Bio Inspired Heliotropic Solar Cell system

PROJECT REPORT REVIEW

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Literature Review:

S.No	Name of Model/System	Brief description	Advantages	Disadvantages
1	Design and Implementation of Automatic Solar Tracking System	This article describes how to run a photovoltaic system, how it has been described to generate electricity and provide maximum energy production under what conditions. It also mentioned some cases where the photovoltaic system will be adversely affected and the geographical location is shown as used in the most efficient manner.	Includes all the advantages of clean source and sustainable source of energy.	The production of energy highly varies with the change in geographical and Climatic parameters.
2	Nature inspired solar pv panel tracking using sunflower based heliotropism	In this paper, sunflower based heliotropism has been considered as the base mechanism for tracking the solar PV panel. This nature inspired solar PV panel tracking would be able to provide an efficient, sustainable, low maintenance and cost-effective approach for optimizing the efficiency of solar PV system. Pulvinus, a joint like thickening at the base of the plant, is mainly responsible for the heliotropism of sunflowers. Here the natural heliotropism based solar tracking has been discussed. The possible design of maximum power tracker (MPT) using sunflower (and like plants like alpine, the snow buttercup) inspire mechanism has been discussed and analyzed for optimal operation of solar PV power systems.	Highly sustainable and low cost solution only if successfully implemented	Implementation involves synthesis of lab grown/Modified tissue.
3	Design and Structural Analysis of a Robotic Arm	have achieved the design of a 3-jointed robotic arm where the base is fixed and the remaining joints move in vertical and horizontal directions. The end effector is also designed such that to lift the sheet we use suction plates where the sheet is uplifted with a certain pressure.	Highly efficient implementation along with automation and low operating and low time consuming arm.	Susceptible to errors and changes which might cause inconsistency in performance of the system.

4	Software interfacing of servo motor with microcontroller	This paper presents the implementation of a PIC Microcontroller with Graphical User Interface (GUI) in Matlab to track the rotational angle of a DC servo motor. The movement of the slider on GUI will act as an input signal into the Microcontroller to change the rotation angle.	The controller helps achieve precise rotations which are not possible in general operating devices.	High initial cost of setup and sustained computing power.
5	Research on energy consumption of injection molding machine driven by five different types of electro-hydraulic power units	The energy efficiencies of the asynchronous motor, the servo motor and the hydraulic pump under different working conditions are firstly analyzed. Then, the power consumptions of five different types of electro-hydraulic power units during different injection molding stages are compared and analyzed. Finally, the energy consumptions of the injection molding machine during a working cycle driven by these five power units are tested and analyzed respectively.	Significant energy-saving effect could be achieved by adopting the speed variable power unit.	High initial cost of setup
6	Introduction to linear regression analysis	presents both the conventional and less common uses of linear regression in today's cutting-edge scientific research.		
7	Precise tradeoffs in adversarial training for linear regression	Despite breakthrough performance, modern learning models are known to be highly vulnerable to small adversarial perturbations in their inputs. While a wide variety of recent \emph{adversarial training} methods have been effective at improving robustness to perturbed inputs (robust accuracy), often this benefit is accompanied by a decrease in accuracy on benign inputs (standard accuracy), leading to a tradeoff between often competing objectives. Complicating matters further, recent empirical evidence suggests that a variety of other factors (size and quality of training data, model size, etc.)		precisely characterize the standard/robust accuracy and the corresponding tradeoff achieved by a contemporary mini-max adversarial training approach in a high-dimensional regime

		affect this tradeoff in somewhat surprising ways. This paper provides a precise and comprehensive understanding of the role of adversarial training in the context of linear regression with Gaussian features. In particular, we characterize the fundamental tradeoff between the accuracies achievable by any algorithm regardless of computational power or size of the training data.		

