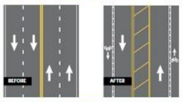
TRAFFIC SPEED AND INCIDENT ANALYSIS FOR FORBES RECONSTRUCTION PROJECT

Anamika M. Shekhar
Civil and Environmental Engineering

Introduction:

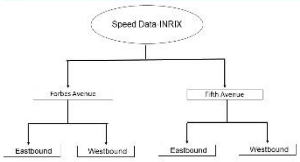
- Used to analyse traffic speed, bus counts, pedestrian counts, bus ridership, incident, noise and air quality for different road configuration given in order to achieve a road safe and friendly for all it's users



Data:

- Speed Data – INRIX
- Incident Data - Western Pennsylvania Regional Data Center(WPRDC)

Method:



1. Area of analysis for speed :

- Different period of construction
- One Lane Vs Two Lane
- Before and during Construction
- Peak Hour Traffic
- Different Seasons

2. Area of analysis for incident :

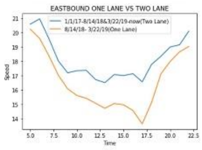
- Count and type of accident
- Correlation between the reason for accidents
- Total Societal cost
- Composition of Total Societal Cost

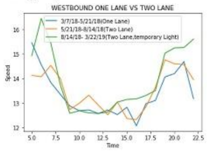
Traffic Speed is not affected by reconstruction of road

Result:

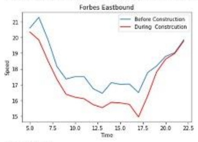
1.Speed

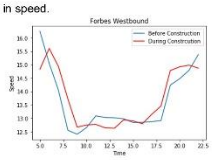
- Forbes Eastbound shows decrease in average speed





- Forbes Eastbound shows a decrease in speed.



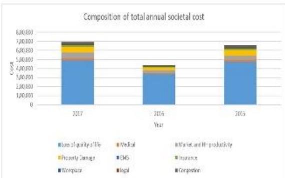


2.Incident

- Most accidents are collision type.

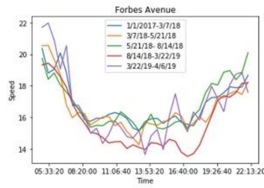
Count of accident

YEAR	COUNT
2017	4
2016	2
2015	4



Conclusion:

- Average traffic speed not affected by reconstruction of road.
- Seasonal Changes don't affect the average speed of road.
- The change in lane from two to one do not affect the speed to a great extent.
- Though we don't have the data of incident for after construction, we hope to see a decrease in collision because of the provision of centre turn lane.



Acknowledgement:

The completion of this study would not have been possible without the expertise of Prof. Chris Hendrickson, Prof H. Scott Matthew, Prof Zhen(Sean) Qian. I would also like to thank Rick Grahn and Corey Harper for their guidance. Last but not least, I would like to extend my gratitude to Prof. Susan Finger for her constant support throughout the tenure of this study.

Carnegie Mellon University
Civil & Environmental Engineering

Traffic21

PROJECT REPORT

In the initial days of my internship, my Professor gave me certain topics to study so as to get acquainted with the basics of my field,i.e. Computer Vision. I also implemented some basic programs on those topics, such as Image Stiching, Corner Detection in an image, Image Homography, computing the depth map of stereo images etc.

After understanding the basic concepts involved, I progressed towards my project which was to build a Cloud Predictor Model.

Sun is a renewable source of energy and with the current rate of depletion of fossil fuels, there has been an increasing shift from non-renewable sources to renewable sources. Bur sunlight is not a reliable source since the amount of sunlight available for utilization is not constant and varies throughout the day.

The sunlight available depend upon the amount of cloud presence in the sky.

The goal of my project was to predict the movement of clouds in the sky so as to get a picture of the amount of sunlight which would be available for utilization. The project involved building a CNN which takes two sky images as input and predicts the next sky image after a fixed time interval. Initially a very simple model was developed but its prediction was not very accurate. So then a UNET model whose performance improved and the model was able to do the prediction correctly.

LANDSLIDE ANALYSIS USING COHESIVE ZONE MODELING

Nishant Kumar Singh

Advisor: Prof. Amit Acharya

ALTERNATIVE TO METHOD OF SLICES

Landslide is a common disaster in India. Method of slices has been used to analyze slope stability of inclines. The limitations attached to the method of slices are ignored which are fundamental and considerable. The inter-slices force are assumed to be zero whereas the fracture curve is assumed to be made of very small straight lines. These approximations are eliminated by using the finite element method which considers small elements having nodes that can move horizontally and vertically and cover all possible dimension into triangular or rectangular elements.

Cohesive zone model is implemented which assumes the failure surface of the landslide. A zero-size element lining is assumed at the fracture surface whose dimensions are increased to simulate a realistic crack and separation of the surface. The model is simulated on ANSYS and the results are verified using calculations and predictions.

A 3D reconstruction of real landslide analysis using artificial intelligence is created and the properties of soil are taken from the Allegheny County, Pittsburgh.

The limitations of the method of slices are removed by using finite element method and implementing cohesive zone modeling. The future work of the research would be to scan an incline and predict its factor of safety.

Role: Student Intern

Branch: Civil and Environmental Engineering

College: Carnegie Mellon University, PA

Duration: 8 weeks

The research successfully demonstrated a relation between soil mechanics and fracture mechanics.

A new method to analyse slope stability was developed successfully.

I deeply acknowledge with gratitude, the contribution of **BITMAA-NA** and **BIT Mesra** for partly sponsoring my Immersive Summer Research Experience (2019) at

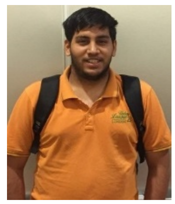
Carnegie Mellon University, Pittsburgh.

Horizontal Ribbon Growth - ICE MACHINE

Advisor: Dr. Erik Ydstie & Mr. Matt Cline (Lab Instructor)

Department of Chemical Engineering, Carnegie Mellon University

Unit Operations Laboratory



Vidur Ahluwalia (BE/10379/16)

Chemical Engineering

ABSTRACT:

This project aims to model and prove the theory that continuous production of solar-grade silicon wafers is possible replacing the most common Czochralski batch method. Solar energy is one of the most widely used form of renewable energy. Solar panels or photovoltaic cells are made up of semiconductors and are used to convert sunlight into electricity. However, the current common method of production, the Czochralski batch process, which produces solar-grade silicon wafers, is very inefficient and high cost as it wastes significant material. Horizontal Ribbon Growth (HRG) is a continuous method of producing monocrystalline silicon wafers that do not need additional processing. This method may prove to be more efficient and lower cost with further research. Current issues with the HRG method include uneven ribbons of silicon that prevent this method from being commercialized. A model using water to produce ribbons of ice instead of silicon was used to develop and improve this method at a much lower material cost. This model can be used to refine techniques in producing stable layers of ice with uniform thickness. The components of the experimental setup as shown in Figure 1 are:

1. A liquid nitrogen tank (XL- 160L)
2. 600 rpm water pump and it's controller
3. A thermostat and a (0-120V) transformer
4. Cooling plates and a liquid nitrogen plate
5. Conveyor belt with a (0-10 mm/s) speed controller
6. A metal seed to pull out the ice wafers
7. Water bath

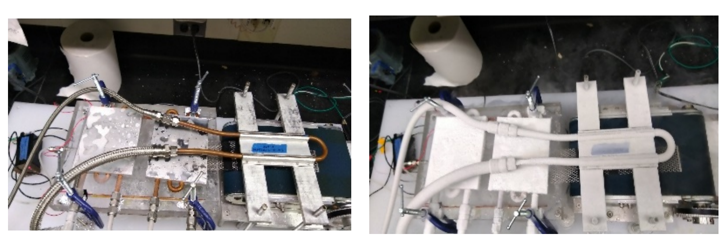


Figure 1

My project objectives were to pull out long enough (theoretically endless) ice wafers with accurate thickness measurement. The process to achieve that was to start pump and the thermostat beforehand to make the water in the bath cold enough (~4-5 deg C) to freeze as a precursor for successful working of the setup. A quicker to achieve this was found out by circulating ice water into the bath, in a tub placed beneath the bath. Not performing this and directly starting with the experiment might lead to no ice formation in the bath. Initially liquid nitrogen is flown into the bath at a slower rate, with the attainment of equilibrium (which is the ice formation on the top most surface of water), seed pulls out of the bath at a faster speed (6 mm/s) which is reduced(1-2mm/s) when the seed reaches the lip of the bath. After steady state is achieved, the liquid nitrogen rate is increased subsequently to cope up with the zoned cooling and pulling speed of the conveyor for ideal indefinitely long ice wafer which in reality does break apart.

I faced my challenges and had to make significant changes in the existing experimental setup to achieve my project objectives. The changes made were the angle of the conveyor and the lip of bath was adjusted by leveling the screws on its base, so that the seed pulls out ice wafers horizontally from the bath resulting in longer ice sheets at steady liquid nitrogen flowrate. A foam container was made to provide adiabatic environment to the setup so that the no external heat transfer took place with the surroundings leading to faster cooling of the water in the bath, reducing unnecessary wastage of liquid nitrogen. The seed getting stuck on the lip was one of the most challenging issues to tackle as it hampered the production of ice wafers. This was resolved by overflowing water over the lip such that the seed didn't the touch the lip at all, making it feasible to pull out ice wafers [Figure 2(a)&(b)].

Ice wafer thickness measurement was proposed to be measured by confocal displacement sensors (CL Series). These work on the simple principle of measuring distance between reflection on the top and bottom surface. This method is very promising as it is accurate to a few micrometers and can measure thicknesses between 0.25 mm to 2.5 mm.

