Prediction of Solar Energy Harvesting with Optimal Battery Management System of a Wireless Sensor Node

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Abstract
The Wireless Sensor Nodes of a network have some major constraints due to their limited energy, storage capacity, computing power and frequent battery replacement factor, when they meant to collect the information from an unattended location using various sensors. Hence the proposed research implements a novel power management system by introducing pack of two solar powered batteries and an automatic battery switching system. However, they are not a reliable, consistent source of energy because of the Sun's cycles and the ever changing weather conditions. Thus, in this paper we present a fast, efficient and reliable solar prediction algorithm, namely, Weather-Conditioned Moving Average (WCMA) that is capable of exploiting the solar energy. Which enhance the battery management system for providing total energy control for wireless node even in Hill stations, barren region, and unattended locations.

Keywords
Weather-Conditioned Moving Average, Wireless Sensor Networks Battery Management

I. Introduction

Solar energy harvesting is by far the most effective for wireless sensor nodes. A great application example is mobile .The amount of energy needed to execute these tasks is substantial, thus being able to understand how much energy is currently available, and how much can be harvested in the next time interval is very important. Online strategies that understand these tradeoffs and can plan in near term how to best spend the energy received via energy harvesting need to be developed. The sensor node should exploit the extra energy available from energy harvesting sources once the batteries are charge dup. In this paper, we propose Weather-Conditioned Moving Average (WCMA), a novel accurate yet very low overhead, solar energy prediction algorithm based on the Exponentially Weighted Moving-Average estimation method. The algorithm can be used to accurately estimate the amount of energy that will be harvested by solar panels in the near future, so that it is possible to deploy power-efficient task management methods on solar energy-harvested wireless sensor nodes. The rest of the paper explains the optimal battery management system using microcontroller. Your The huge decrease in power consumption and size of CMOS circuitry has led to a huge research effort Based around the idea of omni present networks of wireless sensor nodes. As the cost and size of such wireless sensor nodes continues to reduce, the probability of their use becoming extensive in automobiles, buildings, aircraft, industrial environments increases. As their cost and size reduces, and as their occurrence increases, effective power provisions become a larger problem. The problem is that the scaling down in cost and size of electronics has put the scaling of power density in batteries, which are by the most common power supply presently used. Therefore, the power supply is usually the main and most costly component of the promising wireless sensor nodes being projected and designed. Normally, the power consumption includes the sensors placed in the nodes, Microcontrollers, wireless transceivers etc (M.T.Penella, 2007). Typically, the sensor node power consumption is calculated by monitoring the battery level of the corresponding node by some special sensors. A frequently used and low cost (in terms of computation need) energy prediction algorithm is Exponentially Weighted Moving-Average (EWMA). The method is designed to exploit the diurnal cycle in solar energy and to adapt to the seasonal variations. EWMA calculates the value Of energy likely to be harvested at a particular time as a weighted average of the energy received at the same time over a set of previous days [10]. Although EWMA-based algorithm is accurate for consistent weather conditions, when cloudy and sunny days are mixed, recent days energy values introduce significant prediction errors. Therefore, to prevent this problem, we introduce in this work a new prediction algorithm that not only takes into account the solar conditions at a certain time of the day, but also adjusts the energy intake estimation for the changing weather conditions throughout a day. Other solar prediction algorithms have been recently proposed, based on mean expected values. In , it is shown that the average-daily solar system performance may be calculated from the product of clear-sky solar performance and the average time fraction of clear sky. This approximation greatly simplifies the solar system performance prediction, but does not offer specific energy guarantees at certain daily intervals, not been suitable for short term predictions. Also, introduces a new method for modeling daily sun radiations, based on Takagi-Sugeno fuzzy systems. This method uses a non-linear technique, defined by a set of If-Then rules with linear consequent parts, which establish a local linear Input- output relationship between the variables of the model. Then, the parameters of the model are identifiey using the fuzzy clustering combined to the least square algorithm. This model produces accurate results, but requires a very high computation, making this algorithm not applicable on small Wireless sensor nodes as we target in this work.

