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Advance Design of Solar Dual Axis Tracking System using fuzzy Logic Controller

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Abstract

Solar energy is a clean and naturally available source of energy. Recently Scientifics works to improve the materials and methods that used to harness this power source. There are two major approaches; maximum power point tracking and sun tracking. These two methods required efficient controllers. The controller may be conventional or intelligent such as Fuzzy Logic Controller (FLC).The main problem that face producing the maximum amount of electricity by sun tracking system is weather change .The objective of this research, is to design sun tracker system using Fuzzy Logic Controller (FLC) , this system follows the movement of the sun and able to solve the problem of climate effects by using the sun– earth geometrical angles among the alternation of night and day to obtain the greatest amount of solar energy. A tracking mechanism composed of photovoltaic module, stepper motor, sun-earth geometrical relationships input/output interface and expert FLC controller that to track the sun and keep the solar cells always face the sun in most of the day time. The proposed sun tracking controller is tested by chosen Wad medani city (14.40^{o}) latitude). The system was tested in Matlab/Simulink environment. The results give that in 21th march when the values of altitude angle hour angle and declination angle were (14.40 ^{o}), (-90^{o}) and (-0.40^{o}) respectively the result zenith angle was (90o). In the day of 21th December march when the values of altitude angle hour angle and declination angle were (14.40 ^{o}), (-90^{o}) and (-23.4^{o}) respectively the result of zenith angle was (90^{o}). The results show that the controller has a good response and receive more power than traditional system. This study recommends to design combination of the sun Tracker with two axes follow the movement of the sun using conventional sensors and sun-earth geometrical relationships via Fuzzy Logic Controller (FLC).

Keywords: Fuzzy Logic Controller; Solar Dual Axis Tracking System; Solar energy

1. Introduction

Renewable energy sources play an important role in electric power generation. There are various renewable sources which used for electric power generation, such as solar energy, wind energy, geothermal etc. Solar Energy is a good choice for electric power generation, since the solar energy is directly converted into electrical energy by solar photovoltaic modules. These modules are made up of silicon cells. When many such cells are connected in series we get a solar PV module. The current rating of the modules increases when the area of the individual cells is increased, and vice versa. When many such PV modules are connected in series and parallel combinations we get a solar PV arrays, that suitable for obtaining higher power output. (Neij L ,2008)

Main factors that affect the efficiency of the collection process are solar cell efficiency, intensity of source radiation and storage techniques. The efficiency of a solar cell is limited by materials used in solar cell manufacturing. It is particularly difficult to make considerable improvements in the performance of the cell, and hence restricts the efficiency of the overall collection process. Therefore, the increase of the intensity of radiation received from the sun is the most attainable method of improving the performance of solar power (T.P. Chang., 2009). There are three major approaches for maximizing power extraction in solar systems. They are sun tracking, Maximum Power Point (MPP) tracking or both.

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Maximum power point tracking (MPPT) is the process of maximizing the power output from the solar panel by keeping its operation on the knee point of P-V characteristics. MPPT technology will only offer maximum power, which can be, received from stationary arrays of solar panels at any given time. The technology cannot however increase generation of power when the sun is not aligned with the system. (Daniel, A,1983)

Solar tracking is a system that is mechanized to track the position of the sun to increase power output than systems that are stationary. It is a more cost effective solution than the purchase of solar panels. There are various types of trackers that can be used for increase in the amount of energy that can be obtained by solar panels. The basic Categories of trackers are single axis and dual axis. Single axis tracker has one axis of freedom, vertical or horizontal. Dual axis tracker has both a vertical and a horizontal axis of freedom, so it able to track the position of the sun precisely (Protik.2015). These methods need controllers may be intelligent such as fuzzy logic controller or conventional controller such as PID controller. Fuzzy set theory has been introduced in 1965 by Lofty A. Zadeh. a fuzzy system consists of a mapping between input and output using rules of type IF-THEN. There are two important classes of fuzzy models. First class includes the fuzzy logic models where the antecedent (input) and the consequent (output) parts are linguistic expressions. The second class includes the Takagi-Segno fuzzy models where the consequent part is a mathematical function while the antecedent part is a linguistic expression. The advantage of the fuzzy logic control is that it does not strictly need any mathematical model of the plant. It is based on plant operator experience, and it is very easy to apply. Hence, many complex systems can be controlled without knowing the exact mathematical model of the plant. In addition, fuzzy logic simplifies dealing with nonlinearities in systems. The nice thing about fuzzy logic control is that the linguistic system definition becomes the control algorithm. (E H Mamdani,1974)

