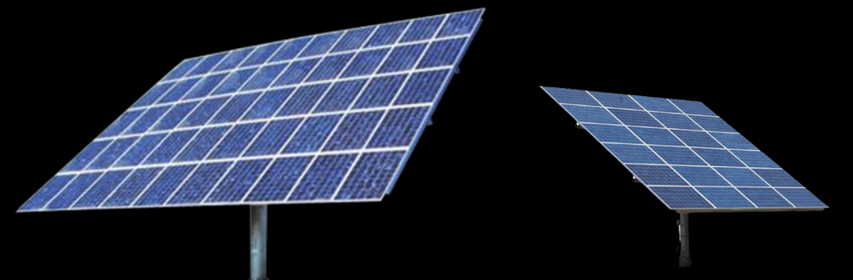
Amped Up Solar Panels

Building a Dual-Axis Solar Tracker Enabled by a Gradient Boosting ML Model to Increase the Electricity Generated by Solar Panels



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Introduction & Background

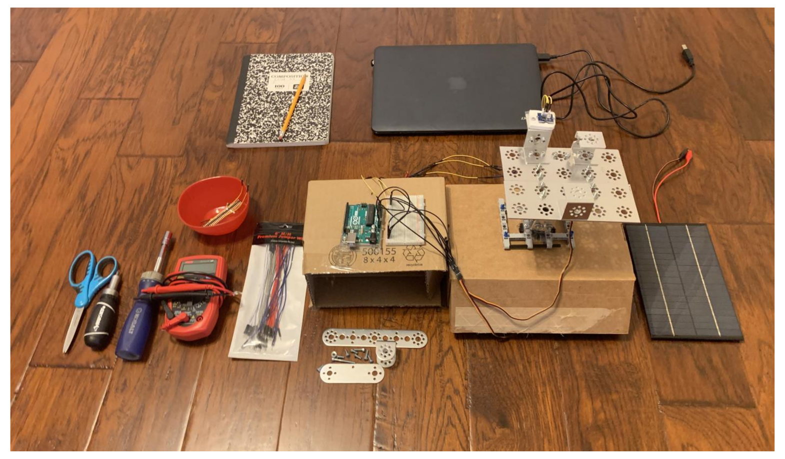
Solar energy is one of the most widely used sources of alternative energy. Although new advancements have made solar panels more efficient and cost effective, they have not been used to their full potential, so fossil fuels remain the largest source of electricity. Tilting the panel towards the sun is a simple way to ensure maximum sunlight reception throughout the day. The purpose of our project is to maximize the amount of electricity generated by solar panels using a smart dual axis solar tracker. By using machine learning to predict solar output, we can decide the optimal times to tilt thereby lowering the energy consumption of the robot to increase the net electricity generated.

