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A REVIEW ON SENSORS FOR TRACKING THE SUN POSITION

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Abstract:

A brief review of current advances of sun location sensors used in solar technology like photovoltaic modules, satellites, solar collectors and other applications is provided in this paper. In depth, the operating principles and geometric designs of many types of sensors for sun location are discussed. The research takes into account the assessment of the advantages and disadvantages of different design criteria, such as accuracy, solar Tracking failures, desired properties, field of view (FOV) and marketing, and the assessment of external parameters influencing the performance of sun location sensors (climate conditions: solar radiation, pollution and temperature); On the other end, it was reported in various studies that the major obstacles for this technology are which requires a solution are: cost-effectiveness, temperature operating range and efficient transmission of information, so that future studies can focus on these issues.

Keywords: *Direction, Sensors, Signals, Solar, Tracking, Sunlight, Geometric designs.*

I. INTRODUCTION

In recent years, owing to its possible effects on solar concentrating applications and aerospace applications, solar energy has attracted a lot of interest. Numerous reports have indicated that there are various criteria for each solar application in order to make the most of solar energy, including geometric optimization, the proper use of materials and the synchronisation of solar systems with the Sun's rays. The criteria of solar orientation are taken into account in this work because their benefits are: minimising the power loss in the solar system, aligning the solar system's surface in the Direction of the Sun's rays at all times, and optimising the efficient use of solar radiation [1].

The atmosphere of the solar system must be perpendicular to the rays of the Sun in order to properly take advantage of the Sun's energy. For this cause, many scholars have suggested a wide variety of solar Tracking systems. The orientation mechanism, degrees of freedom and electronic regulation are categorised according to them. The mechanism of orientation refers to the type of mechanism that the device would be used to turn and position. Many implementations have indicated mechanisms for gears, pulleys, belts, engines, hydraulic devices, bar mechanisms, etc. The authors showed that with the use of sun monitoring systems in solar applications, about 19-30 percent more solar energy can be collected. Other scholars have studied these systems' performance, operating phase, and feasibility [2]. The authors have shown that these criteria are crucial to solar systems' competitiveness and profitability. Authors have researched the sun monitoring mechanism deployment techniques, energy usage, repairs, faults, structural deformation and its imbalance for wind loads, as they have an effect on the system's cost-benefit. The authors are researching the most powerful means of monitoring satellite motion and the sun tracker process in aerospace applications (satellites). They must understand the form of design concept, the components, weight and its application in the satellite for this scenario [3].

The second element, the degrees of freedom, applies to the kinds of movements that would have to be produced by the mechanisms of sun Tracking and sun location sensors. In other words, from East to West or North to South, solar systems would have to rotate or obey the Sun. This feature plays a crucial role in investment costs, operating costs and the accuracy of solar monitoring, as per the authors. Finally, in recent years, greater focus has been paid to electronic regulation. The authors explored the use of actuators, astronomical mathematical models or sun location sensors, and control techniques that could be used in solar monitoring. Due to costs and their simple execution, several experiments related to this topic have introduced astronomical mathematical models in solar applications. Their key drawback is that, among many others, they do not recognise the system's misalignment by wind disruptions, thermal deformations, and inadequate implementation. In this case, authors, for example, have introduced sun location sensors that can track the Sun with a high degree of precision and communicate with the composition of the solar system. Fast deployment, simplified architecture, low cost and adaptability are the benefits that this product provides [4].

