RESEARCH ARTICLE OPEN ACCESS

Artificial Neural Network and Array of Photoresistors for Solar Tracking System

Marjun S. Sequera[1]

[1]Department of Electro-Mechanical Technology, University of Science and Technology of Southern Philippines, C.M. Recto Avenue, Lapasan, Cagayan de Oro, Philippines

Email: marjunsequeradem t@gmail.com

Abstract:

The world now is gradually shifting from conventional energy source to renewable energy such as the solar energy. The acquisition of this type of energy is very expensive as of the moment if fully used to supply the entire household. This study aims to develop an apparatus for tracking the apparent motion of the sun utilizing an array of photoresistors to optimize generation of energy. The angles of the servo motors are determined by the artificial neural network with inputs coming from the array of photoresistors.

Keywords **— Renewable Energy, Solar Energy, Solar Tracking.**

I. INTRODUCTION

The generally rising capital cost of energy supplies from non – renewable energies such as fossil oil and coal is causing economic stagnation and price inflation to low – income developing countries like the Philippines.Its net oil imports increase from 166 million U.S. dollars in 1973 to 1.470 billion U.S. dollars in 1984 and that is a 885 percent increase in terms of price [1].

Pollutions are one of the longrun growth and environmental problems during recent years. It seems like the origins of these many real-world pollution problems are from the use of non-renewable resources. This is due tothe the burning of fossil fuels that producesgreenhouse effect and acid rain [2].

The interest around the world into producing clean, sustainable power in substantial quantities from renewable energy sources has been aroused and this is stimulated by recent technological developments and increasing concern over the sustainability and environmental impact of conventional fuel usage.The principal types of these renewable energyincludes solar, thermal, photovoltaics, bioenergy, hydro, tidal, wind, wave, and geothermal [3].

The best choice for renewable energy is the solar energy since the Sun provides the Earth largeamount of energy which is 1.2 x 10^5 terawatts. This amount of energy literally dwarfs any other renewable energy sources [4].

However, solar energy conversion technologies are costly and its scalability is low for a complete energy system. Capturing, converting, and storing solar energy is currently ineffective in terms of cost [5]. Since it is costly, the collected beam radiation can only be maximized through the use solar tracking systems to follow the sun as it moves each day [6].

The solar tracker has to maintain the tilt angle of the solar panel with respect to the Sun as it rise from East and set to West. The Sun rise also in different direction throughout the year since the Earth axial tilt or obliquity is more than 23 degrees from the line perpendicular to the orbit direction. However, solar tracking devices are still expensive due to the sophistication of its design, components involved and coding.

Designing solar tracker using an array of photoresistors as the system that track the position of the Sun and utilizing artificial neural network to determine the tilt angle of the panels using motors based on the direction determined by array of photoresistors may provide cheaper way of tracking the position of the Sun hence, optimizing the generation of energy.

II. PHOTORESISTOR ARRAY

Photoresistor isvariable resistors with resistance decreases as the incident light increases. The type of photoresistor used are CdS photoresistor with maximum resistance of 600k ohms with each photoresistor pulldown resistor of 10k ohms when in complete darkness a total of reading of 610k ohms when supplied with 5 volts and minimum of 10k ohms when in broad daylight. The photoresistors are arrayed like a dome as shown in Fig. 1, with borders separating the photoresistors that define the boundary of ranges which each of the photoresistor must be active.

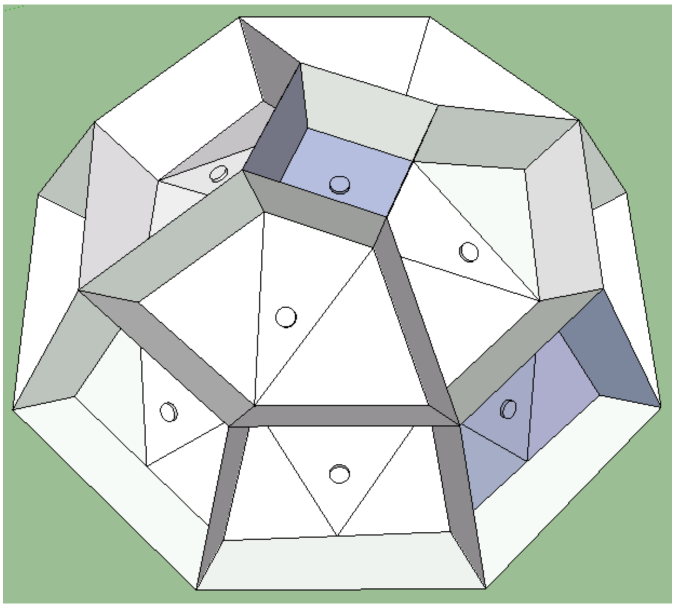

Fig. 1The dome shape of the photoresistor array

The photoresistor array is divided into three levels as shown in Fig. 2: the upper level with one photoresistor, the middle level consisting offour photoresistors and lower level consisting of eight photoresistors. The total number of photoresistors used is thirteen.The four photoresistors in the middle level represents the four major directions: North, East, South and West. The lower level has eight photoresistors to represent not only the major directions but also the minor directions: North-East, North-West, South-East and South-West.

