IT Technology
Project Part 1 Report
Group 2 Solar Panel

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1 Abstract

Renewable energy plays a key role in fulfilling the needs for lack of energy and creating a carbon less future by reducing greenhouse gas emissions. Ever since, developing an efficient renewable energy solution has been the quest for securing energy supply that will meet global energy demands. Solar power harnessed directly from the sun is one of the most common, efficient ways of producing renewable energy and offers more freedom as the sun rises and sets on a predictable schedule.

Solar power is simply usable energy generated from the sun in the form of electric or thermal energy. Solar energy is captured in a variety of ways, the most common of which is with a photovoltaic solar panel system, or PV system, that converts the sun's rays into usable electricity. When the sun shines onto a solar panel, energy from the sunlight is absorbed by the PV cells in the panel. This energy creates electrical charges that move in response to an internal electrical field in the cell, causing electricity to flow[1]. The goal simply is to harvest as much energy as possible that the solar panel can produce.

Therefore, in the effort of increasing efficiency and maximizing energy production this report will focus on one of the issues when it comes to the limitation on solar panel movement. Finding solution for making sure the solar panels face the sun's direction and fundamentally program it to perform work in a specifically desired way that would maximize its energy harvesting capability.

2 Chapter Summary

The content of this report has presented the best available knowledge the project team has gained throughout the project. The Introduction chapter will give you an overview of what the whole project is about, it is preceded by the background of the project giving the reader a description of the development process based on the requirements that were specified in the beginning of the project work. The chapter also includes the problem statement that will be analyzed thoroughly with the goal of being able to find solutions by the end of this report.

The main topics that were discussed on this report will bring you to the areas wherein the group provided a thorough visualization of the whole system being built, use case that were utilized and talked about management, team structure and how it has helped in the development process of building the project. Included in the methodology chapter is a process where the group described the best ways of reproducing their work. Through Project Testing and software design the team showed the results gathered in the report. The development also discussed the challenges and gave insight into how the project might be improved in the future.

Finally, the conclusion answering the project problem statement and giving a summary of the knowledge and experiences gained throughout the development of the project work.

[1] https://earth.org/the-growth-of-renewable-energy-what-does-the-future-hold/

3 Introduction

This is Project Part 1 Report on Solar Panel from group 2. The report covers everything the students have learned during the semester and showcases the skills that have been developed over the course of the project. The report also builds on knowledge gained during the first and second semester.

The scope of the first part of the project is to create a solution whereby positioning of the solar panel is switched from being controlled by a joystick to a guided user interface as well as implementing a limiter to prevent excessive movements.
To be able to do this, the students will apply their knowledge in programming, electronics, embedded systems, and they are also going to utilize the combined skills they stand to gain from the PCB and electronics electives undertaken during this semester.

Be aware: This report was not written with a finished product, since this is a mid-way exam report and therefore a lot of features will be added after turning in the report, however, these features will also be described in the report.

4 Background Description

The solar panel is mounted on a rack which has two linear actuators; one controls north and south, and the other controls east and west.

The solar panel has nearly a full 360 degrees movement ability. It is connected to a controller that is using an old-school joystick capable of sending 4 signals, each containing a digital input of either 0 or 1 to control if the motor should activate or not.

Unfortunately, the solar panel is incapable of recognizing its limitations through the current control setup, meaning it is very likely that if there is any equipment or buildings around the solar panel, the solar panel would crash into it and damage itself and the surroundings.

Therefore, the scope of the solar panel project is composed of three parts:

1. Develop a way to make sure that the solar panel doesn't go out of its boundaries and hits other material around it.

2. Make a functional guided user interface, to control the solar panels linear actuators.

3. Make a functional tracking system making the solar panel able to follow the sun’s position during daytime.

In project part 1, the team members have chosen to focus on two of the three points which are the development of limitations system and making a guided user interface.
Afterwards, in the second part of the project, they are going to elaborate on the last subject, the tracking of the sun’s position.

5 Problem Statement

The 3rd semester students have been given the task of finding solutions for the current issues facing the Solar panel project, as described in the Background Description, one of which is the system not recognizing whether it is going too far in any given direction.

The issues have been divided into the following sub-issues to get a better understanding of the main problem:

- How to make a sub sensor that stops the system when it reaches the limitation?
- How to make it stop at the right time, since the linear actuators have no control?
- How can the guided user interface be made to replicate the movements of the joystick?

6 Definition of Purpose

The purpose of the report is to come up with solutions that will help UCL to have a more efficient and customizable movement for their solar panel. This is a two-part project, both of which will cover solutions given the several requirements involved.

The goal for the first part of the report is to create a) a solution that sets a limitation on the movement capabilities of the solar panel, by setting up safe boundaries for the solar panel's movement direction and b) to implement a solution whereby the manual joystick is replaced by a guided user interface.

7 Project Management

Every Tuesday during the project class, each group has an allotted time to have meetings with the lecturers where they discuss the requirements for each specific project's tasks, the lecturers are also giving advice on how to make the project easier and make sure the students are on track in following the timeline.
The students likewise have the opportunity to visit the lab and become familiar with the solar panel they are working on as well as ask questions of the teacher involved with the project.