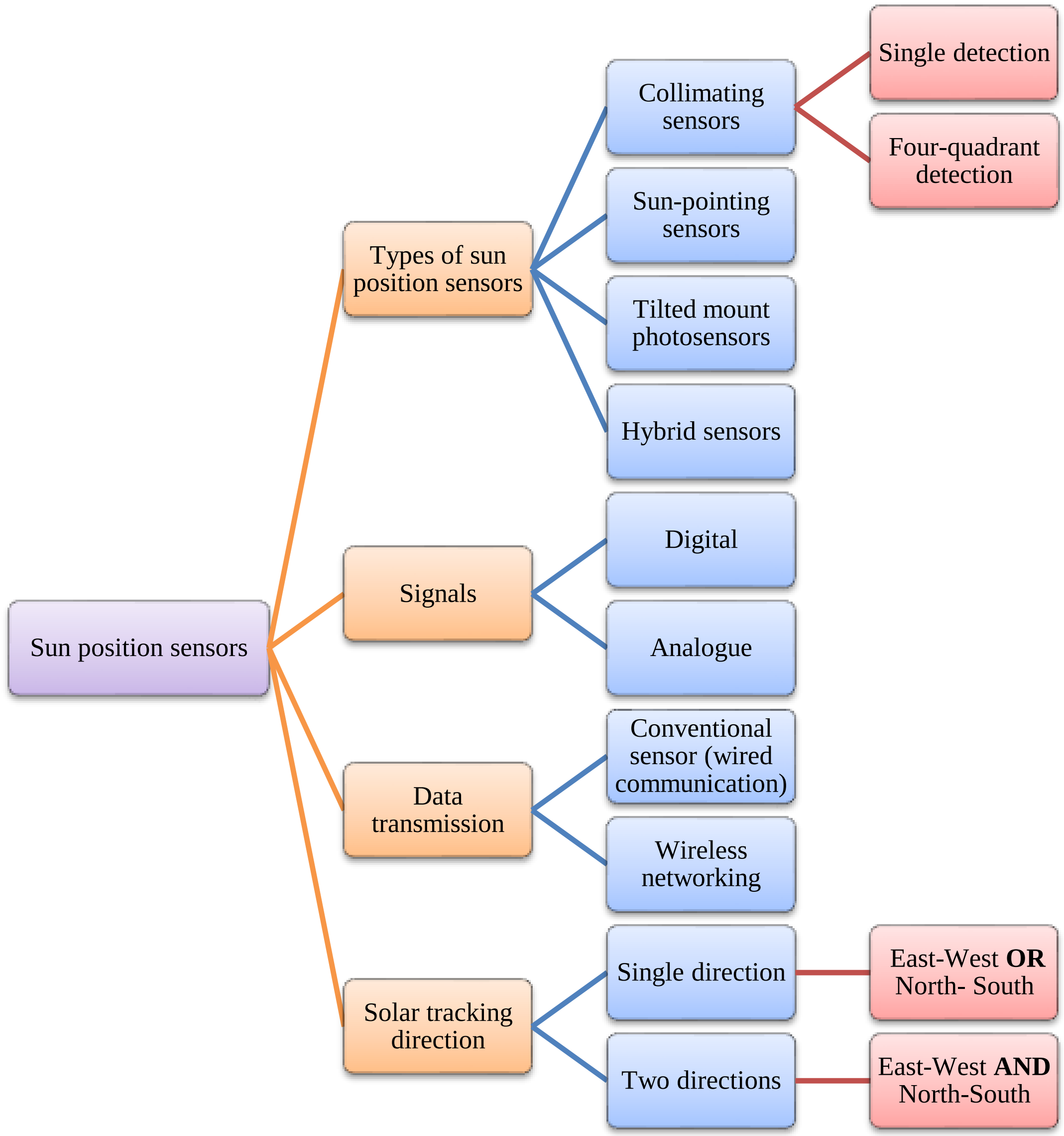

Fig. 1 Classification of sun location sensors

II. CLASSIFICATION OF SUN POSITION SENSORS

A Sun Position Sensor is a system that detects the orientation of the Sun in relation to the position of the sensor. Over the past few years, a number of sun location sensors have been developed and improved. The designs, components, and sizes are obviously based on solar applications [5]. The most general classification of sensors for sun location is based on the form of sensors, the type of signals, the propagation of data and the orientation of solar monitoring. Figure 1 summarises the classification of sun location sensors that will be extensively explored in this article.

Type of sensors

The physical and organisational aspects of the sun location sensors are referred to by the class of sensors, i.e. the geometric configuration, the operating theory (how the sensor calculates the Direction of the sun), the accuracy, and their effectiveness. Four key types are considered in this classification: a) collimated sun sensor, b) sun-pointing sensor, c) angled photosensor, and d) hybrid sensor. The following section describes these classifications in detail.

Collimating sensor: The collimating sun sensor is a system that at a certain point within the sensor narrows the sun's rays. Two prototypes based on working standards have been identified: (1) Detection on a plane and (2) Detection on Four-quadrant[6].