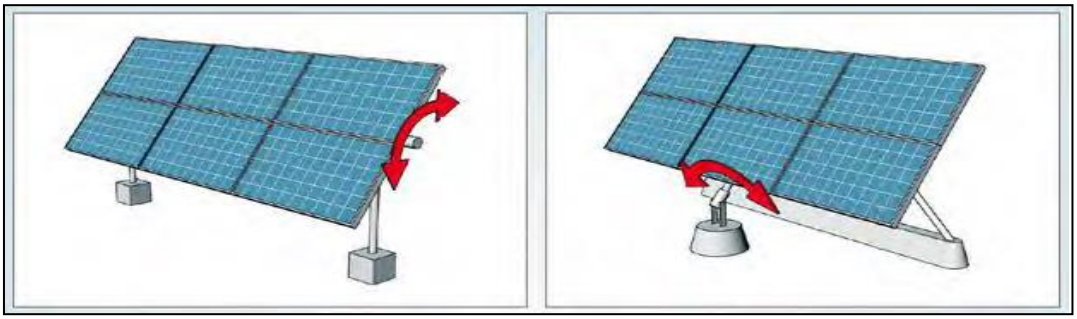

Figure 1 Horizontal and tilted single axis solar panel

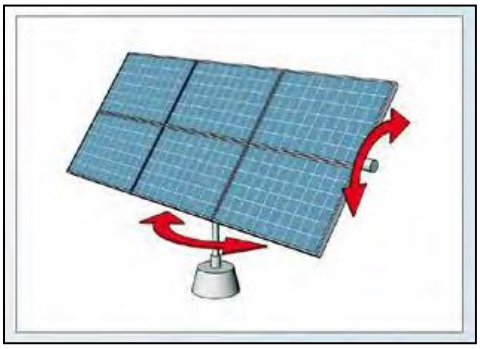

Figure 2 Dual axis solar panel

Objectives

The objective of this research is to design a sun tracking system to sense the sun position to the maximize solar radiation through solar panel regardless of the weather.

2. Methodology

This research focused on designing and building an intelligent solar tracking system to track the sun position in any time. The design used fuzzy logic control to track the movement of sun (light radiation) using sun-earth relationship angles to determine the position of sun and sends the proper instruction to move stepper motor accordingly.