After the meetings with the teachers, the students spent the rest of the day catching up with their group, where they discussed ideas, the feasibility of the project and made sure everyone had a clear understanding of the scope of the project required.

The group delegated tasks and depending on the difficulty, they would work together to figure out solutions.
They would also have a summary of the tasks each member has been doing every week.
This is a good way of catching up with everyone so that each of the members will have the same knowledge of each of the components of the project.

The group has been introduced to working on agile development, specifically SCRUM, over the last semester, so they have decided to continue working on this process framework over the course of

this project.

They also continue to utilize their knowledge of the Gitlab Issue Board, so majority of the files they have been working on are shared on a common platform project group in Gitlab.

As for communication during the project, they will be using their own discord server and a specific server created by the students working on the same project with Solar Panel, this is very helpful in providing an avenue for sharing ideas and resources with the other students' part of the project.

In case of emergency or technical difficulties and faster means of communication, the group also created a Facebook messenger group purely for this purpose.

8 Team Structure

Building up the team structure for this project happened to be quite a challenge at first, the group members came from a bigger group, thereby having to work in a smaller group would mean less workforce for the big task that the project required.

Additionally, the team has been hit by a great deal of sickness and family matters.
Due to this, the team members have only been able to meet up and work together as a group a couple of times.
But they are hopeful that things will get better eventually, given that they must work even harder for the second part of the project.

Therefore, building the team structure has been mostly put in the hands of the team members that were participating in the lectures.
In this case every member is given the role of project manager responsible for different areas of the project, thereby utilizing each person’s strengths and allowing them to use any prior knowledge they can add for the benefit of the project.
Through this the work management of the team will be done as efficiently as possible taking into consideration each person’s difficulties and private situation.

9 Requirement Draft

After talking to the teacher involved with the Solar Panel Project from UCL, several requirements have been made clear to the project group, which were put in place before the start of the project, and in order to complete them, the overall project was divided into two parts.

Each part consisted of several attainable goals, namely:

- A limiter, sub sensor that controls the actuator from reaching the limitation in each direction, and a manual control in case of damage or repair.

- A sun tracking sensor, that outputs four digital signals to generate the most energy base on the position of the sun.

- Possibly, Data measurement for power with output created on an interface.

10 Block Diagram

A block diagram provides a functional view of a system. Block diagrams give a better understanding of a system's functions and help create interconnections within it. They are used to describe hardware and software systems as well as to represent processes. Block diagrams are described and defined according to their function and structure as well as their relationship with other blocks.
It is generally used when the visualization of information or control flows is important – or when processes are involved. In this way it can represent complex algorithms or flows of information or communication among individual components within a large system. A graphical representation is often easier to understand than a textual representation.[2]

Below is the overview of the system, for the first requirement, the system that is going to be built will look as follows:

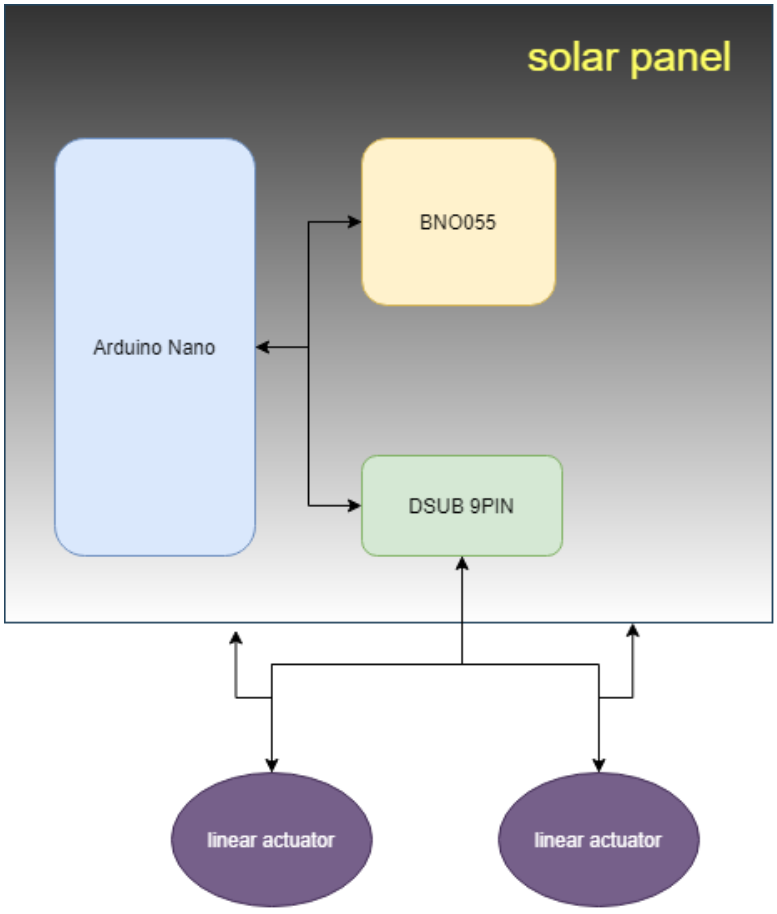

Figure 1: Block Diagram of the system

Reading from the top to the bottom:

- Sensor module BNO055 - attached to the Arduino AVR board (Nano). Together they will be assembled on a board with some LEDs and buttons and will be placed on a box that will be mounted behind the solar panel.