II. WCMA Energy Prediction

The In EWMA, the day is divided on slots and a vector of estimated values for each slot i is stored, i.e., X(i). This equation is used to update the slots, as follows:

$$X(i) = \alpha \cdot X(i-1) + (1-\alpha) \cdot x(i) \quad (1)$$

Where x(i) denotes the value of real energy observed at the end of the slot i and α is a weighting factor.
Fig. 1 shows the actual energy input from the solar panel and the predicted value in five consecutive days, with a mix of sunny and cloudy conditions. In this case, when the sunny and cloudy days alternate, the EWMA produces a significant error in its prediction,

due to the high impact of the solar conditions of previous day in the predicted value. To avoid this effect, our new prediction algorithm takes into account not only the solar conditions at a septic time of the day, but also the weather Conditions in the current day. This is especially important in frequently changing weather conditions, for example, we observed that the energy harvested during cloudy days was less than half of that gathered during sunny days

MD (d, n − K + k − 1)

Then, in order to give more importance to the closest values on time, we weight these values with the distance to the actual point in time using vector
P = [p1, p2, · · · , pK] as follows:
pk =kK(5)
Finally, the weighting factor, GAPk, is computed :GAPk =V · P

III. System Description

The Neural networks and Fuzzy systems and have involved the attention of researchers in a variety of scientific and engineering areas. The main design of fuzzy logic control is to construct a model of a human control specialist who is capable of controlling the device without thinking in terms of a mathematical form. The control specialist specifies the control actions in the form of linguistic rules. These rules are translated into the framework of fuzzy set theory. The good linguistic rules depend on the knowledge of the control specialist, but the translation of these rules into fuzzy set theory is not formalized (F. M. Ham, 2002). The worth of fuzzy logic controller can be affected by the variety of membership functions. Thus, methods for tuning fuzzy logic controllers are essential. WCMA energy prediction offers the opportunity of solving the problem of tuning. A fuzzy logic controller shown in fig.3 is intended to work with the prearranged knowledge in the form of rules and almost everything in the fuzzy system remains highly visible and easily interpretable. Conventional methods of battery life management, which deals with regulating the, protection, charging and monitoring of the battery, are ineffective for two reasons. First, they do not predict the battery charge level and second, they require the battery to be off-line for the period of the measurements of the battery parameters. The proposed battery models advances by combining elements of adaptive and static battery management techniques, dynamic elements drawn from fuzzy logic theory and WCMA energy prediction control reduces the need for empirically derived constants for battery management.

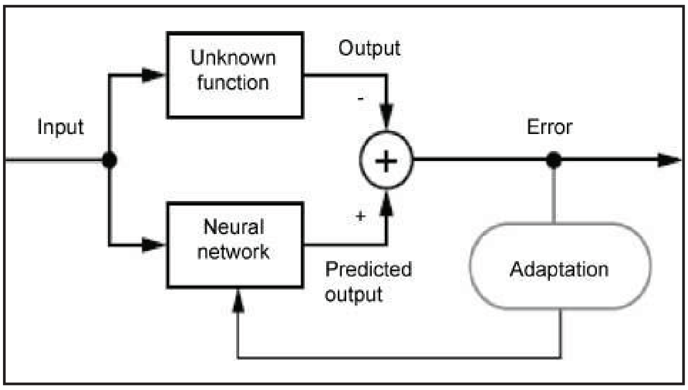

Fig. 1

Hence the proposed research implements a novelty power management system by introducing pack of two solar powered batteries and an automatic battery switching system. The automatic control of a battery charging and discharging system is fully under the control of proposed WCMA energy prediction -Fuzzy Controller (WCMAFC) . The NFC gets power availability in the two batteries and it takes the decision that, on which battery the wireless sensor node will get the power. The logical WCMAFC diagram is shown .As the Conventional methods of battery life management, which deals with regulating the, protection, charging and monitoring of the battery, are ineffective for two reasons. First, they do not predict the battery charge level and second, they require the battery to be off-line for the period of the measurements of the battery parameters.

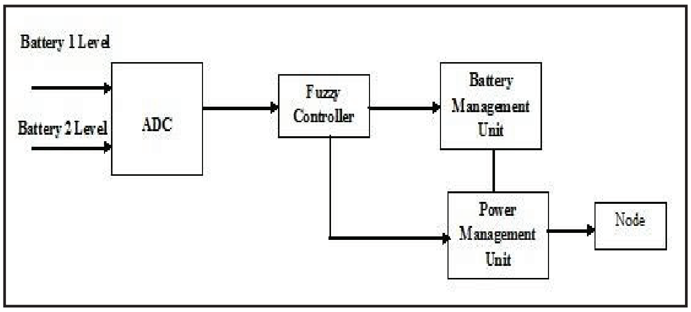

Fig. 2:

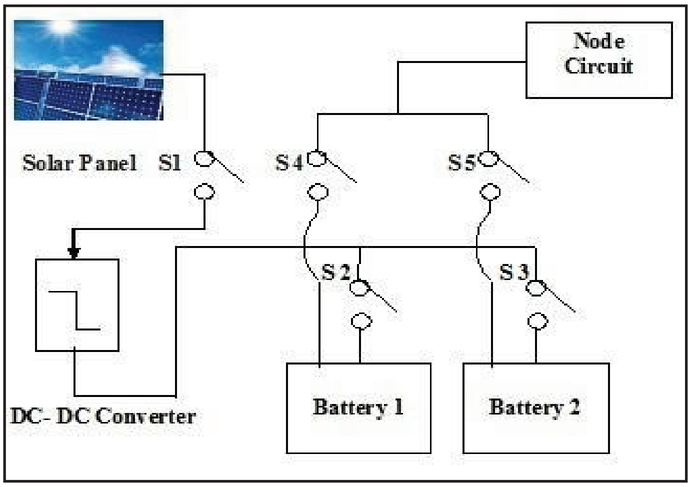

Fig. 3:

Table 1:

Charge/Discharge Condition				Switch Conditions		
Battery 1	Battery 2	S1	S2	S3	S4	S5
Charge	Discharge	ON	ON	OFF	OFF	ON
Discharge	Charge	ON	OFF	ON	ON	OFF

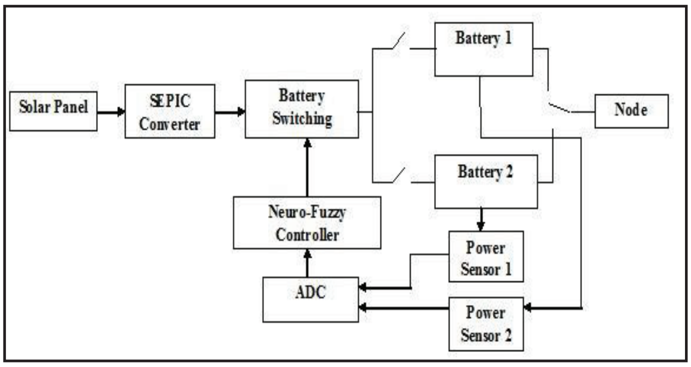

Fig. 4

IV. Automatic Battery Switching System

Author The BCDS (Battery Charging and Discharging System) is connecting electrically the charge and discharge paths between the batteries, the charger module, and the sensor node. It does two functions. In its first function it is routing the current from the solar panels to the charger and from the charging unit to the battery selected. In its second function it connects the selected battery to the sensor node. It works according to the NFC algorithm which always checks CA (Actual Code) and CLPP (Low Power Point Code). If the CA is equal to CLPP means it takes the automatic battery switching decision, else it is keeping the current battery on to charge the wireless sensor node.Therefore, the dynamic connections of the electric circuit are carried out according to table 2 conditions of switches conditions. In the first row, BCDS is programmed to charge battery 1 while it discharges battery 2. The main benefit of the dual selector system is that it allows hot swapping of separated power supplies. In addition, in case both batteries are fully discharged, it is programmed to supply the sensor node directly from the solar panels Proposed Data Acquisition involves: Acquiring signals from real-world sensors, digitizing the sensor signals, Analyzing, displaying and saving the data and showing the battery conditions (Tasdelen, 2010)

V. Lab View WCMA Energy Prediction

Using Lab VIEW system design software to design to feed-forward WCMA ENERGY PREDICTION energy, by using a back-propagation algorithm is designed. Lab VIEW weights each of the inputs Xn is by multiplying each by its respective weight value Wn. A sum of all these results is then calculated and to this a transfer function is applied that generates the neuron's outputs. The Lab VIEW diagram for implementing a neuron would look something like following figure