Abstract :

The report focuses on development of framework and design for mechanically automated heliotropic solar cells. The project does not focus on changing the chemical compositions of the existing industry standard solar cells or their arrangement design patterns.The project focuses on maximizing the solar energy absorbed by making an optimal incidence angle at all times with the incoming rays of sunlight.To achieve variable angles throughout the day we designed a robotic structure which helps the solar plates move between the restricted angles through the day,To achieve this we introduce 2 methodologies which uses a linear regression algorithm working for deciding optimal angle at all the time, this kind of approach is suitable for place with highly varying weather and inconsistent climate conditions as the other method does not make use of any ML algorithm, instead it is fed a fixed route of movement throughout the day.Both of these methods to make the solar plates more efficient have their own advantages and disadvantages discussed later in the report.To implement the movement we have proposed to use servo motor attached to a moving joint where the solar panel is attached.To track the movement of the sunlight focus throughout the day we have taken a separate device to isolate the error possibilities from the solar panel module and make the overall system to be scalable as well as fault tolerant.Theoretically the system should be atleast 29.3%, if we calculate the lost energy due the incident angle,and only assume half of it is usable in form of electricity due multiple losses.

Introduction:

Solar cell working principle

A solar cell is, in principle, a simple semiconductor device that converts light into electric energy. The conversion is accomplished by absorbing light and ionizing crystal atoms, thereby creating free, negatively charged electrons and positively charged ions. If these ions are created from the basic crystal atoms, then their ionized state can be exchanged readily to a neighbor from which it can be exchanged to another neighbor and so forth; that is, this ionized state is mobile; it behaves like an electron, and it is called a hole. It has properties similar to a free electron except that it has the opposite charge.[8]

Each photon of the light that has a high enough energy to be absorbed by the crystal's atoms will set free an electron hole pair. The electron and hole are free to move through the **lattice** in a **Brownian motion** ; however, on average they will never move too far from each other. When the electron comes too close to a hole during their Brownian motion, they will recombine. On the other hand, when they experience an electric field, this will tend to separate the electrons from the holes; the electrons will drift toward the positive pole (the anode), and the positively charged holes will drift toward the cathode. Recombination will then take place in the external circuit (within the electric wires). Consequently a current will flow. Since it is generated by photons, one speaks of a photo current. And the semiconductor that performs this effect is called a photoconductor. Photo conductors are passive devices. They react to light by changing their electric conductivity. In order to activate them an external electric power source, such as a battery, needs to be supplied to draw a current that increases with increasing light intensity. There are many photo conductor devices in our surroundings; as for example, in cameras, in streetlight controls to switch the lights off at dawn and on at dusk, or for light barriers in garage door safety controls.[8]

However, if an electric field is incorporated into the semiconductor, it will separate the electrons and holes. The part of the crystal that accumulates the electrons will be negatively charged; the part that accumulates the holes will be positively charged. The resulting potential difference, referred to as an open circuit, can be picked up by an electrometer. When electrodes are provided at both sides, a current can flow between them. The crystal, when exposed to sunlight, acts as a battery and becomes a solar cell (see Figure 1).[8]

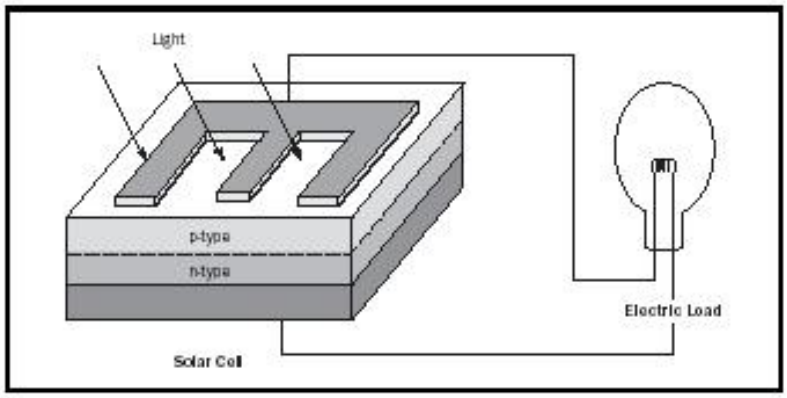


Figure 1. Schematics of a typical solar cell with light falling through an electrode grid onto a semiconductor sheet containing a *pn* junction that separates electrons and holes that flow to the respective electrodes and create a current through an external circuit.[9]

Aim:

The purpose of this project is to develop a system that helps optimize the light energy absorbed by the solar panels deployed.The method discussed is to continuously or discreetly change the angles of the solar panel so that it coordinates with the incident light rays from the sun and maintains an angle such that it results in maximum absorption of light and as a result maximum energy generation.

Methodologies:

To design the system there are 2 methodologies to implement this optimization technique.One is using linear regression and the other technique is without Linear regression.