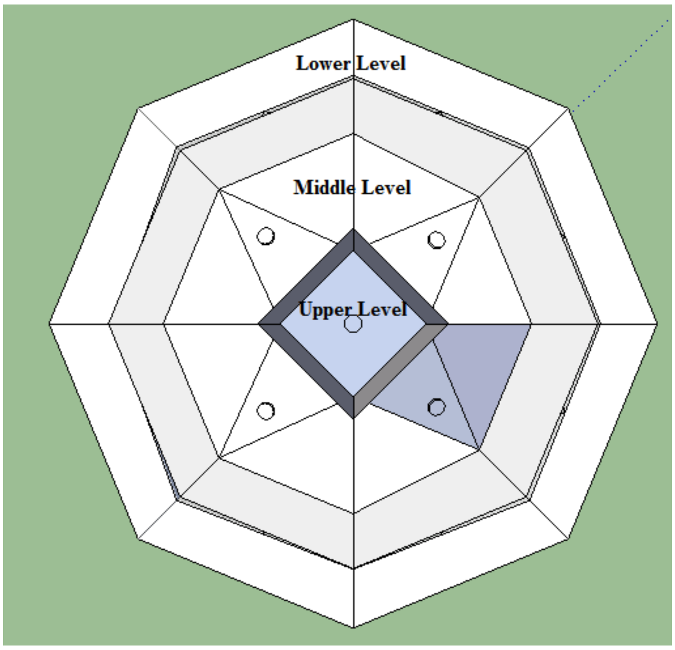

Fig. 2The three different levels of the photoresistor array

The depth of which each of the photoresistors are positioned is 2 cm from the lateral surface of the dome as shown in Fig. 3, enough to minimize receiving light incident rays that it should not be receiving.

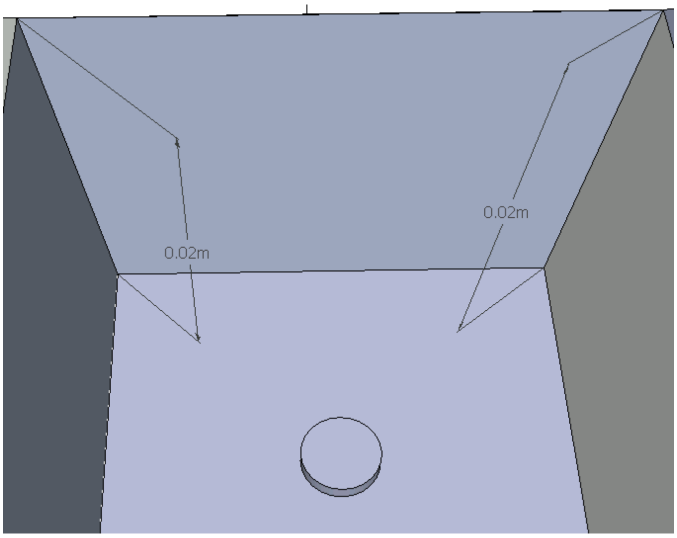

Fig. 3The depth of the photoresistors from the lateral surface of the dome

The angular separation of three levels is by thirty degrees as shown in Fig. 4.