[2] https://www.microtool.de/en/knowledge-base/what-is-a-block-diagram/

- A connection will be made using a DSUB 9PIN from the board that will be connected to the controller box of the solar panel that has two linear actuators.

- Finally, incorporating a custom guided user interface that uses Processing, to be implemented to the code, from the computer which controls the system.

11 Use Case

Use case is a great way of presenting ideas, by presenting simple information, it makes it possible for readers to understand the logic behind the system. By emphasizing the perspective and user goals, the readers will get an idea to whom the system is built for, the goals involved and different scenarios that are involved, instead of simply asking for a list of system features, but without overcomplicating the idea.

Here the group will explain the key idea of the use case based on the requirements of the project.

11.1 Actor context

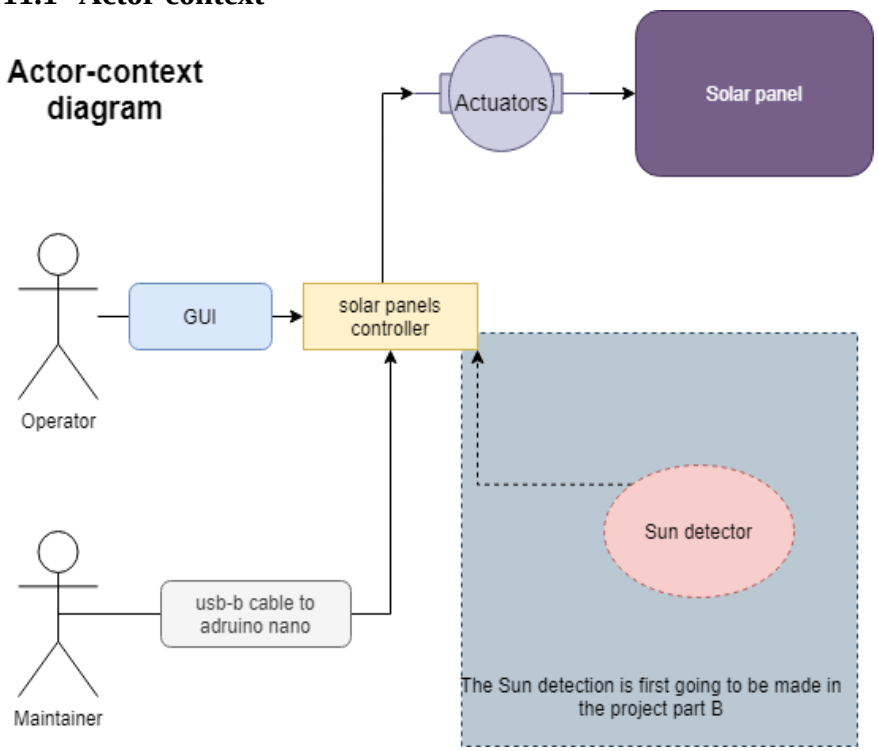

Figure 2: Use Case

As shown in the context diagram above, the operators of the solar panel will now be able to plug their computer into the mini USB and control the solar panel directly from their computer via the guided user interface that the students have created.

The maintainers of the solar panel will have to connect directly into the arduino, to have the possibility of uploading code or see what is happening with the programs that are running.

12 Overview of Hardware Components

In order to accomplish the goals of the system the group has been attempting to acquire, several components which had to be purchased before the work of the project could begin.

Luckily enough, the students are using the same components that were required for use in the Advanced Electronics elective course, which meant the project could begin earlier than would have been possible without said elective course.

12.1 Components.

The hardware components which are being utilized in the project are as follows:

12.1.1 Arduino AVR Board – Nano Every

The group has chosen to work with an Arduino Nano Every, since as mentioned, they are using it for a similar project they are working on for a different course, and it was therefore available for use in the project and compatible with the requirements given by the problem statement.
Furthermore, it is one of the smallest microprocessor boards available on the market, and it is compatible with the breadboard that the students are using to make the prototype.
The Arduino Nano Every is using an ATMaga4809 Processor.
It has an operation voltage of 5 Volt, it has 5 PWM PINS, 8 ANALOG INPUT PINS. Furthermore, as seen in the matrix below it is more than enough to satisfy our processing power for this project.