3. Flow chart

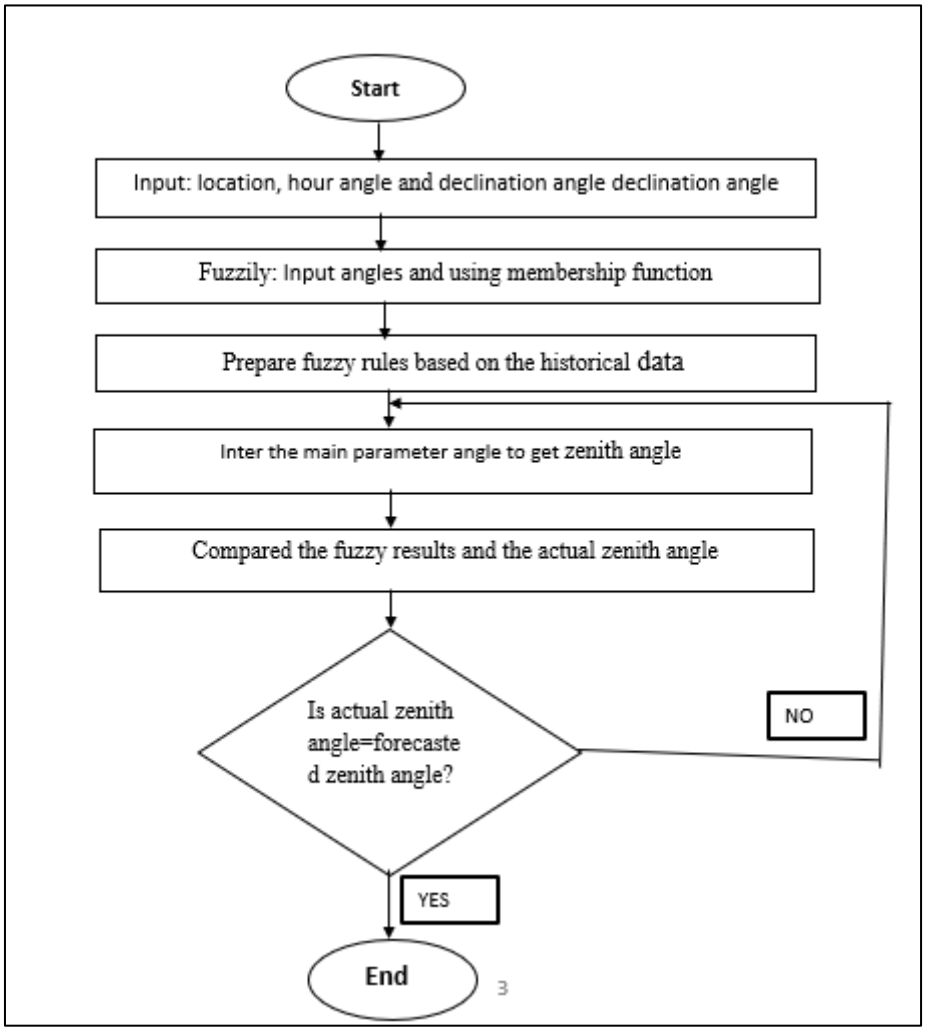

Figure 3 System Flow Chart

4. Research contribution

The proposed solution helps the tracking system uses sun-earth geometrical relationships to identify the location of the sun regardless the weather factors.

5. Results

The experimental data of the zenith angle are calculated, for different months in wad medani by calculated the hour angle and declination angle for the same in each hour and calculating the range value for all months Table (1) shows these value.

Table 1 Comparison of the experimental results obtained with and without using fuzzy controller

month	Hour angle Range (in degree)	Declination Angle range (in degree)	Zenith angle rang without fuzzy (in degree)	zenith angle range with fuzzy (in degree)
Jan	90 — -90	-17 — -23	32.1 — 95	30.5 — 93
Feb	90 — -90	-17 — -8	22.6 — 94.2	30 — 90
March	90 — -90	-8 — -4	10.7 — 92	11.2 — 90.8
Apr	90 — -90	4 15	8 — 8 9	7 — 88
May	90 — -90	15 — 22	7.5 — 86.3	7 — 90
Jun	90 — -90	22 — 23	7.6 — 84.6	7 — 90
July	90 — -90	23 — 18	3.7 — 85.5	7 — 90
Aug	90 — -90	18 — 8	6.2 — 87.9	7 — 86
Sep	90 — -90	8 — 4	6.6 — 90.9	7 — 90
Oct	90 — -90	-4 — -15	18.6 — 93.7	20.2 — 90.9
Nov	90 — -90	-15 — - 22	30.9 — 95.3	30,5 — 95
Dec	90 — -90	-22 — -23	30.5 — 95.6	30,5 — 93

The maximum actual zenith angle, and maximum fuzzy forecast zenith angle are present as shows is Figure

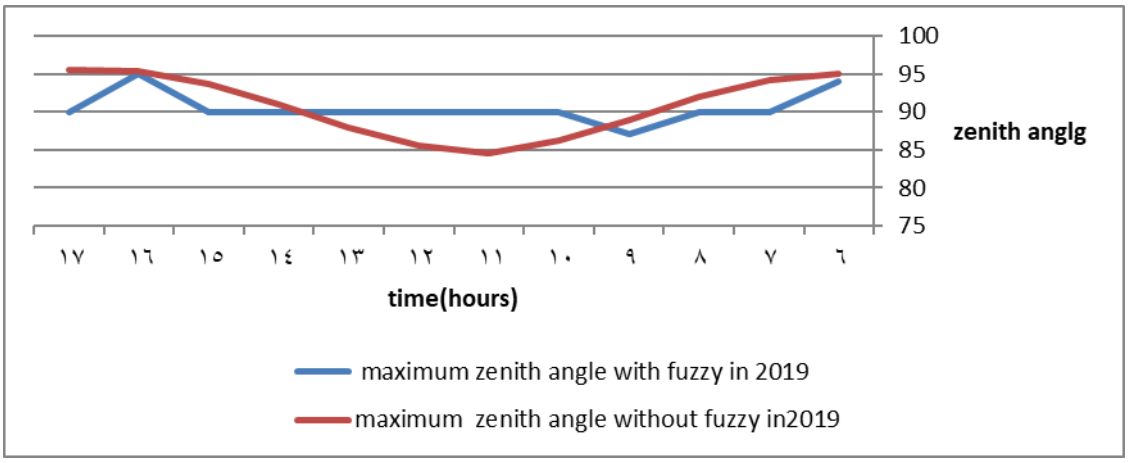

Figure 4 Maximum zenith angle curve of 2019

The minimum actual zenith angle, and minimum fuzzy zenith angle are present as shows is Figure