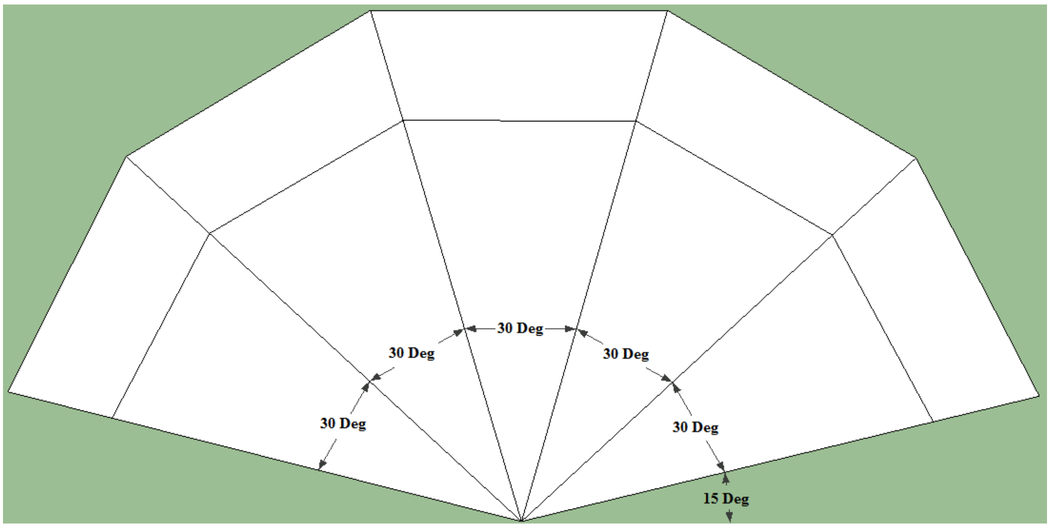

Fig. 4The angular separation between levels

III. ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) is an algorithm that mimics the structure and behaviour of the human brain. Its structure consists of nodes and synapses networked together like how the neurons are networked in the human brain. It has also the capability to learn through inputting observations in several epochs and perform backpropagation to adjust the weights of the synapses to compensate the computer error at the output side.

Shown in Fig. 5 is the artificial neural network architecture used in this solar tracking system. It is the most common architecture of an artificial neural network with only three laters: input layer, hidden layer and output layer, with synapses fully interconnected between layers. It has thirteen input nodes for each of the photoresistiors in the array, five hidden nodes and two output nodes for the two servo motors for yawing and pitching.There is only one layer for the hidden layers and limited number of nodes to speed up the computation of the output since the system always monitor the position of the Sun.

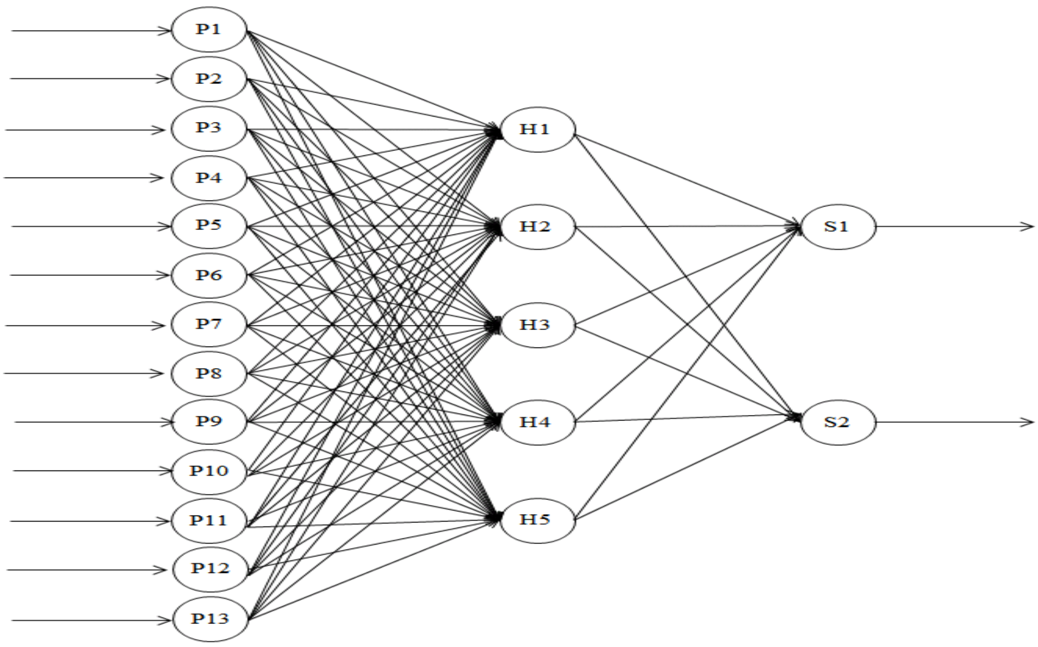

Fig. 5 The artificial neural network architecture used

The weights are learned by performing forward propagation by inputting the normalized values of the photoresistor array, compute the percentage error between the produced output and the normalized values of the servo motors and backward propagation to adjust the weights based on the computed percentage error at the output side. This is done for every row of the observation matrix. The network was trained in only one hundred epochs.

