TIME BASED SOLAR TRACKING SYSTEM

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ABSTRACT
The most plentiful and pure type of energy that may be gotten from the sun is solar energy. Energy is converted by solar panels to produce solar power, which is useful for a variety of electrical uses, especially in rural locations. An automatic solar tracking system was developed since a fixed solar panel system can only provide maximum electricity for a few hours of the day when the sun is perpendicular to the panel. Many sun tracking systems have been created and suggested throughout the years, and some of them have been examined in the literature. But the review works that are currently available have not sufficiently offered a thorough analysis and taxonomy of these solar tracking systems to demonstrate the patterns and potential.

KEYWORDS : Solar tracker , Solar charger controller , Stepper Motor ,Motor Driver , Arduino UNO , Battery.

INTRODUCTION
Renewable energy sources include energy derived from the Sun directly, like solar, thermal, and photochemical energy, or indirectly, like wind, hydropower, and photosynthetic energy stored in biomass, as well as other natural motions and climate regulation, like tidal and geothermal energy. These sources are then transformed into useful forms of energy, like fuels, heat, and electricity [1]. Since the Sun heats the atmosphere, air moves, which regulates the hydrological cycle and produces wind energy, solar energy is the most plentiful renewable energy that can be directly collected from the Sun [2].

A solar panel's ability to produce solar power, sometimes referred to as solar energy, is mostly dependent on how much sunshine it receives. Because solar photovoltaic energy is abundant, adaptable, simple to install, and has a little negative environmental impact on land usage, it has a significantly larger installed capacity than other renewable energy ideas and technologies [3].

The solar panel can only produce its maximum electricity when the Sun is directly overhead. The solar panel must be adjusted so that it is always pointed directly at the Sun because the Sun's location varies throughout the day. When operating a solar photovoltaic panel, especially in solar cell applications, a solar tracker is a device that needs to be extremely precise in order to guarantee that sunlight is focused precisely onto the power device [4]. The development of solar concentration applications, including solar-pumped lasers and parabolic concentrators, is also significantly aided by sun tracking systems [5]. These trackers can lower the size and cost per kilowatt hour (kWh) of the solar photovoltaic system while increasing its overall efficiency.

Over the years, a number of sun tracking systems have been created to improve the efficiency of photovoltaic (PV) systems; some of these systems, including those that have been examined, have been done so. However, since the majority of these reviews are restricted to classification based on two-axis, single-, and dual-axis solar tracking systems as well as classification based on the nature of motion, that is, active and passive solar tracking systems, they did not take hybrid solar trackers or learning-based solar tracking systems into consideration. In order to highlight the trend and suggest future research avenues, this work attempts to present a comprehensive overview of the numerous time-based solar tracking systems that have already been built, based on distinct categories.

LITERATURESURVEY

Due to a lack of resources, modern society has been obliged to find ways to satiate the needs of the latter. The depletion of conventional fuels as a result of human activity has raised concerns about sustainable development challenges with the burgeoning civilization.
The lack of energy and its source led us to adopt the positive strategy of making use of the other resources that nature has given to us, such as solar and tidal power.
It has been believed that the Sun is a vital source of energy. When compared to alternative energy sources, solar energy is more environmentally benign. Technological progress has consequently led to the development of methods for harnessing this energy for constructive use. Including the creation of fuel, electricity, heat energy, and many more. Systems such as photovoltaic or concentrated solar power (CSP) are used to convert solar energy that the earth has appropriated into electrical power. Through the use of photovoltaic arrays, an aligned scaffolding of solar cells, a solar tracking device makes use of this stolen solar power[6]

PROPOSED SYSTEM :