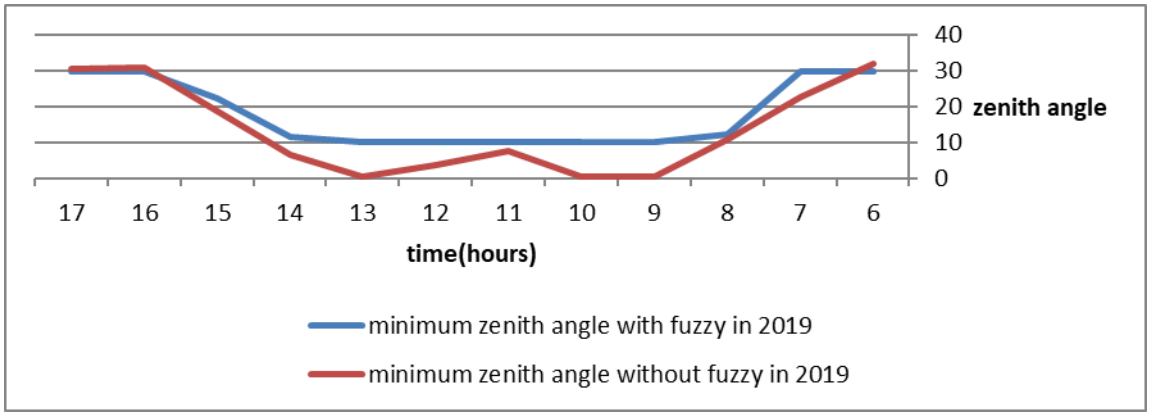

Figure 5 Minimum zenith angle curve of 2019

Table (2) shows the actual zenith angle, and zenith angle Fuzzy also the percentage error in the zenith angle Fuzzy. Zenith angle Fuzzy is done for the day 21 Th March 2019.

Table 2 Hourly zenith angle of 21 Th March 2019

Time of day	Zenith angle output values without fuzzy (in degree)	Zenith angle output values with fuzzy (in degree)	error%
6:00 A.M	90.1	90	0.1
7:00 A.M	75.5	73.9	2.1
8:00 A.M	61.15	59.8	2.2
9:00 A.M	46.91	45.61	2.1
10:0 A.M	33.17	31.8	4.1
11:0 A.M	20.9	19.9	5
12.0 non	14.8	13.9	6
13:00 P.M	20.9	19.9	5
14:00 P.M	33.17	30.8	4.1
15:00 P.M	46.91	44.61	2.1
16:00 P.M	61.15	58.8	2.2
17:00 P.M	75.5	72.9	2.1
18:00 P.M	90.1	90	0.1

Table (3) shows the actual zenith angle, and zenith angle Fuzzy also the percentage error in the zenith angle Fuzzy. zenith angle Fuzzy is done for the day 21th December 2019.

Table 3 Hourly zenith angle of 21th December 2019

Time of day	Zenith angle output values without fuzzy (in degree)	Zenith angle output values with fuzzy (in degree)	error%
6:00 A.M	95.6	90	6
7:00 A.M	82.4	81.7	0.8
8:00 A.M	69.8	67.6	3.1
9:00 A.M	58	56.8	2
10:0 A.M	47.8	46.9	1.8
11:0 A.M	40.5	38.7	4.4
12.0 non	37.8	36.6	3
13:00 P.M	40.5	38.7	4.4
14:00 P.M	47.8	46.9	1.8
15:00 P.M	58.04	56.8	2
16:00 P.M	69.8	67.6	3.1
17:00 P.M	82.4	81.7	0.8
18:00 P.M	95.6	90	5.8

