Abstract—Design of a two-dimensional automated solar tracking system is discussed in this paper. The objectives of the proposed work are to design an automated tracking technique using Light Dependent Resistance (LDR), and solar panel power output to position the solar panel to absorb maximum energy. For positioning the solar panel two stepper motors are used those are controlled using National Instruments (NI) motion assistant and with the program written using Support Vector Machine (SVM) on LabVIEW. The controller is designed using SVM with the inputs as the solar panel output, LDR sensor output and target being the position of solar panel which yields maximum output from solar panel. SVM after being trained, validated, and tested is implemented to control the position of solar panels through two stepper motors. The system was tested and results showed the proposed technique has fulfilled its mentioned objectives.

Keywords—Automation, LDR, LabVIEW, Solar Tracking, Support Vector Machine.

I. INTRODUCTION

The standard of living of the people of any country is considered to be proportional to the energy consumption by the people of that country. In one sense, the disparity one feels from country to country arises from the extent of accessible energy for the citizens of each country. Unfortunately, the world energy demands are mainly met by the fossil fuels today. The geographical non-equidistribution of this source and also the ability to acquire and also control the production and supply of this energy source have given rise to many issues and also the disparity in the standard of living. Climate change concerns, coupled with high oil prices, peak oil, and increasing government support, are driving increasing renewable energy legislation, incentives and commercialization. New government spending, regulation and policies helped the industry weather the global financial crisis better than many other sectors. According to a 2011 projection by the International Energy Agency, solar power generators may produce most of the world’s electricity within 50 years, dramatically reducing the emissions of greenhouse gases that harm the environment.

At present a lot of solar cell panel arrays are basically been fixed and cannot absorb sunlight to its maximum and reduce photoelectric conversion efficiency. A lot of research is carried on in this field, literature survey suggests. In [1], design of automatic solar tracking device is discussed using real time clock in single dimension. In [2], two axis solar tracking system is discussed using the real time clock. In [3], microcontroller based design methodology of an automatic solar tracker is presented. In [4], microcontroller based two-axis solar tracking is designed and developed using LDR sensor and dc motor on a mechanical structure with gear arrangement. In [5], single axis solar tracking mechanism is being discussed using real time clock. In [6], they propose a detector for one or two axis automatic orientation, which permit a continuous tracking for entire zenith angle range. In [7], ripple correlation control method is presented and verified against experiment. In [8], automatic solar tracking system based on one-chip computer is discussed. Here the tracking is based on the real time clock.

In this paper a technique is proposed for automatic two-dimensional solar tracking system using NI Motion Assistant designed on LabVIEW platform. Here LDR sensor is used as a sensor for solar tracker, along with LDR the output of solar panel is also considered as one of the inputs for controlling the tracking of solar panel. Two stepper motors are being used for controlling two axis of solar panel. The control algorithm is designed using support vector machine.

The paper is organised as follows: after introduction in Section-1, a brief description on each component of block diagram is given in Section-2. Section-3 deals with the problem statement followed by proposed solution in Section-4. Finally, result and conclusion is given in Section-5.

II. PROPOSED TECHNIQUE

![Block diagram of the experiment.](image-url)
A. LDR

LDR is made of a high-resistance semiconductor [9]. It can also be referred to as a photo resistor. If light falling on the device is of the high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance. Hence, LDR is very useful in light sensor circuits.

B. Solar Panel

A solar panel is a collection of solar cells [10-11]. Although each solar cell provides a relatively small amount of power, many solar cells spread over a large area can provide enough power to be useful. To get the most power, solar panels have to be pointed directly at the Sun.

C. NI Motion Assistant

NI motion assist consist of a Universal Motion Interface (UMI) and driver for stepper motor. NI motion assist can be directly configured with LabVIEW software through DAQ Assist thus making it user friendly in real time. NI motion assist consists of UMI which acts as an interface between PC and driver (P7060 of NI) [12-14].

III. PROBLEM STATEMENT

An experimental set up is proposed for a two dimensional automatic solar tracking system. The following tasks are to be achieved.

