The Chinese University of Hong Kong

CENG2030 – Fundamentals of Embedded System Design

Homework 1: Embedded System Design

Solution for maximizing solar power system light input incorporated with safety measures

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# Abstract

This proposal presents a comprehensive solution for maximizing the light input of solar power systems while incorporating essential safety measures.

The introduction section provides background information, outlines the motivation behind the product, and highlights its applications.

A thorough comparison is made between existing solutions and the proposed product, emphasizing the unique problems addressed by the latter.

The system description section offers detailed explanations of the hardware and software components, ensuring a comprehensive understanding of the proposed solution.

The proposal concludes with a concise summary, encapsulating the key points presented throughout.

# Introduction

## Background

With The global demand for clean energy has spurred significant advancements in renewable power generation methods, including solar power, wind power, and tidal power. Among these, solar power stands out as a widely recognized and reliable source of clean electricity. Within the realm of solar power, two primary types of solar generators have gained prominence: photovoltaics, which directly convert sunlight into electricity, and solar thermal systems, which utilize solar energy to heat water and indirectly generate electricity. This proposal aims to address the optimization of photovoltaic solar power systems, focusing on maximizing light input and implementing safety measures to enhance efficiency and reliability.

## Motivation

While photovoltaic methods have proven to be easy and reliable for harnessing solar power, their efficiency is heavily influenced by the angle at which sunlight strikes the solar panels. This limitation presents an opportunity for improvement and innovation in solar energy systems. The motivation behind this proposal is to enhance the design of solar power systems and elevate solar energy utilization to new heights. By optimizing the collection of sunlight and maximizing the input of light energy, we aim to unlock untapped potential and push the boundaries of solar energy efficiency.

Additionally, it is imperative to ensure the safety of maintenance workers involved in solar power systems, especially when incorporating moving parts. The proposed solution will encompass robust safety measures, taking into account the potential risks associated with system operation and maintenance. By prioritizing worker safety alongside efficiency enhancements, we strive to establish a comprehensive solar power system that not only maximizes energy output but also creates a secure working environment for maintenance personnel.

## Application of the System

The proposed system serves a critical role in ensuring the safety of maintenance workers while maximizing solar energy generation. By employing an ultrasonic sensor, the system prioritizes the presence of individuals within the range of the moving solar panel area, making worker safety the utmost priority. If the area is clear, the system unlocks, enabling the motor to rotate. Additionally, the system includes sensors to detect the angle of sunlight and subsequently adjusts the solar panel's position based on the angle of the incoming sunlight. These actions are executed continuously, ensuring optimal solar energy capture.

A diagram of a computer

Description automatically generated with medium confidence

Fig.1. Block diagram of product running logic

The system is powered by an Arduino UNO board, utilizing the solar power input as its energy source. This design eliminates the need for battery replacements or external power sources, allowing the system to operate seamlessly and sustain its functionality indefinitely.

# Existing Solution

## Problem of existing product and our advantage over them

A screen shot of a computer

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Fig. 2. Price of single axis tracker on the market. Adapted from[1]

Problem addressed: Existing solar tracking systems are usually costly, but they can only cover single-axis tracking, usually by rotating along the z-axis only, while the tilting of the solar panel is fixed. Usually, they also lacks protection system, which means that user have to manually shut down the system to work safely with them.

## Product Requirements

* Lower cost per system size
* Cover 2-axis rotation
* Auto-lock upon entity detected

# System Description

## Hardware

In the proposed system, a deliberate decision has been made to utilize only two motors instead of the traditional three in axial motion in a 3-dimensional space. This decision is based on careful considerations and optimization for the specific application of solar tracking. As the sun moves in an orbital rotation, the necessary movements for tracking are tilting and horizontal rotation. These movements can be effectively achieved with two degrees of freedom, eliminating the need for the additional motor and reducing production costs.

For the motor selection, servo motors have been chosen over stepper motors due to their higher torque capabilities. This allows the system to handle the rotation of larger solar panels effectively. By utilizing servo motors, the solar tracker can support heavier loads while maintaining affordability, making it an ideal choice for larger solar panel installations.

The solar tracker system is powered by an Arduino UNO board, which draws power from the solar battery. This design ensures self-sustainability, as the system utilizes the solar power input to power its operation. This eliminates the need for external power sources or the replacement of batteries, enhancing the system's reliability and reducing maintenance requirements.

The integration of two motors, servo motor selection, and self-sustaining power through the Arduino UNO board and solar battery exemplify the careful hardware considerations made to optimize the solar tracker system for efficient and cost-effective solar power generation.

A diagram of a solar panel

Description automatically generated

Fig. 3. Overall design of the solar tracking system

A diagram of a machine

Description automatically generated

Fig. 4. Servo Motor box enclosing a servo motor

A computer drawing of a machine

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Fig. 5. Ultrasonic sensor for entity existence checking

A blue and white object with a silver circle

Description automatically generated with medium confidence

Fig. 6. Photoresistor used to determine the intensity of sunlight

A diagram of a solar panel

Description automatically generatedFig. 7. Exploded view of design

Fig. 8. Circuit Diagram of demo solar tracking system

A circuit board with wires connected to it

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Fig. 9. Wiring drawing of system

A computer circuit board with many wires

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Fig. 10. Actual wiring for demo video

## Software

To ensure stable and efficient operation, a dead band level of 20 has been implemented in the system. The dead band refers to a range of error or deviation within which no corrective action is taken. In this case, before initiating rotation, the system checks for any significant deviation from the desired position. If the deviation falls within the dead band level of 20, no rotation is activated to avoid unnecessary oscillation.

Implementing a dead band level helps minimize power costs by preventing continuous adjustments and rotation when the solar panel is already within an acceptable range of alignment. By setting a threshold for deviation, the system optimizes energy consumption by avoiding constant micro-adjustments that may not significantly improve solar tracking accuracy.

A screenshot of a computer program

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Fig. 11. Code for demonstration – Constant and Pin Declaration

A computer screen shot of a program code

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Fig. 12. Code for demonstration – Ultrasonic sensor for detecting entity distance

A screen shot of a computer program

Description automatically generated

Fig. 13. Code for demonstration – Servo driver code

# Conclusion

In conclusion, this proposal has presented a comprehensive solution for maximizing the light input of solar power systems while prioritizing the safety of maintenance workers. By optimizing solar energy collection and implementing safety measures, the proposed system aims to enhance the efficiency and reliability of solar power generation.

By implementing Arduino UNO board for the embedded system, multiple sensors and motors, all work together to achieve efficient solar tracking and ensure safety. Additionally, with the self-sustaining power management system, it requires minimum maintenance to keep functioning.

Overall, the proposed system offers a reliable, cost-effective, and safe solution for maximizing solar power system light input. By addressing key challenges and incorporating innovative features, this solution has the potential to advance solar energy utilization and contribute to a greener and more sustainable future.

# References

[1] Charlie Clissitt, "Solar Tracker Costs 2024," theecoexperts.co.uk. https://www.theecoexperts.co.uk/solar-panels/tracker-costs (accessed Apr. 19, 2024)