The technique without using Linear regression: This method includes collecting a large amount of data for a region, and making a model and applying that mathematical model into the machine of the geographical area.Several parameters might include the weather of the geography,refractive index of the air, altitude of the place ,climatic conditions, scale of deployment.

The problems associated with this is,a lot of human hours are needed to make mathematical models of several sectors in the region and then mathematical deployment on requirement.

Due to generality in mathematical models, efficiency might suffer and the overall efficiency of the sector and hence the region might suffer.

The major advantage this method faces is no need for external computation power and hardware for deciding the moving path.

One undecided factor that remains open is that if the external required power for computation of intelligent ML based systems is covered up by the increased efficiency due to the intelligent MLbased system generated paths.,

Intelligent ML based system,which works by generating a path and deciding the rotating angle for the solar plated at the specific location of the solar module.This allows hyper customized paths for each deployment for their overall high efficiency in generating electricity.The system initially need training time and rotations for some days to generate an optimal mathematical model for deciding a path of rotation/Angles of rotation with respect to time,as there is no perfect defined path for optimal energy generation there will always be some local factors which include dust patterns,cloud patterns, changing patterns of sunlight intensity with respect to time

Each parameter has their own effect,dust in the air might affect the refractive index and hence, slight variation over months can be observed.The cloud patterns might seem to be a noise in the model,but long term patterns of cloud in the period of years acts as favourable factor towards the accuracy of the mathematical model.Due the earth's own phenomenon, the intensity of light at a certain time point might be different on different days, so knowing the yearly pattern which is identified by the linear regression model is extremely helpful.

Implementation Design:

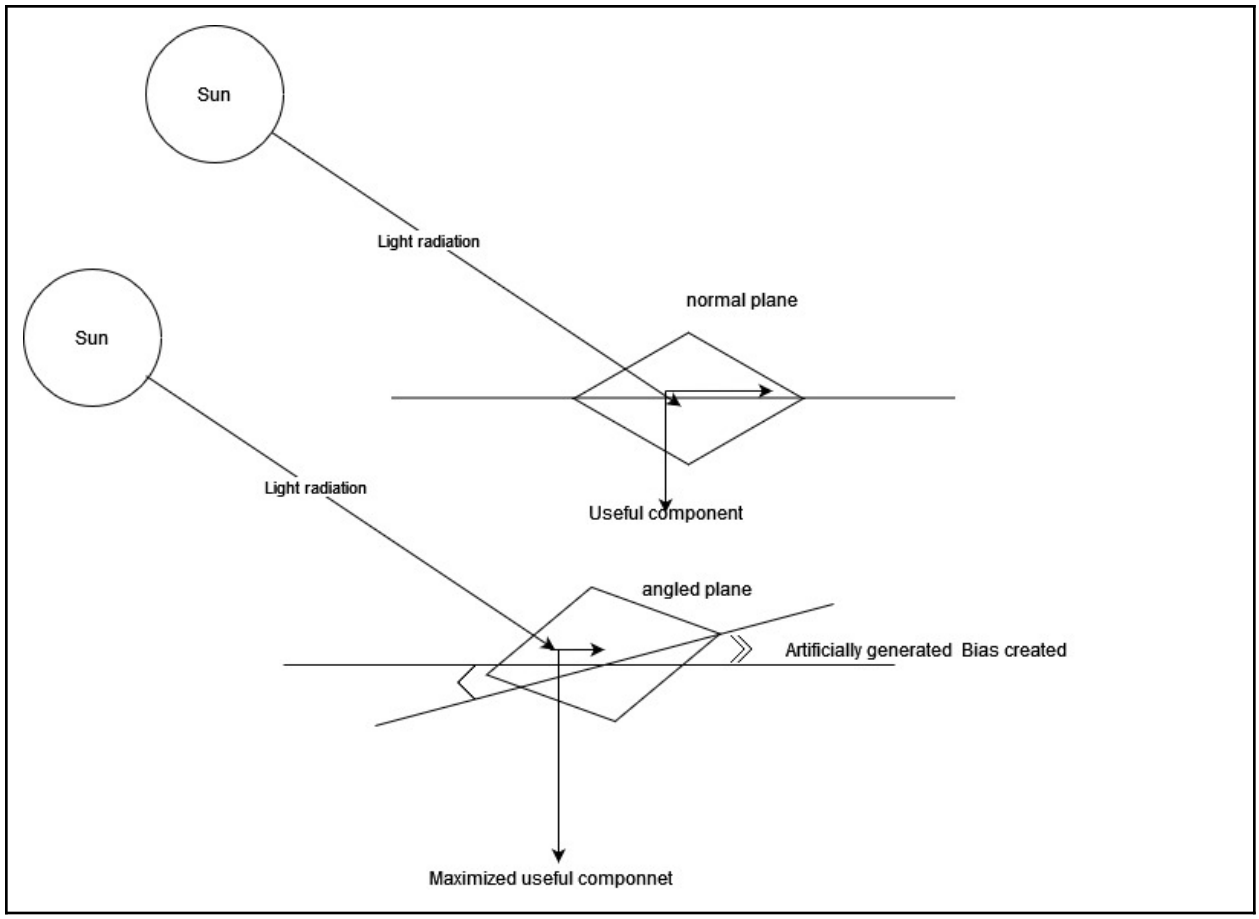


Fig.1: DIsplays underlying objective

This is the representation of how by artificially changing the incident angle, we can increase the efficiency of the solar cell unit.

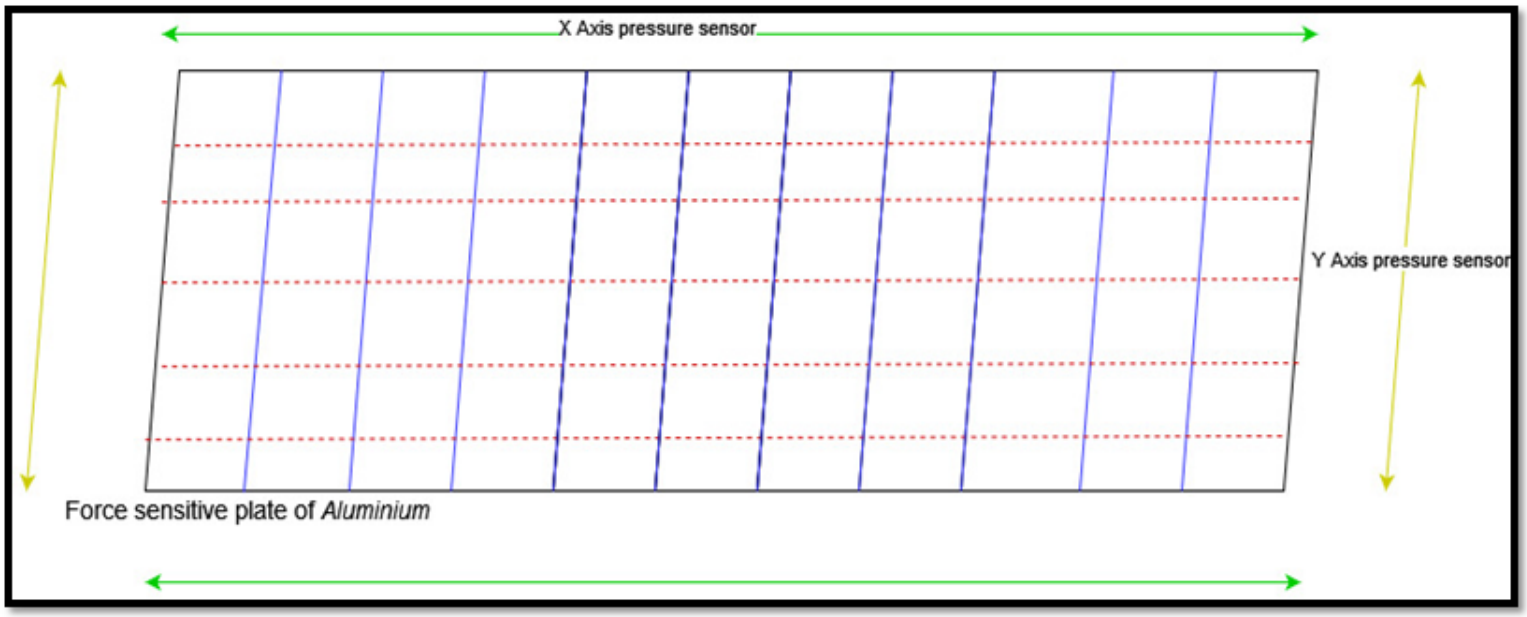


Fig 2 Sensor design

This sensor is sensitive to intensity of light by measuring the changes in the pressure on the frames

Sensor Design for tracking maximum sunlight:

The sensor will be a custom designed sensor, with a square frame of force sensitive sides, where opposite sides are coupled.Aluminium Wires with mechanical tension are attached along x axis and y axis.

