Parabolic Concentrator Controlled by Fuzzy Logic

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Abstract-- This paper proposes and evaluates a control system for solar tracker controlled by fuzzy logic to position it correctly and get the highest incidence of sunlight at a specific point, controlling the movement by two DC motors.

Keywords---Parabolic concentrator, fuzzy logic.

I. INTRODUCTION

The following article shows how to make a solar tracking system with two degrees of freedom for positioning a parable regarding the apparent path of the sun giving an azimuthal movement and elevation (east-west, north-south), using a diffuse control system , as shown in Figure 1.

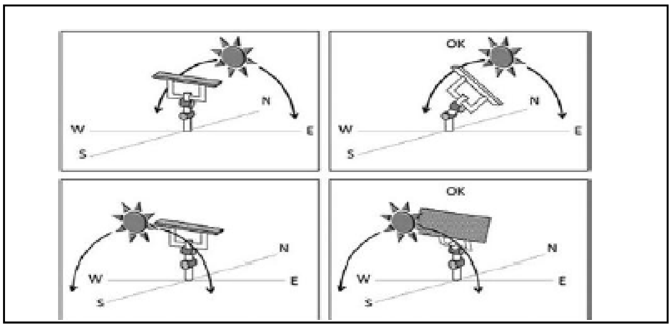

Fig. 1. Positioning the sun

II. PROBLEM

Currently have developed numerous sources of clean energy transformation and means to manipulate it, as in the case of the energy generated by the incidence of sunlight in auto sustainable systems; however, these can be very cost besides just having the highest levels of efficiency during peak hours. The aim or purpose is to get an inexpensive alternative to follow the apparent path of the sun and get the highest incidence of sunlight during the day.

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III. PROTOTYPE

Is proposed to use a parabolic system of two degrees of freedom, as shown in Figure 2.

Fig. 2. Parabolic Concentrator prototype.

Which is composed by two direct current motors and a system of sensors placed at the focus of the parabola, the engines directed the system as follows:
Motor 1: Horizontal position (north-south, south-north). Motor 2: Vertical (east-west, west-east).
The mathematical model is based on the following equations:

$$\frac{di}{dt} = \frac{Vapp}{L} - \frac{R}{L}i - \frac{K\Phi}{L} \quad (1)$$

$$\frac{dw}{dt} = \frac{K\Phi}{J} - \frac{b}{J}w \quad (2)$$

Where Vapp is the voltage of application, R is the electrical resistance, L is inductance, b is the friction, J is the rotational inertia for the motor and this has an electromagnetic field [1], represented in figure 3.

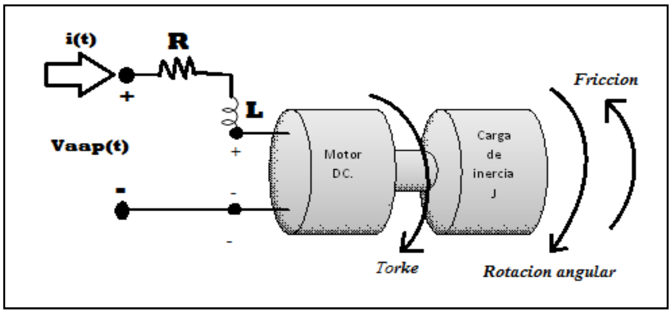

Fig. 3. DC Motor

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IV. CONTROL

To the control stage is proposed to use fuzzy logic because this emulates the human reasoning and can make decisions based on inaccurate data [2]. This is because the sunlight in the morning is different than noon, and sensors not have an exact logical value. It was used a microcontroller in which fuzzy rules are scheduled and situate the parabolic concentrator at the four cardinal points.

As sensors, were used four Light Dependent Resistor LDR [3] as inputs to the system, represented by the letter "S" in the order of "S1 and S2" (East West), "S3 and S4" (north-south), plus a fifth sensor which is a phototransistor with UV protection "S5" only detecting infrared radiation emitted by the sun [4], and controls the signal of the other four sensors.

The analog signal of S1-S2 and S3-S4 sensors is sent to the microcontroller with analog inputs [5] so that this decides which is the right strategy to follow and control the direction to take for the motors 1 and 2, which is constantly fed back, comparing the analog input value of the sensor for accurate positioning of the parabola, if the difference of these is in the diffuse area of OK [2]. Figure 4 shows the physical structure of the sensors.