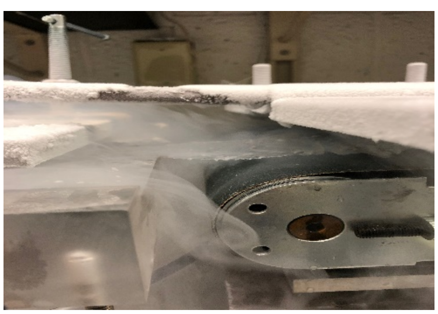


Figure 2(a)

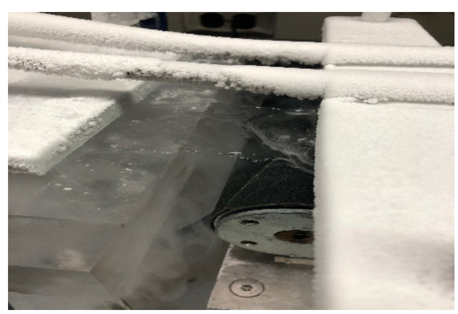


Figure 2(b)

CONCLUSION:

This model is capable of pulling long enough ice wafers and with accurate thickness measurements data and a few fixed initial parameters can be used on an industrial scale for continuous production of solar-grade silicon. With the proposed confocal sensors being capable of measuring thickness of the silicon wafer and being heat resistant, the setup is can be used for commercialization(with another set of challenges related to handling of temperatures above 1500 deg C).

My journey for this internship started way back in the 5th semester. I had applied for this internship on the recommendation of a friend not thinking much about it. Fortunately, I got selected for an internship with CMU, ranked #3 for Computer Science in the world. I had always wanted to know how it feels like to study in the top ranked institutes of the world. This also helped me realise my dream of doing my MS abroad. My internship started on the 3rd of July. We had attended an orientation session and then we went kon to meet our professors. Our professor Mr. Aswin Sankaranarayanan was very understanding and learnt that we had not taken any undergraduate course in Computer Vision : the topic our research project was based on. So he directed us to an undergraduate course in Computer Vision that was a part of the CMU Computer Science Engineering. The first few weeks were spent on trying to get my head around this course. Once our professor was satisfied with what we had learnt, he then gave the abstract of the project we would be working on.

As we know the world is fast moving towards using renewable sources of energy, solar energy being one of them. But due to the intermittence of sunlight during the day, it cannot be used as a renewable source of energy. Our aim was to predict the amount of solar irradiation in a very small geographical area given the camera images of the sky from that area. During the night the solar irradiation is zero. During the day, the only hinderance to the sunlight are passing clouds that might obscure the sun. So, our problem reduced to predicting the movement of the clouds and checking whether it obscures the sun or not. Due to the limited time that we had, we were only able to solve the first part of the problem: predicting the state of the sky at a given point in time. We implemented a deep neural net that took in sequential images of the sky at intervals of 1 minute and predicted the state of the sky 2 minutes later. This information could be used to predict the solar irradiation values for a particular day. On the last day of the internship I presented this in front of a lot of PHD students. Overall it was a good course.

Aishanee Pattnai

UNDERGRADUATE PROJECT REPORT

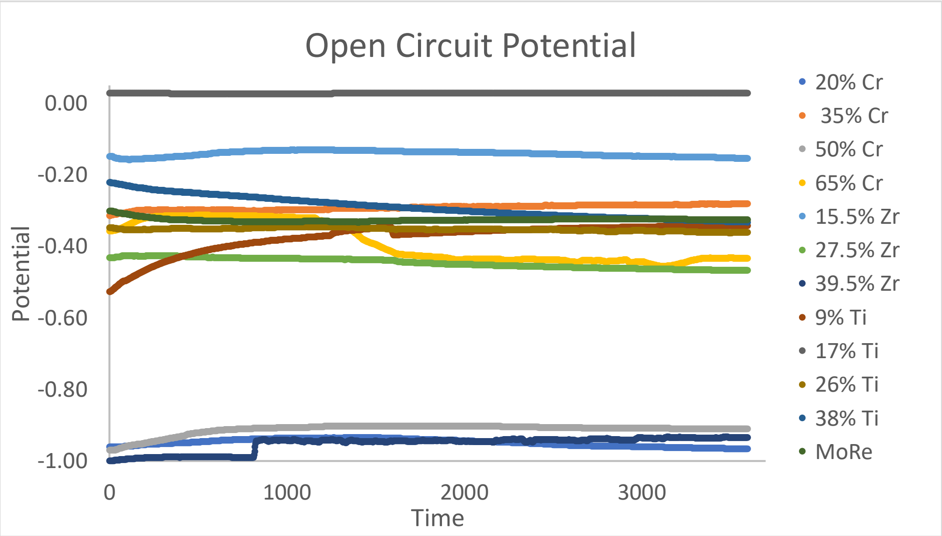
PROJECT 1

OBJECTIVE

The objective of this project is to conduct Cyclic Potentiodynamic Polarization tests on Molybdenum-Rhenium (MoRe) alloys used in small implant devices to determine its pitting corrosion susceptibility in accordance with the ASTM F2129 Standard (Standard Test Method for Conducting Cycling Potentiodynamic Polarization Measurements to Determine the Corrosion Susceptibility of Small Implant Devices) and compare its effective passive film formation.

THEORY

Small implant devices like vascular or ureteral stents, filters, cardiac occludes etcetera are often made of alloys that have a high resistance to corrosion, however if these surgical implants are susceptible to pitting or crevice corrosion they are likely to yield unwanted derogatory effects on nearby tissues, which might not be limited to malicious tumours. This experiment is designed to test the extent of passive film formation of varied compositions.



Aishanee Pattnai

UNDERGRADUATE PROJECT REPORT

PROJECT 2

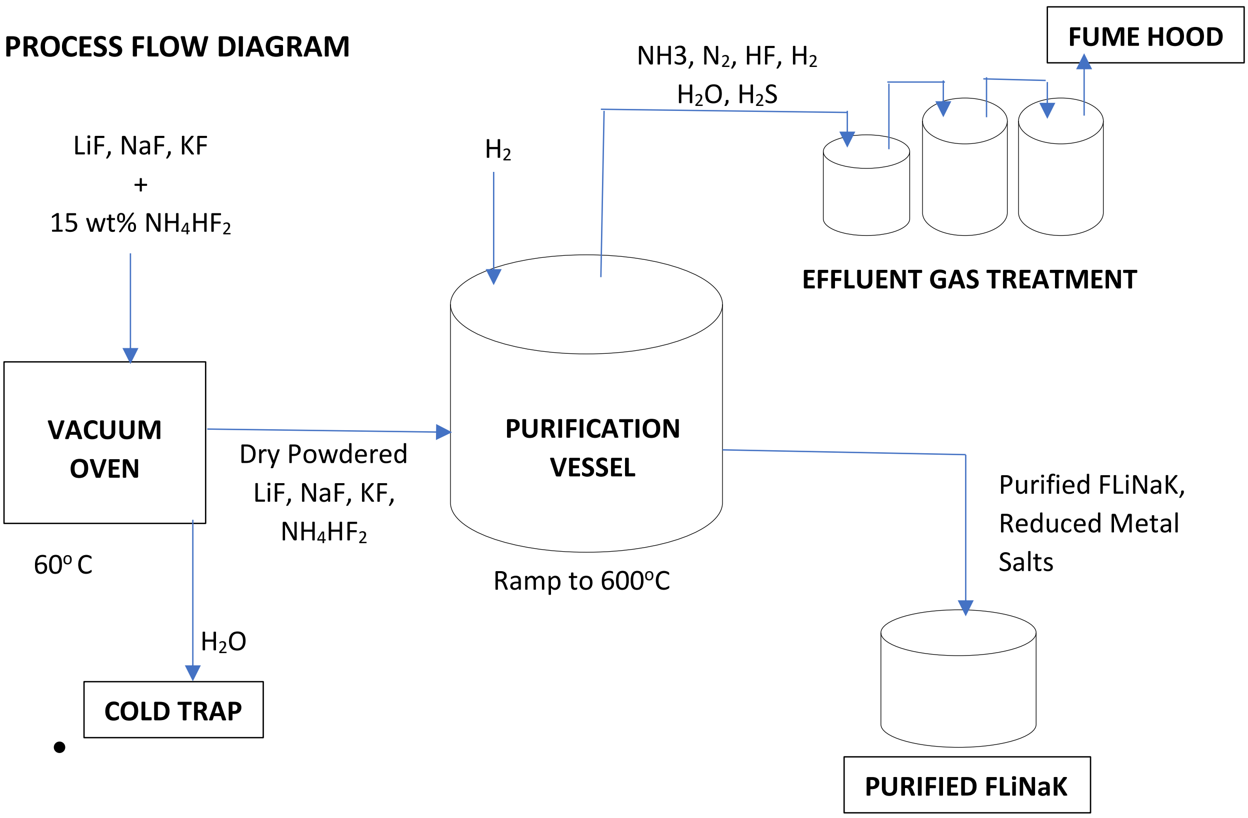
OBJECTIVE

The objective of this project is to construct and analyse a purification process for a molten fluoride salt FLiNaK, a ternary eutectic alkaline fluoride salt mixture of Lithium Fluoride (LiF), Sodium Fluoride (NaF) and Potassium Fluoride (KF).

THEORY

FLiNaK, a ternary eutectic alkaline fluoride salt mixture of LiF-NaF-KF, is often used in corrosion experiments. They are produced by combining its high purity salt components, but still contain enough impurities to cause a derogatory effects on corrosion experiments. This process aims to produce high purity FLiNaK by hydro-fluorination of fluoride salts, ramped to 600°C, and a Hydrogen (H_2) and Hydrogen Fluoride (HF) spurge followed by switching to an Argon spurge for 24 hours. HF converts the oxides and to fluorides and both HF and H_2 are responsible for reducing metal fluorides. HF will be generated in-situ from the thermal decomposition of Ammonium Bi-fluoride (NH_4HF_2) to avoid costs for the specialized equipment required for the safe handling of HF.

