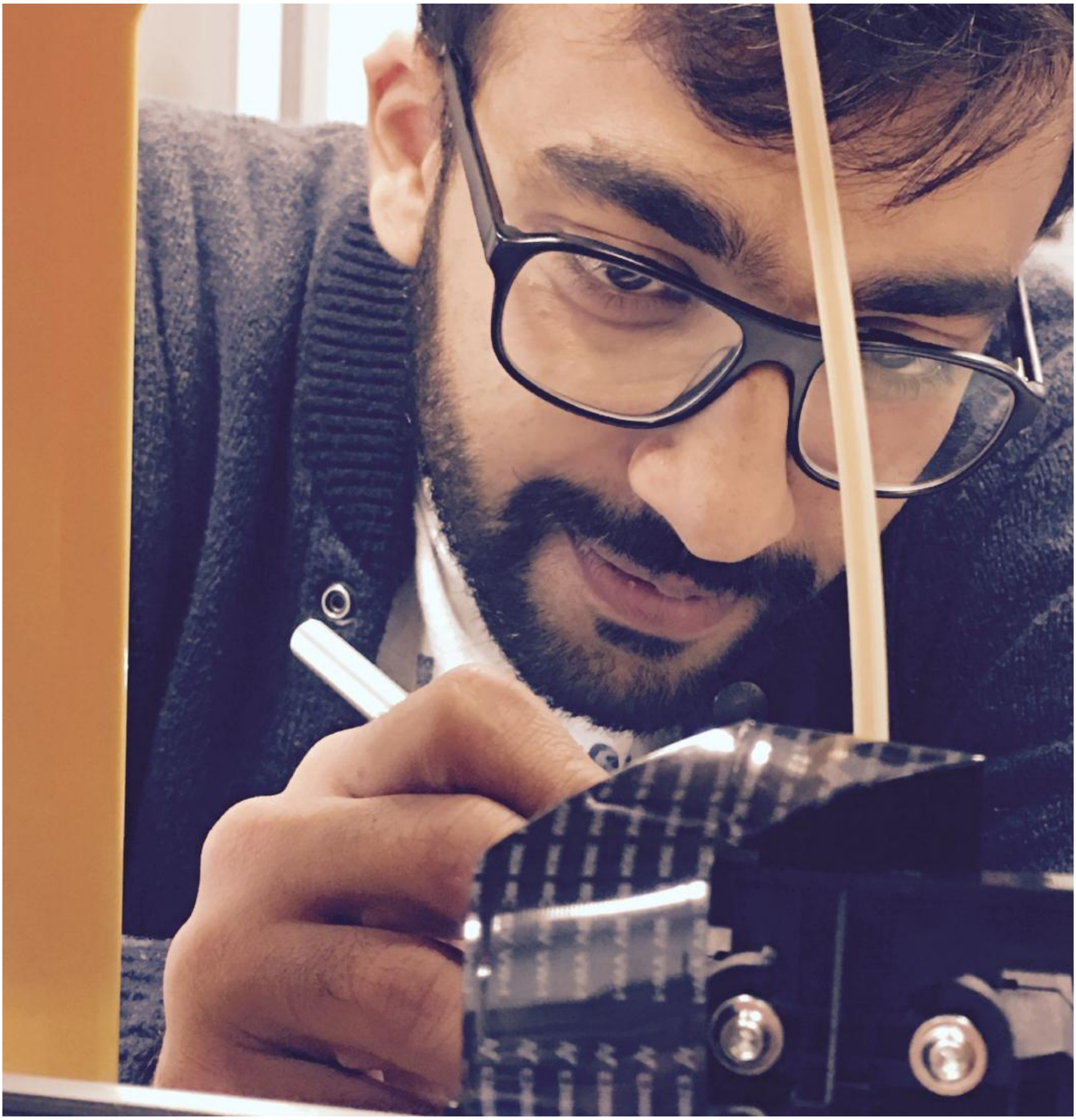

Aditya Singh Rathore

Engineering Portfolio

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Introduction

Hello! My name is Aditya Singh Rathore. I am an engineering student at State University of New York at Buffalo, majoring in Computer Engineering. I am currently in my senior year. This portfolio provides an elaborate description of the projects I have worked on, and my role in team based projects. Before I begin, I would like to express my gratitude to UB, for its exceptional engineering program, and professor Dr. Wenyao Xu (***https://www.cse.buffalo.edu/~wenyaoxu/***), for his wide research activity in 3D printers. I was able to take advantage of this from my junior year by joining Embedded Sensing and Computing Lab, initially as an intern and later becoming a research assistant.

