A Neural Network Based Solar Tracker for Optimization in Grid

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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**

***Index Terms*— neural network, neural controller, solar trackers.**

I. 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. To further complicate matters, 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 temperature of the panel is also crucial to its normal operation, the silicon junction needing a steady and not too high temperature (80 degrees Celsius). The optimal performance is attained around 30 degrees Celsius. The dependence of the solar panel performance on direct isolation 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

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 problem with variable parameters

II. NEURAL AND NERVOUS NETWORKS

There are many types of neural networks, some as complicated as multiple redundancy models in the form of complex algorithms running on powerful computers or as simple as a ring of oscillators having a continuously adjusting duty cycle under the influence of the varying input. Although research has focused almost exclusively on complicated designs, in the recent years a number of very simple neural networks sprung from the fruitful research of Mark Tilden. He patented two simple configurations that mimic the biological neurons, and several ways to interconnect them [2].

Also from his research, a complementary concept to the well-known neural networks was derived: the nervous network. Following the biological analogy, the nervous network is also a ring of coupled oscillators, much like the central pattern generators in living organisms. The main difference between the classic and this new type of neural controller hence forth referred to as NU-net is that the latter incorporates sensors and actuators as feedback and weight adjusting mechanisms

The main advantages of this configuration over the microprocessor approach is that it needs less power and has a much lower cost per unit, without sacrificing the performance.

III. PAPER OBJECTIVES

This paper discusses the new generation of neural – driven solar trackers, using NU-net and nervous chains (NV-nets) analogues to the structures observed in biologic organisms to achieve a better integration of sensors and effectors, without the need for programmed and presents such a neural controller able to drive a small tracking flat solar panel

At the end, the final schematic and experimental data gathered to-date are given, along with plans for further improvement

Solar tracking systems (using light intensity sensing) are shown to boost efficiency of solar conversion up to 100% during summer and up to 40% during winter, compared to maximum power point trackers that allow increases of up to 50 % maximum overall

IV. SOLAR TRACKING AND EFFICIENCY

Solar tracking, like all optimization measures, has some inherent limitations and some parameters to be considered before a final solution is applied. Although beneficial as a method of maximizing solar panel output tracking is to be made using motors or actuators, controllers. This has to be carefully balanced to the gains of the system, in each case, if we want to design a completely self-sustaining plant.

The objective of this work is to describe a low power, possibly self-sustaining research solar tracker that uses a

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rotary encoder to calculate the position of the Sun and to aim several other large panels or instruments that are not mounted on the tracker. Using this system allows for a small panel and a small motor to do the actual tracking minimizing loss, the angular data being exported to drive the heavy trackers after the position is found. Another requirement for this type of tracker is simplicity in design, a reduced number of moving parts interchangeability of the main parts and low service.
. That implied using simple solutions based on analog/digital circuitry, to build a new reflex neural-net controller, and small motors and mechanics to keep costs down. An initial version of the tracker, using worm gears was designed, and simulations and calculations showed it to be capable of using two quarter-watt DC or stepping motors to drive a small 2.5 kg solar panel of 750 W of power rating

However, it was still expensive as it required machining large diameter gears and a smaller prototype, carrying only sensors, is designed and tested.
Several reports in India have shown tracking to be particularly effective in summer, where the increases in output reached 60%, while in autumn they neared 30% -40% depending upon technology used.

Solar tracking implies moving parts, and control systems that tend to be expensive, so single-axis tracking appeared, using a tilted panel mount and a single engine to move the panel on an approximate trajectory relative to the Sun. This system has tracking errors that cannot be corrected and are accepted as such. Still, the efficiency is in all cases, above that of a stationary panel

Dual axis tracking means a specially designed mount able to move the panel on a trajectory as close to the sun path as possible.The errors of this kind of tracker are minimal. It achieve better efficiency than single axis tracker.

To asses correctly the efficiency of tracking for a certain region, the best way to go is to experiment with a micro plant that has a capacity of 2-3 watts (no more), using both a fixed and a tracking panel, and to constantly monitor the output and compare the efficiency, by automatically calculating the power output over a period of several months of a year using using a data acquisition system to monitor and compute generated power for a fixed and tracking miniature solar panels.

The power consumption from the grid power the tracker is taken into account but it is not subtracted from the total output of the moving panel, because calculations have shown that the relation between the needed motor power, the weight of the panels and their generated power is not linear so it would be irrelevant for the larger system.
Based on the data gathered it can be focused that dual axis tracker is used for large system whereas no tracking or single tracking can be used for medium to small systems.

V. The Neural Reflex networks: Basic and Functions

A. Basic topology

The neural controller described in this paper has a lineage directly traceable to Mark Tilden's neural (NU) and nervous (NU) neuron constructs - patent that he kindly released under "Creative Commons "license agreement The final construct is original only to the extent in which it uses existing parts for a novel function that is to build one of the simplest devices that can control a stepping motor or a dc motor for solar tracking purpose.

The basic topology consists four independent units Fig. 1. The basic NU neuron responds to a prolonged change in input. If a high signal is applied to the input, after a delay, the output will switch from high to low and will remain low as long as the input stays high. Because of this behavior, it is suited for solar tracking.