PROCESS FLOW DIAGRAM



Exhaust Gas based Material Detection

IoT based system to identify material being processed using exhaust gas data

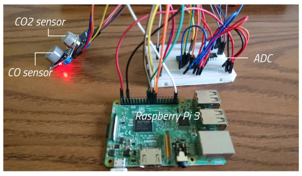
Project Team : Shubh Goel, Birla Institute of Technology Mesra & Dr. Amit Jariwala, Georgia Tech

Objectives

- Developing a system to detect materials being cut or engraved in laser cutter and monitor usage.
- Identifying materials unsuitable for machining in laser cutters as they cause damage to laser lenses.

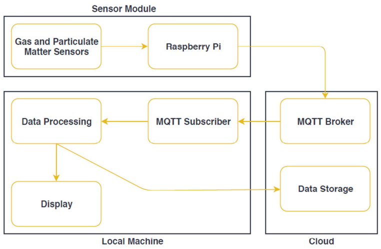
Approach

- Laser machining of materials produces specific sets of gases and particulates. System monitors concentration of these gases for material detection.
- Gas and particulate matter sensors placed in the exhaust duct of machine.



Sensor Module Prototype

- Gas concentration data sent wirelessly to central console.
- Data runs through an algorithm that checks it for tell-tale signs of different materials.
- Parameteres for decision making process-
  a. CO2 conc.
  b. CO conc.
  c. Volatile Organic Compound(VOCs) conc.
  d. Moisture content



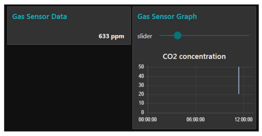
Flow of Data

Challenges Faced

- Being housed in exhaust duct, sensors pick up considerable amount of dust that produces inaccurate readings.
- Certain materials don't produce gaseous products in detectible concentrations.

Technical Aspects

- MQTT used to transmit data from sensors to the cloud; being hosted on Amazon AWS server enables scaling to additional machines without need to alter existing mechanism.
- System being cloud based allows data monitoring from remote locations with only internet access.



Sample Sensor Data

Future Work

- Incorporating VOC sensors for detecting different types of plastics.
- Sensing gasesous products that potentially pose health risks to makersspace users.
- Additon of automated warning system that sends alerts on damage causing materials.

Contact

Dr. Amit Jariwala (*amit.jariwala@gatech.edu*)

Project Report for Shivam Mahajan

Objectives:

1. Gain hands-on training in Invention Studio prototyping tools
2. Conduct research on training users on prototyping
    1. Design a final checklist masterpiece that each trainee could build individually using a variety of prototyping tools. Example: multi-purpose toolbox

Skills Gained or in progress:

1. Prototyping tools:
    1. Laser cutter
    2. Electronics workbench
    3. Waterjet
    4. 3-D Printers
2. Research tools:
    a. Collaboration tools: Google Docs
    b. How to develop a research topic/research Question
    c. Locate Information: Google Scholar, GT Library. How to draft literature review
    d. Evaluate and analyse information
    e. Write, Organize and communicate findings
    f. Cite Sources: Citation tools: Paperpile.com
    g. Project management tools: Slack

About the Project:

The project started with the aim to complete the checklist of the Flowers Invention Studio at George W. Woodruff School of Mechanical Engineering, Georgia Tech. The aim of the checklist was to teach the tools and prototyping methods that can be used at the Invention Studio.

While working on the checklist, I also started working with a team of six members including me. The aim of the project was to help develop he course which will help users on the subject of manufacturing and rapid prototyping. My work in this project was to design a new checklist masterpiece that the students taking the course would build and which would also replace the checklist at the Invention Studio.

Here is the overview of the project (on next page):

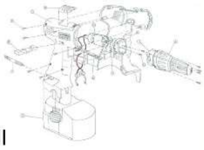
ME 1801: Rapid Prototyping for Product Design

A five-week hands-on course where students will learn to utilize prototyping processes as a means to validate design

Course Development Team:, Alejandro Campos, Shivam Mahajan , J. Auston Ferrarer, Drew Bailey, Rohan Banerjee, Emily Toomer and Dr. Amit Jariwala

Classwork

Lecture
- Overview of the design process
- Proper shop safety techniques
- Prototyping process
- Process planning

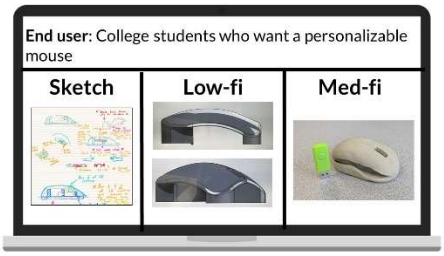


Group Activities
- Concept generation
- Deconstruct power drill

Interactive Discussion
- How to provide constructive feedback
- Learn-n-Share sessions where teams provide feedback on prototypes during design iteration

Teamwork

Project
The class will be split up in teams based on skills and project preferences
- Teams will identify an end-user, develop sketches, CAD models and build prototypes to receive feedback from instructors and others teams
- Teams will role-play as a customer/end-user for another team
- Teams will document their progress and key outcomes from each design iteration on a poster



Example of Group Project Deliverable

Personalized Workshops

Training in Invention Studio
- Documentation on machines
- "How to" videos
- In person training during office hours
- Scheduled studio hour blocks to work on ME 1801 class projects

The individual "masterpiece" assignment will provide an opportunity to demonstrate safety and competencies in utilizing prototyping tools.

Example of Individual "Masterpiece"

Sponsors/Partners

AUTODESK. SGA Milwaukee

References

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Contact

Dr. Amit Jariwala (amit.jariwala@gatech.edu)

Data Analysis for Alzheimer's: Searching for the curative drug

Alzheimer's disease, named after German psychiatrist, Dr. Alois Alzheimer (1864-1915) is a severe brain disease associated with symptoms like memory loss, cognitive decline and challenges in planning or solving problems, which progresses slowly, eventually leading to death. Even after massive advancements in modern medical science, we haven't yet found a cure for the disease. The first survivor of Alzheimer's disease is still awaited. There have been attempts to find a drug that can reverse the symptoms but the attempts have only led to little mitigation in the symptoms. The quest for the cure is ongoing. This paper provides the description of the attempts to find a curative drug for the disease by going through large perturbational datasets from the Connectivity Map project of the Broad Institute of MIT and Harvard. By definition, "The Connectivity Map, or CMap, is a resource that uses transcriptional expression data to probe relationships between diseases, cell physiology, and therapeutics." The project compares the changes in the gene expression of the brain cells of Alzheimer's disease patients to the impact the various drugs have on the immortalized cell lines in the laboratory. The best match is looked for.

I. INTRODUCTION

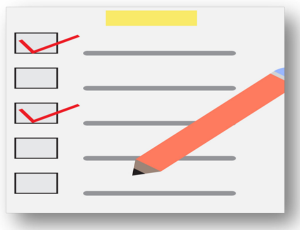
Alzheimer's Disease is an irreversible, progressive disease affecting nearly 44 million people worldwide. The cause of the disease as per research points to genetic, lifestyle, and environmental factor. Though the exact cause is still not known. A lesser prevalent form of Alzheimer's, 'Early Onset Alzheimer's Disease' is found to be associated with certain genes which increase the risk of its occurrence. However, a large number of AD cases are of 'Late Onset Alzheimer's Disease', which does not show any correlation with heredity. Numerous attempts have been made to find a drug that can reverse the symptoms of the disease. Unfortunately, even after all the advancements, we haven't

yet been able to do so. At the most, we have found a way to bring down the symptoms temporarily, to a small extent. Alzheimer's disease once diagnosed, is still no less than a death sentence to the patient. This research aims to find a suitable curative drug by scanning through the Broad Institute's Connectivity Map database. We have data from AD diagnosed patients' brain cells and we have data from the drug influence on cells. We bring it all together in this research to search for a possible drug.

II. METHODS

Gene Shortlisting

Results from previous research on Alzheimer's disease (AD) has revealed a set of genes (29) associated with AD. This project analyses expression data from these selected genes. Expression for 28 of these is found to be present in the AD study gene expression data.



AD Expression: FPKM to z-scores

Gene expression data from diseased RNA Seq. profiles (152) is then converted from the FPKM values to standard z-scores by taking the median and median absolute deviation for each selected gene from the control population and applying the formula:

$$\text{Z score (standard score)} = \frac{\text{observed value - median value of the reference population}}{\text{standard deviation value of reference population}}$$

This is done to bring the expression data to a common measure. The Connectivity Map Database's Level 5 data has z-scores as the unit of expression.

What on the C-Map data?

The expression data is also sub-set to have only the desired genes' expression. The signatures obtained from the HEPG2 liver cancer cell line are selected for analysis. The CMAP data is found to have values for 26 out of the 28 selected genes. The gene set is updated accordingly.

Possibility Score

Top 3 signatures are selected as a match for each RNA Seq. profile while scanning through the C-Map database based on a calculated possibility score (PS). Three signatures for each RNA Seq. profile are obtained in a file (Total 152*3 =456). Owing to repetitions in this list, a frequency is obtained for each unique signature.

$PS = -\sum \max(|a_i|, |b_i|) / \min(|a_i|, |b_i|)$

where a_i and b_i are z-scores of gene i from AD and C-MAP signatures respectively.

If the gene is upregulated in the AD patient, it must be upregulated in the perturbation data. Only then can it be said to reverse the effects.

High Possibility Score => A good match

III. RESULTS

The top 3 C-Map signature matches (for each RNA Seq. profile) based on the Possibility Scores are stored for further analysis. These signatures (456) are then compiled to a single list. Further, as expected, some of these signatures were found to occur multiple number of times. This is reflected as a frequency. Some of the frequencies are as shown in Figure 1, and Table 1 with more details.