About Me

As a child, I was highly passionate about computers. But that passion was only limited to gaming. During my middle school, I always used to have interactions with my friends about how games should be like. Gradually these conversations shifted from gaming to its platform. Since I always wanted to sound smart in front of my friends, I used to read about the hardware, such as processor, graphic cards, required to support variety of games. First it was just a few new words that didn't make much sense, but gradually these words began to have much more impact. I wanted to study more about these but I needed not just information but a detailed step by step introduction. I knew that if I choose computer science or electrical engineering, I would be gradually shifted from these topics. This is what introduced me to computer engineering. I must say, before joining the university, I had barely heard about 3D printers but I never decided to go in full detail; the main reason was a widely believed assumption that it is only something exclusively related to mechanical engineering. When I heard that a lot of research is being done on 3D printers from computer engineering perspective, I was intrigued. I immediately approached Dr. Xu to join his lab as I wished to work on this highly emerging technology, so that one day I will have a direct impact on society. Now after a successful publication and upcoming patent, I am prepared to use my knowledge of microprocessors, controllers and software development to make the same impact in respective company and help them move towards their goals by being a part of the big venture.

Energy Characterization of 3D Printers

http://dl.acm.org/citation.cfm?doid=2967360.2967377

The purpose of this research project, which I worked on under the guidance of Dr. Xu, is to emphasize the importance of electricity expenditure in total cost estimation in concurrent to material expenditure which is mainly taken in account. Our study quantified both material and electricity use in the 3D printing and we found that electricity takes upto 32% of the total cost of a product. We broke down the energy consumption that revealed motor and heating dominates the energy sector and we further examined sensitivity of system factors to energy consumption, including motor velocity, heating temperature, cooling power and printing resolution. We chose FDM type printer, Ultimaker 2 Go, due to its low cost and open sourced platform.

My first task was to identify the working states of the printer. I examined and verified the states by power analysis and working condition of system components during it. I also generalized the system architecture to expand the study to all printers of FDM type.