Engineering Goal

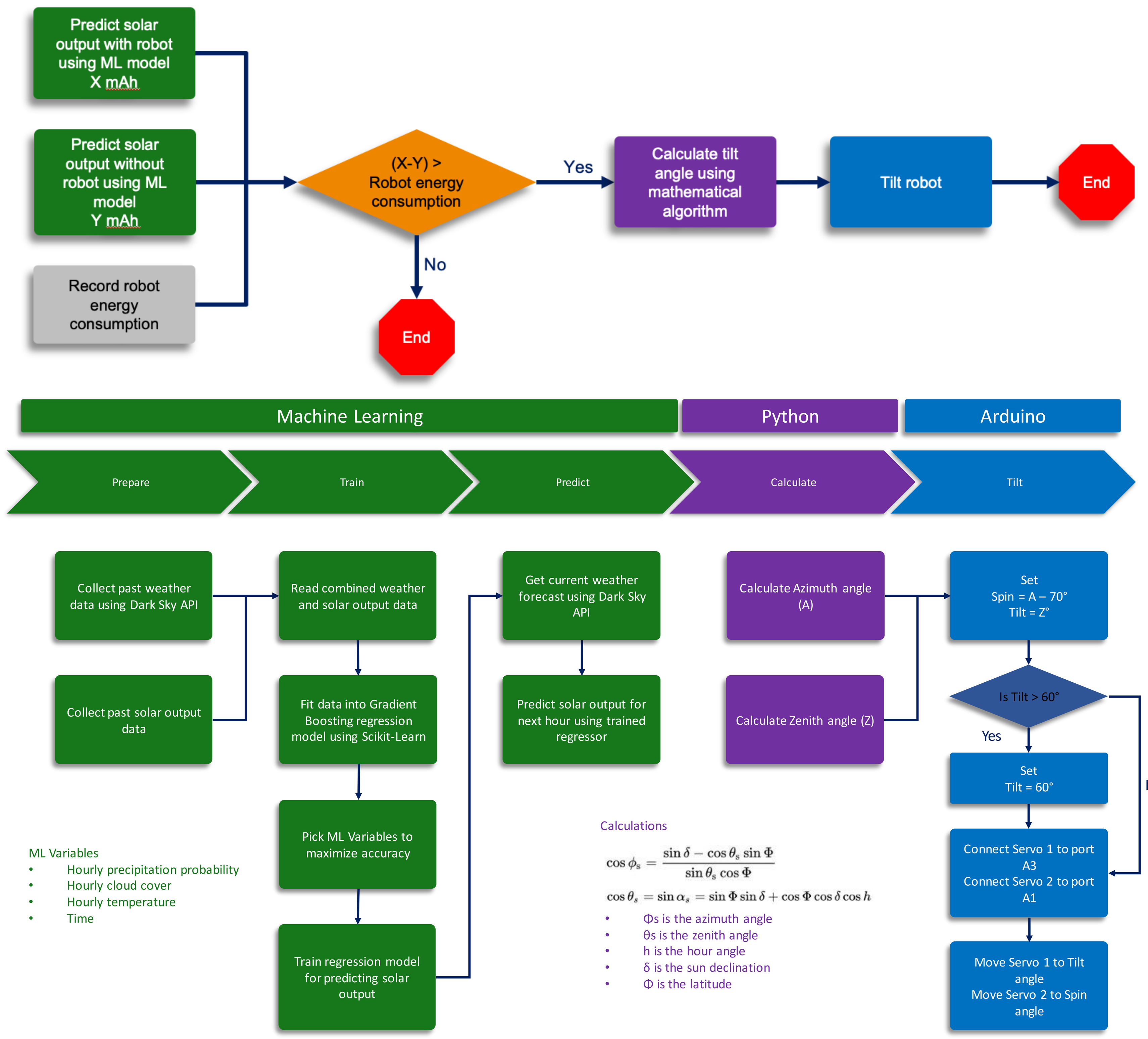
The goal for the dual-axis solar tracker is to increase the net generation of electricity by improving the accuracy of the tilt angle and optimizing consumption with machine learning. The expectation is the electricity generated, measured in milliamp hours, by the dual axis solar tracker, will be double the amount generated by a flat solar panel.