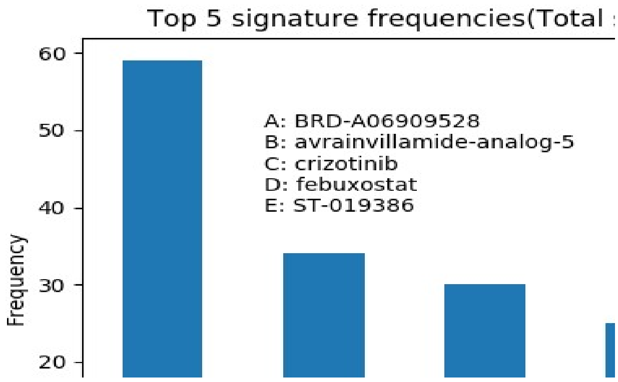


Figure 1.

IV. DISCUSSION

Looking at the results, it is evident that the top-ranking signatures show a positive correlation with respect to reversing the Alzheimer's disease gene expression. These compounds when probed further in the laboratory might offer insights into the pathology of Alzheimer's Disease and help in bringing down the symptoms. Also, similar signatures can be looked for in the C-Map database, the mechanism of action of which are known. However, it must be noted that the C-Map signatures scanned through for obtaining possibility scores were taken from experiments on a liver cancer cell line (HEPG2). Hence, the accuracy of the results is not well founded. A model depicting the correlation between the HEPG2 based gene expression changes and the actual brain cell gene expression changes if found can reaffirm the findings of this research.

The Connectivity Map algorithms also fulfil the objectives of this project. The C-Map algorithm takes the lists of the upregulated and downregulated genes as input to show suitable matches. This project on the other hand uses the numerical gene expression values and looks at how much it has been upregulated or downregulated.

V. CONCLUSION

Compound BRD-A06909528 (as per the C-Map data) shows a higher possibility of reversing the AD Gene expression changes than the following compounds. It is very often found that the compounds that we expect to work often end up showing a number of side effects and cannot be used as pharmacological

drugs. These compounds hence, may or may not be

Compound	Frequency (of compound occurrence)	Perturbation time	Dosage
BRD-A06909528	59	6 hours	10μM
avrainvillamide-analog-5	34	24 hours	10μM
Crizotinib	30	24 hours	10μM
Febuxostat	25	6 hours	10μM
ST-019386	25	6 hours	10μM

Table 1.

suitable for human consumption and more research is needed to bring clarity to it.

VI. ACKNOWLEDGEMENTS

- Armour College of Engineering Undergraduate Research Program
- Connectivity Map: The Eli and Edythe L. Broad Institute of MIT and Harvard
- National Institute on Aging Genetics of Alzheimer's Disease Data Storage Site
- The Aging, Dementia and Traumatic Brain Injury Study: Developed by a consortium consisting of the University of Washington, Kaiser Permanente Washington Health Research Institute and the Allen Institute for Brain Science.

I want to thank the IIT Armour College of Engineering for accepting me into the Research Immersion Program. Thanks to Birla Institute of Technology (BIT), Mesra, India and BIT Mesra Alumni Association – North America (BITMAA - NA) for sponsoring the program. Last, but not the least, I am thankful to my parents for supporting my endeavors.

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Parika Vyas, IIT Chicago

BE/10445/16 , ECE Department, BIT Mesra

Title of Project: Hyperparameter Tuning for Neural Network Optimization

Neural Networks are computing systems modeled on the human brain and nervous system. They have a widespread application in every field and hence their optimization is of utmost importance. Consider the use of neural networks for classifying whether a tumor is cancerous or not, helping a tesla car navigate, etc such applications demand the best kind of neural networks with accuracy as high as 100 percent and error as low as possible. Meanwhile, they are called black boxes as their exact working is very difficult to understand and it is tough to visualize the exact computations going on inside the network. Hence, the major challenge in designing a neural network is determining the best architecture and parameters for the network. Hyperparameters are the parameters that help to tune the neural network. The model can be evaluated and then configured after tuning the hyperparameters for maximum accuracy and minimum loss. My project involved designing a near to perfect neural network. I studied the effect of various hyperparameters on the neural network and optimized the network by tuning these hyperparameters. Examples of parameters are the number of layers and nodes, the learning rates, the activations, optimizers and the dropout rates. Typically, these parameters are chosen based on heuristic rules and are manually fine-tuned, which may be very time-consuming, because evaluating the performance of a single parameterization of the Neural Network may require several hours; hence, a method which can automate the process of determining the best hyperparameters was performed for optimization of neural network. Applications of these optimized networks could be in any field be it technological advances in robotics, computer vision, NLP, smart devices, taxonomy, health related devices and many more. Hyperparameter tuning is the emerging aspect of neural networks as optimized systems capable of approximating the toughest of functions and using them to solve real world problems is the need of the hour. My project studies the effect of these hyperparameters to optimize a neural network used for classification and to plot the effects so they can be used for future reference. My neural network can successfully classify different species of iris flower and different types of clothes as well. It can be further extended in object recognition which can be applied in obstacle recognition for helping visually impaired persons navigate. This project involved extensive self-learning and the academic exposure offered by IIT Chicago was inspiring throughout. It was a great opportunity to study, learn and grow as an individual and I am glad I was able to successfully complete it and am very thankful to the college for this opportunity

High Performance LED Panel Display using ZYNQ AP-SoC

PARITOSH KUMAR SINHA
Electronics and Communication Engineering

SALINI MAHAPATRA
Electrical and Electronics Engineering

Introduction – The objective of our project was to design a high speed multiple RGB panels driver using a ZYNQ AP-SoC. We see RBG panels used all around us in the stadiums, shopping areas and marts for advertisement. The idea behind the project was that instead of specifically designing the RGB panels, even the smaller panels which are a by-product can be used in a similar way as the bigger ones. These could be even used to display emergency information like a storm or an accident and reduce the paper waste used in advertisement industry. This involved around the fields of digital design, (a major Electronics subject), image processing and serial communication using Python (a major and recent Computer subject).

Abstract- This project aims to make a display consisting of multiple RGB LED panels using a ZYNQ processor. This involves the design of hardware logic and implementation of software code to transfer data to the ZYNQ processing system in order to display the required image or animation.

I. HARDWARE

ZYNQ is the new generation All-Programmable System-on-chip (AP SoC). It combines a dual-core ARM Cortex-A9 processor with traditional Field Programmable Gate Array (FPGA) logic fabric. The ZedBoard is just one of the development and evaluation boards available. In comparison to Arduino, ZedBoard can support multiple panels. It is more dedicated (hence faster) than Arduino/Raspberry Pi. It can display true color using 8-bits for each of red, blue and green pixel so a total of nearly 1.7 million color combinations are possible.

II. TOOLS/SOFTWARE

1. Xilinx Vivado Design Suite
2. Python
3. Open-CV (Library for image processing)
4. Xilinx Vivado SDK

III. METHODOLOGY

The project initially focused on developing the hardware design by creating an IP (Intellectual Property) block to drive multiple LED matrix panels. The next step was to design a software program in Vivado SDK (Software Design Kit) for accepting image data to display on multiple LED matrix panels.

Then the focus was to formulate a software program to obtain an image which is to be displayed, from the user. The project also emphasizes on color of the display, hence color (pixel value) was then assessed and color calibration was implemented. The next objective was to transfer image data serially through UART (Universal Asynchronous Receiver Transmitter) to the block RAM of ZYNQ ZedBoard and display it on the LED panels.

I. DISCUSSION

Even though the current display is satisfactory, there is still scope for a lot of future work on this project. The display can still be made better by improving the refresh rate. The project provides a scope of using a large number of LED panels together by using PMOD pins as well MIOs of the ZedBoard. An android application can be made to select images or information to be displayed from any mobile device and then the data can be transferred through Wi-Fi or by using Bluetooth to the ZedBoard for display. This can be helpful in displaying warnings or cautionary messages on the display. However, the serial communication could be added to the system without compromising with the refresh rate of the panels.

II. CONCLUSION

The display on six RGB LED panels was successfully implemented with a decent refresh rate using ZYNQ ZedBoard. The software code was successfully modified to obtain display on a given arrangement of panels. The display of animation is accomplished. The data was transferred through serial communication without any major issues. Thus, if this design is implemented in the commercial field of advertising, we expect it to give satisfactory results.

III. ACKNOWLEDGEMENT

We would like to thank ACE Undergraduate Research Program for their support. We acknowledge Birla Institute of Technology, BITMAA-NA (Alumni Association) and Illinois Institute of Technology for funding this program. A very special thanks to Boyang Wang and all other researchers at the ECASP laboratory for guiding us throughout the project.

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Name – Satyabrat Bhol

Topic – Data Analysis on Alzheimer’s

Project Details –

Alzheimer’s disease is a global health issue and its early detection could slow the progression of the disease. Alzheimer's leads to nerve cell death and tissue loss throughout the brain. With time, the brain shrinks dramatically, affecting nearly all its functions. Instead of opting for more complex examinations, a few blood tests would reveal the possibility of Alzheimer's with quite a good accuracy. However, there is still an utmost need for identification of relevant attributes for its early detection. In my proposed work, the tabular dataset is collected from a Disease Center. The dataset contains Longitudinal Clinical data of Alzheimer’s and Non-Alzheimer's patients. We have applied more than ten classification techniques starting from Naïve Bayes to Neural Networks to the dataset using multiple Python frameworks like Scikit-Learn, TensorFlow, etc. The attributes in the dataset include age, follow-up years of individual patients, blood biomarkers, medication status, and cognitive assessment tests. Methods like Imputation, Balancing, Feature Selection, etc. were used for getting the best attributes. It was observed that Random Forest is performing best (accuracy wise) among all others for the classification of Alzheimer's. My future work entails the use of Magnetic Resonance Imaging (MRI) scans and Positron Emission Tomography (PET) scans along with the Blood Biomarkers for classification of Alzheimer’s.

