

# Energy Efficiency in Off-Grid Solar Generators by Neural Network Solar Tracker

Rajesh Giri<sup>1</sup>, Dr.Sanjiv Kumar<sup>2</sup>, Ajay Kumar<sup>3</sup>

P.G. Student, Department of Energy Technology, Swami Vivekanand Subharti, University, Meerut U.P, India<sup>1</sup>

Assistant Professor, Department of Energy Technology, Swami Vivekanand Subharti, University, Meerut U.P, India<sup>2</sup>

Assistant Professor, Department of Energy Technology, Swami Vivekanand Subharti, University, Meerut U.P, India<sup>3</sup>

**ABSTRACT:** A new model of solar tracker network and another type of neural controller are proposed, purpose to decrease cost and difficulty without sacrifice efficiency of traditional, more difficult neural net-based solar trackers. The explanation is derived from Mark Tilden's neural and nervous networks, using a biologic correlation to faultlessly integrate sensors, artificial neurons and effectors in a single, efficient device. Testing is in progress at the time of the explanation of this paper but available and relevant preliminary results are shown. The project aims to build up a small pilot tracker – based solar plant for testing purposes and to develop a useable skill for the ever-growing require for green power.

**KEYWORDS:** Solar tracker neural networks, Energy efficiency.

## I. INTRODUCTION

The key part in a solar electric power plant is the solar panel. Actually it consists of a flat surface on which several p-n junctions are placed, being associated together through electrically conducting strips. As development in technology, the efficiency of the conversion in solar panels increased gradually, but still it does not go above 12% for the most advanced, sphere-shaped cell designs. To further make difficult matters, the solar panels also display a strongly non-linear I-V characteristic and a energy output that is also non-linearly dependant on the surface isolation. The temperature of the panel is also key to its normal operation, the silicon junction needing a stable and not too high temperature (80 degrees Celsius being the highest recommended operating temperature). The best performance is attained around 30 degrees Celsius. 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 greatest possible insolation for every one positions of the Sun, as the light falls close to the geometric normal incidence angle. Solar trackers have been linked with solar tracker neural networks. The solar panels are powerfully non-linear devices and the problem of their maximum output. Maximum output is also a nonlinear problem, the solar tracker networks being well – known for their capacity to extract solutions to non-linear problems with variable parameters.

The work in this paper is divided in two stages. 1) Text- Detection 2) Inpainting. Text detection is done by applying morphological open-close and close-open filters and combines the images. Thereafter, gradient is applied to detect the edges followed by thresholding and morphological dilation, erosion operation. Then, connected component labelling is performed to label each object separately. Finally, the set of selection criteria is applied to filter out non text regions. After text detection, text inpainting is accomplished by using exemplar based Inpainting algorithm.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

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## II. SOLAR TRACKER NEURAL NETWORK

There are many types of solar tracker neural networks, some as difficult as multiple being without a job models in the form of difficult algorithms running on powerful computers, or as simple as a ring of oscillators having a continuously adjusting duty cycle under the control of the sensory input. Although research has focused about exclusively on complex designs, in the recent years a number of very simple solar tracker neural networks spring from the fruitful research. Researcher patented two simple configurations that mimic the biological neurons, and several ways to connect them. Also from research, a complementary concept to the well-known solar tracker 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 prototype generators in living organisms, calculating the heartbeat or walk step. These are particularly suitable to be used in conjunction with solar tracker networks to generate motion control sequences, for instance the drive sequence for step motors or linear actuators. The main difference between the classic and this new type of neural controller henceforth referred to as NU-net is that the latter incorporate sensors and actuators as feedback and weight adjusting mechanisms. strength and suitability of the NU-net configurations has been proven many times in small autonomous robot configurations as well as in various applications involving intelligent low power motor control. The main reward of this configuration over the microprocessor approach is that it needs less energy and has a much lower cost per unit, without sacrifice the performance.

## III. SOLAR TRACKER NEURAL NETWORK

This paper discusses the new creation 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 combination of sensors and effectors, without the need for programmed elements (controllers, memory cells, etc), and presents such a neural controller able to drive a small tracking flat solar panel. At the end, the final diagram 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 change 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. The final chapter of the work will discuss practical aspects, such as design and technical solutions chosen to satisfy these requirements, and alternatives for scaling the concept to larger plants.