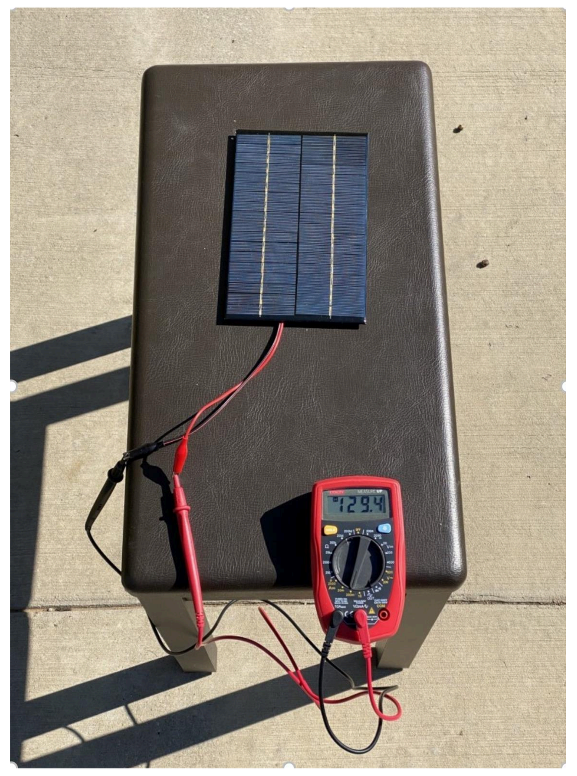
Materials

- 4.2W 18V (20 x 13 cm) Solar Panel (2)
- Ammeter
- Arduino Uno with power cable
- Hitec Servo HS – 485HB & horn (2)
- Breadboard
- Jumper Wires Male-Male (8)
- Jumper Wires Male-Female (3)
- TETRIX MAX Building Plate 4x5
- TETRIX MAX Channels 1x1 (3)
- TETRIX MAX L Brackets (5)
- TETRIX Screws & Nuts
- LEGO Beam Frame
- Computer with Arduino Software
- Screwdriver
- Velcro
- Small cardboard box
- Stool (2)
- Gyro Sensor



Flow Chart

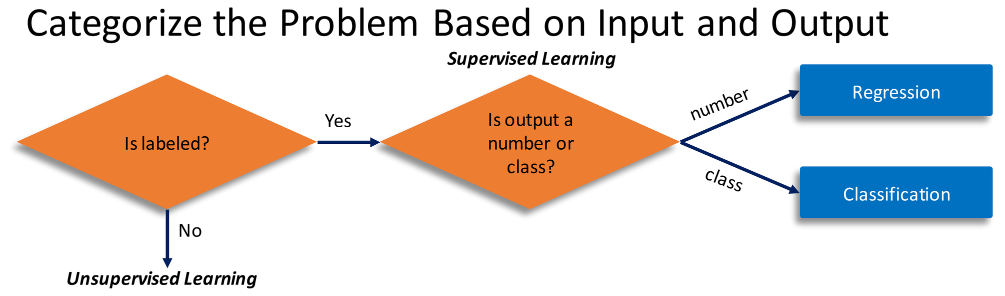




Machine Learning Model Analysis

How to Pick the right ML Model?

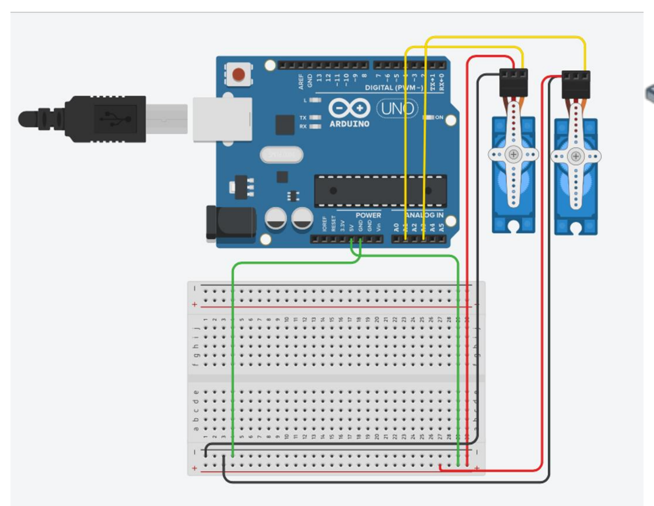
1. Understand Your Data
   - Look at summary statistics
   - Correlations indicate strong relationships
2. Clean Data
   - Deal with missing values & outliers
3. Curate the Data
4. Categorize the Problem Based on Input and Output

