Thermal Concentrator Fresnel Controlled by Fuzzy Logic

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***Abstract*—This paper proposes and evaluates, a fuzzy logic control for thermal concentrator Fresnel, in order to achieve an autonomous control system, which obtains the correctly position of the mirrors system to the thermal collector.**

I. Introduction

THIS paper presents a control based by fuzzy logic to control a thermal concentrator Fresnel (FTC) [1], to achieve thermo solar energy, trough the positioning of system of mirrors in relation to the thermal concentrator, the control algorithms move the FTC from east to west along the apparent path of the sun, the FTC position control is represented in figure 1.

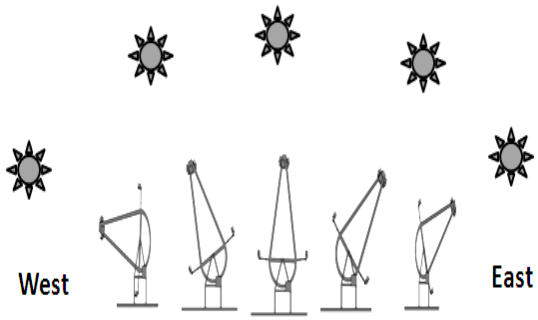

Figure 1. FTC tracking the apparent path of the sun

II. PROBLEM

The system needs to control two direct current motors, the first motor to follow the apparent move of the sun during the day from east to west, and a second motor to move the thermal concentrator. The fuzzy logic control makes the optimal strategy to align the mirrors system, to the thermal concentrator to catch all the possible light. The motors and sensors are shown in figure 2.

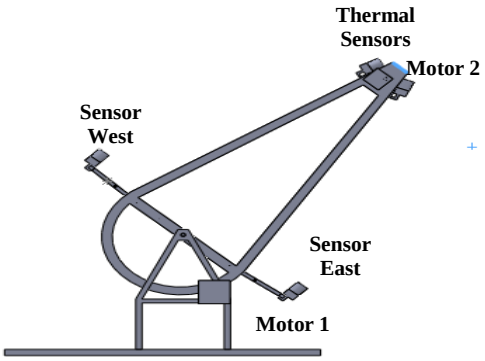

Figure 2. Thermo concentrator Fresnel sensors

III. PROTOTYPE

The direct current motor proposed for this system needs to move the FTC to find the most solar incidence. The sensors proposed are two light sensors (Photo resistive) used to measure the tension difference of the light, and two temperature sensors used to measure the tension difference for thermal incidence, the position of the sensors are shown in the figure 3.

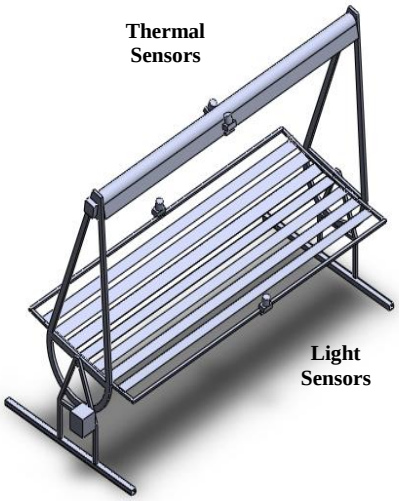

Figure 3. Fresnel mirrors

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The following equations are used to model the direct current motors:

$$P = \tau\omega \quad (1)$$

$$\tau = \mathcal{F}a \quad (2)$$

$$P = (mgd)(2\pi\omega) \quad (3)$$

$$\mathcal{F} = mg \quad (4)$$

$$\frac{di}{dt} = \frac{Vapp}{L} - \frac{R}{L}i - \frac{K\Phi}{L} \quad (5)$$

$$\frac{d\omega}{dt} = \frac{K\Phi}{J} - \frac{b}{J}\omega \quad (6)$$

P is power, τ the rotor torque, Vapp the applied tension, b the friction, J the moment of inertia for the motor and $K\Phi$ the electromagnetic field [2], shown in the figure 4.