## IV. SOLAR TRACKING AND EFFICIENCY

Solar tracking, like all optimization measures, has some natural limitations and some parameters to be considered before a final solution is applied. Although useful as a method of maximize solar panel output, tracking is to be made using motors and a controller that will add to the “inside service quota” of the solar plant. This has to be balanced to the gains of the system, in all case, if we want to design a fully self-sustaining plant. Still, there are relatively a number of research plants implementing several types of solar trackers to compare various solutions and their efficiency, using a power grid connection to provide necessary supply to tracking motors. The objective of this work is to describe a low power, possibly self-sustaining research solar tracker that uses a revolving 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 important trackers after the position is found. Another requirement for this type of tracker is simplicity in design, a reduced number of stirring parts, interchangeability of the main parts and low service quota. 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 by two quarter-watt DC or stepping motors (with minimal modification to the electronic circuit) to take a small 2.5 kg solar panel and up to two optical/thermal instrument in tubes, up to 1 kg each (possibly radiometers). However, it was still costly as it necessary machining large diameter gears and a minor prototype, carrying only sensors, is planned and tested. The question of efficiency therefore is significant and key even in small scale applications, typically household other sources and tiny plants up to 10 kW. allowing for the high cost-per-watt of

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the solar energy while, tracking is a practical alternative. numerous reports in USA have exposed tracking to be mainly effective in summer, where the increases in output reached 100%, while in autumn they neared 30- 40% depending on the technology used. Solar tracking imply moving parts, and control systems that tend to be costly, so single-axis tracking , with a tilted panel build up and a single engine to move the panel on an estimated trajectory relative to the Sun. This system has tracking errors that cannot be corrected and are established as such. Still, the efficiency is in all cases of a well designed system, above that of a immobile panel. Two axis tracking means a specially designed mount able to move the panel on a path as close to the sun path as possible. The errors of this kind of tracker are negligible and can be corrected. Figures of efficiency improve versus costs vary widely depending on latitude and hi-tech level of the plant, so it is not easy to give accurate figures for a assured installation without total specifications; though it is accepted that for small deployments, single axis is cheaper while two axis tracking is more efficient, up to 45-50% , according to Red Rock Energy Heliostats , From data accessible on various sites and in reports, it is clear that not only latitude influence the efficiency of tracking, but also the meteorological phenomenon and neighborhood climate factors, from which the yearly average of the sunny days is the most important. To asses properly the efficiency of tracking for a definite region, the best way to go is to test with a micro plant that has a capacity of 2-3 watts (no more), by both a fixed and a tracking panel, and to continually monitor the output and measure up to the efficiency, by mechanically calculating the power output over a period of more than a few months, optimally one year. Such an trial is currently going on in university lab, using a data gaining system to monitor and calculate generated power for a fixed and tracking miniature panels. The power utilization from the grid needed to power the tracker is taken into account but it is not subtracted from the total output of the moving panel, because calculation have exposed that the relation between the needed motor power, the heaviness of the panels and their generate power is not linear and does not scale as such, so it would be immaterial for a larger system. However it is relevant to compare several tracking solutions, about their efficiency at a certain scale (it is predictable that for tiny systems, no tracking and one axis tracking to be the best solutions even as for medium-sized to large systems, two axis tracking to be more useful). This report is based on data gathered from various sites relating solar technologies and their effectiveness.

## V. THE NEURAL IMPULSE NETWORK BASIC TOPOLOGY AND FUNCTIONS

A. Basic Topology The neural regulator described in this paper has a family 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 make is unique only to the level in which it uses offered parts for a novel function that is to build one of the simplest devices that can control a step motor or a dc motor, via a suitable H-bridge, for solar tracking purpose. The basic topology consists in four self-regulating units (NU neurons), Fig. 1. The basic NU neuron responds to a extended change in input. If a high signal is applied to the input, after a wait, the output will switch from high to low and will continue low as long as the input stays high. Because of this performance, it is right for slow tracking applications, such as solar tracking. The basic controller we are going to use in this application features one NV and several NU neurons in a essential design, able to drive one stepping motor or one H-bridged DC motor, according to the conventional input. The simulation have shown this simple ring oscillator to be self-stabilizing and the green LEDs suitable as sensors, because they offer a very directional answer which, while not linear, can be easily approximated with linear curve segments. B. Functions of the Neural Network This particular type of neural network does not work in a typical 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 impulse network, reacting on time at ecological changes, monitored by sensors that are directly attached to it.