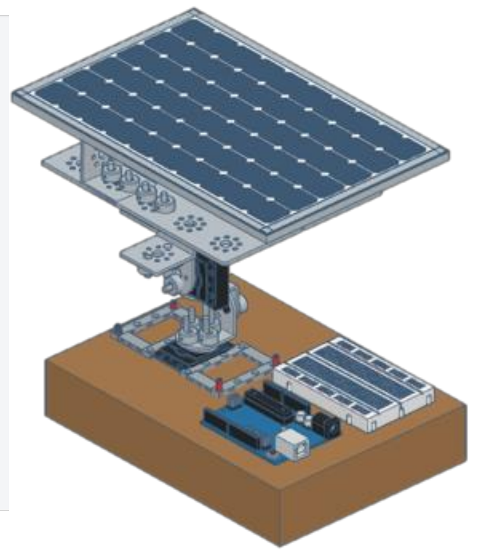


5. Find Your Algorithm by Comparing Accuracy

	Linear Regression	Nearest Neighbors	Decision Trees	Ensemble
Definition	**Ordinary Least Squares** minimizes the sum of the squared residuals between observed data points	**K Nearest Neighbors** is the weighted average in a neighborhood with distance (k)	**Decision Tree** represents each outcome as a branch	**Gradient Boosting Regression** builds on decision trees to produce a powerful ensemble
Accuracy of solar output prediction using Scikit-Learn	32%	53%	88%	98%

Circuit Diagram & 3D Model





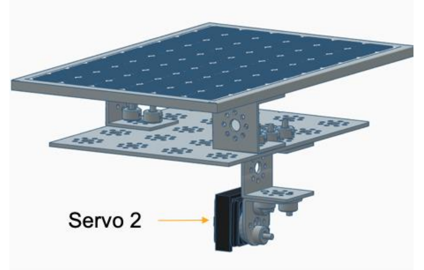
Procedure

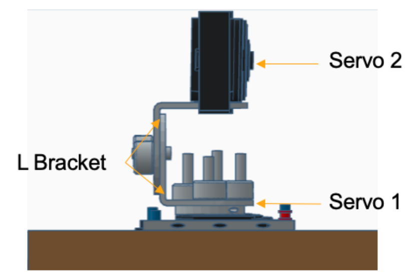
Construction

1. Attach Servo 1 horn to the L Bracket using screws and nuts
2. Make a cardboard cutout for Servo 1 and secure it using LEGO frames
3. Secure an L Bracket onto the bottom of Servo 2 using Velcro
4. Connect the L Brackets on Servo 1 and Servo 2
5. Attach Servo 2 horn to a plate using a MAX Channel and an L bracket
6. Attach two MAX Channels to the plate and tape the solar panel onto the MAX Channels