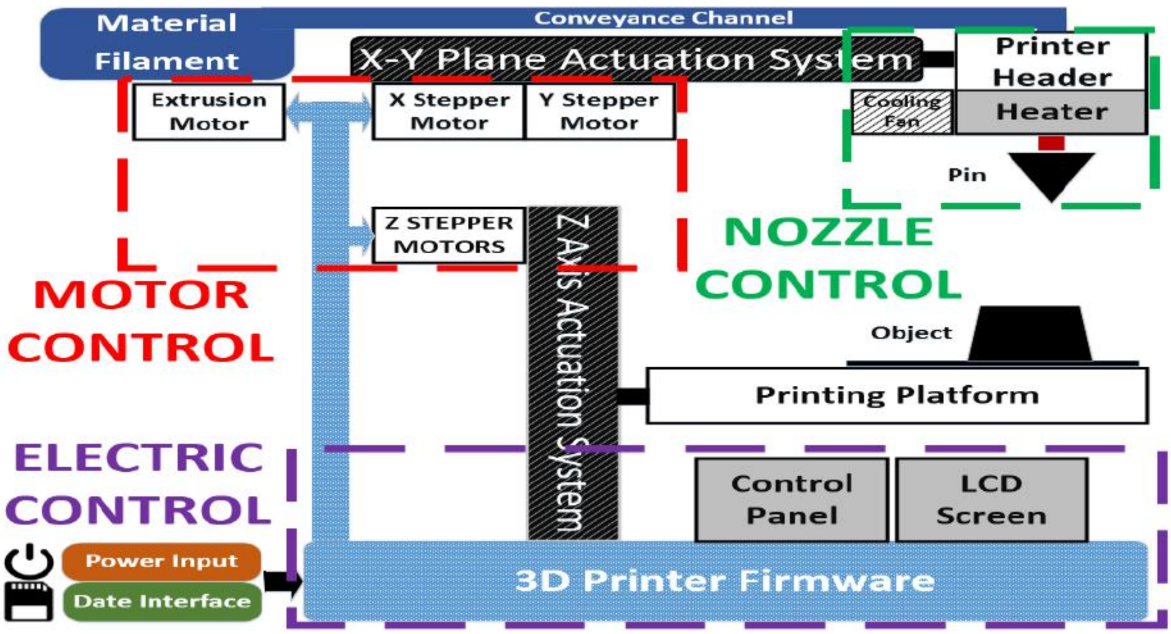


Fig: System Architecture generalized to all FDM Type Printer

Next, I used Kill-A-Watt power meter to quantify the energy consumed while printing different models. I chose all the models from different domains, with different layout and calculated the ratio of electrical cost to material expense.

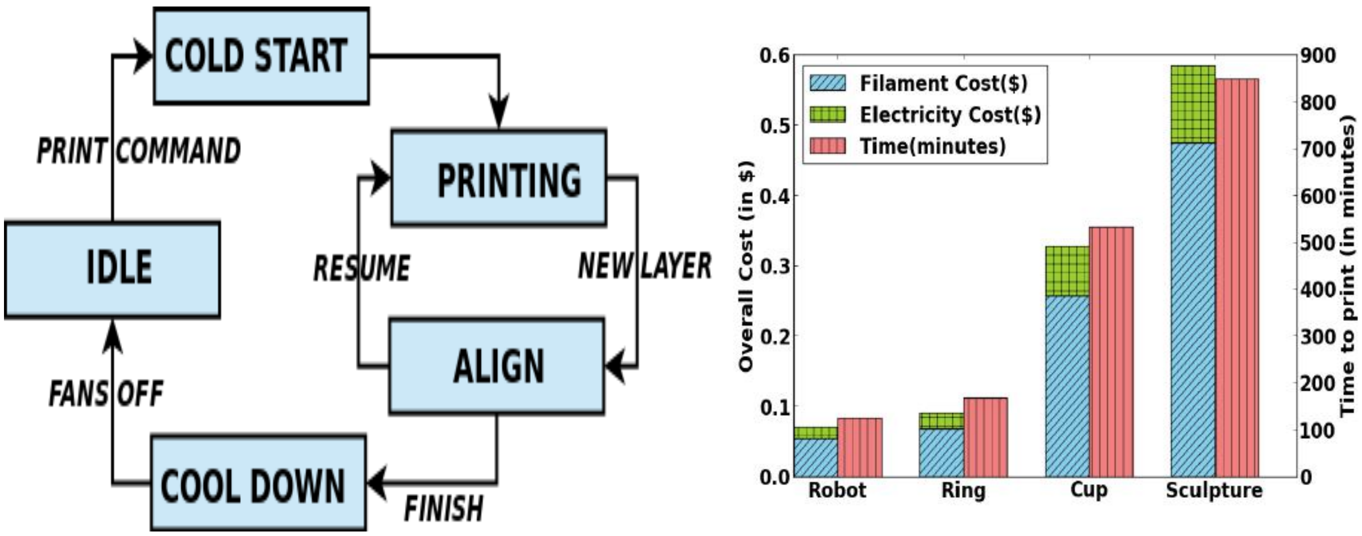


Fig: The Working State Transition (Left) & Cost and Time Statistics for models (Right)

I investigated the impact of electricity cost on overall manufacturing cost by considering two aspects, i.e., design complexity and fabrication quality. I made an important conclusion by looking closer at the cost breakdown, that electricity cost acquires 28% on average and up to 32% portion in overall expense to print a 3D model. This opens up the possibility to further optimize the manufacturing process to reduce the energy consumption (later described).