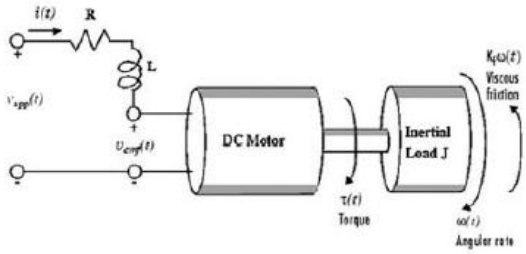

Figure 4. DC motor

IV. CONTROL

The system control is based in fuzzy logic because the decisions are based on inaccurate data [3]. The light incidences in the system are different in the morning and in the afternoon and it´s not sunny every day. The signal from the sensors, the motors and the fuzzy control are simulated in Matlab/ Simulink in this order:

LSE	Light Sensor East
LSW	Light Sensor West
TSE	Thermal Sensor East
TSW	Thermal Sensor West
MTEW	Motor Thermal East to West
MTWE	Motor Thermal West to East
MMEW	Motor Mirrors East to West
MMWE	Motor Mirrors West to East
TS	Thermal Sensor OK
LS	Light Sensor OK

The dc motor equations and voltage inputs from the sensors signals were simulated in Matlab/Simulink, (figure 5, 6.) The system interprets the light and thermal sensors.

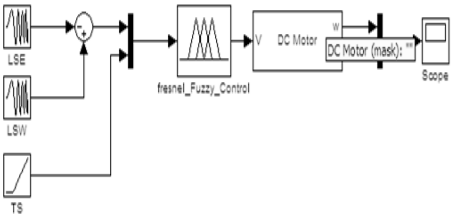

Figure 5. Mirrors position control in Simulink

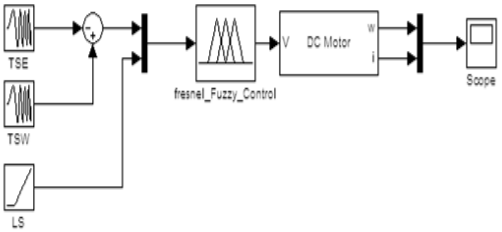

Figure 6. Thermal position controls in Simulink

The control uses the signal from sensors like fuzzy input variables with linguistic interpretations [4]; giving a strategy to redirect the mirrors and thermal concentrator to the optimal light and temperature incidence [5], controlling the direction and velocity of both motors. The membership functions of light and thermal sensors are shown in figures 7, 8, 9, 10.

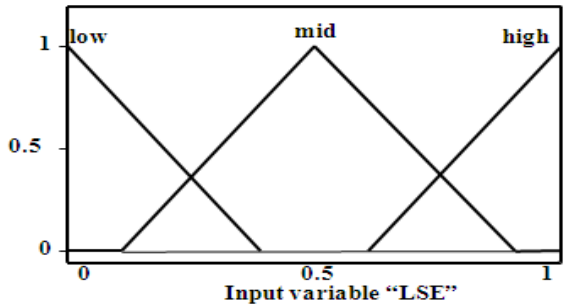

Figure 7. Input fuzzy set for east light sensor

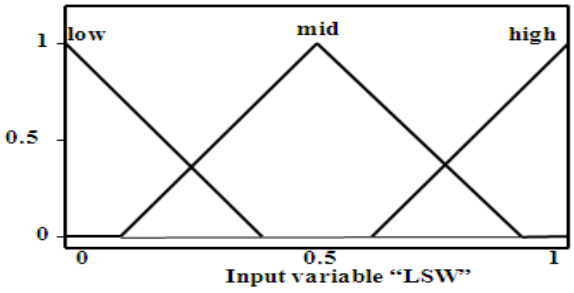

Figure 8. Input fuzzy set for west light sensor

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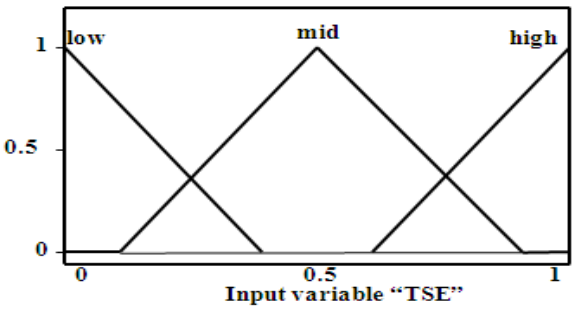

Figure 9. Input fuzzy set for east thermal sensor

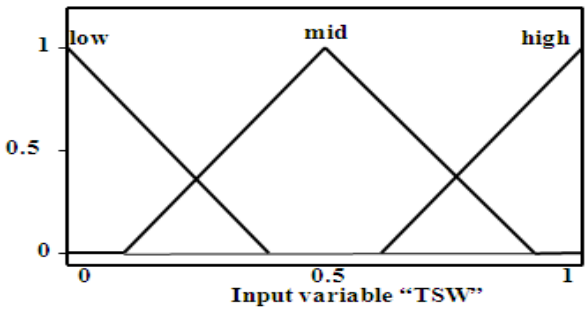

Figure 10. Input fuzzy set for west thermal sensor

The output of the fuzzy control of the mirror motor and the thermal concentrator motor are represented in figures 11, 12, and 13.