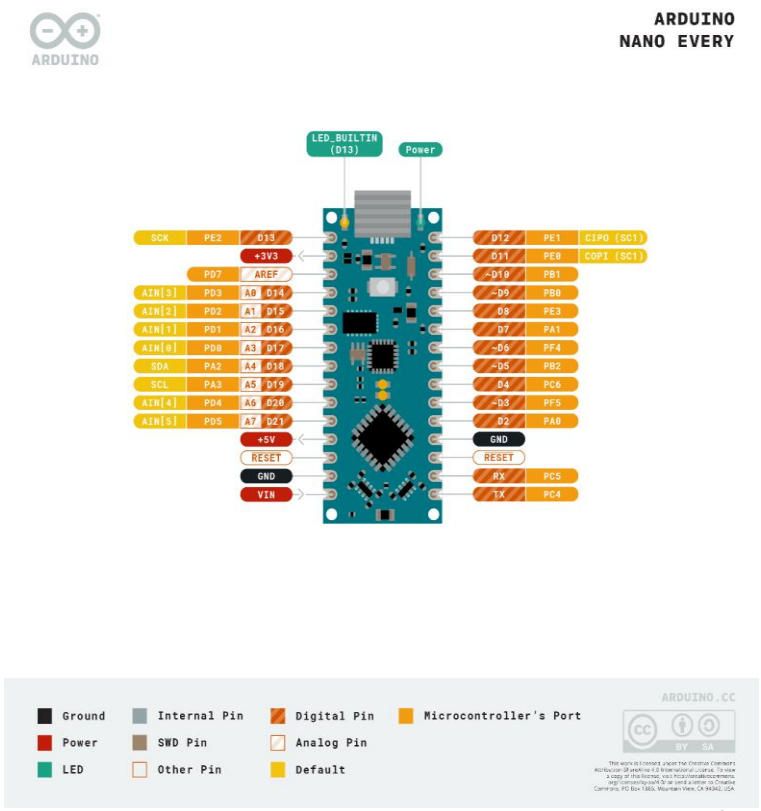

Figure 3 : Arduino Nano Envy, Picture is from here [3]

[3] https://store.arduino.cc/products/arduino-nano-every

12.1.2 Technical specifications for Nano Every

MICROCONTROLLER	ATMega4809
OPERATING VOLTAGE	5V
VIN MIN-MAX	7-21V
DC CURRENT PER I/O PIN	20 mA
DC CURRENT FOR 3.3V PIN	50mA
CLOCK SPEED	20MHz
CPU FLASH MEMORY	48KB
SRAM	6KB
EEPROM	256byte
PWM PINS	5
UART	1
SPI	1
I2C	1
ANALOG INPUT PINS	8 (ADC 10 bit)
ANALOG OUTPUT PINS	Only through PWM (no DAC)
EXTERNAL INTERRUPTS	all digital pins
LED_BUILTIN	13
USB	Uses the ATSAMD11D14A

12.1.3 BNO055

This is a 9-axis orientation device which has an accelerometer, gyroscope and magnetometer.
After a bit of research into this component our team quickly realized that this was the way to go.
Not only is BNO055 precise, but you also have the possibility to view it in a 3D space orientation which would be a nice addition to the project.
Enabling the ability to see the actual solar panel move around on the screen at the same time it that is also moves in the real world, will open a lot of possibilities for visualization.
But for now, the project will only be utilizing the accelerometer and gyroscope because the project group has not discovered a use for the magnetometer within the scope of the project.

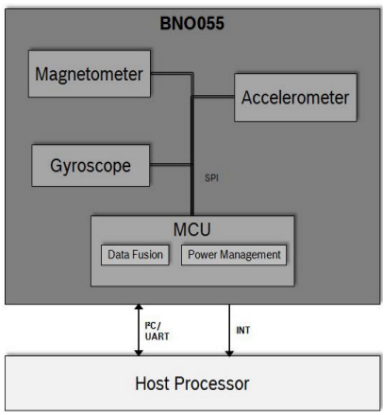

Figure 4: Picture of block diagram is from: BNO055 Data sheet

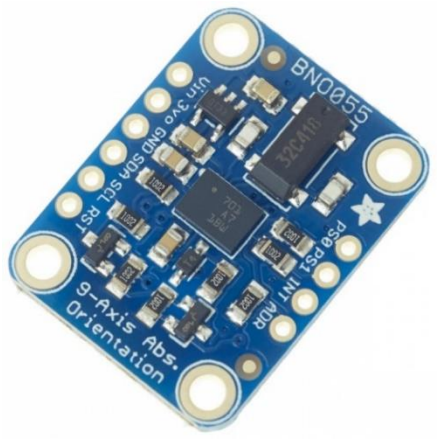

Figure 5: Picture is from this website[4]

13 Guided User Interface (GUI)

Figure 6: Guided User Interface

In order to create the guided user interface (GUI), the team used a program called processing.
The idea of the design should be simple and easy to understand for anyone looking at it.
For this, a GUI with a simple window which can do five things was created.
Four buttons visualizing, its ability to go in either an upwards or downwards direction on one axis, and equally left or right on the other.
Lastly, it can be programmed to stop for safety purposes.

[4] *https://www.tandyonline.com/adafruit-9-dof-absolute-orientation-imu-fusion-breakout-bno055.html*

Furthermore, if for some reason something goes wrong with the code, it is possible to give a full-stop command, that stops all signals going to the Arduino Nano.