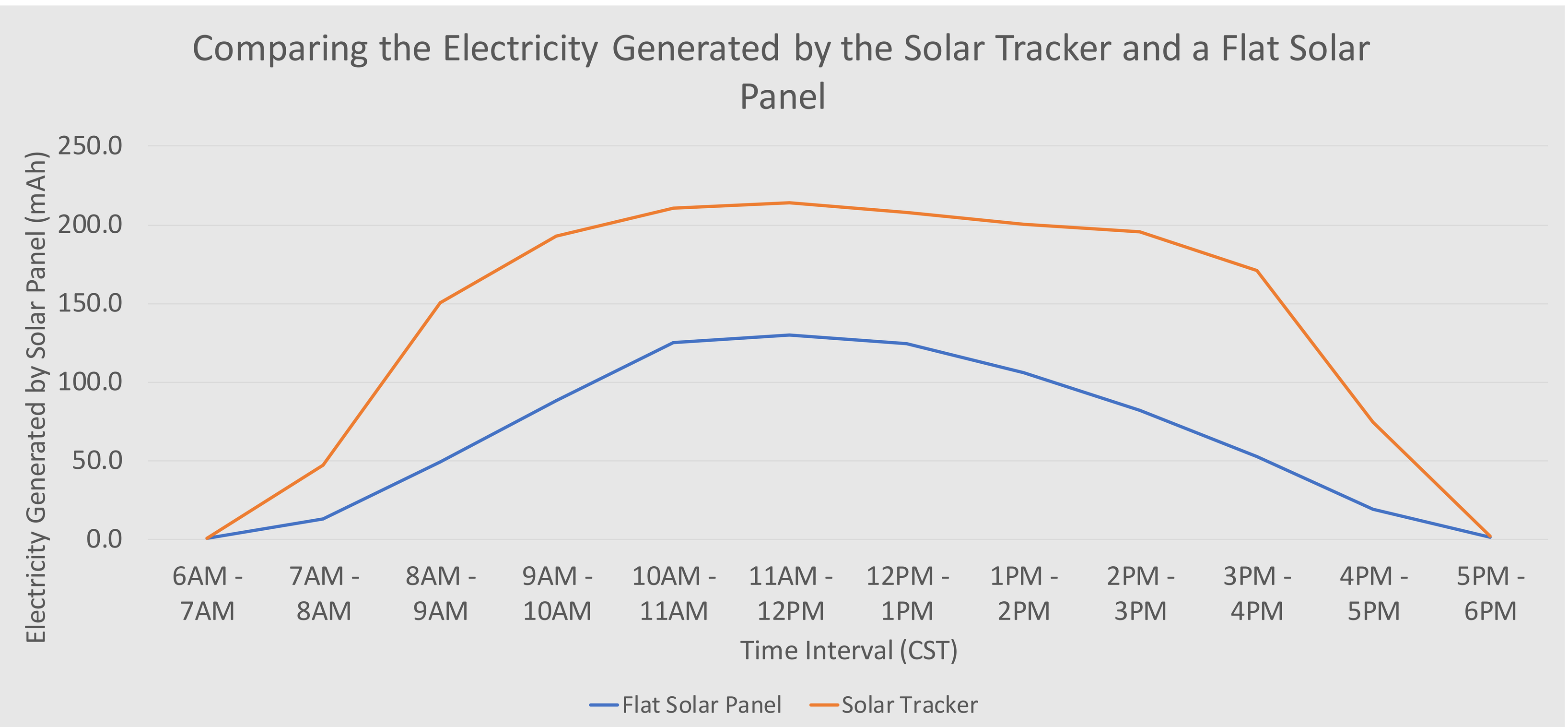
Data Collection

1. Place the solar panel on one stool and solar tracker on another from 6:00 am to 6:00 pm.
2. Run the machine learning algorithm.
3. Based on the prediction, robot tilts toward the sun.
4. Connect the leads of the solar panel to the black and red wires of the ammeter and record the milliamps (mA).
5. Repeat steps 2-4 every hour until 6:00 pm for multiple days.