My team submitted our findings, as a research paper, to ACM Asia-Pacific Workshop on Systems, 2016 (***http://www.cs.hku.hk/apsys2016/program.html***). Our paper, "Don't Forget Your Electricity Bills! An Empirical Study of Characterizing Energy Consumption of 3D Printers" was accepted in July 2016, with me as second author. Writing a research paper and getting it published, while addressing the concerns of the reviewers, was an invaluable experience. I represented my team in Hong Kong, China to present presentation for published paper and poster. This gave me an opportunity to present before technical audiences and meet various students, professors and companies to hear their valuable feedback about on how to improve my work.

APSys'16 Poster and Presentation held at Hong Kong, China

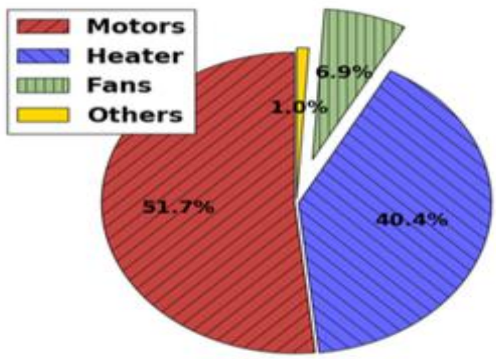
Instruction Level Power Analysis and Optimization of 3D Printer

After completing the previous paper, my team built an instruction-level power model and leveraged it to study and optimize the 3D printing process by power-gating the components that consume most energy. We took into consideration the unique properties, such as backup issue and instruction inertia, in mechatronic cyber-physical system and further proposed an instruction level cross layer approach to reduce the overall power consumption of 3D printer. We chose Ultimaker 2 Go to test our simulator and our implementation reduced the energy consumption by 25%!

I built the instruction level power model to analyze the power consumption and a parsing algorithm to identify the instructions in a Gcode file, and modify them to successfully implement power gating on components. New instructions were also introduced by utilizing the GPIO pins.

Instruction Category	Avg. Power(W)
Alignment Instruction (G0 Type)	
G0 F7200 X Y	21.3
Movement Instruction (G1 Type)	
G1 F1800 X Y	39.9
G1 F2400 X Y	40.03
G1 F3600 X Y	39.94
G1 F4800 X Y	39.81
G1 F5200 X Y	40.38
G1 F5400 X Y	39.85
G1 F7800 X Y	40.06
Control Instruction (C Type)	
G4: Pause	2.41
G20: Units to Inches	2.4
G21: Units to mm	2.43
G28: Move to origin	20.84
G90: Absolute Co-ordinates	2.41
G92: Set Position	2.39
M84: Disable Motors	2.4
M106: Fan on	3.61
M107: Fan off	4.44
M82: Extruder Position	2.43
M104: Set Temperature	3.5
M109: Attain Temperature	31.19

Fig: Instruction Level Power Consumption (Left) & Energy Sector for Different Components (Right)

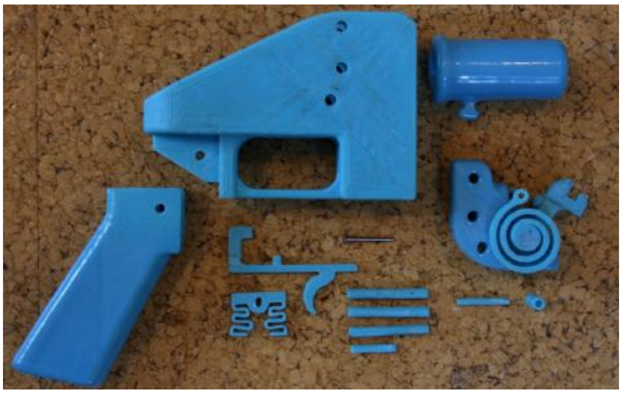


I have submitted a paper at International Conference on Architectural Support for Programming Languages and Operating Systems (ASPLOS'17) describing our findings, and I expect the response to arrive in November 2016. My team also filed a patent for the energy simulator we built, and we plan to make it open source as soon as we hear the response from the conference.