Human-Computer Interface Design using Head Tracking & Eye Blink Detection for Physically Disabled Person

Shreyas Shubhankar (BE/10197/16)
Embedded Computing and Signal Processing Laboratory
Department of Electrical & Computer Engineering
Illinois Institute of Technology, Chicago, Illinois
Advisor: **Dr. Jafar Saniie**

In recent times, various image processing and computer vision techniques are being used to design systems to assist people with vision trouble and physical functioning. In this research project, I investigated the application of eye blink detection and head tracking to solve a real-world problem faced by people with impaired mobility. People traditionally use mouse and keyboard to control their computer. In the case of a physically disabled, it is not possible for the user to use their hands. Eye-tracking hardware is available to use eye movement as an input and can cost upwards of hundred dollars. Webcams are relatively common, and this research inspected the possibility of using it to replace dedicated hardware as an input device for the user.

The goal of this project was to implement eye blink detection and head tracking algorithm using images of eyes as a template, to design a user friendly and fast interface for typing anywhere using eye blinks, and to design an interface for using head tracking to move the mouse cursor and using eye blinks to click, scroll, and type in a browser. The programing language used was Python along with OpenCV, a computer vision library.

Using the system implemented in this project, a user is able to use their computer to perform basic tasks by themselves after someone calibrates the system for them. The user can then read e-books or webpages, type in a browser or a word processing software, and open web links, applications, and files and folders on their computer just using their head and eyes.

I would like to thank Birla Institute of Technology Mesra, Birla Institute of Technology Mesra Alumni Association – North America (BITMAA-NA), and Illinois Institute of Technology, Chicago for partly sponsoring this research.

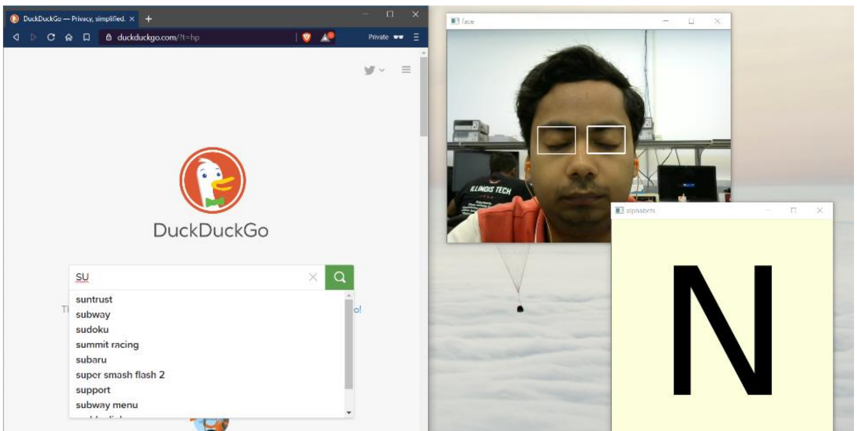


Fig. Opening a browser and typing in it

I deeply acknowledge with gratitude, the contribution of BITMAA-NA and BIT Mesra for partly sponsoring the Immersive Summer Research Experience (2019) at Illinois Institute of Technology, Chicago.

Implementation and Analysis of Cruise Control Methods in VISSIM

By Soumil Dutta

BE/10318/16

Production Engineering

Advisor: Baisravan HomChaudhuri

Assistant Professor,

Department of Materials, Mechanical and Aerospace Engineering,

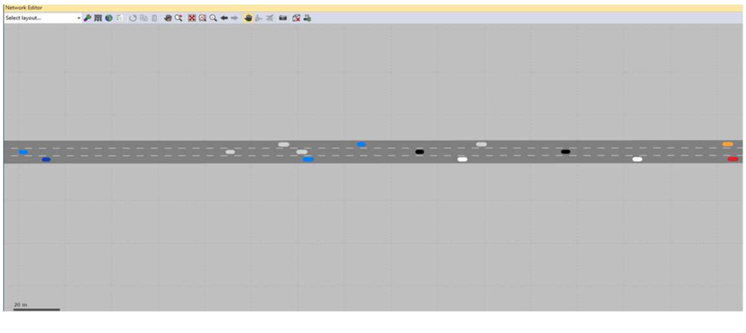
Illinois Institute of Technology, Chicago

Abstract:

In this project, Adaptive Cruise Control and Cooperative Adaptive Cruise Control methods were implemented on a group of heterogeneous vehicles which included human driven vehicles and Connected and Autonomous Vehicles in VISSIM, a microscopic traffic simulator using COM interface and DLL API. The performance of these cruise control methods was analyzed based on their impact on the fuel efficiency of all the vehicles in the simulated traffic network. A 5 km three-lane highway was used as the traffic scenario in our simulation. The results showed that with increasing penetration rate of autonomous vehicles, the average fuel efficiency of the traffic increases, human drivers perform better in the presence of autonomous vehicles and the average fuel efficiency improves with more cooperation amongst the vehicles.

Methods:-

The traffic scenario where the cruise control methods were implemented was a 5 km (3.1 miles) stretch of a three-lane highway (Fig. 1). VISSIM allows us to set the vehicle composition of the traffic in terms of number of vehicles of each type. This helps us to have a traffic network with both human drivers (running on Wiedemann Car Following Model) and autonomous vehicles controlled by user defined control methods using external model DLL API. Hence, we could make analysis of the vehicles at various penetration rates of the autonomous vehicles. The vehicle input i.e. number of vehicles entering the network per hour was also specified and needs to be specified by the user. In our case, it was set at 1200 vehicles per hour.



Fig, 1: Traffic Network in VISSIM

$$a_v = k(v_{des} - v)$$

$$a_d = k_1 a_p + k_2(v_p - v) + k_3(s_p - l - s - s_{min} - s_{hd})$$

$$s_{hd} = t_{hd}(v_p - v)$$

$$a = \min\{a_v, a_d\}$$

$$-3\, m/s^2 < a < 2\, m/s^2$$

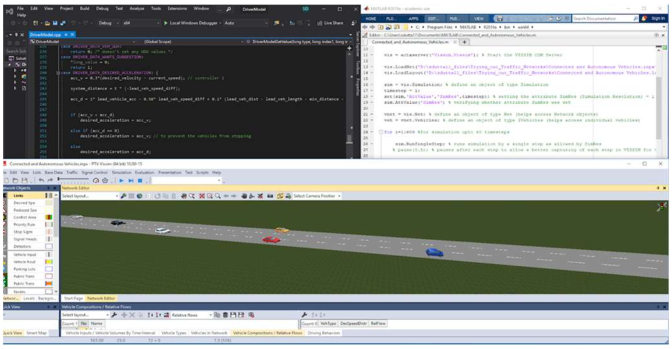


Fig. 2: Simulation Environment consisting of VISSIM, MATLAB and Microsoft Visual C++

A code was written for the set of equations given. It was implemented in Microsoft Visual C++ Project file provided by VISSIM and a DLL file was generated. VISSIM sends data about each vehicle at each simulation time step to the DLL file. The updated values are calculated according to the code specified and sent back to VISSIM. The whole simulation environment is shown in Fig. 2.

Using COM interface, the simulation was started by writing a code for that in MATLAB and data for each vehicle at each simulation time step (i.e 1 s) was saved in MATLAB via the Interface to VISSIM. Using the distance travelled and fuel consumption data for each vehicle at each second calculated in MATLAB, total distance travelled and total fuel consumption for each vehicle was obtained and fuel efficiency was calculated for each vehicle by dividing the total distance travelled by total fuel consumption and finally a mean fuel efficiency was obtained. This was done in case of different penetration rates of autonomous vehicles.

	Fuel efficiency (mpg)		
Penetration Rate	Autonomous	Human	Overall
0	-	44.80402116	44.80402116
20	51.17173686	46.38067009	46.78118256
40	51.69907363	47.66367876	49.30180935
60	51.56614311	47.64482761	49.9357014
80	51.51526241	47.70724085	50.77370032
100	51.54940618	-	51.54940618

Table 1: Fuel efficiency in miles per gallon for autonomous vehicles and human driven vehicles at different penetration rates of autonomous vehicles

Conclusion:-

Different control strategies for connected and autonomous vehicles were compared in terms of their fuel efficiency. Our analysis shows that higher penetration of autonomous vehicles increases the fuel efficiency (miles per gallon) of all the vehicles in the traffic network. It has also been shown that human drivers perform better when following autonomous vehicles. Moreover we have shown that more connectivity results in better performance of the controlled vehicles.

Student Name: Srishti Gupta
Branch: Chemical Plastics and Polymer Engineering
Birla Institute of Technology, Mesra

Mentor: Dr. Donald Chmielewski
Chemical and Biological Engineering
Illinois Institute of Technology, Chicago

Project Title- Design of Pumped Hydro Energy Storage for Smart Grid Applications

While countries are pushing their goals to be solely green energy producers, engineers need to solve the challenge that arises by relying on wind or solar resources - irregularity. Renewable energy sources need a lot of storage to ensure that the grid is not energy deficient in the absence of the resource. This is where the idea of a pumped hydro energy storage system saves the night! During the day or windy periods-when energy production is high and the cost of electricity is low, the reversible turbines or pumps utilize this excess energy to pump water from a lower reservoir into an elevated-higher reservoir. This stored energy is released during peak hours or at the time of deficiency in the wind or solar resource.

The objective of this project was to design the model of a pumped hydro energy storage system and optimize the parameters of the model so as to maximize arbitrage opportunities. This model repurposes abandoned quarries and uses dynamic energy prices to make predictive calculations for the operation of the storage system and affirms a potential application of PHS in Midwestern surroundings.

This research project creates a design and MATLAB model and checks on the feasibility of submerged pump hydro storage systems. Opposed to an elevated PHS system which is prevalently being used in and around the world, the submerged type is still a conceptual idea and not in use. Repurposing an abandoned quarry to work as the lower reservoir also controls and avoids flooding in areas with higher rainfall. Rainfall also refurbishes the shortage of water incurred due to evaporation which leads to energy loss. This in turn indicated that the submerged types PHS model are better suited to areas with higher rainfall and lower evaporation. The receding horizon concept used for simulation incorporates the modified power due to pressure drop and losses due to evaporation and rainfall. The simulation along with the optimization works to reduce fluctuations and errors in the predicted proposed schedule thereby giving us a more realistic picture into the future. Losses were calculated to simulate a plant operation which was utilized in the loop. Overall, our investigation of the feasibility of a PHS was successful. We obtained a return on investment period of 6 years!

