A Simple Neural Network Solar Tracker for Optimizing Conversion Efficiency in Off-Grid Solar Generators

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Abstract. A new model of neural network and a new type of neural controller are proposed, aiming to reduce cost and complexity without sacrificing efficiency of traditional, more complex neural net-based solar trackers.

The solution is derived from Mark Tilden's neural and nervous networks, using a biologic analogy to seamlessly integrate sensors, artificial neurons and effectors in a single, efficient device.

Testing is in progress at the time of the elaboration of this paper but available and relevant preliminary results are shown. The project aims to develop a small pilot tracker – based solar plant for testing purposes and to develop a useable technology for the ever-growing demand for green power.

Key words

Solar tracker, neural networks.

1. Introduction

The main element in a solar electric power plant is the solar panel. Physically it consists of a flat surface on which numerous p-n junctions are placed, being connected together through electrically conducting strips. As technology evolved, the efficiency of the conversion in solar panels increased steadily, but still it does not exceed 12% for the most advanced, spherical cell designs. The solar panels also exhibit a strongly non-linear I-V characteristic and a power output that is also non-linearly dependant on the surface insolation. The dependence of the solar panel performance on the direct insolation is one of the main reasons for a sun tracking system. Compared to a fixed panel, the mobile panel on a tracker is kept under the best possible insolation for all positions of the Sun, as the light falls close to the geometric normal incidence angle.

Solar trackers have been associated with neural networks since the beginning of the study, because as we have seen, the solar panels are strongly non-linear devices and the problem of their output maximization is also a non-linear problem, the neural networks being well – known for their ability to extract solutions to non-linear problems with variable parameters.

2. Proposed Neural Network Solar Tracker

There are many types of neural networks, some of them very complicated, based on complex algorithms running on powerful computers, others as simple as a ring of oscillators having a continuously adjusting duty cycle under the influence of the sensory input.

The types of neural network used in this work differ slightly to the mainstream concept, as they do not use memory and resistive connection adjustments, nor software emulation, but a simple ring oscillator structure, first described by M. Tilden. He used them to build small autonomous robots that presented emergent behavior and exhibited fast response to stimuli and increased adaptability. The simple structure of these machines means they can easily be produced and serviced, and the potential for induced phototropism by adding just a few sensors being another strong point. The neural controller we are developing is based on these machines, but adapted to pinpoint the Sun.

The simple schematic we have built for testing the motor driving capabilities is given below, along with a few results, Fig. 1. As the motors have not been chosen yet, a series of tests are conducted to find out the necessary type of drive and their most effective implementation so that the costs of the entire system do not to rise too much, but without sacrificing the efficiency.

So far we have proven the self-stabilizing properties of the neural network circuit, and found the mathematical function that computes the output; this has been very useful in simulations and design, we have written a Lab View application to compute the main parameters of such a network prior to building it, to ensure maximal compatibility with the motor types once chosen.

3. Obtained Results

Waveforms in different points of the circuit, Fig. 1, have been recorded and analyzed, and found in accordance with our theory on the operation of these relatively new neural networks.

The mathematical function that describes the output for each neural node, for every moment of time, is :

$$F_{n,a}(x) = V_h/2 \ \mathrm{sign}[-\sin(2\pi-(a-1)\pi/n)/(T/rand)] + V_h/2, \quad (1)$$

where:

- V_h =oscillation amplitude, given by the Hi level (5 V standard for TTL but different, 15 or 3.5 or up to 30 for CMOS, low power CMOS, and industrial logic respectively);
- a = neuron number in the core, a= 1, 2, 3, 4 in this particular 4NuCore;
- n=the number of neurons in the network,
- T= mean period of oscillation (corresponding to a 50% fill factor).

The result is a fully controllable ring oscillator that can receive sensor inputs directly at the polarizing nodes (the capacitor-resistor junction on the schematic) to adapt its oscillation frequency and fill factor. Using this in conjunction with light intensity sensors, such as photodiodes or even green LEDs, and motor drivers, a simple reliable and cheap tracker can be built.

On the frame of the tracker we intend to mount a miniature solar panel and various instruments- for testing purposes- and two rotary encoders to adequately code and send the position of the Sun to more mobile panels in the area. We investigate various solutions for these requirement. Some pictures of the installations and various simulation results are presented in Figs.2 - 3.

4. Conclusion

This paper proposes a new model of neural network and a new type of neural controller, aiming to reduce cost and complexity without sacrificing efficiency of traditional, more complex neural net-based solar trackers.

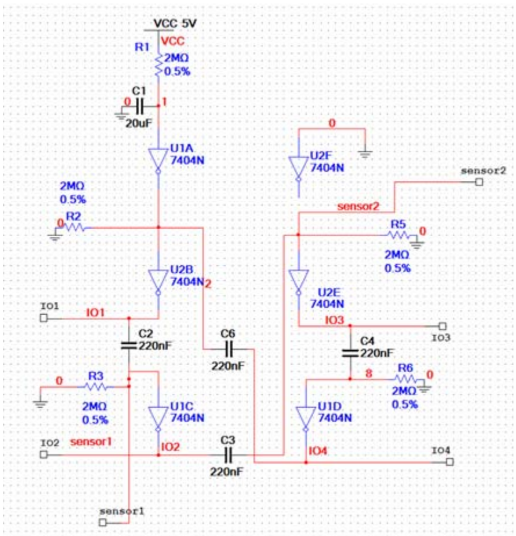

Fig. 1. Tracker core.

Fig. 2. Testing the proposed Neural Network.

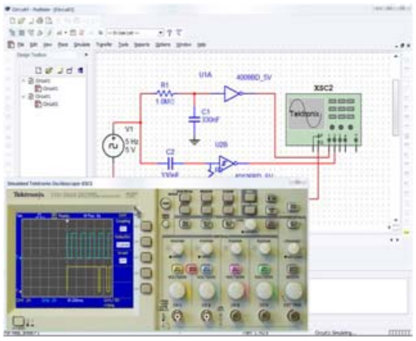

Fig. 3. Simulating the Neural Network parameters

The researches carried out so far are promising being focused on the testing of the proposed neural network technique, on the elaboration of the simulation model of its operation and on the design of the tracker mechanics.

Further researches aim to develop a small pilot tracker – based solar plant for testing purposes using the proposed neural network technique.

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