Figures 5 and 6 show the representation of the analog values of S1 and S2 ranging from 0-1024, these correspond to intermediate values of [0, 1] as it would be done using discrete values, and displays the diffuse area of "Ok" where the parable would be directed to the sun East-West or North-South. Information for vertical values or east-west elevation is similar to the horizontal values or azimuth North-South because analog input values are the same.

The output fuzzy set shown in Figure 7 is similar for the two engines because both share the same electrical and mechanical properties.

The fuzzy set input of sensor S5 is to detect solar radiation, this will be located outside the system and will send the signal when it is day, to turn on the control system, this means that other sensors begin to capture the maximum sunlight when the sensor S5 is activated and stop doing its job if it is night [4], to avoid unnecessary movements If some light fall upon them as other light sources these are not taken into account because the sensor is only sensitive to sunlight. The fuzzy set output of S5 is shown in Figure 8.

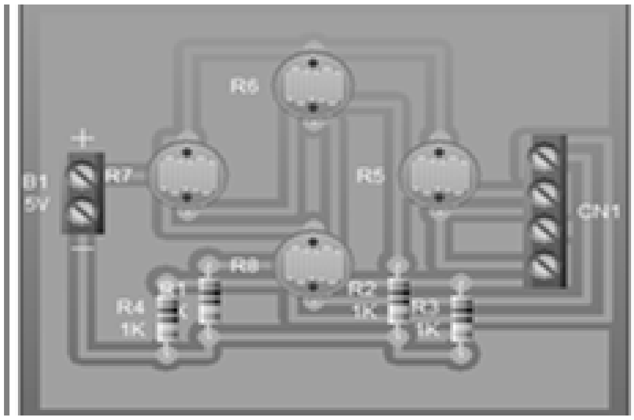
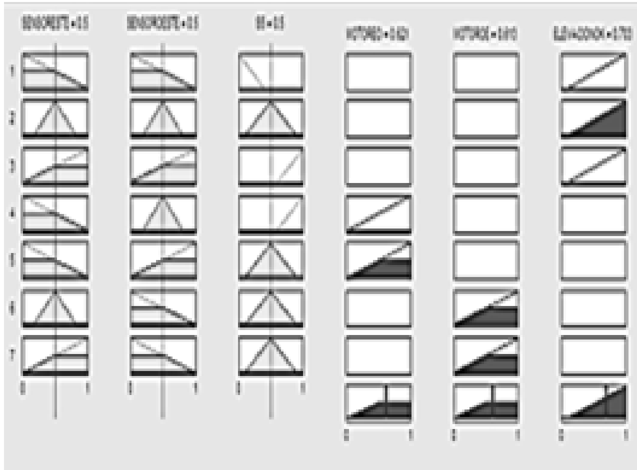


Fig. 4. Physical structure of the sensors.

Fuzzy control rules for the system upright or lifting are shown in Table I.

Table I. Rules of fuzzy control for horizontal position.