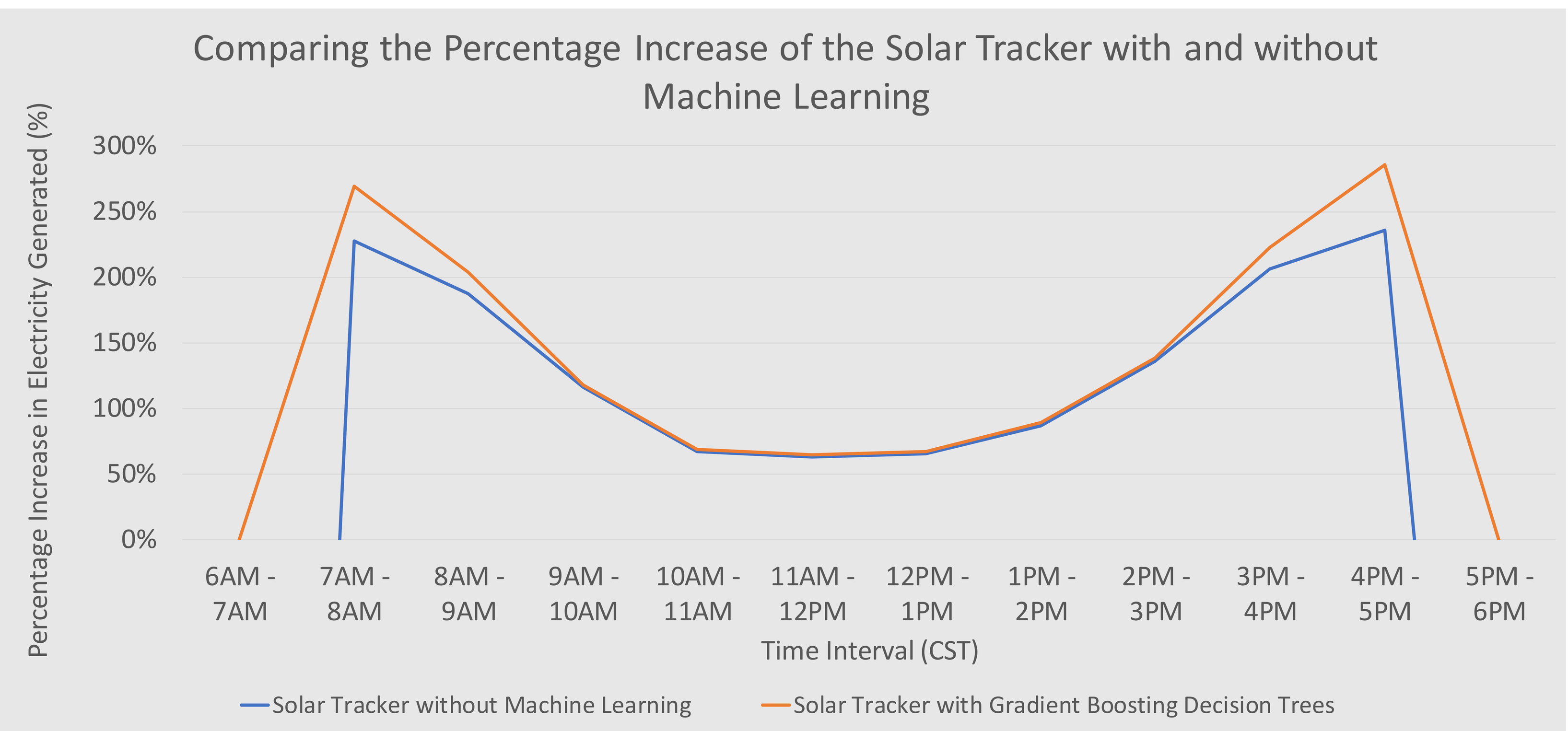




Graph – Final Comparison



Graph – Percentage Increase



Data Analysis

- The stationary panel, on average, produced over 120 mAh for a duration of 3 consecutive hours with a peak value of 129.8 mAh. In comparison the robot, on average, produced over 120 mAh (net generation) for 8 consecutive hours with its highest value at 213.9 mAh.
- The use of a dual-axis solar tracker ensured that there is maximum sunlight reception for a sustained period of time in contrast to one peak value for a short period of time without the robot.
- The robot without machine learning produced an average increase of 96% from the flat panel. The addition of machine learning produced a 124% increase in net generation of electricity.
- The greatest increase in electricity generation was 7:00 – 8:00 AM and 4:00 – 5:00 PM when the sun shines brightly but is not directly above the flat panel. The solar tracker graphs are shaped like a table top, and the flat solar panel graphs are shaped like a bell curve.

Conclusion

The stated engineering goal was confirmed. The electricity generated was 124% greater in the robot surpassing the goal of a 100% increase. The robot was able to maximize energy production and sustain it for a longer duration, thus enabling the dual-axis robot to generate more electricity than the solar panel would have on its own.

Application & Future Research: Using a machine learning and mathematical approach with a dual-axis solar tracker, solar panels can be used to their maximum potential and be a greener, cost effective way to produce electricity. Future research could include the incorporation of energy generated from solar farms. The machine learning algorithm could be improved to include data throughout the year in multiple locations. Additionally, ideal geographical locations for solar power generation can be further explored to find maximum sunlight reception.