IoT based dual-axis solar tracking system

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Abstract. This paper discusses the implementation of IoT (Internet of Things) for maneuvering and remote monitoring the orientation of the solar panel from anywhere. Solar energy is clean, abundant, eco-friendly and it is a renewable type of energy. In order to maximize the efficiencyof the solar panel, it should be perpendicular to the solar rays emitted from the sun. It can be achieved by rotating the solar tracker along with the sun throughout the day. Sun's position is determined by its Azimuth and Elevation angles. Nowadays the world is moving towards anew era called the Internet of Things and everything can be found on the internet. These angle data can be also found on the Internet, which makes this solar tracker precise, cheap, and accurate for tracking. It also makes monitoring the solar tracker position from anywhere at any time.

1. Introduction

At present, there are more applications that make use of solar energy in order to run, so there is a need for a device that yields maximum power from the sun. Photovoltaic panels are used for harnessing solar energy from the sun and converting them into electrical energy. But they can't fully harness the solar energy during the day if they are kept static at a particular angle. In order to obtain maximum power output, photovoltaic panels should be moved along with the sun. There are two types of solar trackers: Single-axis and dual-axis tracker. Single-axis tracker tracks the sun from east-west direction and with an optimal tilt angle, it is found that electrical output from the single-axis solar tracker is atan average of 30% more when compared to the fixed solar panel[1]. In dual-axis solar trackers track the sun position based on its solar azimuth and solar elevation angle. The solar azimuth angle is the horizontal angle measured between observer position and the vertical plane of the sun whereas solar elevation is measured between the horizon and the center of the sun and the output is found to be 81.68% higher than the fixed panel[2].

So dual-axis solar tracker is more efficient than a single-axis solar tracker. There are many methods for tracking the sun in dual-axis solar system. A simple method is by using LDR (Light-dependent resistor) for finding the position of the sun. LDR is a photoresistor that changes its resistance based on the intensity of light falling on it. By placing four LDRs at each side of the photovoltaic panel, that rotates the photovoltaic panel in a particular direction when that particular side LDR output is low with this method the sun can be tracked with ± 4% degree precision[3]. By using cameras the angle of precision can be improved. Either a fixed camera setup like a fish-eye camera or a setup of 16 cameras that are mounted near the photovoltaic panel to monitor the sun movement[4, 5] or by placing the camera directly on the solar tracker to track the sun and it moves along the tracker[6]. A mathematical model can also be used, here the sun position is calculated priorly by using mathematical formulas which requires latitude and longitude of the solar tracker position as an input here there is no need for sensors to track the sun[7].

Hybrid PV tracker which uses Geographical data like latitude and longitude data that can be obtained from GPS can be used for offline computing the sun position and the solar tracker position can be uploaded to the internet and it can be monitored[8,9].

2. Methodology

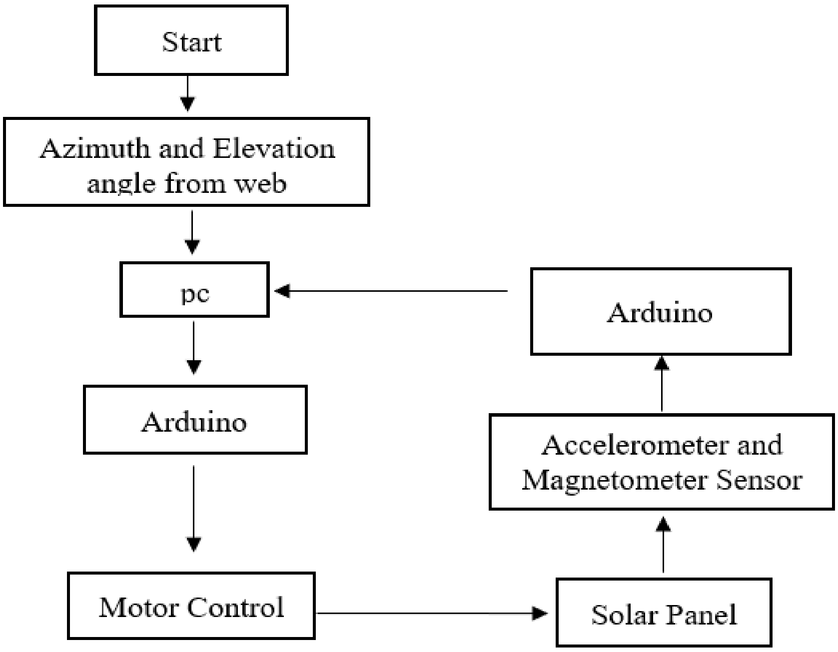

Figure 1. Solar Tracking system flowchart.

This proposed solar tracker setup is made of Mechanical structure and electrical systems. The mechanical structure is used for controlling the Azimuth and Elevation motor of the solar tracker based on the angle information collected from a website. The electrical system is used for controlling the motors, reading the sensor data. The Internet of things is a structure of interconnected with computing devices and mechanical devices and it has the capability to transfer data through the web which makes the system fully automatic and there is no need of a human to system interaction. Azimuth and Elevation angle of the sun for the solar tracker location is obtained from the website named suncalc.org they track the sun position throughout the day. These data are collected for every 5 minutes interval from morning (8:00) to evening (5:00). These position data are given to Arduino for controlling the motor which rotates the solar tracker so that the solar panel can be oriented perpendicularly and this is done every five minutes. In order to check whether the solar tracker is oriented correctly with the given angle accelerometer and gyroscope sensor is used. The accelerometersensor gives the tilt(Altitude) angle of the solar tracker whereas the gyroscope sensor gives the azimuth angle of the solar tracker. These sensor data and web data are uploaded to the internet, and they can be monitored by anyone from anywhere at any time who as access to the internet.