On receiving heat, the aluminum wires show highest thermal expansion, then the wire changes the length and the tension in the wire changes,exhibiting the changes on the sides of the frame, which can be electronically recorded.

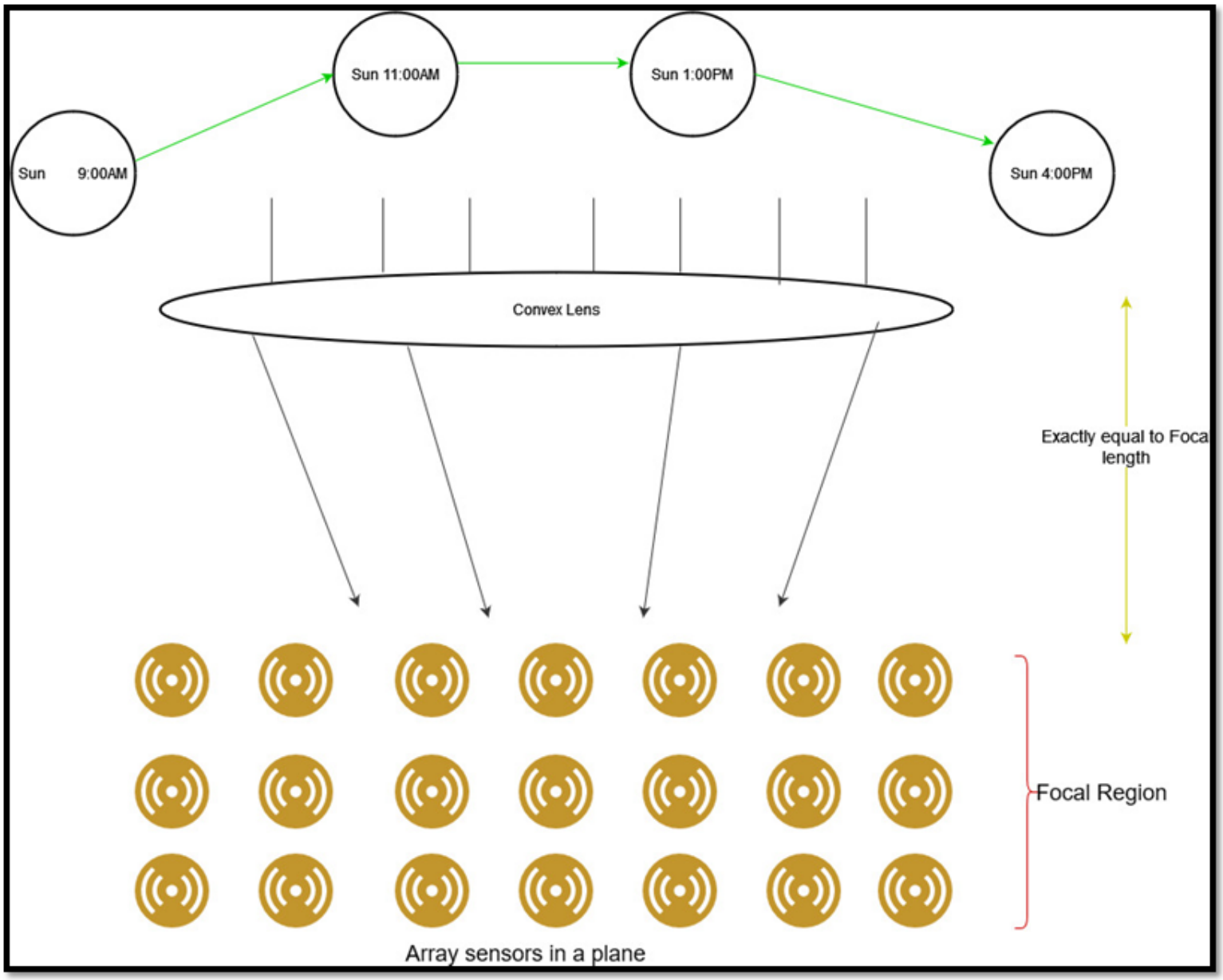


Fig 3: High level design of sensor subsystem

The subsystem detects the change in the angle of the incident rays by measuring the change in intensity of the sunlight incident on the surface of the solar panels.
The Array of sensors helps get an average change in intensity over the focal region.
The sensor subsystem is only made up of thin aluminum wires,therefore can be placed on the solar panels.

