Neural Based Sensor Signal Change Detection By Using Radial Bias Function

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ABSTRACT

The paper describes the basic techniques involved on the detection of sensor signal changes, and describes their possible implementation on the lower level in sensor networks. Embedded into the communication protocols, the signal change detection will allow data compression for improving network efficiency. It might enhance reliability and security also. The algorithms utilizes a neural network function prediction methodology in order to determine if the sensor signals have changed. The literature survey is done and the different algorithms are studied based on their performance and parameter choice and the relationship between the threshold values and false positive and negative rates are studied the basis algorithms involved in this work are MLP and RBF Algorithms.

Keywords:- Multi layer Perceptron , Radial Basis Function , Sensor networks, Artificial Neural networks

INTRODUCTION

A wireless sensor network is a collection of nodes organized into a cooperative network. Each node consists of processing capability (one or more microcontrollers, CPUs or DSP chips), may contain multiple types of memory (program, data and flash memories), have a RF transceiver (usually with a single omni-directional antenna), have a power source (e.g., batteries and solar cells), and accommodate various sensors and actuators. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. Systems of 1000s or even 10,000 nodes are anticipated. Such systems can revolutionize the way we live and work.

SENSOR networks (SN) technology has the potential of becoming the backbone of a new generation of real intelligent systems, capable of achieving symbiosis with the environment and embracing the methods and mechanisms that exist in natural intelligent systems. In order to accomplish this goal, sensor networks have to adopt some elements of cognition in addition to collecting data from the environment and communicating them ,such as continuous self-development and self-modification with the goal to significantly improve self-reliability, efficiency, and security.

The goal of the research presented in this paper is to develop a detection system, which warns about a change of sensor signals in complex network systems by comparison of currently acquired measurement results against an association model derived during execution. The detector operation should minimize probabilities of missing the change (false negative) and/or false positive alarms (recognizing a "normal" deviation, which is due to the inaccuracy of measurement results, as a change). Normally measurement results fluctuate with some degree, which does not constitute any significant change. The detection should be performed by comparison of imprecise data against uncertain models.

Change detection is as an identification of unforeseen change in general characteristics and parameters of the signal observed. The case involving time series is one of the most interesting applications of the problem, attracting much attention, while being more complicated than an outlier detection .A number of different approaches and algorithm which did not produce a generic solution, have been proposed for change detection. New results in the development of a neural network based change detector. This describes the architecture of the change detection system based on the neural network function predictor. The neural network inputs a few different sensor signals that allows detecting changes not in one signal only but also in the relationships between signals. This feature improves detection reliability.

NEURAL NETWORK SIGNAL CHANGE DETECTION

Neural networks are computational models that share some of the properties of the brain. These networks consist of many simple "units" working in parallel with no central control, and learning takes place by modifying the weights between connections. The basic components of an ANN are "neurons", weights, and learning rules.

In general, neural networks are utilized to establish a relationship between a set of inputs and a set of outputs. ANNs are made up of three different types of "neurons": (1) input neurons, (2) hidden neurons, and (3) output neurons. Inputs are provided to the input neurons, such as machine parameters, and outputs are provided to the output neurons. These outputs may be a measurement of the performance of the process, such as part measurements. The network is trained by establishing the weighted connections between the input neurons and output neurons via the hidden neurons. Weights are continuously modified until the neural network is able to predict the outputs from the given set of inputs within an acceptable user-defined error level.

Although change detection in signals had been investigated for a considerable time, over the last two decades there have been new important developments. The literature on change novelty detection is rapidly growing due to applications in engineering, financial mathematics and economics. These detection techniques have developed into various models. From a generic point of view, ANN models seem to be appropriate as a base for developing fundamental algorithms utilizing opportunities, which arise from networking of sensor systems.

—Neural networks are distributed nonlinear devices Their ability to deal with nonlinear, non stationary, and non-Gaussian processes makes them attractive for WSN practical applications. Accordingly, ANN have the inherent ability to model underlying nonlinearities contained in the physical mechanism responsible for generating input data.

—Neural networks, operating in a supervised manner, are universal approximators

They can approximate any continuous input-output mapping to any desired degree of approximation, given a sufficient number of hidden units.

—A neural network consists of a massively parallel processor that has the potential to be fault tolerant.

As MLP consists of a large number of neurons arranged in the form of layers with each neuron in a particular layer connected to a large number of source nodes in the previous layer. This form of global interconnectivity has the potential to be fault tolerant, in the sense that the performance degrades gracefully under adverse operating conditions. If a neuron or its synaptic links are damaged, the recall quality of a stored pattern is impaired, but owing to the highly distributed nature of the network, the damage has to be extensive before the performance is seriously affected. This property open an opportunity to design an ANN topology distributed over a SN infrastructure.

—Neural networks have a natural ability to adapt their free parameters according to changes in the environment in which they operate.

In this tuning of free parameters in a neural network is a more straightforward task (and therefore easily accomplished by a non expert user) than would be the case with other nonparametric methods.