The basic controller we are going to use in this application features one NV and several NU neurons in a basic configuration, able to drive one stepping motor or one H-bridged DC motor, according to the received input

A. Functions of Neural network

This particular type of neural network does not work in a classic train-and-replay mode; it does not feature memory whatsoever, apart from short-lived timing interaction between the composing neurons. As such, its functions are more of a reflex network, reacting promptly at environmental changes, monitored by sensors that are directly attached to it

The transfer function of the neurons is sigmoid, as the classic step output of the logic gates is shaped by the RC low-pass filter. The NV network is thus similar to a nervous net, more than a bona-fide neural net: it responds directly, hard-wired, instead of computing its output. The response time is much faster than that of a classic neural network that requires at least one pass through the entire structure to produce the right output. Here we have instant response instead, by directly altering the parameters of the circuit.

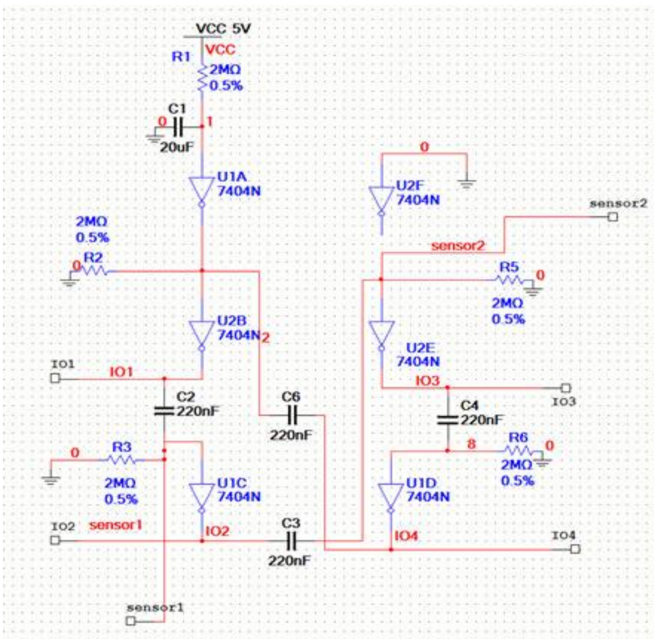

Fig 1 Tracker

The way this tracker works is closer to the phototropic behaviour in primitive sea organism like jellyfish

While the network can be active without external input, it needs a time-setting oscillator to set the pace at which the processes take place in the neural net. It has been shown that such a pace-setting oscillator exists in biological organisms and controls, for example, the walking gait the nervous neurons in the net control the walking motions such as position adjustments of the limbs and dynamic equilibrium, but the pace is set by an external oscillator; also the heartbeat is generated by autonomous oscillator. The external oscillator here injects square pulses into the ring oscillator, and prevents its saturation limiting the oscillation mode to one.

VI. Tracker Control by Proposed Technique

The outputs of the nervous neurons are square wave oscillations that are in phase opposition. Their fill factor and their frequency are influenced by the potential at the input nodes, given directly by sensor output. The motor connects at the output nodes, through a reversing H- bridge or buffer amplifier, depending on its configuration, stepping or DC, and is controlled by the pulses to drive the load in a certain direction with a certain speed (if it is a DC motor), or if it has a half- stepping/PWM-controlled stepper driver for a stepping motor The research that has been carried out so far was focused on the testing of the proposed neural network technique on the elaboration of the simulation model of its operation. The tracker we have designed is to be used mainly medium sized(1 sq meter) solar panel along with tube-cased instruments meant to measure the solar radiation and spectral composition of light. The tracker will use incremental to give the absolute position of the Sun and be to drive an entire array of panels connected via conventional or "slave" neural nets Simulations made in LabView helped us to design andtest neurons prior to their integration in a neural network. Shown in Fig 2

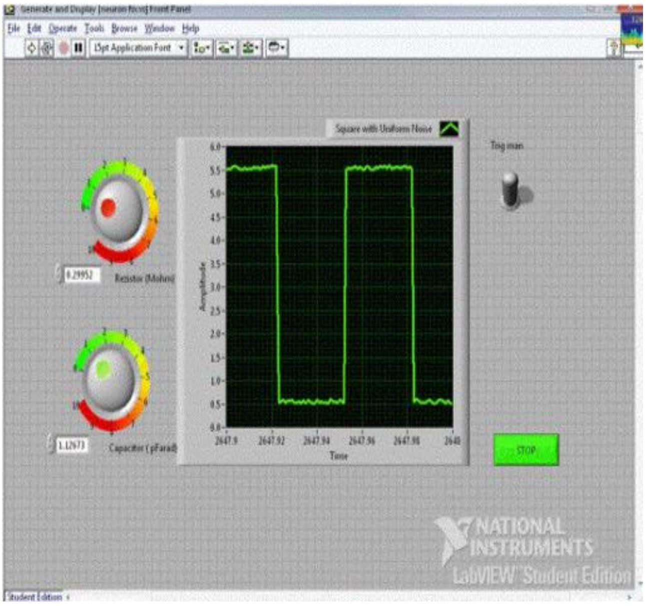

Fig 2 Solar tracker using labview

VII. 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

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

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