In the future, it would also be good to implement an additional feature, for example, a drop-down window for further options, one being the possibility to visualize the calibration and view how many degrees the solar panel is turned in each direction.

14 Software Design

The project group used C++ to construct the code for the control system of the GUI and BNO055. This translates into all the code that the team has utilized in this project has mainly been C++, However, to make use of the virtualization of the solar panel, use of Python is required.

14.1 Nano Every Code

Seen below is a sample from the code controlling the limitation of the motors based on the input from the BNO055.

```
// Safety code based on the BNO mesurements. ment to protect the solar panel
from breaking the motor.

  if(thetaG > taG_UPPERBOUND) {
    digitalWrite(10, LOW);
  } else if(thetaG < taG_LOWERBOUND) {
    digitalWrite(9, LOW);
  } else if(phi > phi_UPPERBOUND) {
    digitalWrite(8, LOW);
  } else if (phi < phi_LOWERBOUND){
    digitalWrite(7, LOW);
  }
```

Seen below is a sample of the inserted high-pass and low-pass filter in the code.
This is to ensure that the output data from the BNO055 is the most precise it can be.
Since the gyroscope is unreliable in times where there has been no movement in the system, over a long period of time this can make the BNO055 think that it has been drifting.
Therefore, it is important to rely more the data coming from the accelerometer in the times where there is no movement, and then rely on the gyroscope when there is movement.

```
thetaM = -atan2(acc.x() / 9.8, acc.z() / 9.8) / 2 / 3.141592654 * 360;
phiM = -atan2(acc.y() / 9.8, acc.z() / 9.8) / 2 / 3.141592654 * 360;
phiFnew = .95 * phiFold + .05 * phiM;
thetaFnew = .95 * thetaFold + .05 * thetaM;

dt = (millis() - millisOld) / 1000.;
millisOld = millis();
theta = (theta + gyr.y() * dt) * .95 + thetaM * .05;
phi = (phi - gyr.x() * dt) * .95 + phiM * .05;
thetaG = thetaG + gyr.y() * dt;
phiG = phiG - gyr.x() * dt;
```

The rest of the code can be found in appendix 1.1

14.2 GUI Code

Below here displays the code for each button that tells the Arduino to send a signal to the motors.

```
void UP(){
  port.write('u');
}

void RIGHT(){
  port.write('r');
}

void LEFT(){
  port.write('l');
}

void DOWN(){
  port.write('d');
}

void STOP(){
  port.write('s');
}
```

The rest of the code can be seen in appendix 1.2

15 Project Testing

The project testing has mostly been put in the hands of the team members.
A significant part of the testing has been done by the team members out of a breadboard.
To give an example, testing has been done to show how the limitation systems work.
Additionally, they have looked at the solar panel to confirm that the project solution can be attach firmly to the frame so it will be fastened in a way that it would not move, and it is placed securely, so in the event of a unit failure, the project will not fall off.

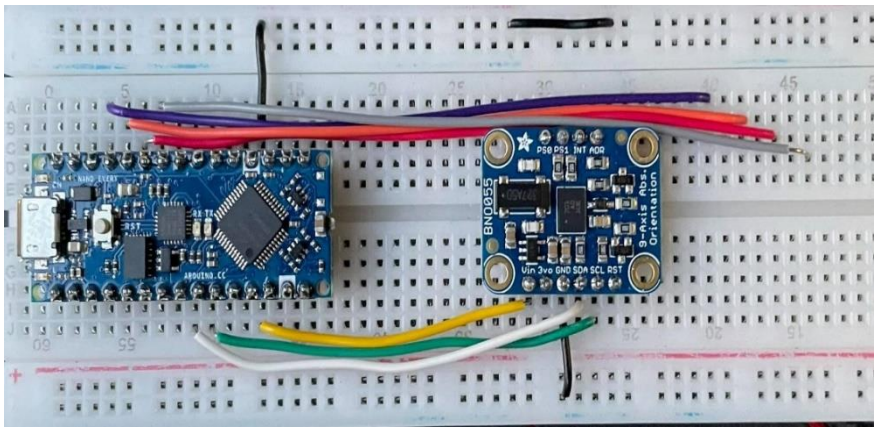

Figure 7: Here we have all the components built on a breadboard

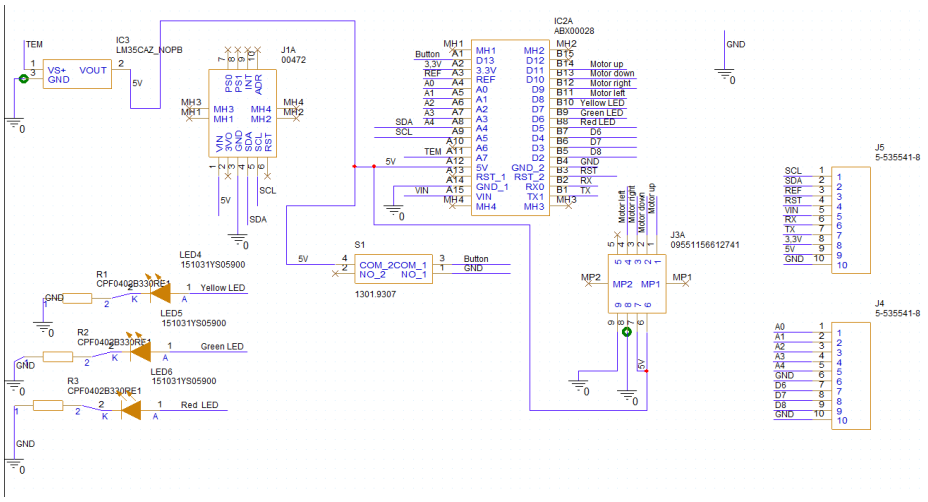

Figure 8: This is the schematic diagram of the whole system we are currently building