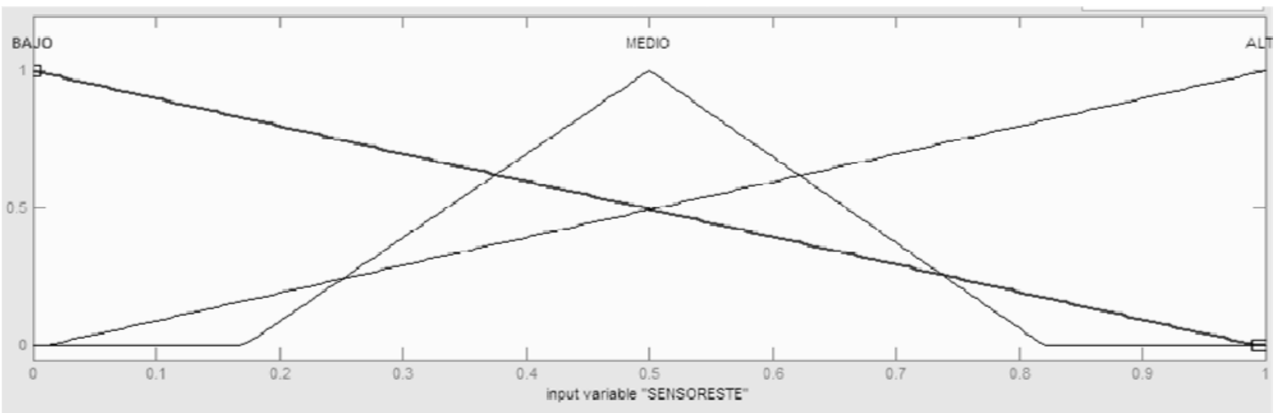


Fig. 5. Input fuzzy set West - Sensor

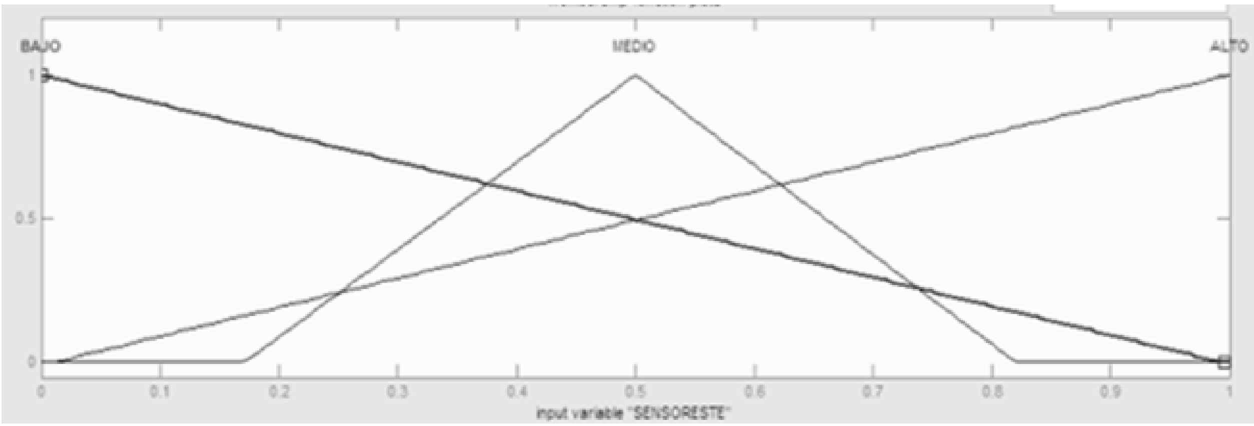


Fig. 6. Input fuzzy set East - Sensor

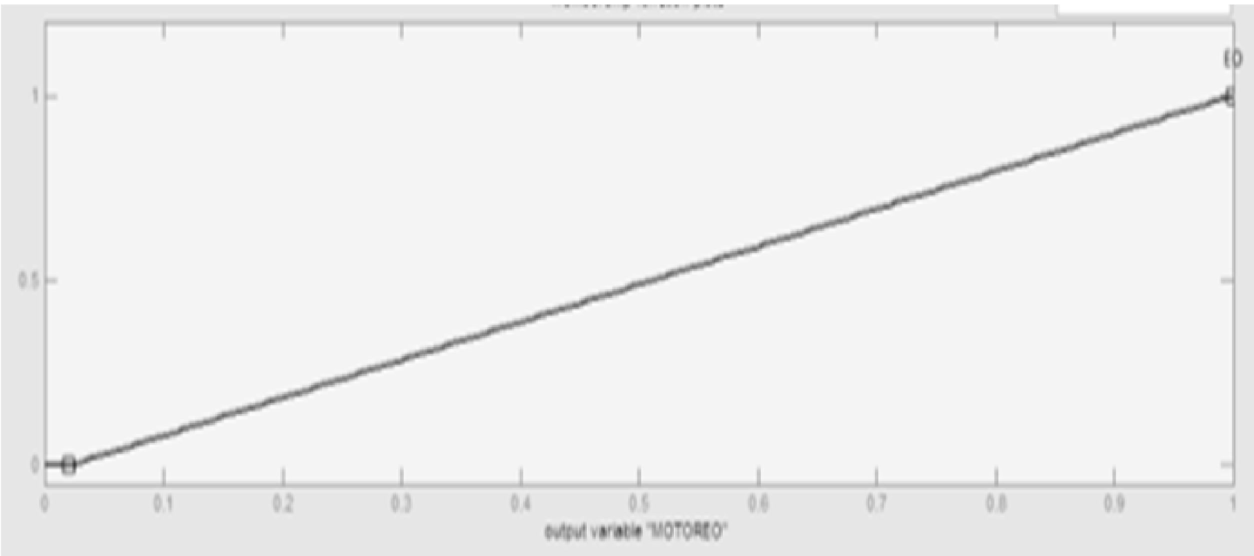


Fig. 7. Output fuzzy set for the fuzzy controller of the EO motor

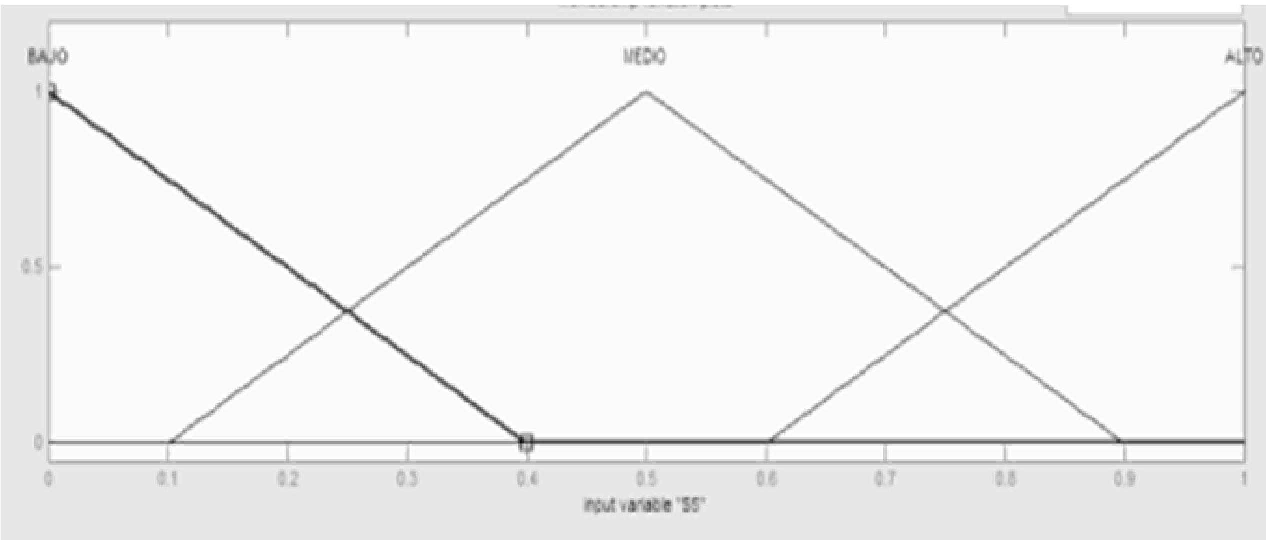


Fig. 8. Fuzzy set sensor output 5.

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V. SIMULATION

The system was simulated in MatLab using fuzzy control library, in which the following results were obtained, for example, the interaction between the east and west sensors with the motor output EO (east-west) where the motor response is observed relative to the signal sensor as shown in Figure 9.

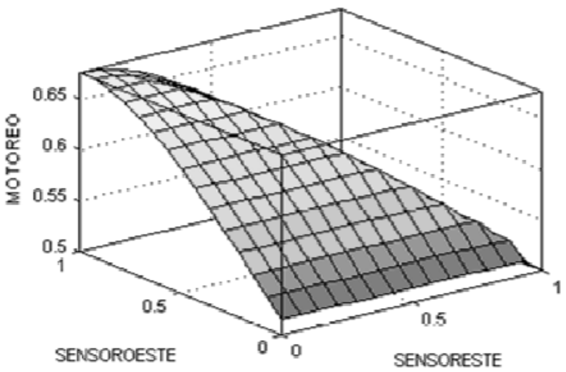

Fig. 9. Graphic of output of East and West sensor with respect to the Motor EO output.

As well as the interaction between the sensors and the output of the OK system as shown in Figure 10, which shows how is the output response lifting OK (engines do not move) with respect to the sensors of East and West.

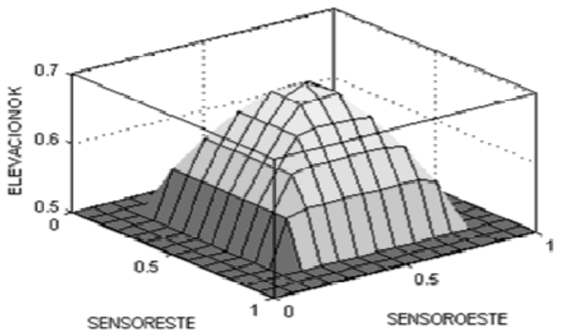

Fig. 10. Graphic output of the East and West sensor with respect to the Elevation OK output.

VI. CONCLUSIONS

Simulating the system in Matlab facilitates predicting system responses, but not until the circuit is completed and the fuzzy control system is downloaded to a microcontroller is when the real answer of this is noted, at this time the research team seeks to install the system in a real parabolic concentrator and take heat samples obtained in this, is expected to present these results in the future and discuss it with other researchers in the area.

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