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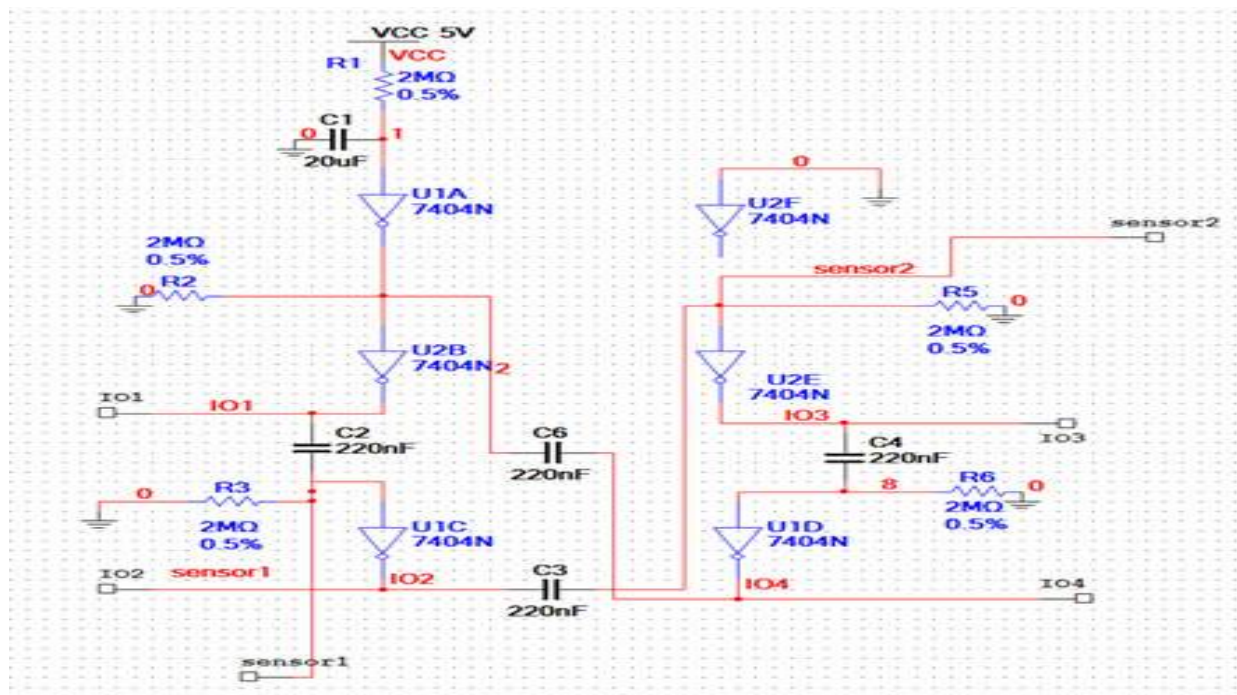


Fig. 1 Tracker core.