Due to paper's current state, I am not permitted to fully describe the project, but I hope that in short time, I can share my enthusiasm about findings with everyone!

Pattern Recognition of 3D Models via Power Analysis

This was an independent project I worked on while working as an intern in Embedded Sensing and Computing Lab, UB. The idea behind this project was to discover the possibility of pattern recognition between two models, based on power consumption.



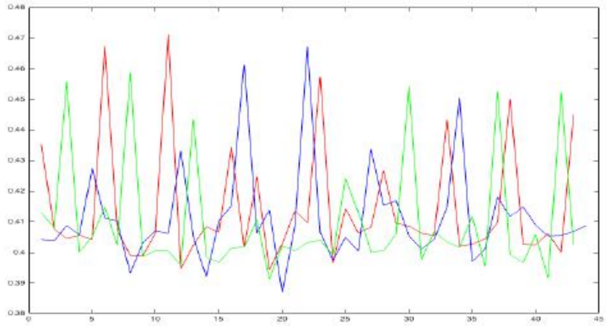


Fig: Model of 3D printed gun (Left) & Variation of current for a 3D model (Right)

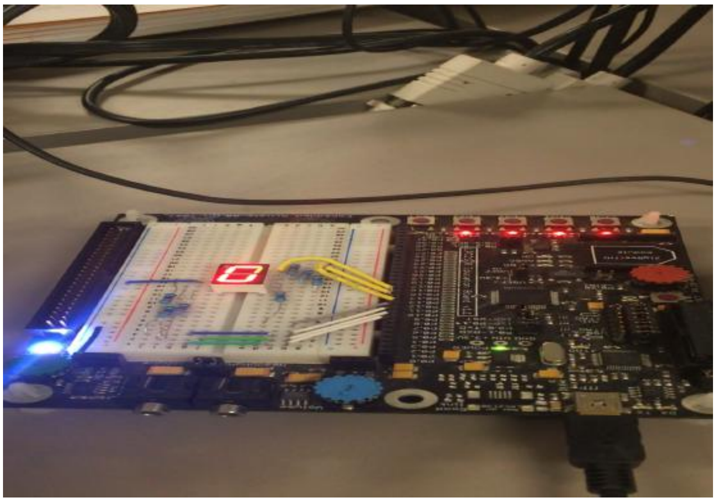
The motivation came from learning about increasing articles about gun abuse and the emerging news about people making 3D printed guns which have the same capability of firing bullets as a real gun. To work towards stopping this, I implemented a prototype methodology, where first the restricted model is printed on the printer and based on this power variation is analyzed. This variation can be stored in a library that contains variations of other restricted/patented models, which can be compared to the readings that we get when consumer prints a model.

I found that the variations were only constant to an extent, and the comparing parameters like skewness or kurtosis were not enough to fully induce this methodology. The initial accuracy that I observed was only 38%. I heard from professor before about the algorithm that one uses in pattern recognition of images, i.e., bag-of features. I implemented this algorithm for readings observed during power analysis of 3D model, by first segmenting the whole signal and evaluating non-linear parameters on individualized segments and comparing to check whether a certain segment is a line, arc or other pattern. By following this approach, the accuracy was increased to 63%!

Q*Bert

https://github.com/asrathor/ARM

For this project in *CSE379/380: Microprocessor and Microcontrollers,* I engaged with another person from my class to develop the arcade game, Q*Bert, by utilizing the concepts of ARM Assembly learned in the course. The game was initially developed in 1982, but we were free to design the game however we see fit. While the game controls or the initial gameplay remained similar to publicly available version, our game was fully implemented in ARM Assembly on a ARM7 LPC2138 microcontroller. Since the game was fully synchronized with the microcontroller, the user was given the option to either use keyboard to play or use buttons on the controller.