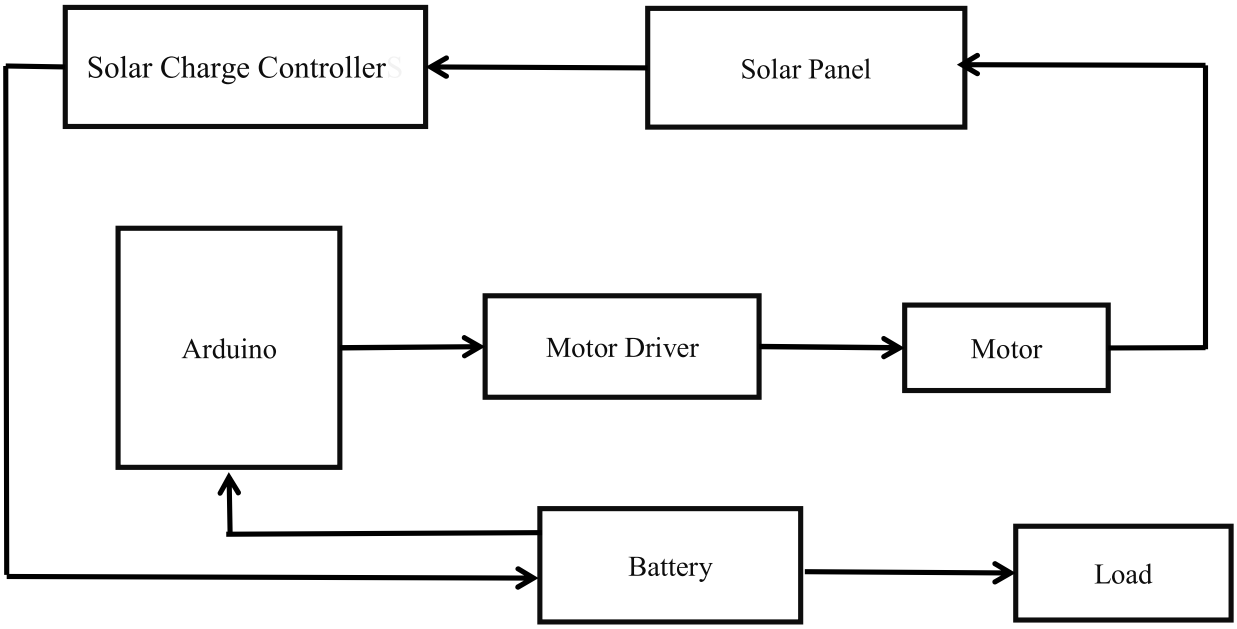
In order to maximize energy yields and enhance sustainability in solar energy production, the suggested system aims to strike a compromise between real-time responsiveness and adaptation to shifting environmental conditions. The project aims to optimize solar panels by implementing a dynamic sun tracking system that utilizes real-time intensity-maximizing approaches in addition to timing algorithms.

Solar tracking system :

Instead of depending on real-time sunshine tracking, a time-based solar tracking system modifies the orientation of solar panels or collectors according to the time of day. Time-based solar tracking systems follow a preset schedule, in contrast to active solar tracking systems that continuously move panels to face the sun using sensors and motors.
The movement of the solar panels in a time-based solar tracking system is usually programmed to follow a predetermined course during the day based on the sun's known passage across the sky.Since time-based systems don't rely on sensors or moving elements to track in real time, they usually require little maintenance once implemented.

BlOCK DAIGRAM:

A time-based solar tracking system is a mechanism that adjusts the position of solar panels or collectors throughout the day to maximize their exposure to sunlight. The purpose is to optimize energy production by ensuring that the panels are always facing the sun directly. Here's a basic block diagram of a time-based solar tracking system:



SOLAR PANEL:

These are the components that actually capture sunlight and convert it into usable energy. They are mounted on a tracking system that allows them to move in response to the sun's position.Here we have procured six solar panels, each rated at 12 volts.The photovoltaic cells within the solar panels absorb solar radiation when it is exposed to sunlight and electricity flows as a result of this energy's creation of electrical charges that move in response to the cell's internal electrical field.

SOLAR CHARGE CONTOLLER:

The specific rating of the solar charge controller, in this case, a 20A (ampere) controller, indicates its capacity to handle a maximum current of 20 amps.To guarantee that the batteries receive the ideal charging current, the solar charge controller controls the voltage and current coming from the solar panels. It helps to extend the life of the batteries by preventing deep discharge and overcharging.

BATTERY:

The energy produced by the solar panels during the day is stored in batteries so that it can be used throughout the night or on overcast days when sunshine isn't accessible. This battery has a 3 ampere-hour capacity and a 6 volt voltage and is charged and discharged under the supervision of the solar charge controller.

MOTOR DRIVER:

The L298N motor driver has been included into our system.This motor driver is crucial in maximising solar panel exposure and energy output because it provides precise control over the panel's movement. It does this by controlling the voltage and current delivered to an electric motor, which in turn controls the motor's speed and direction of rotation.

MOTOR:

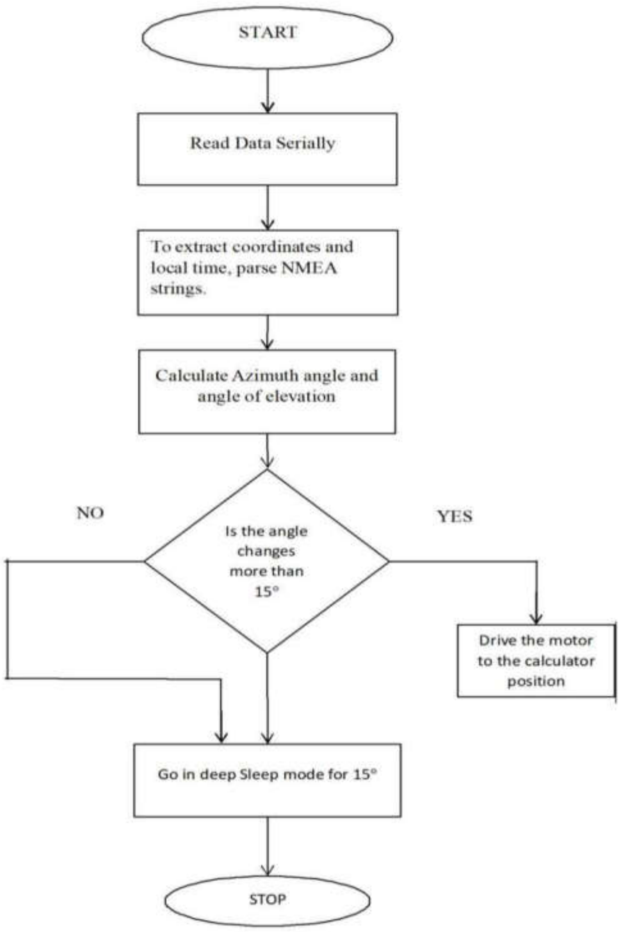
An electromechanical device called a DC gear motor combines a DC motor with a gearbox, to produce torque and speed characteristics that are ideal for a range of applications. This device that tilts or rotates the solar panels to follow the path of the sun is coupled to a 12V DC gear motor. It offers the mechanical strength required to precisely reorient the panels.

ARDUINO:

The Arduino UNO is an open-source, programmable microcontroller board that is inexpensive, versatile, and simple to use. It may be used in a wide range of electronic projects. The Arduino Uno generates control signals to modify the solar tracking mechanism based on the determined ideal position. The motors that tilt or rotate the solar panels to follow the sun's path across the sky may be controlled by these signals.

FLOW CHART:

A time-based solar tracking system's flowchart shows the decisions and processes that must be made in order to track the sun's position over time. This is a condensed flowchart:



Calculations:

The following list of additional parameters needs to be assessed as intermediates in order to use the equations for computing the azimuth angle and angle of elevation.

A.Local Standard Time Meridian(LSTM):

The Prime Meridian, which is used for Greenwich Mean Time, is comparable to the Local Standard Time Meridian (LSTM), a reference meridional used for a time zone. Equation is utilized in the computation.

$LSTM = 15° \times \Delta GMT$

In this case, the hourly difference between Local Time (LT) and Greenwich Mean Time (GMT) is expressed as ΔGMT.

B.Equation of Time (EoT) :

An empirical formula known as the equation of time (EoT) (in minutes) accounts for both the axial tilt and eccentricity of the earth's orbit.

$EoT = 9.87 \sin(2B) - 7.53 \cos(B) - 1.5 \sin(B)$

Where,

$B \text{ (in } °) = (360/365) \times (d-81)$

d is the number of days since the year's beginning.

C. Time Correction Factor (TC) :

When taking into consideration the EoT, the net time correction factor (in minutes) takes into consideration the variation in longitude that causes the Local Solar Time (LST) inside a given time zone.

$TC = 4 \times (\text{Longitude} - LSTM) + EoT$

D. Local Solar Time (LST) :

It is possible to find the Local Solar Time (LST) by modifying the local time (LT) with the two prior adjustments

$LST = LT + (TC/60)$

E. Hour Angle (HRA) :

The amount of degrees that the sun passes across the sky is converted from local solar time (LST) by the hour angle.

$HRA = 15° \times (LST - 12)$

F. Declination(δ) :

The sun's angular distance north or south of the equator is known as declination. In relation to the plane of the earth's orbit around the sun, the equator is inclined 23.45 degrees. Therefore, as the earth revolves around the sun, declination varies from 23.45 degrees north to 23.45 degrees south at different periods of the year.

$\delta = -23.45° \times \sin((360/365) \times (d+10))$

G. Angle of Elevation(α) :

The angle that separates the observer's line of sight from an item above them and their horizontal line of sight is known as the angle of elevation. The horizontal plane is used to measure it upward. Finding the height or distance of an object or location is a common use of this angle in a variety of disciplines, including surveying, engineering, astronomy, and navigation.The line from the observer's eye to the object of interest and the horizontal line of sight form an angle known as the angle of elevation. Trigonometric functions can be used to determine the angle if you know the opposing, adjacent, and hypotenuse sides of the right triangle that is produced.

α = sin-1(sin δ sin φ + cos δ cos φ cos(HRA))

H.The Angle of Incidence :

It is the vertical angle formed by the sun's beam direction and the normal to any surface on Earth. When considering a horizontal surface, the values of the incidence angle (θ) and zenith angle (Φ) are the same.The law of reflection states that the angle of incidence and the reflected angle are equal. Together with the normal, the angles of incidence and reflection are on the same plane and are always equal.