The observation matrix is generated by pointing the flashlight at full intensity in every photoresistor, log the readings of the thirteen photoresistors and the angles of the servo motors to make the solar panel face to the source of light. Every photoresistor is taken data for four intensity of the flashlight: high, medium, low and off. The total number of rows of the observation matrix is fifty two rows. The photoresistors values are normalized by dividing them by 610k ohms and the servo motors values by 180 degrees.

IV. RESULTS AND DISCUSSIONS

Basically, the whole system consists of three major parts: (1) the solar tracking system which is actually the photoresistor array, (2) the control system inside the control box, casing the microcontroller and power supply and (3) the panel positioning system that yaw and tilt the panel according to the Sun position.

The whole system was tested through pointing the ray of the flashlight onto one photoresistor and observe the reading of the photoresistors and the computed angles for the servo motors by the designed artificial neural network being implemented by the microcontroller. It was observed that if the position of the light source is monitored in real – time, there is logging that has occurred and since the angles computed, although the differences between the computer angles are close, also changes, the panel positioning system is shaking because the servo motors are constantly changing its angles. So instead of monitoring the position of the light source in real – time, the system was set into tracking the position of the light source by intervals which is about five minutes.

The generated angles for the servo motors was observed determining the angles of displacement. There are discrepancies which is natural because even the computed angle of the artificial neural network is varying due the constant fluctuating readings of the photoresistor array. However, the angles generated by the control system are not that far from the actual angles the servo motors performed.

A. *Solar Tracking System*

Shown in the Fig. 6 – 7 is the actual solar tracking system with its array of photoresistors arranged in three levels.

Fig. 6Isometric view of the array of photoresistors

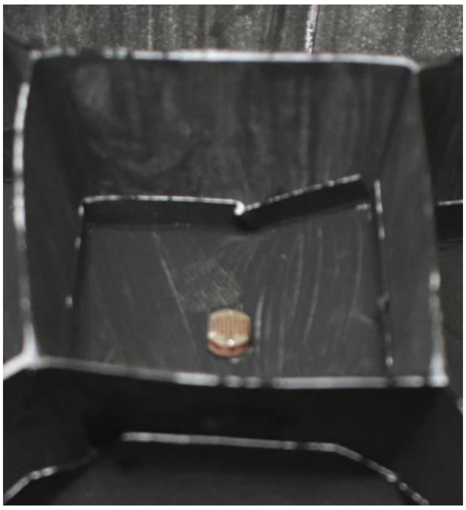

Fig. 7The depth of a single photoresistor section

B. Control System

Fig. 8show the control box which housed the Arduino microcontroller where the designed architecture of the artificial neural network has been uploaded into. Ventilation system was also added to keep the control box interior from overheating through installing the computer chassis fan at the side of the control box.

Fig. 8The control box

C. Panel Positioning System

Fig. 9 shows the platform where two servo motors are installed. The two servo motors are responsible for yawing and tilting the solar panel to face the direction of the light source based on the send angles from the microcontroller.

Fig. 9The panel positioning system above the control box

V. CONCLUSIONS AND RECOMMENDATIONS

The system was able to position the solar panel facing the direction of the light source however, because of the interval and the unstable reading of the photoresistors, while the solar panel is facing the light source, the solar panel is still shakes every five minutes.

Another is that due to the limited number of observations used in training the artificial neural network, setting the light source in positions not included, some of the trials resulted into unsatisfying result.

It is recommended therefore that the observations to be used for training of the artificial neural network be increased and for better accuracy of the yawing and tilting of the solar panel, stepper motors maybe used.

ACKNOWLEDGMENT

The realization of this study would like to express the profound gratitude to my beloved family for their moral, emotional and financial support and to our Almighty God for the strength, wisdom and guidance.

REFERENCES

1. *Goldemberg, J., Johansson, T. B., Reddy, A. K., & Williams, R. H. (1987). Energy for a sustainable world (p. 119). Washington, DC: World Resources Institute.*
2. *Schou, P. (2000). Polluting non-renewable resources and growth. Environmental and Resource Economics, 16(2), 211-227.*
3. *Boyle, G. (2004). Renewable energy. Renewable Energy, by Edited by Godfrey Boyle, pp. 456. Oxford University Press, May 2004. ISBN-10: 0199261784. ISBN-13: 9780199261789, 456.*
4. *Crabtree, G. W., & Lewis, N. S. (2007). Solar energy conversion. Physics today, 60(3), 37-42.*
5. *(Lewis, N. S. (2007). Toward cost-effective solar energy use. science, 315(5813), 798-801.)*
6. *(Jamil Ahmad, M., & N Tiwari, G. (2009). Optimization of tilt angle for solar collector to receive maximum radiation. The Open Renewable Energy Journal, 2(1).)*