Multi-Layer Perceptrons (MLPs) are neural networks that have nodes arranged in multiple layers, with connections from one layer to the next. Data is feed forward through the network to produce output. An error is determined for the output and propagated backwards through the layers. Finally, these errors are used to adjust the connections between nodes. The backpropagation algorithm allows for movement to a minimal error over the course of the training process. Each time the weights are changed, the direction and magnitude of their change is determined so as to make a move towards the minimal error.

The main idea of the methodology is

1. To perform change detection on a set of networked sensor signals based on the differences between current signal values and predicted ones.
2. A neural network is employed to produce these signal predictions from a recent history of sensor measurements.
3. The neural networks can be utilized with no priori information on the data distribution of the domain and without specifying other parameters related to the data.
4. This allows the network to detect changes and after that “renormalize” itself by learning new signal values to be used for further change detection.

From a generic point of view, ANN models seem to be appropriate as a base for developing fundamental algorithms utilizing opportunities, which arise from networking of sensor systems. The basic techniques involved in signal change detection is explained .

LEON REZNIK et al [1] (2005): develops intelligent protocols, based on the detection of sensor signal changes. The signal change detection will allow data compression for improving network efficiency. The protocol utilizes a neural network function prediction methodology to determine if the sensor signals have changed. The parameter choice and relationship between the threshold values and false positive and negative rates are studied. Change detection is based on the difference between current signal values and the predicted values. Novelty detection is utilized to detect changes and after that to relearn new signal values to be used for further changes detection. The results of the experiments conducted demonstrate that the change detection system is both accurate and reliable. These results confirm the benefits anticipated from the modified neural network and demonstrate its usefulness in sensor prediction and change detection.

Tayeb Al Karim et al (2) (2011) The paper describes the results of an empirical study aiming to demonstrate that a cognition ability may be treated as a generic sensor network feature. The new architecture with neural networks distributed over the sensor network platforms was developed for sensor network engineering applications. The detection system learns to detect the change of not only the signal levels but also sensor signal shapes and parameters that represent a more complicated task. The architecture allows for a significant reduction in resource consumption without compromising the change detection performance. Implemented as an agent controlling the sensor network self-adjustment to the objects under measurement in the sensor network composed from typical sensor motes, the novel neural network structures may achieve a significant saving in power consumption and an increase in a possible network deployment time from a few days to a few years. The experiments prove that a neural-network-based change detection system is feasible for sensor networks application designs and could be successfully implemented on the technological platforms currently available on the market. The proposed MTBMLP architecture has been tested and compared against a conventional MLP on changes of both frequencies and amplitudes signal parameters and with different types of signals (sine and square waves, constant values).

LEON REZNIK et al [3] (2005) describes the design and implementation of a novel intelligent sensor network protocol that enhances reliability and security by detecting a change in sensor signals. Neural network function prediction methodology is used to predict sensor outputs to determine if the sensor outputs have changed. The experiments performed to the different training times and threshold values and these experiments demonstrates that the system performs better when presented with correlated data rather than randomly generated data the difference between the false alarm rates and detection for the correlated and uncorrelated sensor and changes have been seen and these results confirm the benefits anticipated from the modified neural network and shows its usefulness in sensor prediction and novelty detection. Detection rates and false alarm rates become better when data and changes presented to the system are correlated in positive. The limitation is the system's inability to learn properly long clock signals. The second problem is the predetermined error threshold. The threshold can be set very high or very low causing a notable increase in the false alarm rate and too high causing a drop in the detection rate.

GREGORY VON PLESS [4] et al introduces Modified time based multilayer perceptron (MTBMLP), complex structure composed by a few time-based multilayer perceptrons. This modification reduces connections, isolates information for each function and produces knowledge about the system of functions as a whole. It is powerful function predictor that converges quickly and accurately predict cyclic sinusoid functions. This neural network is applied for novelty and change detection in signals delivered by sensor networks and for edge detection in image processing.

JODY PODPORA et al [5] (2008) develop an intelligent and power conservation scheme for sensor networks. The power savings are evaluated from the perspective of the WSN nodes. Power mode switching is determined via change detection in measured signals. The change detection is based on the observation of number of signals which are measured in the environment and the measurement results delivered to the base station for processing. To perform this change detection ANN based intelligent agent has been developed and implemented and a novel neural network topology has was designed for wireless sensor networks. The architecture is built upon a multilayer perceptron neural network to reduce the number of connections between the layers. The experiment conducted confirms that this network decreases the resources such as time and power consumption required for its implementation without causing any increase in false alarm rates.

LEON REZNIK et al 2008 puts the concept of cognitive sensor networks. This research paper describes the results of an experimental study and development of novel neural network intelligent technique for signal change detection in sensor networks. The detection system learns to detect the change of not only the signal levels but also sensor signal shapes and parameters. The ANN is capable to handle detection with both problems as well as to adapt to the new pattern. The ANN architecture maps with the ANN structure and reduces connectivity. Signal propagation through the ANN faster in both forward and backward directions that allows increasing speed of the application. At the same time novel structure reduces the consumption of major resources network bandwidth processor power and memory usage.