3. Design

After considering different design parameters Solar tracker CAD model as shown in Figure 2 is designed and simulated in CAD software. It was designed with parameters to minimize the usage ofthe material and weight of the solar tracker.

Figure 2. CAD model.

Figure 3. Fabricated model.

4. Tests and results

Solar tracker is programmed to run by scheduling it to run every day from morning 8:00 am to evening 5:00 pm. Azimuth and Elevation angles are collected from a web site for every 5 minutes. This data is used for rotating the solar panel.

As the solar tracker moves its orientation was measured using an accelerometer and gyroscope sensor. They are uploaded to the internet. The test was conducted in summer for the given location whose geodata are latitude: 12.81° and longitude: 80.02°. And the position data of the sun and the orientation are graphed. The following figures show the web data and solar tracker orientation which was tested on 30th March 2020. Figure 4 shows the altitude of the sun, Figure 5 shows the azimuth angle of the sun, Figure 6 shows the tilt angle of the solar tracker and Figure 7 shows the azimuth angle of the solar tracker.

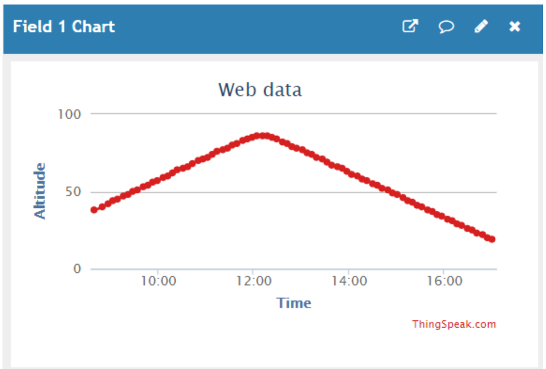

Figure 4. Altitude data from web.

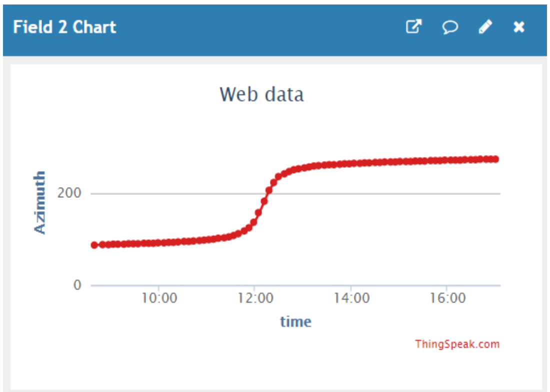

Figure 5. Azimuth data from web.

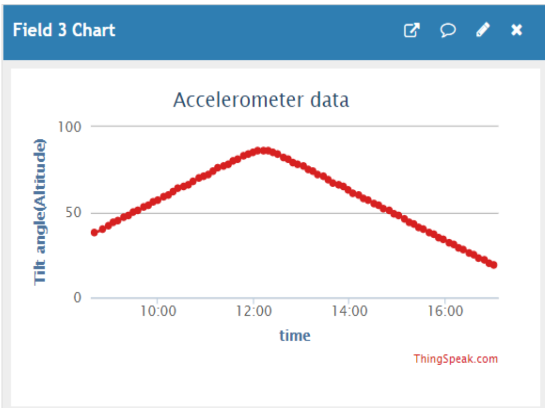

Figure 6. Tilt angle of solar tracker.

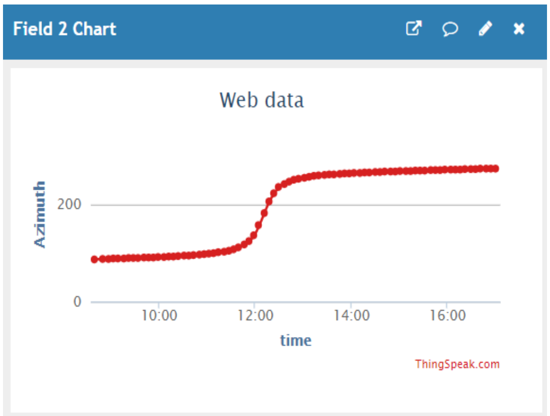

Figure 7. Azimuth angle of solar tracker.

From the above graph, it can be found that Figure 4 & Figure 5 shows that altitude from web and accelerometer reading was found to be the same. And Figure 6 and Figure 7 shows that azimuth data from the web and gyroscope were also found to be the same. In terms of efficiency, based on the sensor error tracking efficiency can be $\pm 2°$. And from studies [1, 2], it can be found that dual-axis solar is (30-40%) more efficient than single-axis solar tracker whereas 81% higher when compared to the fixed solar panel.

5. Conclusion

This proposed solar tracker will be reliable and accurate throughout the operation and yields maximum output power when compared to the single-axis and static solar system. And the implementation of IoT can avoid human errors. It will be a good competitive solution for growing technology that uses solar energy for power. And it is expected to contest with other complex and expensive systems. As future work MPPT technique can be implemented for extracting maximum power from the photovoltaic module and high precision sensors can be used to increase precision.

6. References

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