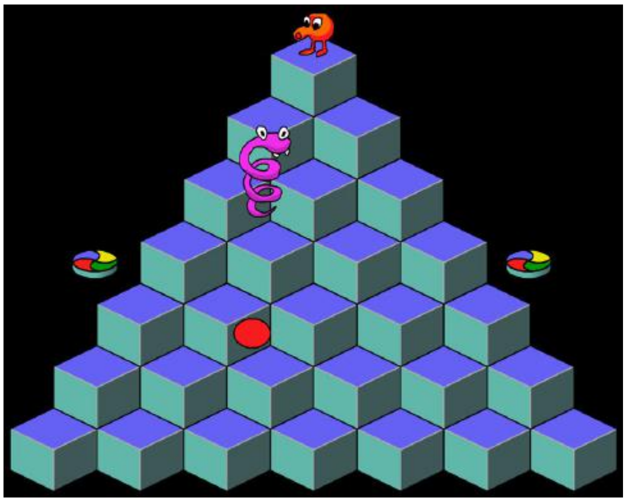


Fig: ARM7 LPC2138 microcontroller showing 0 as level, 4 red lights as player's life, blue light as game's current state. The game can be paused or played using the controller.

Fig: Q*bert game screen, showing red as player, snake as enemy and other components. Our display was generated as black and white.

The subroutines I implemented were for initializing GPIO pins, Time Handlers (managing the time player takes to complete a level), restart (ability to restart the game), level up (multiple levels in the game), print map (creating the board on which player can move), score management (manage the score board), enemy path planning (movement enemy will undergo to catch the player).

My team successfully finished the project 2 weeks before deadline, thus receiving the maximum credit for this project! We exhibited our work to technical audiences and submitted documentation describing logic used and flowchart of the game.

ScheduleMe

https://github.com/matt2929/ScheduleMe

For this project in *CSE442: Software Engineering,* I am working with five teammates to design a cross-platform app that solves the issue of groups or co-workers not being able to efficiently schedule meetings due to time conflicts.

This app will link users to their google calendars and will automatically estimate the time, user will be available with their location at that specific time. The app will use scheduling algorithm to look for available time between two individuals or a group and just ask the user to pick an ideal time.