As mentioned in the first step of testing, the project solution is done by building it on a breadboard, and possibly drawing the schematic diagram as shown on the images above.

This is to ensure that everything is functioning as intended with the components and the circuit. Afterwards, the system can be tested independently by coding on the Arduino Nano Every connected to BNO055 to make sure that it can complete the task it is built to do.
At the same time continuously testing in order to try and catch any unexpected errors that might occur when the system is being put together.

Once the circuit has been tested on the breadboard, it can then be placed on the Solar Panel and final adjustments can be made to it with the controller box and troubleshooting while adding and testing the code for the GUI.

At this moment in the project, most of the tests that have been done have mainly focused on the software part as well as testing the physical parts for exposed wires and defective components.

Once the whole project is completed, the group plans on implementing further improvements through user testing by letting people outside the group test the working system. Afterwards, the members will then observe possible errors and make sure to take note of a more efficient way of troubleshooting.

A video is of testing the system can be seen here[5].

The complete system test and full image views can be found in appendix 2

16 System Recreation

This guide consists of step-by-step instructions, it has been made to provide any person willing to recreate the system with the capability to do so.

[5] https://www.youtube.com/watch?v=tv00NfjB46c

Inventory

Hardware:

- Arduino AVR board – Nano Envy
- BNO055
- Cables/Wires
- LEDs

Software:

- Processing (For the GUI)
- Arduino IDE
- Libraries
  o Adafruit Unified Sensor
  o Adafruit BNO055

Protocols:

- Programming Language
  o C++

16.1 Software

For interaction and uploading code to the Arduino Nano the Arduino IDE was used.
So, start by installing the Arduino IDE[6] from their website.
Then add the libraries needed for this project by clicking on **Tools > Manage Libraries**.

In the library manager search for **Adafruit BNO055** and install it, if prompted for installation of dependencies press accept, this should include the **Adafruit Unified Sensor**, if not search for this and install that too.
As for the GUI install Processing[7] and extract it to its own folder.

[6] https://www.arduino.cc/en/software
[7] https://processing.org/download

16.2 Hardware

For hardware connect the Arduino Nano, the BNO055 and the D-SUB9 into one circuit.

16.2.1 Wire connection guide

In the diagram below is the wire connection setup for the for recreation of this project, it must be followed otherwise the code will not work.

Arduino nano, pin D10	**D_SUB, pin, 1**
Arduino nano, pin D9	**D_SUB, pin, 2**
Arduino nano, pin D8	**D_SUB, pin, 3**
Arduino nano, pin D7	**D_SUB, pin, 4**
Arduino nano, pin 5V	**BNO055 pin, VIN**
Arduino nano, pin A5	**BNO055 pin, SDA**
Arduino nano, pin A4	**BNO055 pin, SCL**
Arduino nano, GND	**BNO055 pin, GND**
Arduino nano, GND	**D_SUB, pin, 6**
Arduino nano, GND	**D_SUB, pin, 7**

Figure 9: Wire connection information

16.2.2 Visual wire connection guide

For a clear version of the connections, a visual guide is provided for an easier way of replicating the hardware components of the system.

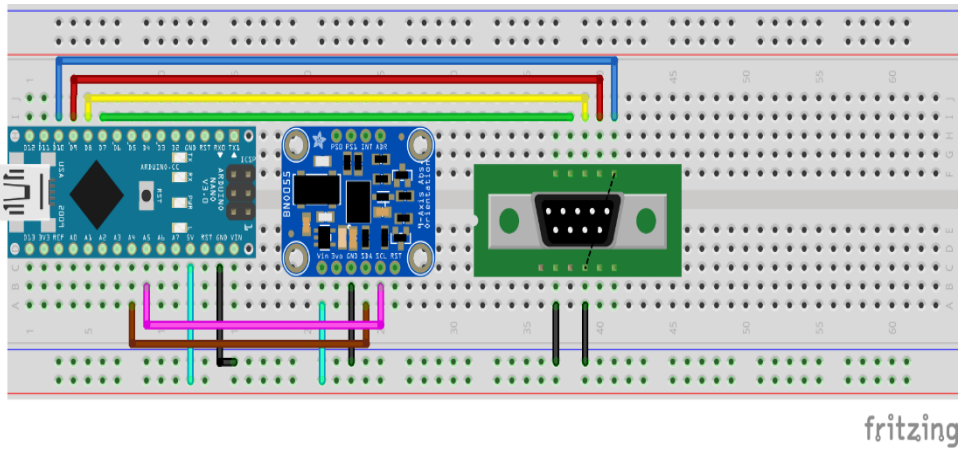

Figure 10: Components built on fritzing software program

16.3 Code

For the code used on the Arduino Nano, copy the code from appendix 1.1 and paste it into the Arduino IDE, then make sure to select the right COM port under **Tools > Port** and then press upload.