The way this tracker works is closer to the phototropic behaviour in ancient sea organisms, such as certain kind of jellyfish that steer towards the light to keep to the surface. Though not so expected, the output of the network is bounded and self-stabilizing, as it corresponds to a limit cycle. The repeatability and constancy of the neural network response has been proved by Beiu, Frigo & Moore in [4]. The transfer function of the neurons is sigmoid, as the typical step output of the logic gates is shaped by the RC low-pass filter. The NV complex is thus similar to a worried net, more than a bona-fide neural net: it responds honestly, hard-wired, instead of computing its output. The reply time is much quicker than that of a usual neural network that requires at least one pass from side to side the entire construction to create the right output. Here, we have an instant answer instead, by directly altering the parameters of the circuit. Here the sensors' outputs themselves play the role of weights in a standard neural approach, thus we have a very fast, dynamically flexible matrix-shifting neural net, or simpler – a nervous net. The analogy with the reflex path in biological organisms is obvious. While the network can be active without outside input, it needs a time-setting oscillator to set the pace at which the process takes 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 location adjustments of the limbs and lively equilibrium, but the pace is set by an external oscillator; also the heartbeat is generated by autonomous oscillators, but the pace is set externally. The external oscillator here injects OPTIM 2006, Romania four-sided figure pulses into the ring oscillator, and prevents its diffusion limiting the oscillation modes to one.

## VI. TRACKER CONTROLLING TECHNIQUE

The results of the nervous neurons are square wave oscillations that are in segment opposition. Their fill factor and their rate of recurrence are influenced by the potential at the input nodes, given straight by sensor output. The motor connects at the output nodes, through a reversing H-Bridges or buffer amplifier, depending on its configuration, stepping or DC, and is controlled by the pulses to take the load in a certain direction with a certain speed (if it is a DC motor), or



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if it has a semi stepping/ PWM-controlled stepper driver for a stepping motor. The light intensity sensors set on the panel move as well, and their output change proportionally (in the case of green LEDs quasi-linearly), and it adjusts the weights to the neuron inputs. Changes in patterns of oscillation take effect instantly. The research that has been carry out so far was focused on the testing of the proposed neural network technique, on the explanation of the simulation model of its operation and on the design of the tracker mechanics.



Fig. 2 Testing the proposed Neural Network.

- $V_h$  =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).

This result helped us to design neural networks having a original frequency suitable to drive stepping motors, avoiding their critical frequency.

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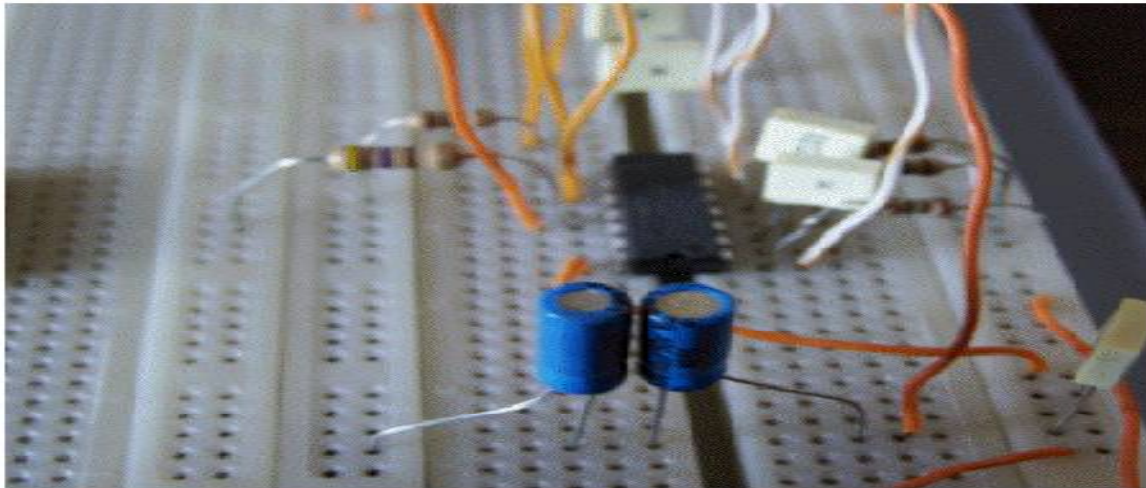


Fig. 3. A close-up of the experimental neural network.

## VII. CONCLUSION

This propose of this paper is a new model of neural network and a new type of neural controller, aim to decrease cost and complication without sacrificing efficiency of usual, more complex neural net-based solar trackers. The researches agreed out so far are promise being focused on the testing of the proposed neural network technique, on the explanation of the simulation model of its action and on the design of the tracker mechanics. advance researches aim to develop a small pilot tracker – based solar plant for testing purposes using the proposed neural network technique.

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