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Design and Development of an Automatic Solar Tracker

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Abstract

Energy crisis is one of the most crucial topics in today's world. Conventional energy resources are not only limited and costly, but also the prime cause for environmental pollution. The environmental pollution and rising cost of the fossil fuels have drawn considerable attention to renewable energy sources. Solar energy, being the cleanest and most reliable renewable energy source, is widely utilized in thermal systems to heat water and air. It offers a vast opportunity for public and private organizations to reduce carbon emissions and cut electricity costs. A viable approach to maximizing the solar panel efficiency is solar tracking. This paper, therefore, proposes an automatic microcontroller-based solar tracker with a hybrid algorithm for locating the sun's position. The proposed hybrid solar tracking algorithm combines both sensors and mathematical models to determine the precise sun's position, thereby harnessing optimal solar energy for all weather conditions. Experimental results consistently show that the hybrid solar tracking algorithm can yield higher solar power that the traditional active and chronological algorithms. A webpage was also developed to facilitate real-time monitoring of solar data. As such, the solar tracking process is fully automated, maximizing the collection and management of solar energy for solar thermal systems.

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Keywords: Renewable energy; Solar energy; Solar tracker; Energy harnessing algorithms

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1. Introduction

Finding energy sources to satisfy the world's growing demand is one of the foremost challenges for the next half-century. Over the recent years, greenhouse effect has caused global warming and irregular climate changes. To generate electricity, few countries still depend on fossil fuels which produce greenhouse gases that can severely impact human and wildlife population. Environmental pollution and rising cost of the fossil fuels around the globe rouse individuals to concentrate on renewable energy sources. As per scientific predictions, the consumption of fossil fuels will decrease by 80% and of non-fossil fuels will increase by 50% within a period of 30 years. Statistics has shown that available fossil fuels will deplete by 2080. Thus, the primary energy source has to be non-convention sources [1].

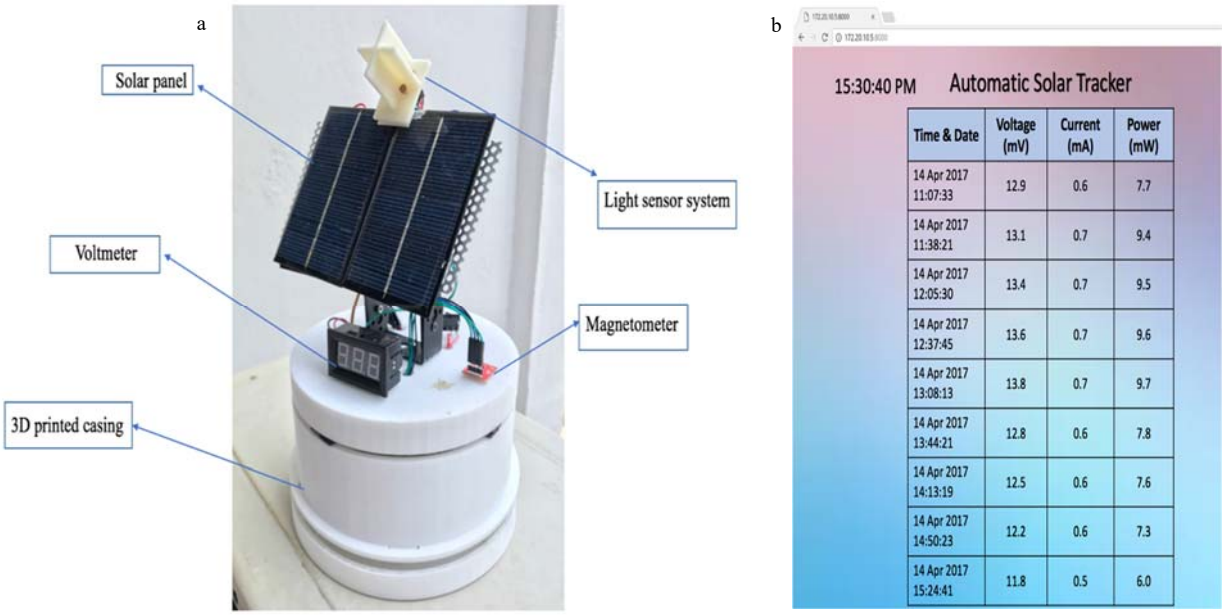
The earth receives $16x10^{18}$ units of energy from the sun annually, which is 20,000 times the requirement of mankind on earth [2]. On a sunny day, energy radiated from the sun is about 1 kW/m^2. As mentioned in [3], "the International Energy Agency predicts that approximately one-quarter of the renewable power, or 11% of worldwide electricity, could be supplied from solar energy in 2050."

This paper, therefore, aims to optimize the harnessing of solar energy by designing and developing an automatic microcontroller-based solar tracker with a hybrid algorithm that can locate the precise sun's position. Experiments were conducted to evaluate the proposed solar tracker's performance under local climate. To facilitate timely monitoring of solar data, a webpage was also developed.

2. Design and implementation

2.1. Electromechanical system

The proposed solar tracker has light dependent resistors (LDRs), Arduino mega microcontroller, Arduino Wi-Fi shield, servo motor, stepper motor and driver, HMC5883L magnetometer, current sensor ACS712, and solar panel with supporting metallic servo bracket, as pictured in Fig. 1 (a). This electromechanical system consists of two drivers with a stepper motor and a servo motor: the former is for rotating about north and south directions, and the latter for east and west directions. The solar panel produces a voltage proportional to the sunlight intensity, while the LDRs determine the system misalignment and send signals to the microcontroller, which in turn automatically adjusts the motors to correct the solar panel position.



Time & Date	Voltage (mV)	Current (mA)	Power (mW)
14 Apr 2017 11:07:33	12.9	0.6	7.7
14 Apr 2017 11:38:21	13.1	0.7	9.4
14 Apr 2017 12:05:30	13.4	0.7	9.5
14 Apr 2017 12:37:45	13.6	0.7	9.6
14 Apr 2017 13:08:13	13.8	0.7	9.7
14 Apr 2017 13:44:21	12.8	0.6	7.8
14 Apr 2017 14:13:19	12.5	0.6	7.6
14 Apr 2017 14:50:23	12.2	0.6	7.3
14 Apr 2017 15:24:41	11.8	0.5	6.0

Fig. 1. (a) Proposed solar tracker; (b) Data monitoring webpage.