User Programmable Home Automation and Security System

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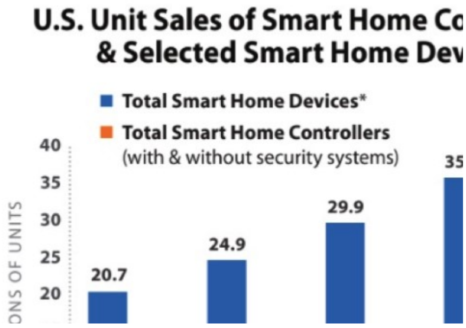
Illinois Institute of Technology
Chicago, Illinois
Advisors: Dr. Jafar Saniie, David Arnold

Abstract: With the world moving drastically into the field of automation, and towards smart devices; the existing technology becomes irrelevant. To make the old devices smart and control them effectively and efficiently we build the Autovate Home Security and Automation System. The system has the following features: 1.Allowing to turn any device ON/OFF from anywhere in the world. 2.See the live sensor(temperature, motion, smoke, sound) from the real-time website. 3.Self program the website to control any device based on the sensor parameters. 4.View the live video of the environment in real-time on a webpage. 5.Motion Capture and Detection that sends the user an email with the recorded pictures and save the videos offline on the R-Pi.

I. INTRODUCTION

The world is drastically moving towards a smart IoT based environment where everything connects to the internet. The internet holds a great part in making things automated and enabling ease of use. With people relying more and more on energy, our system works to quench this need. Our model allows any device to become smart, therefore allowing old working technology to be modernized. This prevents the increase in accumulation of existing electronic waste-pile. There are many reasons why home automation still lacks the demographic. Some of these include: 1.Extremely expensive to procure setup. 2.Fairly complex to set up. 3.Requires smart devices to work. 4. Requires change in indoor decor setup. 5.Very rigid and not user based products.

As we all can see that the world is moving faster towards automation. The following study shows an accurate depiction of growth of home automation systems as well as security systems. When it comes to controlling home appliances and reading the indoor environment, our system ensures it using Advanced Encryption Standard (AES) - 256 bit .



(Fig1. Sales Recorded of Smart Devices)

The system also holds a secondary part that involves a Home Security System. This ensures a safe secure environment in the house that prevents break-ins,. The system doesn't store redundant video footage but only of the parts where motion is recorded. While the video gets recorded, pictures are taken parallely and send to the email with attached pictures captured. Along with the email, we also have a link sent out that once clicked on, can access the live footage of the room the setup was installed into.

As a part of the automation part, multiple sensors gather information i.e. sensor data and these are sent to the cloud using low power internet compatible microcontroller ESP8266 NodeMCU Firebase is a Backend-as-a-Service platform on Google Cloud Platform. The Firebase Realtime Database is a cloud-hosted database that lets you store and sync data between the users in real-time.

(Fig2. Applying capabilities of Google Firebase Platform)

The objectives achieved in this setup are as follows: 1. Use advanced low power microcontroller ESP8266

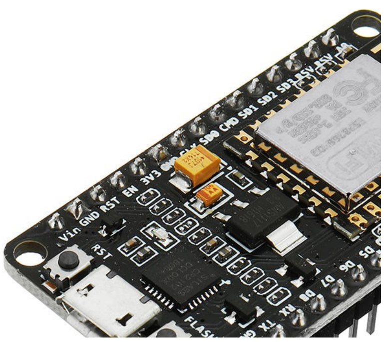
NodeMCU to collect data.
2. Prepossessing data before sending it to Google Firebase (Real-time Database)
3. Cloud computation to post process the data for multi-platform access.
4. Pulling the data from the cloud and displaying it on the website.
5. Giving access to the user to change the status of the plug based on temperature, sound, smoke, time and motion data.
6. Make a 3D printed model to house the electronics, components along with the PCBs.
7. Laser-cut transparent acrylic sheets for a see through view of the internal electronics and their connections.

II. METHODS

1. <u>Choosing the perfect microcontroller for this setup:</u>

It was mandatory to pick the ideal microcontroller for our project something that was economical but at the same time economical in order to make the setup as economical as possible. After much speculation, we chose to work with the ESP8266 NodeMCU board.

NodeMCU is an open source IoT platform. Which includes firmware which runs on the ESP8266 Wi-Fi Module from Espressif Systems,and hardware which is based on the ESP-12 module. The term “NodeMCU” by default refers to the firmware rather than the dev kits. NodeMCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in NodeMCU.



2. <u>Sensors integration with the ESP8266:</u>

There are 4 major sensors involved, i.e. PIR motion sensor, temperature sensor, sound sensor and the smoke sensor. Each one was integrated with the microcontroller (ESP8266 NodeMCU) individually to ensure correct working of each sensor. The code for each sensor was written and checked with the respective sensor separately. There was extensive analysis done on each sensor module and their outputs were altered to meet our requirements.

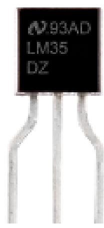
- **PIR Motion Sensor:**

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

(Fig3. Motion Sensor)

- **Temperature Sensor:**

Temperature sensor is a device which senses variations in temperature across it. LM35 is a basic temperature sensor that can be used for experimental purpose.It give the readings in centigrade(degree Celsius)since its output voltage is linearly proportional to temperature. It uses the fact that as temperature increases, the voltage across the diode increases at known rate(actually the drop across the base-emitter junction of transistor). Its disadvantage is its sluggish response.



(Fig4. Temperature Sensor)

- **Smoke Sensor**

This flammable gas and smoke sensor detects the concentrations of combustible gas in the air and ouputs its reading as an analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm.The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.

(Fig5. Smoke Sensor)

- **Sound Sensor**

Can detect the intensity of the sound environment, use note: the sound sensor can identify the presence of sound (according to the principle of vibration) or a particular frequency of sound does not recognize the volume of the sound. Sensitivity adjustable digital potentiometer to adjust.

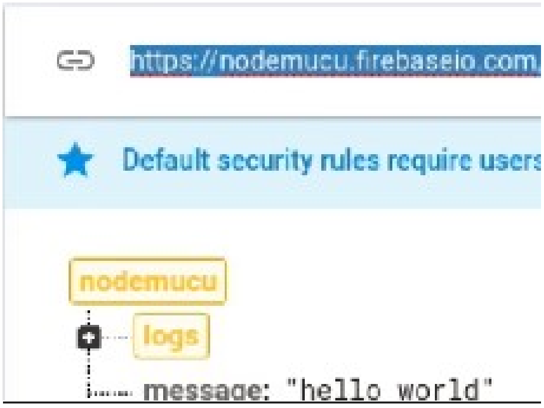
(Fig6. Sound Sensor)

3. Local Host Setup (NodeMCU):

Before moving on to connect the hardware that is the Node-MCU to the internet, we implemented a smaller step i.e. to connect it to a local network and access data sent from the hardware to a device on the same network. This enabled us to implement data communication locally(for cases where user needs data only locally)

4. Cloud Communication Setup:

To get the data communication set up between the NodeMCU ESP8266 and the Google Firebase Platform, we started off by sending basic strings, integers and boolean values to confirm it's functionality. This was implemented successfully thanks to the detailed Google Firebase Documentation.



5. Integration with all sensors to the ESP8266 NodeMCU:

All the sensors were individually connected to the NodeMCU and their values were recorded on the serial monitor. These values were then manipulated according to our further process needs. Once the individual processes were completed successfully, we started to add one sensor at a time in order to bring them all into one microcontroller. But the problem came into the picture as we wanted all the sensors to be reading data parallely, so that there are no reading left ignored. Also a NodeMCU is equipped with only 1 analog pin that prevents us to work efficiently since we have multiple analog sensors. Therefore we switched into using two NodeMCUs for our setup.

6. Camera integration with Raspberry-Pi:

While testing, we needed to learn some basic image processing (OpenCV Python,) in order to write the code that saves images, saves videos and livestream from the built-in camera of a laptop. We then implemented a code that detects motion and it was effective. The technique used in the written code is based on frames differencing; the difference between the consecutive frames is observed to detect motion only if the difference exceeds the threshold. Only while motion is detected in the room, the camera would be recording a video, and pictures would be taken every few seconds. If the room is unoccupied(motion is not detected), the video was not recorded.

7. Local Host Setup (LiveStream):

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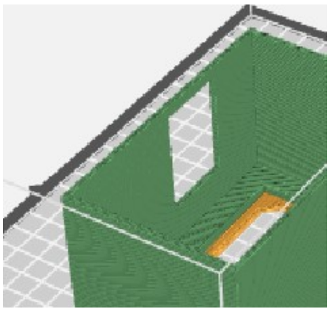

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III. RESULTS

1. Website:

a) HOME PAGE

The home page was primarily built on the bootstrap architecture in HTML and CSS, whereas the logic was worked on it by JavaScript. This page is extremely user friendly and view friendly on multi-platforms like mobile phones, tablets, etc. This page has access links to many other pages such as Login page, Sign-up page, Sign-in page, etc.