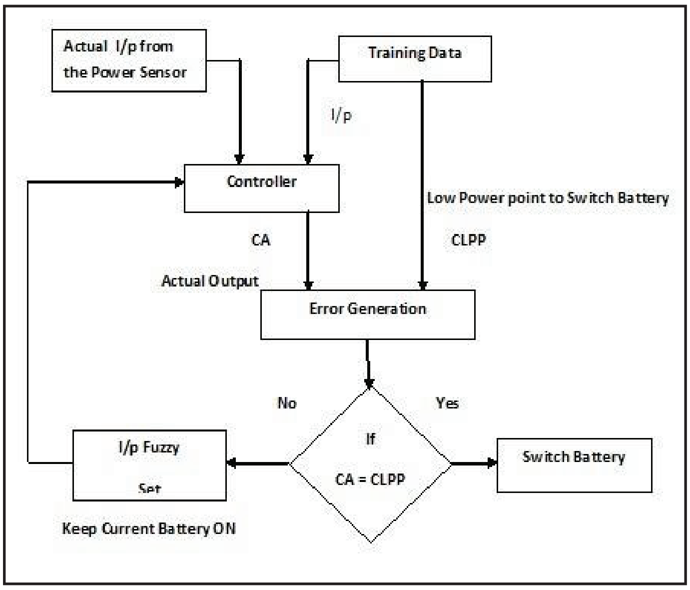

Fig. 5:

Times when the simulation is over, the result files contain data over time which can be directly analyzed to present the results below result windows. Results are grouped into Sensors data, battery1 and battery2 data, charging discharging details of both battery date time and all other necessary data required in the WSN System. For each device the simulator provides the equipment value, equivalent graph the voltage, and the power. Thus, harvested energy, total consumed energy, battery changing time, battery conditions and power peaks are easily monitored and stored in the database.

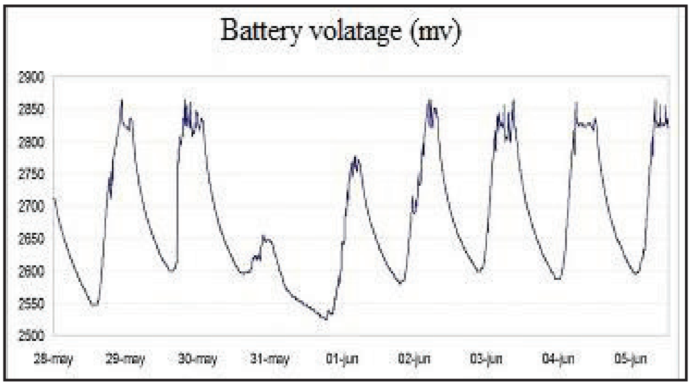

Fig. 6:

VI. Conclusion of the Proposed System

Type Battery management system has moved toward a lengthy way from the time of constant current chargers that did not attempt to check the battery to modern neural networks based models. This proposed Research focused on introducing the 3rd generation power supply management and control system with the inbuilt energy harvesting system. This energy harvesting system is not like a typical power system for nodes, but it is implemented with two rechargeable batteries with automatic battery charging discharging switching system. Thus it provides a high performance energy management system for wireless sensor node for while comparing with single battery energy harvesting system. The replacement time of the battery is increased and the effort need for battery monitoring is decreased. Of all current research in this field, neural networks and fuzzy logic are in the best position to provide such an increase in efficiency.

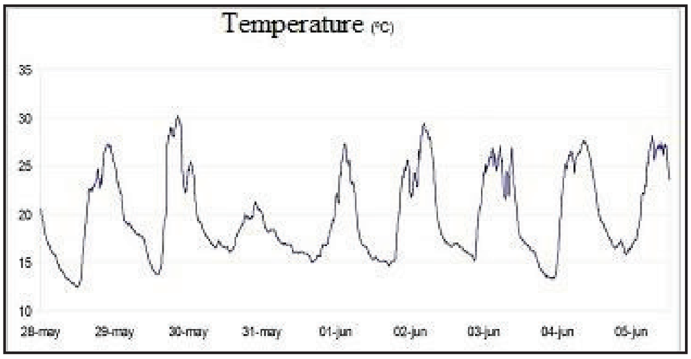

Fig. 7:

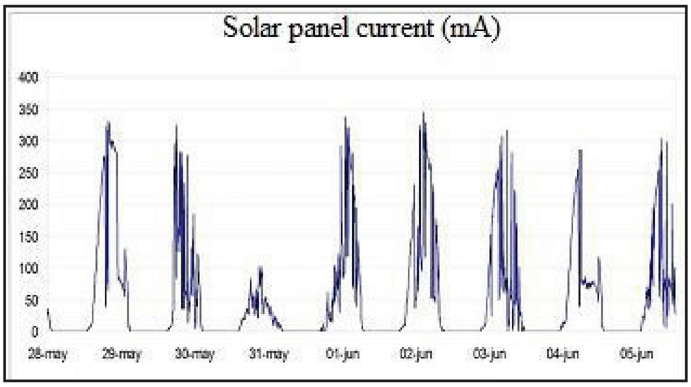

Fig. 8:

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