TAYEB AL KARIM et al (2005) In this research paper detection system is developed and change of sensor signals in complex network systems is studied by comparing currently acquired measurement results against an association model derived during execution. The detector operation should minimize the probabilities of false negative or false positive alarms. Measurement results are not always accurate, they always fluctuate with some degree. This paper describes the architecture of the change detection system based on the neural network function predictor. Two function prediction designs are compared based on the standard multi-layer perceptron (MLP) and Radial basis function network (RBF).

It studies the dependence of the detection and false alarm rates on the threshold values for different signals and changes. With respect to the training time, the detection rates and false positive rates remained unchanged with training times at any given threshold. With respect to the threshold detection rates went down with higher thresholds. MTBMLP performs much quicker than the MLP. Different experiments were conducted in this paper which includes turning lights on/off, flickering lights, gradual change of temperature with opening a door.

1. PROBLEM FORMULATION

The analytical formulation of the research is based on function prediction using neural network .There is rapid enhancement in this field of application and their comparative factor have to be explored to generate recurrent priority. We have different algorithms in neural networks for sensor signal change detection. Multilayer perceptron (MLP) and Radial basis network (RBF) are used to determine change in sensor outputs. RBF performs well than MLP for all parameters. Now days a number of structures have been proposed for signal change detection. Structure based on RBF function is expected to perform better in predicting accuracy with low false alarm rates. Thus in this paper we purpose a structure based on RBF algorithm which will improve the parameters (threshold and training lengths) in signal change detection of the sensor networks then the existing.To improve the performance of RBF by varying intrinsic parameters (threshold & training length) is the major objective which we realise from the research gaps of the basic literature survey.

2. RESULTS AND DISCUSSIONS

The RBF are able to predict the sensor functions with greater accuracy. With the threshold set to 0.1 these changes were detected with a rate of 98%.This allows the use of a lower threshold value in the novelty detector. The improved RBF has its optimal performance at a lower threshold. At lower threshold it is able to detect 100% of sensor signal changes. The MLP operates optimally at the 0.5 threshold value, however the results are significantly worse than that of the RBF. With 100% detections, the MLP has an average false alarm rate of 7.19%. The Figure shows the relationship between threshold and detection rates for MLP, RBF and IMPROVED RBF.

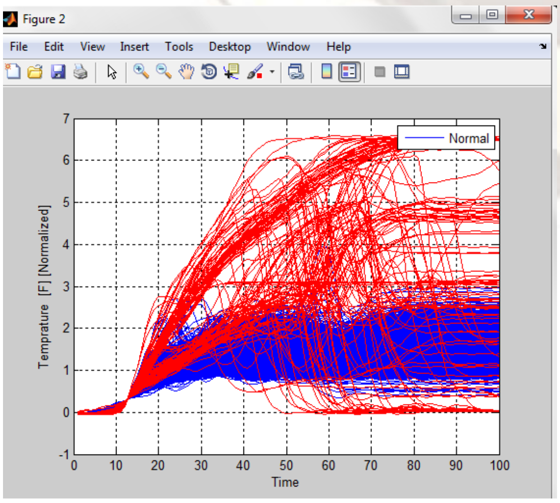

Fig 1: Basic Performance of temperature with sensors deployed

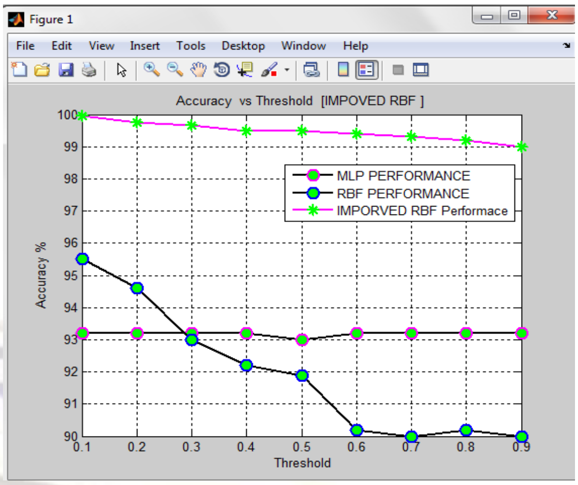

Fig 2: Relationship between threshold and detection rates for MLP, RBF and improved RBF

3. CONCLUSION

It is necessary to develop new ANN topologies to produce the most efficient ANN based applications on network platforms. Ideally the topologies should be scalable over large networks and have made apparent an advantage in performance and efficiency when using Radial Basis activation for sensor network change detection purposes. The greatest advantages are the greater signal prediction accuracy. The learning rate advantage could be used most effectively for change detection in sensor signals with changes that are densely distributed over time. False alarms were virtually nonexistent in the RBF network. A Radial Basis activation function is clearly the better choice for sensor signal change detection systems.

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