As or the GUI copy the code from appendix 1.2 and paste it in the processing.

17 Risk Analysis

Risk is made up of two parts: the probability of something going wrong, and the negative consequences if it does. Risk can be hard to spot, however, let alone to prepare for and manage. And, if hit by a consequence that is not planned for, costs, time, and reputation could be on the line. Similarly, overestimating or overreacting to risks can create panic, and do more harm than good. This makes Risk Analysis an essential tool. It can help identify and understand the risks. In turn, this helps developers manage these risks and minimize their impact on the plans. By approaching risk in a logical manner, the project team can identify what they can and cannot control and tackle potential problems with measured and appropriate action.[8]

This part of the project, the group will study the potential risks involved in doing the project, and how the uncertainties will affect it.
Here are some of the risks that the team has analyzed that could have the potential of changing the course of the project, and the possible solutions for them.

1. Since the pandemic is still not 100 percent over, there is still a possibility for another lockdown.
   The group will take in the factor of having to work at home and be available for communication online.

2. Another issue is the limited time the team can work with the system, especially considering that a lot of the 3rd semester students have chosen to work on this specific project.
   The project group must maximize the time that they have been given since they cannot all work physically on the solar panel at the same time.

3. If the unit has been calibrated in a wrong way, the group would waste a lot of time redoing the measurement.
   So, they need to make sure that they get it right the first time and done correctly and consistently each time so the room for error will be as low as possible.

4. The project being too big to handle for a short span of time.
   To be able to overcome this, they must make sure to allocate the task with a clear goal and deadline in mind, set an honest expectation to reach each milestone.

[8] https://www.mindtools.com/pages/article/newTMC_07.htm

18 Milestone

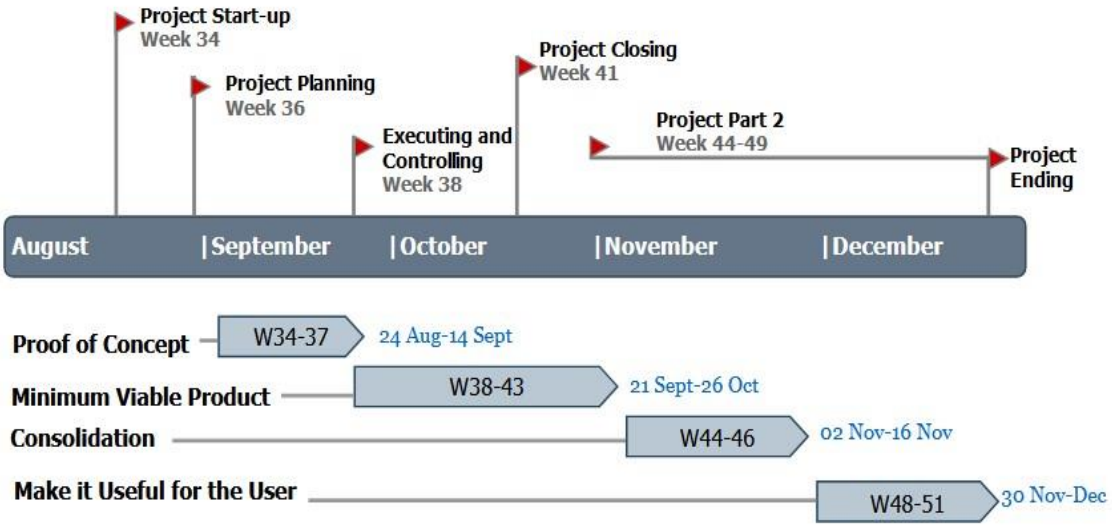

Figure 11: Milestones of the project

Before starting any kind of project, it is always a good idea to create a plan, break each of the components into smaller tasks to be able to monitor it efficiently, and set up a deadline or a timeline to achieve.
In the project's case we called it milestones.
The figure above shows the stages in the project's development.

In the Proof-of-Concept Phase (POC): This is where the group started planning and determining if the idea is feasible given the requirements involved.
Data gathering and analyzing were done and what components to be used and purchased were completed.

The next stage of development involves the Minimum Viable Product (MVP): This is the phase where the minimum core features of the first part of the project was defined.
During the Executing and controlling of the project, the group started creating the logical design and building the components together, making sure the hardware and software parts communicate and function as intended in preparation for closing this stage of the project.

Consolidation: Here is where the second part of the project starts, this is the part where we determine the solution for the additional requirements of the project, we can say that it is solving a different problem but not entirely different as this is the stage where the functionality is expanded to include more features that will make the entire project complete.
The stage where we combined the first part with the second part of the project and made them into a single more effective or coherent whole.

