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Heliostat Mirror Technology: A Survey

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Abstract

This review intends to analyze the recent trends in heliostat design technology, the constraints and the solutions proposed in various literatures. The paper mainly portray numerous technology enforced in heliostat system, its advancement and then describes the main threats encountered during implementation

Keywords: Heliostats, Solar, CCD camera, Image processing, Wireless sensor network.

INTRODUCTION

The maximum abundant sustainable supply of power is the sun. But a small amount of solar energy is enough for reaching the earth surface might be sufficient to meet the worldwide expected strength demand. Even though most renewable energies pick up their power from the sun, solar energy refers to the direct use of solar radiation. One of the greatest medical and technological possibilities faced is to increase efficient ways to acquire, convert, store and make use of solar electricity at low cost [1]. This study is being focussed to gather maximum solar electricity by enforcing a few new techniques that fits better for the Heliostat system. The paper describes the diverse strategies carried out in Heliostat device to offer maximum reflection of sun rays so the maximum solar electricity can be collected. Some illustrative literatures are given.

A tangible alternative of conventional solar panels to generate solar energy are **"The Heliostat system"**. The foremost benefit of those Heliostats over Solar Panels are, they are less sensitive to dust and can be without difficulty spray washed successfully, seeing that they're set up on an open surroundings this standards performs a vital position. Heliostat panels encompass lots of mirrors that reflects the sun light onto the focal point at the receiving tower. The solution which might be diagnosed till date to focus the solar light directly to the focal point making use of mild sensors and CCD cameras [2].

The paper is organized as follows:

Section 2: Technologies used to calibrate the heliostats. **Section 3**: methods used to determine the position of the sun.

CALIBRATION OF HELIOSTATS

The solution given in [2] for the calibration of heliostats is to have a charge coupled device to analyze the reflected image of the sun projected at the heliostat. In this case it is far viable to calculate the real orientation of the heliostat only when the position of every heliostat is known. As this setup tends to examine the most effective projection, as a way to make it a very simple setup the position of the digital camera need not be recognized. The disadvantage identified in this approach is that only one heliostat may be calibrated at a time , which makes this system improper for a large heliostat field, which in turn makes the system more costly. Moreover the aid structure isn't always stiff, and at times it is able to go through small deformation, as a consequence the position of the heliostat may also change. The subsequent method is presented in [3], here in this system a digital camera is added to hit upon the rims of each heliostat through image processing by the way of mounting a digital camera at the receiving tower and focusing it directly to the heliostat field. This technique leads to a couple of heliostat calibration at a time. This approach limits the practical implementation, due to the fact that, part detection require a very excessive precision. For the reason that camera is positioned a few hundred meters away from the heliostat field, it requires a bifocal lens to come across the rims, which leads to small area of view, that in turn requires a large number of camera to focus large number of heliostats. Some other disadvantage analyzed in this technique is it has measured only the position of the heliostat but not of the mirror. In different words "due to deformation of the mirror the maximum position of the heliostat would barely deviated.

The work carried out in [4] is an extension to the above noted technology. Here the CCD is not positioned at the mid of the target but over it. This method uses reflected circumsolar radiation rather than direct radiation to find orientation of the heliostat. This approach considerably lowers the drawback faced by [5] (i,e) decreasing brightness and heat flow on the camera. Another method described in [5] CCD camera is used to capture the sunlight pondered from every heliostat. Then each heliostat is tilted to provide the most reflection which ends up in an optimal orientation. This solution suits well only in theory but when it comes for real time its use is restrained. The CCD camera requires extensive cooling since large amount of heat float at the camera from many heliostats. The sun light immediately is reflected on to the digital camera which ends up in overexposure. It additionally reduces the location, which in turn reduces the performance of the tower.

The solution provided in [6] says that the camera isn't always placed at the target but at the perimeter of the heliostat area. The sunlight is pondered on to the digital camera with the aid of the heliostats. Rather than aligning all the heliostats , except few replicate the sunlight on to the camera on the identical time. This additionally overcomes the disadvantage of [5].

DETERMINING THE POSITION OF THE SUN

On this phase [7] offers a method for determining the location of the sun. It makes use of astronomical equations for monitoring the sun. These astronomical equations require the longitude and range (worldwide position) of the heliostat and the time of the day if required to decide the altitude and azimuth angle that the sun makes with the heliostat. In massive scale power plant, a computer is used to calculate the altitude and azimuth angles of the sun for every heliostat.