The following formula is used to get the angle of incidence:

cos θi = sinϕ (sinδ cosβ + cosδ cosγ cosω sinβ) +

cosϕ (cosδ cosω cosβ – sinδ cosγ sinβ) +

cosδ sinγ sinω sinβ

where, β is the tilt angle.

I.The Altitude angle :

It is the angle that separates the sun's horizontal projection across the earth's surface from its direction in space. The solar elevation angle, also known as the altitude angle, indicates the height of the sun as it appears in the sky. One way to determine the altitude angle (α) would be to

$$\sin \alpha = \sin \delta \sin \emptyset + \cos \delta \cos \omega \cos \emptyset$$

J.The Zenith Angle :

The angle formed by the zenith and the Sun's disc center is known as the zenith angle. The solar elevation angle is the difference between the sun's projection on a horizontal plane and its angle of ray direction, which represents the sun's height. Since the angles of altitude and zenith are complementary, the cosine of one equals q the sine of the other.

$$\cos \theta_z = \sin \delta \sin \emptyset + \cos \delta \cos \omega \cos \emptyset$$

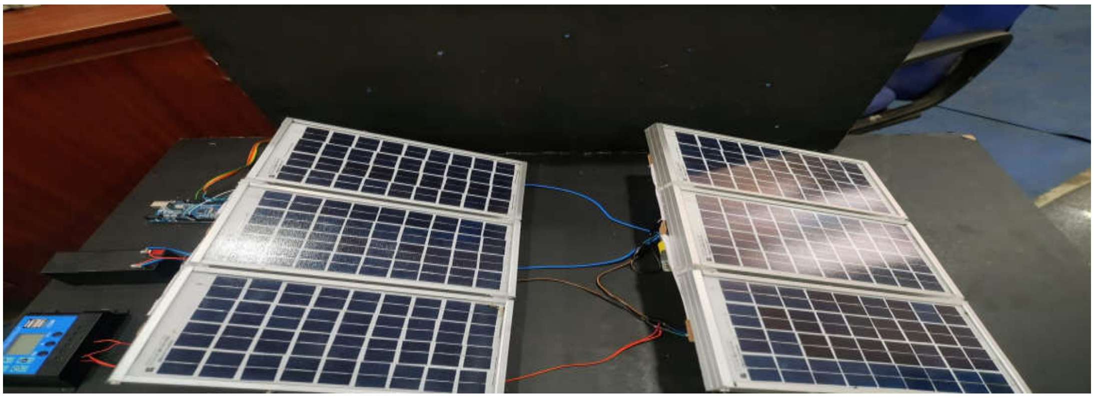
$$\theta_z = (90 - \theta)$$

K.The Azimth Angle :

It is the angle, expressed in a horizontal plane, between the sun's horizontal projection's meridian location and the North Meridian. The latitude, hour, declination, and altitude angles can be used to determine the azimuth angle (Ά) as follows

$$\cos \gamma = \sec\alpha(\cos\emptyset \sin \delta - \cos \delta \sin \emptyset \cos \omega)$$

Result:



Without Tracking :

TIME	VOLTAGE
8:00	10V
10:00	12V
12:00	14V
2:00	12V
4:00	7V

With Tracking:

TIME	VOLTAGE
8:00	12V
10:00	14.3V
12:00	15.4V
2:00	14.92V
4:00	9V

Evaluating a time-based solar tracking system's ability to capture solar energy entails a thorough examination. This is usually accomplished by calculating the increase in energy yield when compared to fixed panels. Precise alignment of the panels with the sun's location during the day is dependent on accuracy. Seasonal adaptation evaluates how well it does at different times and angles of sunshine. Additional benefits are seen as compared to fixed panels. Energy savings and carbon reductions are examined in terms of environmental impact. Improvements can be made based on the installation and usability input from users.

Conclusion:

In summary, the development of a time-based solar monitoring system is a major step forward for solar energy technology. Through dynamic orientation adjustment of the solar panels, this system maximises energy capture and improves overall efficiency based on the sun's location throughout the day.

Comparing time-based tracking to other tracking techniques like dual-axis or astronomical tracking, one of its main benefits is how easy and affordable it is. It does away with the need for complicated sensors and actuators by depending on preset algorithms based on location and time of day, which lowers installation and maintenance costs.

Furthermore, time-based surveillance results in higher energy yields, which directly boost solar energy projects' financial returns. This enables better use of available land and rooftops for solar energy generation, making it an appealing alternative for utility-scale solar farms as well as distributed solar installations.

Future scope:

Time-based solar tracking systems have a bright future ahead of them since they maximize solar energy harvesting efficiency. In order to improve sustainability and resilience, advancements could involve integrating AI algorithms for more accurate tracking, optimizing energy storage solutions for continuous power generation, and putting them to use in a variety of applications like off-grid communities, urban infrastructure, and agriculture. Integration with smart grids may also be possible to improve the management of renewable energy sources.

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