1. Accept input from LDR MSS sensor array.
2. Accept input from solar panel
3. Design of controller to achieve maximum efficiency, by positioning the solar panel.
4. To position the panel two stepper motors are used to vary positions in two dimensions. These stepper motors are driven by NI motion assist.
IV. PROBLEM SOLUTION

To achieve the objectives mentioned in the above section LabVIEW software is programmed. The LabVIEW program contains two parts: front panel and block diagram [15-18]. The front panel vi (vi - program written in LabVIEW) is where the user can control and/or monitor the designed system. Block diagram vi is used to write the program for the desired application. Here, to achieve the proposed objectives we have divided the functions in two modes of operation i.e. (i) Fixed mode: in this mode the solar panels are placed in one fixed pre-defined position irrespective of the efficiency from solar panels. (ii) Tracking mode: in this mode solar panels are can be positioned manually or automatically. (a) Manual Tracking: In this mode the position of solar panels is controlled manually, the stepper motor rotates to the angle defined by user using numerical controls on the front panel vi. (b) Auto tracking: In this mode the position of solar panel is set automatically to attain maximum efficiency using a controller designed by support vector machines.

Fig. 8 shows the front panel view of the proposed system. It consists of two selector switches, one switch to select between fixed and tracking mode, and the other switch is used to select auto and manual tracking when tracking mode is activated. Four numerical indicators to indicate solar panel o/p, LDR sensor o/p, Stepper motor 1, and stepper motor 2 positions in terms of step angles. Two numerical controls to feed the step angles by user for stepper motor 1 and stepper motor 2 while using manual tracking mode.

Fig. 5, Fig. 6 and Fig. 7 shows the block diagram view of the proposed system at fixed, manual tracking, and auto tracking modes. Fig. 5 shows the block diagram vi of the proposed system in fixed mode. In this mode the program is written to accept the input like solar panel voltage output, and LDR sensor voltage output using DAQ Assistant. A program is written on a sub.vi to display the actual voltage output. Two DAQ Assistants are used to control the stepper motor step angle. In this mode step angle is pre-defined for both stepper motor 1 and stepper motor 2.

Fig. 6 shows the block diagram vi for manual tracking mode. In this mode the program is written to display the output of solar panel and LDR sensor is processed and is displayed. Based on the two inputs accepted using the numerical control from front panel, data is processed and control signal is sent through the DAQ Assist to rotate the stepper motor to the desired step angle, as indicated by the user for stepper motor1 and stepper motor 2.

Fig. 7 shows the block diagram vi of the proposed system for auto tracking mode. In this mode program is written to automatically vary the position of solar panels to achieve maximum efficiency. The two signals corresponding to solar panel output, LDR sensor output are processed, and displayed using numerical indicators. These signals are also used for the controller design using SVM [19-22] to control step angle of the stepper motor to achieve maximum efficiency. In this mode the position of the stepper motor is first varied based on the LDR (MSS) output. SVM is used to achieve optimal efficiency, i.e. the motor shift by an increment delta on both the direction. The values are noted and SVM is designed to find the position at which solar panel output is maximum. This signal is then sent to stepper motor using DAQ Assist, also the same is displayed using numerical indicators.
The SVM is designed using NeuroSolutions for MATLAB software. The network is trained, validated, and tested to perform the desired task. The network is trained with 80%, validated and tested with 20% of data each. Fig. 12 shows the architecture of the SVM used for the proposed system. Summary of the SVM parameters are tabulated in Table-I.

### Table I. SUMMARIZES THE REQUIRED DATA FOR TRAINING

<table>
<thead>
<tr>
<th>Optimized parameters of SVM Model</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Data base</td>
<td>Training 82</td>
</tr>
<tr>
<td></td>
<td>Validate 27</td>
</tr>
<tr>
<td></td>
<td>Test 27</td>
</tr>
<tr>
<td>Input Projection Algorithm</td>
<td>K-mean Clustering</td>
</tr>
<tr>
<td>Input Optimization</td>
<td>Greedy search</td>
</tr>
<tr>
<td>MSE</td>
<td>4.42E-09</td>
</tr>
</tbody>
</table>

V. RESULT AND CONCLUSION

The system after being trained validated and testing with the SVM is subjected to real time environment. Fig. 13, Fig. 14, Fig. 15, and Fig. 16 shows the front panel vi of the proposed technique for various test cases in real time.
Figure 16. Front panel VI for the test case in auto tracking case 2 mode.

From Fig. 13, Fig. 14, Fig. 15, and Fig. 16 it is clear that the proposed technique has achieved its objectives. It was also noted that the system on auto tracking produced about 38% improvement in efficiency when compared to fixed mode solar panels.

REFERENCES