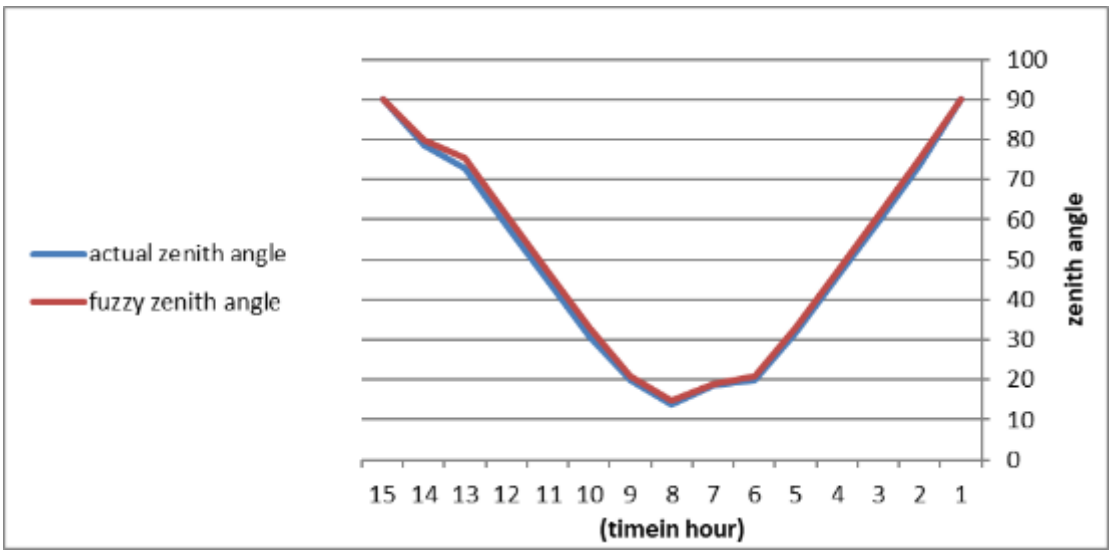

Figure 6 Zenith angle curve of 21th March 2019

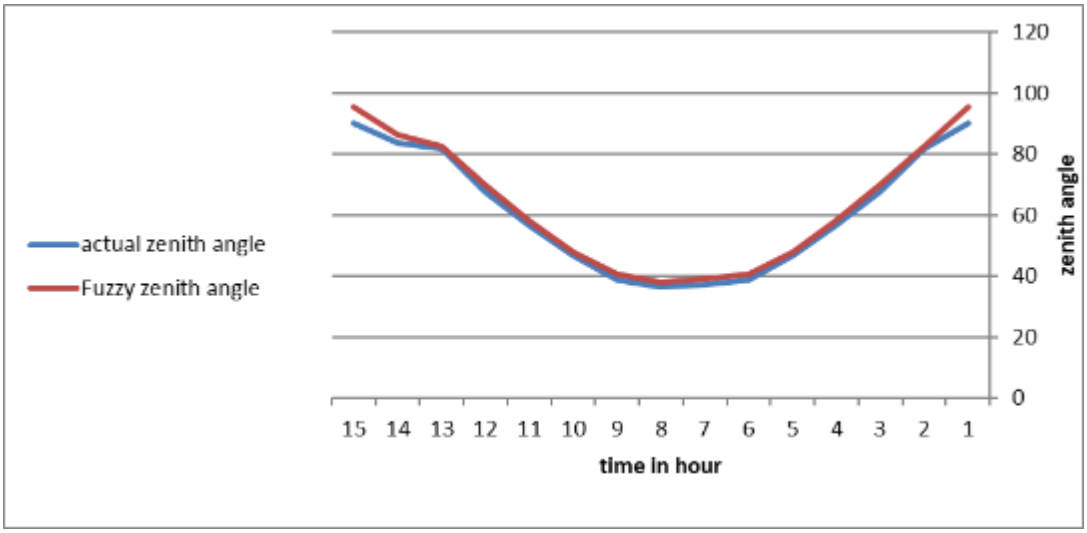

Figure 7 Zenith angle curve of 21th December 2019

6. Conclusion

In this study a sun tracking system has been developed to increase the amount of power generated by the solar panel as the sun travelling across the sky. Fuzzy logic used to control the movement of the solar panel.

In this study fuzzy control used to design tracking system based on geometrical angles of the sun instead of using LDR as used in traditional systems. It is concluded that using, altitude angle, hour angle and declination angle as the inputs and by formulating rules base on fuzzy logic using available data, zenith angle was founded in high accuracy approximately about 6% of error. It is also concluded that fuzzy logic approach is very easy for prediction the results by using simple rule "IF-THEN" statements.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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