Another approach of monitoring the sun [8] makes use of an image based control scheme. In this method a CCD is hooked up to every heliostat pointed within the direction of the mirror's normal captures a picture of the sun every 15 seconds and compares the region of the solar in the image with a predicted place of the receiver tower. This method starts every day while mild depth is identified above a fixed threshold. By means of setting the gain and exposure settings on the CCD to a degree that lets the digital camera to select the distinguishing features at the receiver, the anticipated region of the tower is decided at the beginning of the day and location of the tower is stored in the memory. So over saturation of captured sun's image can be avoided , the gain and exposure settings of the camera are changed. This technique tracks the sun in the day and moves the mirror to have the sun blob and receiver location antipodal with respect to the center of the image.

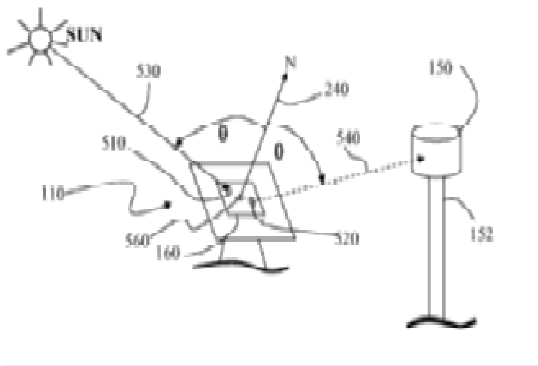


Figure 1: Image-based sun tracking.

[9] Tracking of sun is done with solar sensors, like photo resistors that is able to change its resistance completely based on the amount of incident light. [9] Here heliotracks that makes use of photo resistors in several different orientation. This design uses four photo resistors that are installed surrounding a four walled post. This set up is designed in such a way to shade the sensors based totally on sun's location. The sensor checks the sky till all 4 sensors get similar intensity of light. At the same time as the light source is observed, the angles that the sun makes with respect to the sensor can be transformed into angles of the sun with respect to the mirror. [10] proposed a technique for monitoring both the sun and the target through the usage of photo sensor array acquired from the face of the mirror. A lens permits a slice of the sun's image to bypass through the heliostat and onto a bar of photo sensors. The relative angle of the sun to the heliostat may be envisioned based on which photo sensor are detecting light

Sun Sensor used on Heliotrack's 1m by 1m heliostat.[9]

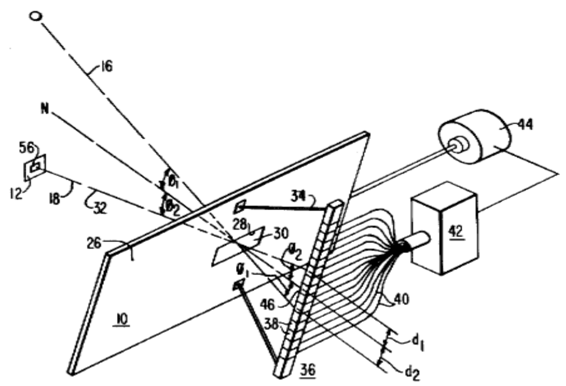
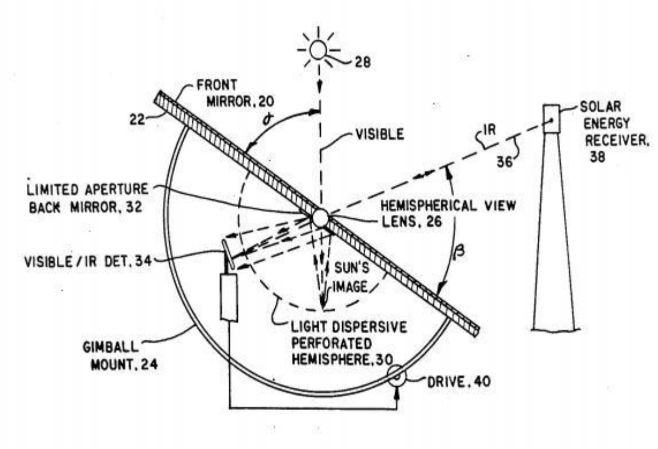
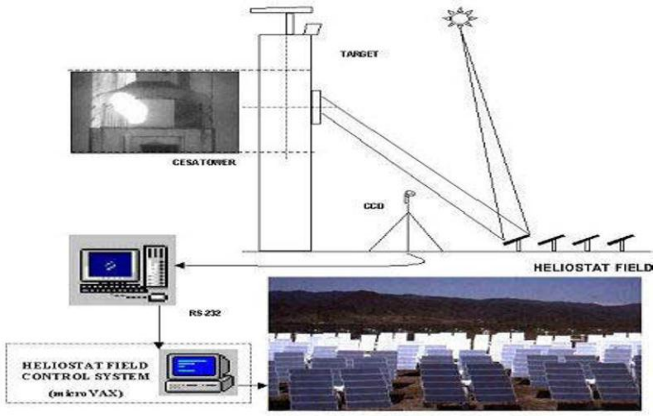