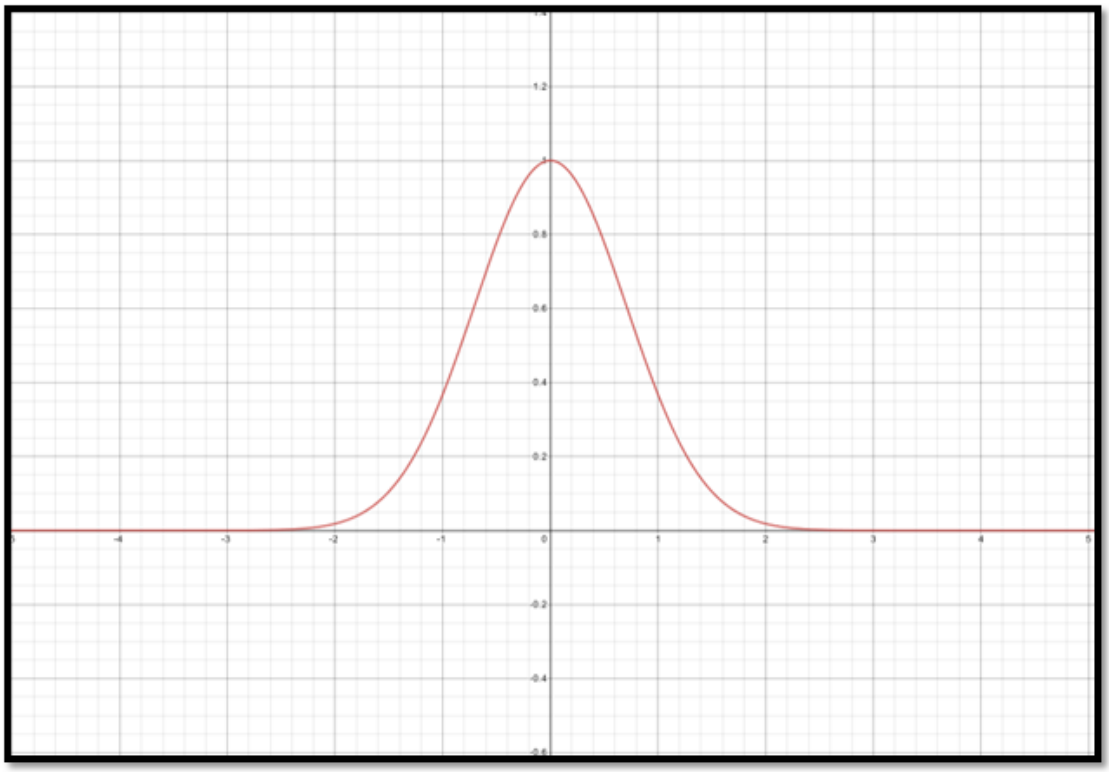


Fig 4. Approximate Variation of light intensity between 8AM to 4PM , 0 signifies 12 PM