Finally, for the last phase of the project, making it useful for the user is the intended goal.
The phase where documenting, testing and recreation are completed, making sure that the project is ready to be presented to the users and company involved.

19 Challenges

There have been some minor issues that the team has encountered along the way, including but not limited to:

Covid

The Covid-19 Pandemic has cause for concern, even though everything is slowly going back to normal, the looming threat of another lockdown occurring has been the cause of much worry and anxiety to most of the group members.

Adjustment

Having been working and coordinating with the team virtually over one and a half semesters has required team members to adjust to the new environment of being back physically in a classroom format.

Another adjustment that has been made was transitioning to a smaller group with working on a project, after having been used to working with more than twice the number of current members.

Coding Language

Another challenge that the group has not anticipated before starting the project is having to familiarize themselves with another coding language without prior experience working with C++. The team was left with no choice because the components they were using required to code with it, therefore they must use the language even though they would have preferred to use Python if possible.

20 Future Improvement

After the first part of the project has been completed, the next thing to consider is ways to improve the system being built.
Therefore, the group thought about several ways of expanding the product.
Those that are considered realistic without jeopardizing the timeline for the second part of the project. Also evaluating if the new feature that will be added is necessary before implementing it.

To improve the system there are a few points worth mentioning.

1. Installation of a button which will allow for easier calibration to the limit stops of the solar panel with a simple push of a button, instead of a maintainer manually going in and inserting the data into the code. This will make the code more user friendly and easier to install.

2. Installation of LEDs which will allow the operators to see if the BNO055 are correctly calibrated and shows if there is any failure in the electrical circuit or the software, after consideration off these details the team believes that 3 LEDs would be sufficient to complete that purpose

3. In the GUI there should be a way to set the solar panel into maintenance mode which means that the solar panel would be placed in such a way that it is easy to get to all electrical components and to do maintenance on the panel.

4. Connection of a wireless module such as a Wi-Fi module would be sufficient, so you did not have to connect physical cable to get control

5. And as mentioned, this is a two-part solar panel project, for the second iteration, the team will incorporate the last requirement for the system, which is solar tracking.

21 Gitlab Project Page

Over the course of education, the students have been using a Gitlab repository for file sharing and workload distribution using issues management, within the students' respective teams.

Therefore, for this semester's Project work, a GitLab page has been created specifically for these purposes. This is done to create an easier overview of the different parts of the project for easier monitoring of progress and efficiency in group work.

For more information about the teams' progress in doing the project work, all the documentation is organized into separate folders like Coding, Documentation, etc., The GitLab project page can be found here[9].

22 Conclusion

For the first part of the project, we managed to program a guided user interface using C++ to control the directions of the solar panels, capable of directing the solar panel both horizontally and vertically to specific parameters, thereby replacing the cumbersome joystick, where the users are forced to assess the direction of the solar panel.
We also managed to implement a limiter, that makes sure the solar panel does not exceed its limits nor bumps into its surroundings, causing damage to itself of the surrounding objects.

Furthermore, we can say that the project ended up a bit harder than expected. There were challenges and issues that the team encountered. For one, starting a project with a specific problem to be solved has given the team less flexibility. Also given that there were a lot of requirements involved for a limited time. Making sure each functionality will be feasible for each stage of the project has proven to be a challenge, since we must work with a smaller group than we were used to.

The good news is that we used this hurdle to plan better and divide the task more efficiently, we learned that there is nothing than a good organization can solve. Through this, we were able to reach our milestones as intended so far. Additionally, we were able to put together different skills that we have been using and practicing in our different courses we have this semester. It has been very nice to incorporate the exercises from advanced electronics and PCB on our project. Because of that we were able to save financial resources and time.

[9] https://gitlab.com/21a-itt3-project-student-group/itt3_solar_panel_group2

Despite the roadblocks, the team came together so in the end they will be able to present a minimum viable product with an actual functioning system, that will later be expanded to include the solution for the second part of the project which they will work towards completing by the end of this semester.

Looking towards the far future. The group is excited to complete the project as it opens a lot of possibility like branching into the solar panel market, and by being able to find solution for the existing problem would be a feat that will allow consumers to replicate and/or improve upon the product.

23 Literature

Webpages:

https://earth.org/the-growth-of-renewable-energy-what-does-the-future-hold/
https://www.microtool.de/en/knowledge-base/what-is-a-block-diagram/
https://store.arduino.cc/products/arduino-nano-every
https://www.tandyonline.com/adafruit-9-dof-absolute-orientation-imu-fusion-breakout-bno055.html
https://www.youtube.com/watch?v=tv00NfjB46c
https://www.mindtools.com/pages/article/newTMC_07.htm
https://gitlab.com/21a-itt3-project-student-group/itt3_solar_panel_group2

Additional links used for resources:

https://www.mindtools.com/pages/article/newTMC_07.htm
https://toptechboy.com
https://www.hackster.io/hardikrathod/control-arduino-using-gui-arduino-processing-2c9c6c
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https://youtu.be/_6QIutZfsFs/
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