Photo sensor array used for determining the position of the sun relative to the mirror.[10]

For determining the position of the sun [11] describes a method that makes use of infrared detectors. In this technique, from the middle of the heliostat, the IR detector is recessed with a lens which lets in IR waves to bypass through the mirrors. Other technique described in [12] makes use of a small mirror on the top of the receiving tower to reflect a least quantity of light into the receiver. The collector correlates the position of the sun's reflected image to the conventional position and can determine offsets. A calibration technique proposed in [13] uses a CCD camera to identify the reflected image of the sun between the heliostat and the target, and compares the sun's position with its conventional position. much like [8] this approach uses threshold detection technique to determine the centroid of sun's reflected image . The location of the reflected image is in comparison with the preferred area of the reflected image. those images are then compared based on intensity of light, then the heliostat is managed accurately.

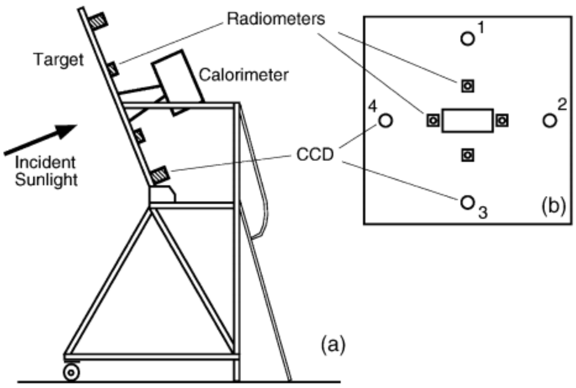


Detecting the tower using infrared receivers.[11]



Position correction based on reflected solar image on target.[13]

Work carried out in [14] describes a method of ultimate the control loop of heliostat via the use of four CCD cameras positioned near the target. The cameras are located in a cross pattern around the target in all four aspects top, bottom, right and left. As quickly as the light is pondered onto the target, every camera captures an image. Those snap shots are then in assessment based totally on intensity of light, Then the heliostat is corrected as a result.



Comparing reflected images with four different cameras surrounding the target.[7]

Another approach of calibration used for determining the optical quality of heliostats is proposed in [15]. This approach projected a stripe pattern onto the control receiver tower of a heliostat field. This system detects canting and different surface detects in the heliostat using a MATLAB script. The heliostats were positioned to reflect the stripe pattern from the control receiver tower into a camera located close to the tower. The cameras capture images of every heliostat and determine defects by the distortion pattern

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WSN IN HELIOSTATS

Numerous wireless heliostat systems were proposed. In [16], a wireless heliostat gadget based on a WSN is proposed. The system uses a charge - coupled device (ccd) digital camera to track the sun's movement in three dimensions, and communicates the information to all the systems wirelessly via a WSN, permitting the mirrors to get hold of the control records as a way to rotate to provide the maximum reflection of the solar energy. In [17], a WSN for heliostat control for a sun thermal cooking gadget is proposed. This system additionally uses a CCD camera to sound the sun's 3-d function, just like the machine in [18]. In the system presented in [18], a digital camera is used for tracking the sun's position.

Additionally, numerous manage strategies for controlling heliostats exist, and those techniques can be labeled into 3 categories: open-loop control; closed-loop manipulate; and a hybrid method which is a mixture of open and closed loop control [19]. The choice of control approach is dependent on requirements including tracking accuracy, heliostat system efficiency, and calibration of the heliostat discipline [20]. The system proposed in [21] fundamental cognizance changed into the trying out of wireless conversation and concentrated on algorithms. A concentrated set of rules is based on vector arithmetic and three-dimensional trigonometry was advanced from initial ideas. The device included a solar tracker which sends the sun's position wirelessly to two heliostats. The improvements can be made are a few regions of the machine which may be progressed. The lean repayment algorithm may be improved to boom the system overall performance while tilt disturbances are imposed on the machine; an improvement within the sensors for the sun tracker might result in reduction of the angular errors; The reliability and security as per [22 - 23] need to be further evaluated and can also take into account improvements in hardware layout incorporating an open hardware design approach [24 - 25].