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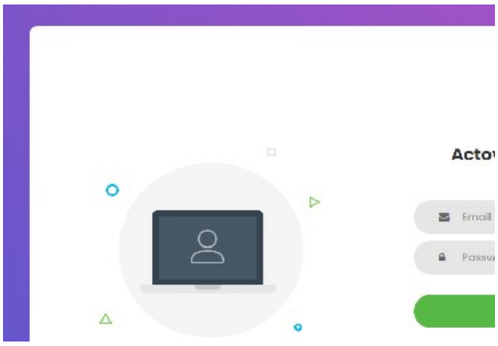
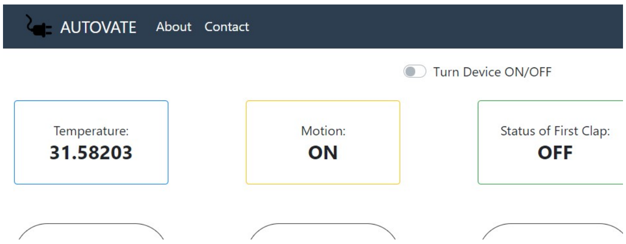


This is a model inspired from a pre-functioning page was implemented with really interactive animation as one scrolls over the page.

c) CONTROL PANEL



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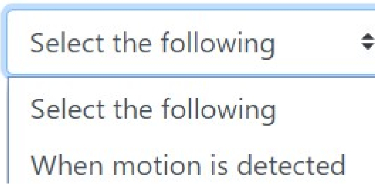
The user can set the AC device plugged into the setup to switch ON/OFF if the temperature goes above a certain temperature or must turn off below a certain temperature. The drop down menu gives the user ease of access.

MOTION PARAMETER:

The user can set the plug to switch ON/OFF depending upon the presence of motion. This can be used to switch ON devices like lights that get activated in case of motion



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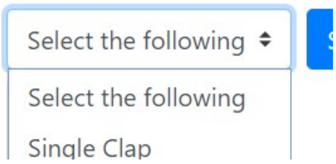

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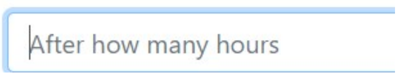

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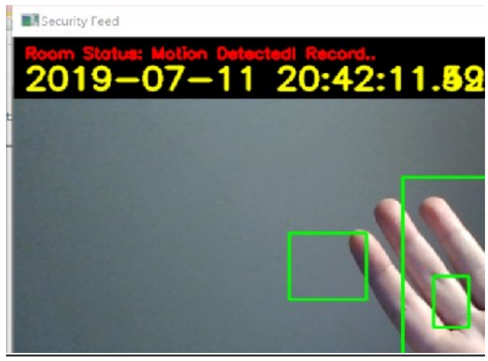
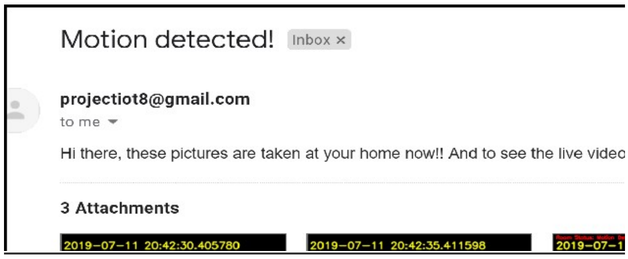


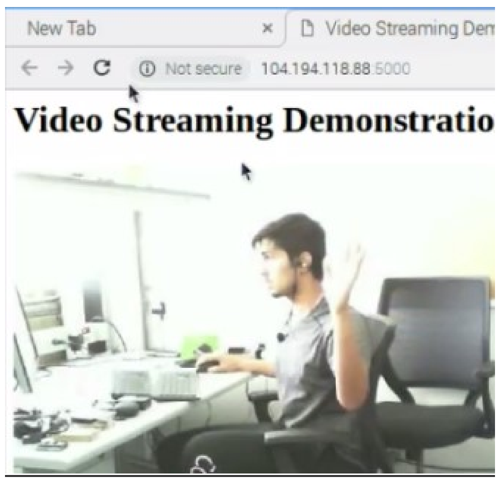
Each recorded frame is time stamped as well as the pictures that are taken. The pictures and the video are saved offline, and the pictures are mailed as mentioned before.

In the next figure we can see that the mail is received with multiple pictures and alerts the user about a break-in.



3. Live Stream:

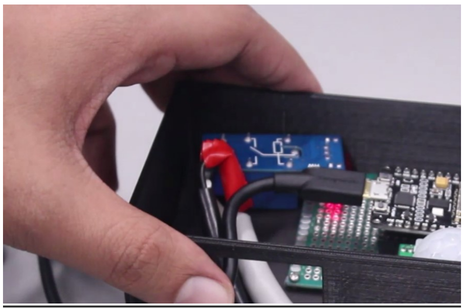
The live stream video worked remotely on a raspberry pi. The process used the concept of multithreading on the Python platform. Also the Python Flask was used to integrate the website with the python openCV file. This ensured multiple user login and anyone on the local network could access the view to live streaming. This ensured live video at all times and can be useful in many different scenarios.



4. Hardware Exoskeleton:

The 3D model of the system was made on AUTOCAD Inventor. The .STL file was exported from the software and uploaded to the maketbot software. This file was then converted to the .MAKERBOT file where all parameters for the print were defined too. The fan speed for the initial layer was set to be 0 and the surface of the print was glued perfectly. This allowed the print to occur flawlessly without any grating. Once the files were exported we fed it into the Makerbot Replicator + which printed out our model in about 4.5 hours.

The next part of the process was to laser cut the top and bottom lids. Since we needed these to be clear and see through to make it was exciting as possible, the dimensions were taken inCAD and exported. The .stl file was fed into a Laser Cutter where they came out perfectly.



IV. DISCUSSION

This truly is a concept much needed but not as prevalent. The world wishes to move to automation but is inhibited because of various factors like cost, setup, etc. This setup eliminates that hassle and works to give the user the best experience. Also considering the future aspects, since there is so much data collected from the sensors, we can apply machine learning algorithms to predict better. An app along with the website can be added to improve user interface.This could be added to other smart assistants like Google Home, Alexa, Bixby, etc.

V. CONCLUSION

The system successfully implements better, more advanced alternatives to existing technology that allows the user to control his/her home more efficiently. This setup allows users to make their home smarter without changing existing devices making it economical for commercial usage. This gives the power to the user and allows one to be the true controller of one's home.

VI. ACKNOWLEDGEMENTS

Thanks to my teammates, David Arnold, Dr Sannie, Dr Won Jae and all the members of ECASP laboratory for their contributions. BITMAA and BIT Mesra for their continuous support.

VII. REFERENCES

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[3] https://github.com/FirebaseExtended/firebase-arduino (library for firebase)

User Programmable Home Automation and Security System

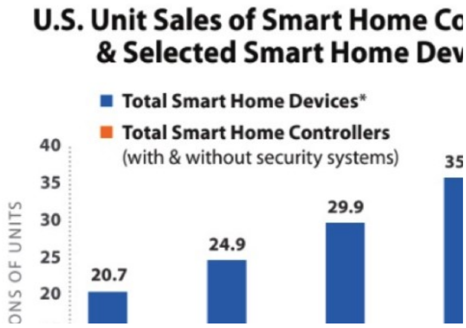
Swapnil Modani
Birla Institute of Technology
Embedded Computing and Signal Processing Laboratory
Armour R&D
Illinois Institute of Technology
Chicago, Illinois
Advisors: Dr. Jafar Saniie, David Arnold

Abstract: With the world moving drastically into the field of automation, and towards smart devices; the existing technology becomes irrelevant. To make the old devices smart and control them effectively and efficiently we build the Autovate Home Security and Automation System. The system has the following features: 1.Allowing to turn any device ON/OFF from anywhere in the world. 2.See the live sensor(temperature, motion, smoke, sound) from the real-time website. 3.Self program the website to control any device based on the sensor parameters. 4.View the live video of the environment in real-time on a webpage. 5.Motion Capture and Detection that sends the user an email with the recorded pictures and save the videos offline on the R-Pi.

I. INTRODUCTION

The world is drastically moving towards a smart IoT based environment where everything connects to the internet. The internet holds a great part in making things automated and enabling ease of use. With people relying more and more on energy, our system works to quench this need. Our model allows any device to become smart, therefore allowing old working technology to be modernized. This prevents the increase in accumulation of existing electronic waste-pile. There are many reasons why home automation still lacks the demographic. Some of these include: 1.Extremely expensive to procure setup. 2.Fairly complex to set up. 3.Requires smart devices to work. 4. Requires change in indoor decor setup. 5.Very rigid and not user based products.

As we all can see that the world is moving faster towards automation. The following study shows an accurate depiction of growth of home automation systems as well as security systems. When it comes to controlling home appliances and reading the indoor environment, our system ensures it using Advanced Encryption Standard (AES) - 256 bit .



(Fig1. Sales Recorded of Smart Devices)

The system also holds a secondary part that involves a Home Security System. This ensures a safe secure environment in the house that prevents break-ins,. The system doesn't store redundant video footage but only of the parts where motion is recorded. While the video gets recorded, pictures are taken parallely and send to the email with attached pictures captured. Along with the email, we also have a link sent out that once clicked on, can access the live footage of the room the setup was installed into.

As a part of the automation part, multiple sensors gather information i.e. sensor data and these are sent to the cloud using low power internet compatible microcontroller ESP8266 NodeMCU Firebase is a Backend-as-a-Service platform on Google Cloud Platform. The Firebase Realtime Database is a cloud-hosted database that lets you store and sync data between the users in real-time.

(Fig2. Applying capabilities of Google Firebase Platform)

The objectives achieved in this setup are as follows: 1. Use advanced low power microcontroller ESP8266

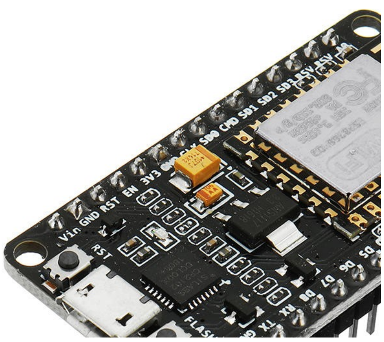
NodeMCU to collect data.
2. Prepossessing data before sending it to Google Firebase (Real-time Database)
3. Cloud computation to post process the data for multi-platform access.
4. Pulling the data from the cloud and displaying it on the website.
5. Giving access to the user to change the status of the plug based on temperature, sound, smoke, time and motion data.
6. Make a 3D printed model to house the electronics, components along with the PCBs.
7. Laser-cut transparent acrylic sheets for a see through view of the internal electronics and their connections.