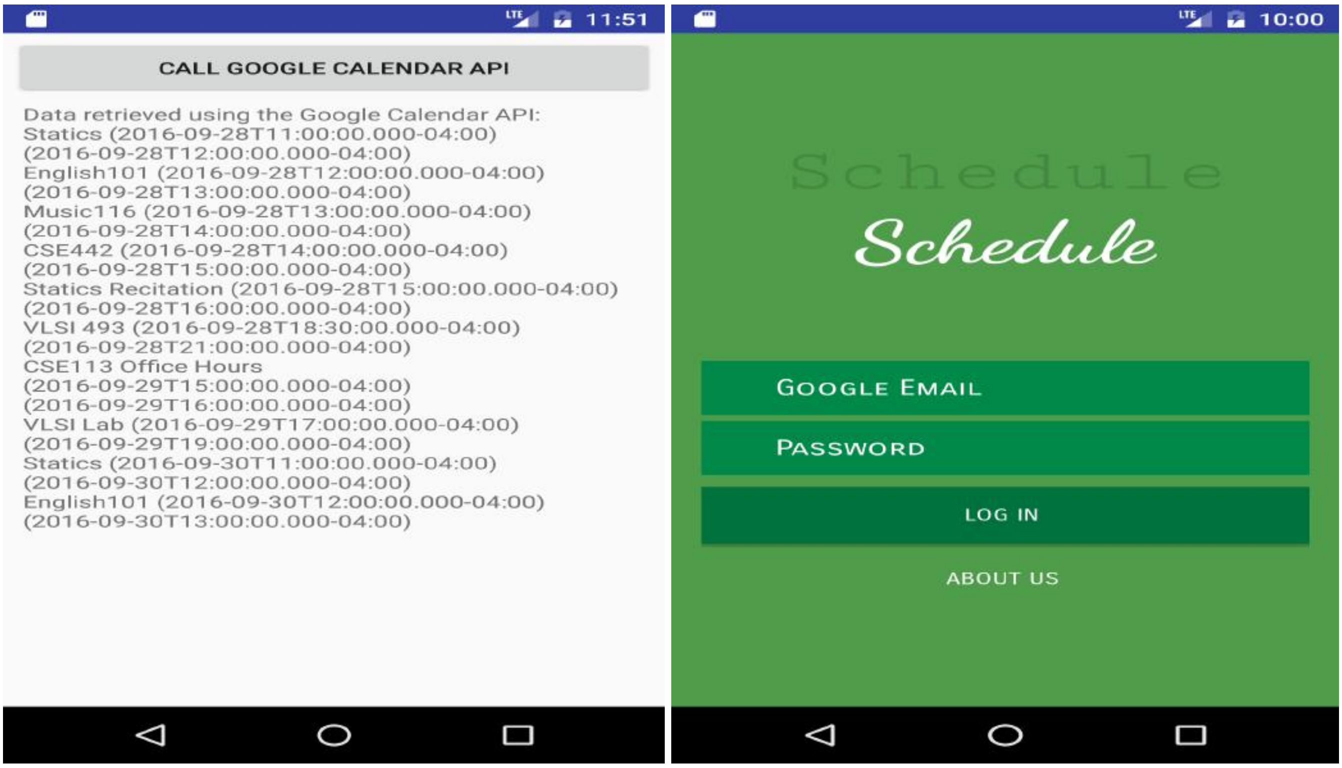


Fig: Data received upon calling the API (Left). Login Page of App (Right).

My first task is to synchronize the app with google calendar API. After getting the data of the user, I developed the scheduling time algorithm to calculate the free time on a certain day. This data, in the form of Boolean string where each Boolean represent availability in respective hour, is then sent to server, where it is compared with the other user's time. The project is still in its initial stage and I am working to further revise the algorithm to make it faster while solving the issues related to authorization related to API's.

Drone Collision Avoidance System

https://github.com/asrathor/Drone-Collision-Avoidance-System

This project involved designing a drone collision avoidance system (DCAS), that monitors and controls the operation of drones landing and taking of at centers and also at their destinations. This was a project individually accomplished and it involves implementing the algorithm to avoid drone collisions without involving the drones. Since I was working alone, I didn't have access to drones. Thus, in the algorithm, I initialized a drone by a specific character and moved them around in a map from home to their destination and back, while avoiding other drones/characters. I started by designing the state diagram to represent life cycle of a drone and used table-driven scheduling for flights monitored by DCAS. I implemented the algorithm in C language using concept of POSIX threads.

Gesture Based Remote Control

https://github.com/asrathor/Gesture-Based-Remote-Control

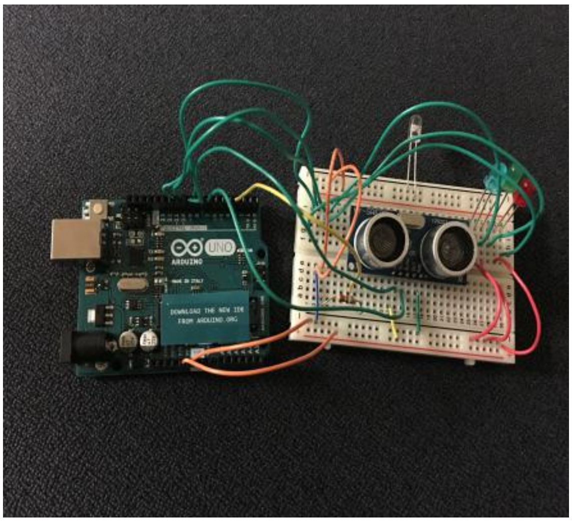


Fig: Remote control with sensor on breadboard connected to Arduino UNO.

Like everyone who use TV, sometimes we lose our remote or have our hands full, thus making us unable to operate the TV for a short amount of time. Since most of the appliances are getting motion controlled, I wondered why is the technology of remote staying the same? To resolve this, I started a small project to use a motion sensor, HC-SR05, that upon measuring the distance from object perform various operations such as changing channel, volume etc. The code was implemented on Arduino IDE.

Thanks for reading!