Sun-pointing sensor: The working theory of the sun-pointing sensor is based on the measurement of the photodetector's light and shadow, and the estimation of the apparent Direction of the Sun via the photodetector's current differences. In several experiments, which used five photosensitive sensors to build a sun sensor, this type of sensor was mirrored. The architecture consisted of a cylindrical tower with a central photosensitive sensor and four small board surfaces that blocked the light and created shade when the surface of the sensor was not aligned perpendicular to the rays of the Sun. With regard to the sun position sensor's metal frame, each surface was tilted at 45 ° and had a photosensitive sensor. The authors contrasted the voltages between the photosensitive sensors to determine the Sun's location. These signals were handled by a CMOS 8-bit micro-controller and the Sun was located. The drawback of this sensor lies in the manufacturing sophistication. The authors did not validate this sun position sensor's accuracy.

Tilted mount photo-sensor: The Tilted Mount Photo-Sensor is a device in the shape of a pyramid mounted on a horizontal plane consisting of two or more tilted planes. The process theory is based on the contrast of the light intensity in the photodetector. The higher-voltage or current photodetector will show the Direction of the Sun.

Hybrid sensor: There are several theoretical papers in literature that combine the above-mentioned working theory of sun location sensors.

The type of signals

Sun position sensors are components that calculate and relay the position of the Sun by analogue or digital signals with respect to the position of the sensor. A control device processes these two types of signals[7].

Digital: An encrypted distinct signal is provided by a digital sun position sensor. There are various research papers in the literature that present the concept of the digital signals-based sun position sensor. Researchers also developed a micro-digital sun sensor for a satellite, for example.

Analogue: An analogue sun position sensor is a system which produces a continuously sun angle feature. This sensor is focused on light being entered into the sensor. The light falls on a photo-sensor and produces a signal that is interpreted by a device of control. Since 2002, some scholars have used analogue signals.

Data transmission

Data transmission represents the flow of data by wires or wireless networking between the sun location sensor and a control device. Several efforts were made to strengthen contact with them[1][8].

Wired communication: Wired communication refers to the transfer of data using a technology for wired communication. In the literature, there are several research papers that have suggested sun location sensors with wired contact. The most recent prototypes introduced a sun location sensor consisting of four photodiodes mounted in a cross-shaped structure. This model used wires that connected the control device and the photodiodes,

Wireless communication: Wireless communication is a mechanism for linking the sun location sensor to the control device using radio waves. For its cost-effectiveness, reliability and its easy application, a small number of studies have suggested a sun location sensor with wireless networking.

Solar Tracking Direction

The Direction of solar Tracking is used to sense the location of the Sun in one Direction (East-West or North-South) or in two Directions (East-West and North-South)[9].

Single Direction: Researchers suggested a sun position sensor in 2013 which sensed the position of the Sun in a single Direction. The sensor was constructed of a T-shaped vertical plastic main plate separating two light-dependent resistors (LDR). The vertical plastic plate was used to remove the solar radiation that was distributed. The sensor was designed to calculate the differences between the voltages produced by the shade and the light through a microcontroller between the LDRs. This computer had manual monitoring, as well as automatic data collection control. It has been confirmed that its precision was 0.41°.

Two Directions: Researchers measured a sun location sensor in 2007 that used the approach of physical simulation and the shadowing effect induced by a slit. Two fine sun location sensors put in parallel were used in the sensor. The strength of the sunlight that passes through the slit was determined by both sun location sensors to measure the azimuth and elevation angles. Each sensor of the sun's location scanned and compared its output voltage, which was proportional to sunlight intensity. The Sun's location relative to the voltage output was determined by a special mathematical algorithm. The authors simulated the sun location sensor's output with a halogen lamp that supplied parallel light rays. Experimental and statistical results revealed that, with a FOV of 60°, the gross average error was 0.054° [10].

III. CONCLUSION

This paper gave a detailed description of the prototypes of sun location sensors for solar technologies, covering their geometric structures and operating concepts that could be helpful in the development of modern sun sensors. Based on the examination of the advantages and disadvantages of the various architecture specifications, it was concluded that the integration of the best characteristics of existing sensors appears to be the most efficient configuration. In this sense, several prototypes have enhanced their designs, taking into account cost-effectiveness, weight, precision, FOV, geometry and development methods, and also the use of modern materials and the advancement in technology in data transmission. Any of these designs have been noted to have attained a certain degree of commercial acceptance. However, the architecture of sun location sensors also has drawbacks, such as: the simplicity of geometric design (modifications) and control algorithms, the working temperature range, the efficient transmission of data and the auto-calibration method. The major challenges facing this technology are: the challenge in choosing the best solar technology sun location sensor, cost-effectiveness, and commercialization strategies. Future research should also focus on these issues, as there are possibilities for researchers to develop this device and look for other use fields.

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