CONCLUSION

One of the greatest challenge in renewable energy is to provide maximum energy at low cost. The aim of this survey is to identify the best suited technique for the heliostat system to obtain maximum solar senergy. This survey has analyzed different techniques for heliostat design technology, calibration of heliostats, determining the position of the sun, and application of WSN in heliostats. The heliostats will replace the traditional solar panels and produces maximum solar energy when compared with conventional solar panels. Heliostat mirror technology is achieved through positioning the heliostat panels according to the position of the sun, with the help of a CCD camera. The major drawback pointed out in this analysis is that the usage of CCD camera requires extensive cooling and reduced brightness, which can be achieved through [4]. For determining the position of the sun several techniques has been analyzed , like determination of altitude and azimuth angle; gain and exposure determination; using of photo resistors and photo sensors. Among these the identified best suited technique is the threshold detection technique.

REFERENCES

[1] Moore Roy A, "Solar Tracker", US patent application US4649899 (1987)

[2] Berenguel, M.; Rubio, F.; Valverde, A.; Lara, P.; Arahal, M.; Camacho, E. & López, M. : Solar Energy 76(5):563-575-2004.

[3] Röger, M.; Prahl, C. & Ulmer, S.: Journal of Solar Energy Engineering MAY 2010, Vol. 132 / 021002-7, 2008.

[4] Kribus, A.; Vishnevetsky, I.; Yogev, A. & Rubinov, T.: Energy, 2004, 29, (5-6), 905-913.

[5] Fitch, J.; Koningstein, R.; Ricket, D. & Mo, V. HELIOSTAT CONTROL SCHEME USING CÁMARAS, Patent US 2011/0120448 A1.

[6] S. Schell. 0038-092X/$ - 2010 doi:10.1016/j.solener. 2010.01.00885 (2011) 614–619

[7] Kribus, A. Energy, 2004, 29, (5-6), 905-913.

[8] Reznik, D. "Camera-based heliostat tracking controller." *U.S. Patent No.12/497,385*. Jan. 2011.

[9] Heliotrack.com.http://www.heliotrack.com /Heliostat1M.html.

[10] Vaerewyck, E. *et al*. "Heliostat Guidance." *U.S. Patent No.4,211,922.* 1978.

[11] Blitz, D. "Solar Energy Sun Tracker." *U.S. Patent No. 4,013,885.* 1977.

[12] Practical Solar. www.practicalsolar.com.

[13] Berenguel, M., Rubio, F.R., Valverde, A., *et al*. Berenguel, M. et al. Solar Energy, 2004, 76, (5), 563-575.

[14] Kribus, A. . et al. Energy, 2004, 29, (5-6), 905-913.

[15] Ulmer, S. Solar Energy 85 (2011) 681–687Jan. 2010.

[16] M. Younis, H. Al-Shehhi, N.A. Hamar, and M. Meribout, GCC Conference and Exhibition (GCC), 2011 IEEE, pp.465,468, 19-22 Feb. 2011.

[17] J.D. Freeman, J.T. Varghese, and R.P. Manoj, 978-1-4673-4444-9/13 Energytech, , pp.1,5, 21-23 May 2013.

[18] J. Thomas, "Tower-tracking Heliostat Array," California Polytechnic State University, California, Masters Thesis 2011.

[19] K. Chong and C. Wong, Solar Energy, vol. 83, no. 3, pp. 298-305, 2009.

[20] D. Lee, W. J. Jeon, S. W. Baek, and S. H. Chang, International Conference on Power and Energy

Systems, 2012.

[21] K Mabusela, CP Kruger, BJ Silva and GP Hancke 978-1-4799-7498-6 2015 IEEE.

[22] G.P. Hancke, K. Markantonakis and K.E. Mayes, Journal of Internet Technology, Vol. 11, No. 3, May 2010.

[23] A. Abu-Mahfouz and G.P. Hancke. Distance Bounding, IEEE Transactions on Industrial Informatics, Vol. 9, No. 1, pp. 16-27, Feb. 2013.

[24] R. Fisher, L. Ledwaba, G.P. Hancke and C. KrugerMDPI Sensors 2015, 15(3), pp. 6818-6844, March 2015.

[25] C.P. Kruger, A.M. Abu-Mahfouz, S.J. Isaac, IST-Africa Conference and Exhibition, pp. 1-9, 2013.