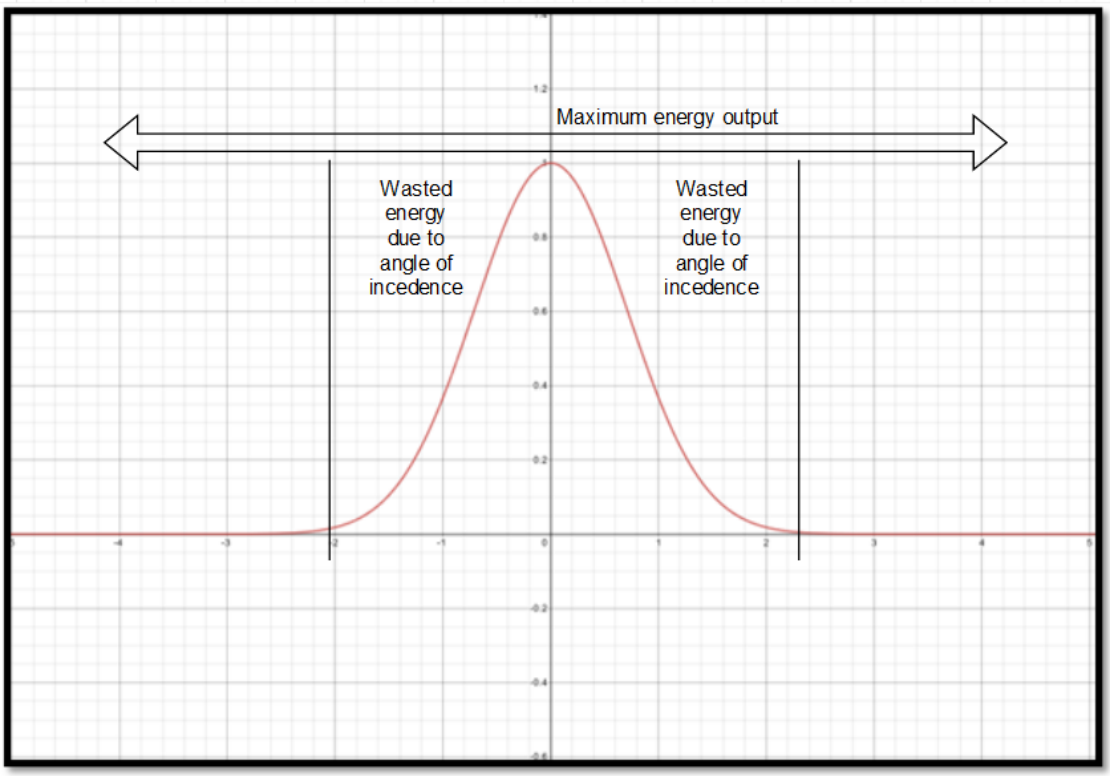


Fig 5. Graph of wasted energy

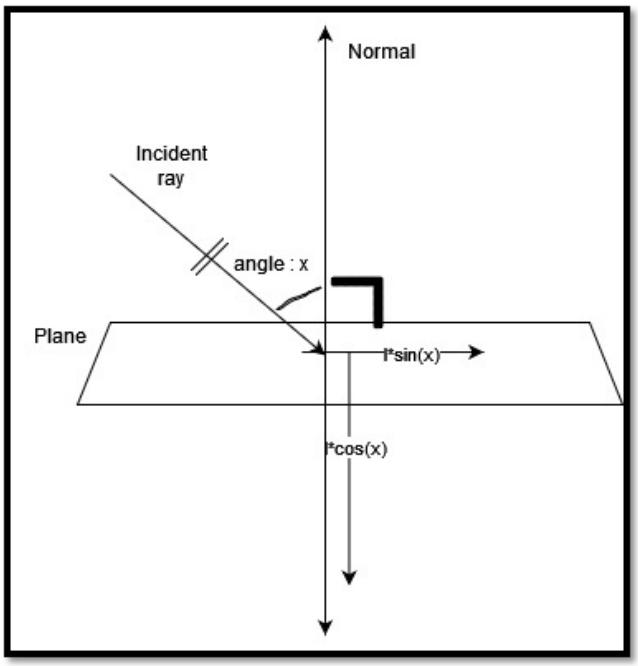


Fig6: This depicts Intensity of the light varies as the I1 = I0*cos(x)

The average value of the function $f(x)$ on the interval $[a, b]$ can be evaluated through the following the following expression:

$$\text{average value} = \frac{1}{b-a}\int_a^b f(x)dx$$

Here, this gives us an average value of:

$$\frac{1}{\frac{\pi}{2}-0}\int_0^{\frac{\pi}{2}} \cos(x)dx$$

Integrating $\cos(x)$ gives us $\sin(x)$:

$$= \frac{1}{\frac{\pi}{2}}[\sin(x)]_0^{\frac{\pi}{2}}$$

$$= \frac{2}{\pi}\left[\sin\left(\frac{\pi}{2}\right) - \sin(0)\right]$$

$$= \frac{2}{\pi}[1-0]$$

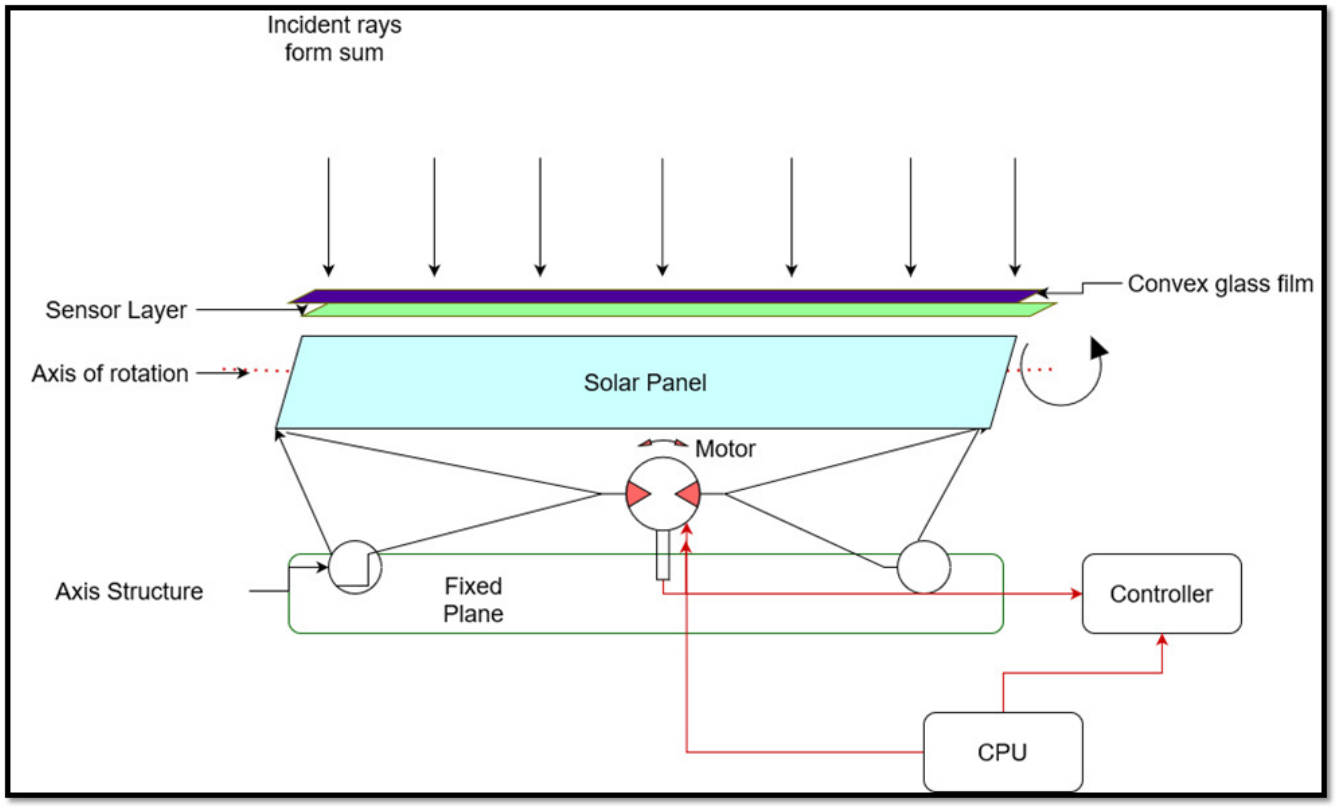
$$= \frac{2}{\pi}$$

The average intensity received is 63.66% of the peak intensity received when the sunlight rays make 0 degree incident angle.
Due to mechanical constraints, assuming the solar plane can move between 60 degrees and 0 degrees we can plot a table assuming the duration we use the Heliotropic solar panel bending system, we experience the Intensity with incident angle 0.

Result:

S.No	Angle of Deviation from Normal	Average Intensity %	Growth %
1	0	63.665%	0%
2	15	63.87%	0.32%
3	30	65.197%	2.4%
4	45	68.6%	7.75%
5	60	75.22%	18.10%

Overall System Design:



Conclusion:

The results implies that the growth in average intensity achieved is practical and would give excellent results when deployed at scale.There are some notes which are to be kept in mind before deploying the system,the energy used in movement and computation should be recovered within a practical time frame for the subsystem to be useful.Due to the inclusion of the moving parts in the overall solar panel system,maintenance might be required more frequently.

Finally we can observe a logically functioning solar panel based electricity generation system which when modified after taking inspiration from heliotropic plants, is able generate significantly more power than it was generating without the modification.

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