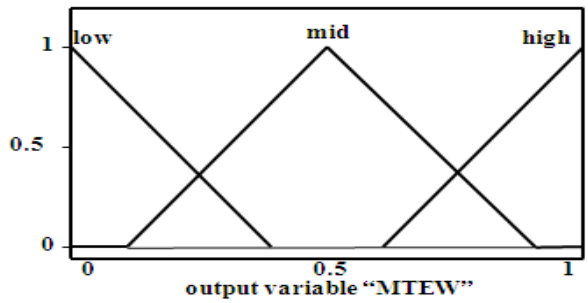

Figure 11. Output fuzzy set for east-west thermal motor

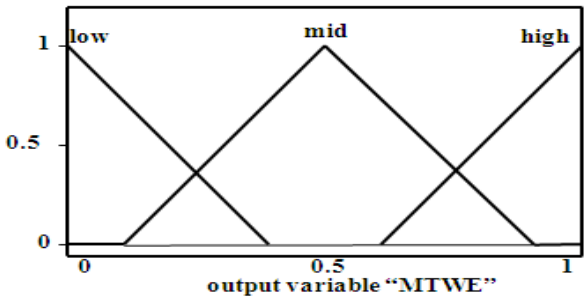

Figure 12. Output fuzzy set for west-east thermal motor

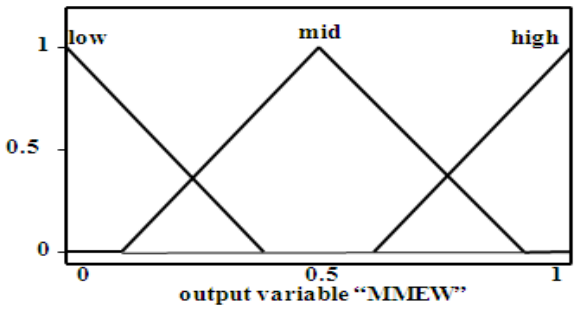

Figure 13. Output fuzzy set for west-east mirrors motor

The fuzzy rules make the strategy [6], to align the mirrors and the thermal concentrator to catch the maximum light and thermal energy which are shown in tables 1 and 2.

Table 1. Rules for the fuzzy control for mirrors

1	If (LSE is high) and (LSW is high) and (TS is high) then (LOK is high)(TOK is high) (1)
2	If (LSE is high) and (LSW is medium) and (TS is high) then (LOK is medium)(TOK is high) (1)
3	If (LSE is high) and (LSW is low) and (TS is high) then (LOK is low)(TOK is high) (1)
4	If (LSE is medium) and (LSW is high) and (TS is high) then (LOK is medium)(TOK is high) (1)
5	If (LSE is low) and (LSW is high) and (TS is high) then (LOK is low)(TOK is high) (1)
6	If (LSE is medium) and (LSW is low) and (TS is high) then (LOK is low)(TOK is high) (1)
7	If (LSE is low) and (LSW is medium) and (TS is high) then (LOK is low)(TOK is high) (1)
8	If (LSE is high) and (LSW is medium) and (TS is medio) then (MMWE is medium)(LOK is medium)(TOK is medium) (1)
9	If (LSE is high) and (LSW is low) and (TS is medio) then (MMWE is high)(LOK is low)(TOK is low) (1)
10	If (LSE is medium) and (LSW is high) and (TS is medio) then (MMEW is medium)(LOK is medium)(TOK is medium) (1)
11	If (LSE is low) and (LSW is high) and (TS is medio) then (MMEW is high)(LOK is low)(TOK is medium) (1)
12	If (LSE is low) and (LSW is low) and (TS is low) then (LOK is low)(TOK is low) (1)
13	If (LSE is medium) and (LSW is medium) and (TS is medio) then (LOK is medium)(TOK is medium) (1)