II. METHODS

1. <u>Choosing the perfect microcontroller for this setup:</u>

It was mandatory to pick the ideal microcontroller for our project something that was economical but at the same time economical in order to make the setup as economical as possible. After much speculation, we chose to work with the ESP8266 NodeMCU board.

NodeMCU is an open source IoT platform. Which includes firmware which runs on the ESP8266 Wi-Fi Module from Espressif Systems,and hardware which is based on the ESP-12 module. The term “NodeMCU” by default refers to the firmware rather than the dev kits. NodeMCU firmware was developed so that AT commands can be replaced with Lua scripting making the life of developers easier. So it would be redundant to use AT commands again in NodeMCU.



2. <u>Sensors integration with the ESP8266:</u>

There are 4 major sensors involved, i.e. PIR motion sensor, temperature sensor, sound sensor and the smoke sensor. Each one was integrated with the microcontroller (ESP8266 NodeMCU) individually to ensure correct working of each sensor. The code for each sensor was written and checked with the respective sensor separately. There was extensive analysis done on each sensor module and their outputs were altered to meet our requirements.

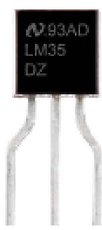
- **PIR Motion Sensor:**

PIR sensors allow you to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors.

(Fig3. Motion Sensor)

- **Temperature Sensor:**

Temperature sensor is a device which senses variations in temperature across it. LM35 is a basic temperature sensor that can be used for experimental purpose.It give the readings in centigrade(degree Celsius)since its output voltage is linearly proportional to temperature. It uses the fact that as temperature increases, the voltage across the diode increases at known rate(actually the drop across the base-emitter junction of transistor). Its disadvantage is its sluggish response.



(Fig4. Temperature Sensor)

- **Smoke Sensor**

This flammable gas and smoke sensor detects the concentrations of combustible gas in the air and ouputs its reading as an analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm.The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.

(Fig5. Smoke Sensor)

- **Sound Sensor**

Can detect the intensity of the sound environment, use note: the sound sensor can identify the presence of sound (according to the principle of vibration) or a particular frequency of sound does not recognize the volume of the sound. Sensitivity adjustable digital potentiometer to adjust.

(Fig6. Sound Sensor)

3. Local Host Setup (NodeMCU):

Before moving on to connect the hardware that is the Node-MCU to the internet, we implemented a smaller step i.e. to connect it to a local network and access data sent from the hardware to a device on the same network. This enabled us to implement data communication locally(for cases where user needs data only locally)

4. Cloud Communication Setup:

To get the data communication set up between the NodeMCU ESP8266 and the Google Firebase Platform, we started off by sending basic strings, integers and boolean values to confirm it's functionality. This was implemented successfully thanks to the detailed Google Firebase Documentation.

5. Integration with all sensors to the ESP8266 NodeMCU:

All the sensors were individually connected to the NodeMCU and their values were recorded on the serial monitor. These values were then manipulated according to our further process needs. Once the individual processes were completed successfully, we started to add one sensor at a time in order to bring them all into one microcontroller. But the problem came into the picture as we wanted all the sensors to be reading data parallely, so that there are no reading left ignored. Also a NodeMCU is equipped with only 1 analog pin that prevents us to work efficiently since we have multiple analog sensors. Therefore we switched into using two NodeMCUs for our setup.

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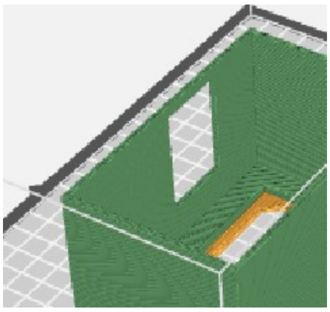

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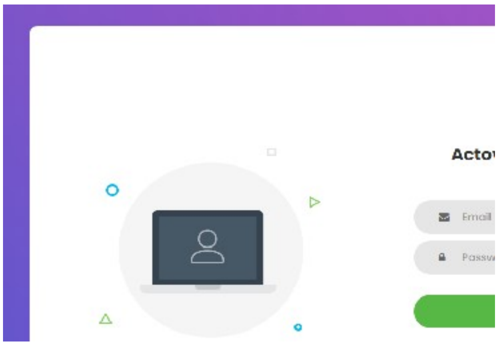

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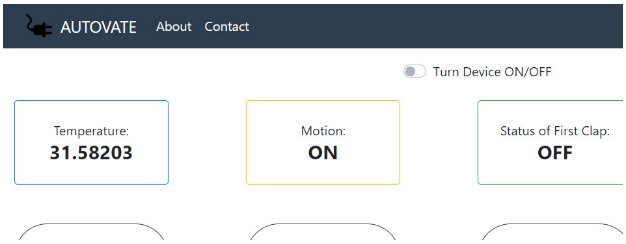

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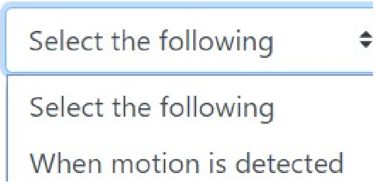

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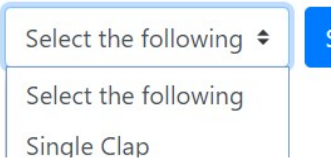

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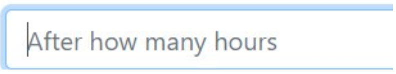

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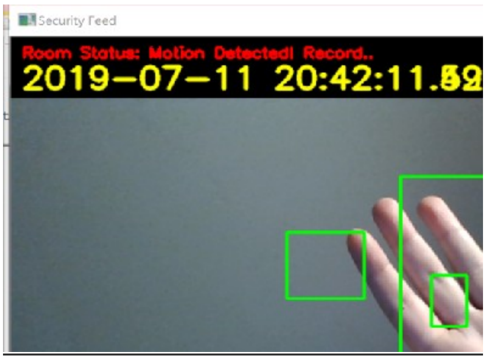
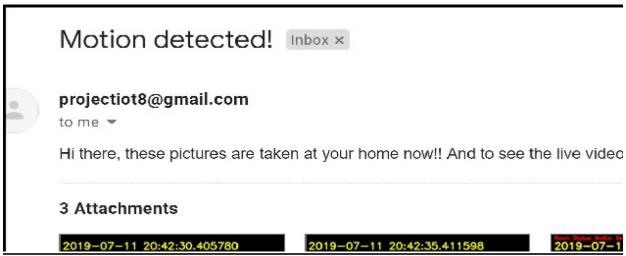
The motion detection worked flawlessly with a set threshold that did not detect small objects move like pets, or curtain. The process would only record the video when there was motion detected, otherwise there was no recorded video. Also there would be pictures taken parallely to the videos. These videos were then compiled and sent to the set email. This ensures the highest level of safety. This worked perfectly on a Raspberry Pi.



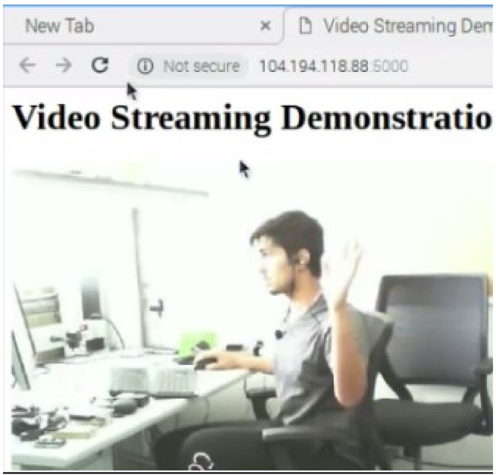
Each recorded frame is time stamped as well as the pictures that are taken. The pictures and the video are saved offline, and the pictures are mailed as mentioned before.

In the next figure we can see that the mail is received with multiple pictures and alerts the user about a break-in.



3. Live Stream:

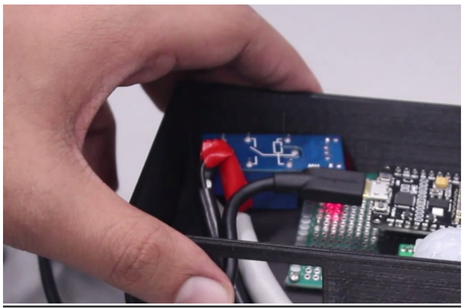
The live stream video worked remotely on a raspberry pi. The process used the concept of multithreading on the Python platform. Also the Python Flask was used to integrate the website with the python openCV file. This ensured multiple user login and anyone on the local network could access the view to live streaming. This ensured live video at all times and can be useful in many different scenarios.



4. Hardware Exoskeleton:

The 3D model of the system was made on AUTOCAD Inventor. The .STL file was exported from the software and uploaded to the maketbot software. This file was then converted to the .MAKERBOT file where all parameters for the print were defined too. The fan speed for the initial layer was set to be 0 and the surface of the print was glued perfectly. This allowed the print to occur flawlessly without any grating. Once the files were exported we fed it into the Makerbot Replicator + which printed out our model in about 4.5 hours.

The next part of the process was to laser cut the top and bottom lids. Since we needed these to be clear and see through to make it was exciting as possible, the dimensions were taken inCAD and exported. The .stl file was fed into a Laser Cutter where they came out perfectly.



IV. DISCUSSION

This truly is a concept much needed but not as prevalent. The world wishes to move to automation but is inhibited because of various factors like cost, setup, etc. This setup eliminates that hassle and works to give the user the best experience. Also considering the future aspects, since there is so much data collected from the sensors, we can apply machine learning algorithms to predict better. An app along with the website can be added to improve user interface.This could be added to other smart assistants like Google Home, Alexa, Bixby, etc.

V. CONCLUSION

The system successfully implements better, more advanced alternatives to existing technology that allows the user to control his/her home more efficiently. This setup allows users to make their home smarter without changing existing devices making it economical for commercial usage. This gives the power to the user and allows one to be the true controller of one's home.

VI. ACKNOWLEDGEMENTS

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VII. REFERENCES

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