Table 2. Rules for the fuzzy control of thermal concentrator

1	If (TSE is high) and (TSW is high) and (LS is high) then (LOK is high)(TOK is high) (1)
2	If (TSE is high) and (TSW is medium) and (LS is high) then (LOK is medium)(TOK is high) (1)
3	If (TSE is high) and (TSW is low) and (LS is high) then (LOK is low)(TOK is high) (1)
4	If (TSE is medium) and (TSW is high) and (LS is high) then (LOK is medium)(TOK is high) (1)
5	If (TSE is low) and (TSW is high) and (LS is high) then (LOK is low)(TOK is high) (1)
6	If (TSE is medium) and (TSW is low) and (LS is high) then (LOK is low)(TOK is high) (1)
7	If (TSE is low) and (TSW is medium) and (LS is high) then (LOK is low)(TOK is high) (1)
8	If (TSE is high) and (TSW is medium) and (LS is medio) then (MMWE is medium)(LOK is medium)(TOK is medium) (1)
9	If (TSE is high) and (TSW is low) and (LS is medio) then (MMWE is high)(LOK is low)(TOK is low) (1)
10	If (TSE is medium) and (TSW is high) and (LS is medio) then (MMEW is medium)(LOK is medium)(TOK is medium) (1)
11	If (TSE is low) and (TSW is high) and (LS is medio) then (MMEW is high)(LOK is low)(TOK is medium) (1)
12	If (TSE is low) and (TSW is low) and (LS is low) then (LOK is low)(TOK is low) (1)
13	If (TSE is medium) and (TSW is medium) and (LS is medio) then (LOK is medium)(TOK is medium) (1)

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V. SIMULATION

The fuzzy control strategies and the interaction of the thermal position system are shown in the figures 14, 15.

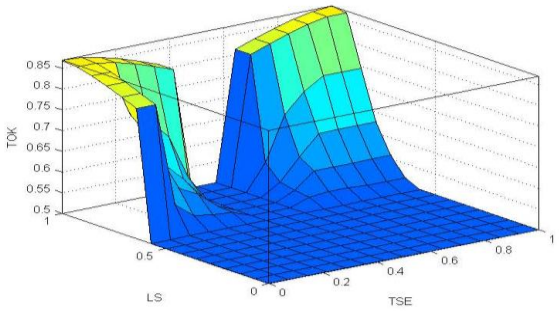

Figure 14. Interactions between TOK, TSE and LS

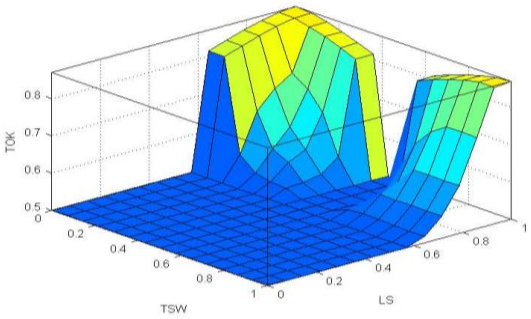

Figure 15. Interactions between TOK, TSE and LS

The fuzzy control strategy to follow the apparent movement of the sun during the day, control the movements of the actuator (figures 16, 17 and 18).

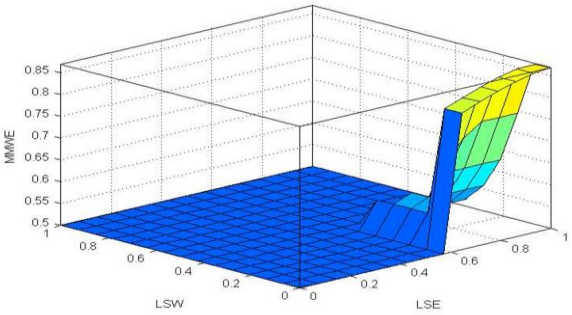

Figure 16. Interactions between LSE, LSW and MMWE

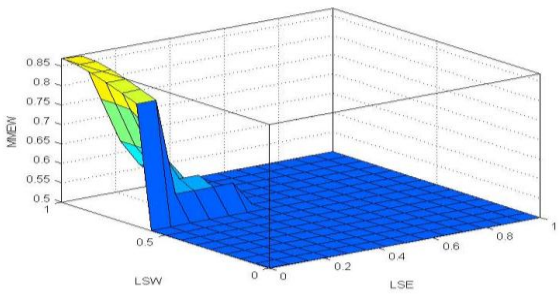

Figure 17. Interactions between LSE, LSW and MMEW

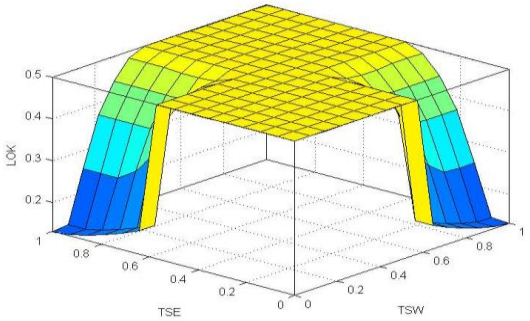

Figure 18. Interactions between TSW, TSE and LOK

VI. CONCLUSIONS

The control strategies give favorable results according to the objectives of the proposed control based on fuzzy logic to follow the apparent path of the sun during the day. The mechanical proposal is being evaluated by the multidisciplinary research group to make a real model, of the proposed control.

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