A Prime Exploration of Collision Detection in WSN: A Review

Aarti Kumari[1], Neha Shrivastava[2], Nitin Kali Raman[3]

[1]M.Tech. (ECE), [2,3]Assistant Professor
Department of ECE
DPG Institute of Technology & Management, Gurugram, Haryana

***Abstract*: Automated learning also stimulates many practical solutions that increase resources and increase the life of the network. In this paper, we present a broad review of the literature on machine learning methods during the period 2002-2018, which is used to solve common problems in wireless sensor networks (WSNs). The advantages and disadvantages of each proposed algorithm are evaluated for the corresponding problem. We also provide comparative guidance to help WSN designers develop the right automated learning solution to meet the challenges of their applications. We plan the embedded web application and discuss the requirements resulting from this analysis. In addition, we discussed the specific treatment techniques in the network and pointed to the similarity between the hop-field nerve network and the back propagation network. The sensor network context is presented in the following neural network. We half the motives and facts of neural networks in a sensor network environment and evaluate the early results obtained through the application of the test. We believe that these models are likely to have a strong impact on future research, especially if they are applied as hybrid technologies. We perform this function for WNS to look for collisions in the sensor network and try to determine the value of the output of data sent over the sensor network.**

***Keywords*: WSN, Hop-Field Network, ANN, Sensor Nodes**

1. Introduction

Wireless sensor network (WSN) is an emerging technology, which is flexible and redundant in deployment [1]. WSN can be potentially applied in target tracking [2], environment monitoring and military fields. Practically, WSN consists of many sensor nodes with limited resources, such as energy and signal processing abilities. For improving the sensing accuracy and robustness, the collaboration between many sensor nodes is desired. Because of the redundancy, properly sleeping/working sensor nodes can minimize the power consumption and prolong the lifetime of WSN in addition to fulfilling the desired sensing accuracy.

Wireless sensor networks consist of individual nodes that are able to interact with the environment by sensing or controlling physical parameters. These nodes have to collaborate to fulfill their tasks. The nodes are interlinked together and by using wireless links each node is able to communicate and collaborate with each other.

Architecture of WSN:

For example, they might spoof, alter or replay routing information to interrupt the network routing [1].As shown in Figure 1.1, the wireless sensor network and the classical infrastructure comprises of the standard components like sensor nodes (used as source, sink/actuators), gateways, Internet, and satellite link, etc.

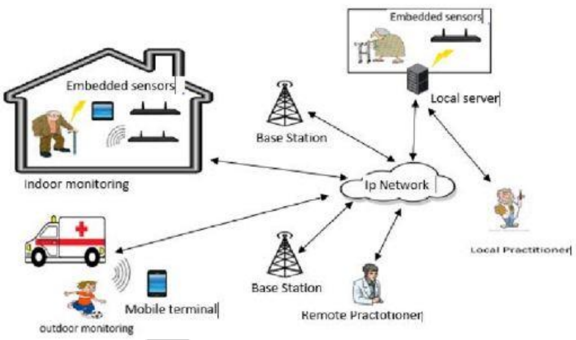

Fig 1: Architecture of WSN

Sensor nodes:

Sensor nodes are the network components that will be sensing and delivering the data. Depending on the routing algorithms used, sensor nodes will initiate transmission according to measures and/or a query originated from the Task Manager. According to the system application requirements, nodes may do some computations [2].

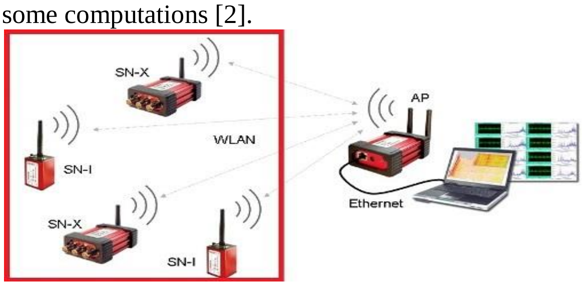

Fig 2: Sensor Nodes working

2. Background

Hu, S. G., et al. (2015) they demonstrate the associative memory on the basis of a memristive Hopfield network. Different patterns can be stored into the memristive Hopfield network by tuning the resistance of the memristors, and the pre-stored patterns can be successfully retrieved directly or through some associative intermediate states, being analogous to the associative memory behaviour. Both single-associative memory and multi-associative memories can be realized with the memristive Hopfield network.

Zhang, S., *et al.* (2015). Fractional-order Hopfield neural networks are often used to model how interacting neurons process information. To show reliability of the processed information, it is needed to perform stability analysis of these systems. Here, they perform Mittag-Leffler stability analysis for them. For this, they extend the second method of Lyapunov in the fractional-order case and establish a useful inequality that can be effectively used to this analysis. Importantly, these general results can help construct Lyapunov functions used to Mittag-Leffler stability analysis of fractional-order Hopfield neural networks. As a result, a set of sufficient conditions is derived to guarantee this stability. In addition, the general results can be easily used to the establishment of stability conditions for achieving complete and quasi synchronization in the coupling case of these networks with constant or time-dependent external inputs. Finally, two numerical examples are presented to show the effectiveness of our theoretical results.

Yang, J., *et al.* (2017) Memristor is a nanoscale electronic device that exhibits the synaptic characteristics in artificial neural network. Some valuable memristor-based synaptic circuits have been presented. However, the circuitry implementations of some simple neural network are still rarely involved before. This paper contributes to construct a novel memristive Hopfield neural network circuit. On one hand, an improved memristor bridge circuit is employed to realize synaptic operation which better performs zero, positive and negative synaptic weights without requiring any switches and inverters, and P-spice implementation scheme is also considered. On the other hand, the proposed bridge circuit greatly simplifies the structure of neural network, and reduces the conversion process between current and voltage signal. Furthermore, the associative memory in binary and color images is demonstrated on the basis of the proposed memristive network. A series of numerical simulations are designed to verify associative memory capability, and experimental results demonstrate the effectiveness of the proposed neural network via the cases of single-associative memory and multi-associative memory.

Rebentrost, P., *et al.* (2018). Quantum computing allows for the potential of significant advancements in both the speed and the capacity of widely used machine learning techniques. Here they employ quantum algorithms for the Hopfield network, which can be used for pattern recognition, reconstruction, and optimization as a realization of a content-addressable memory system. They show that an exponentially large network can be stored in a polynomial number of quantum bits by encoding the network into the amplitudes of quantum states. By introducing a classical technique for operating the Hopfield network, they can leverage quantum algorithms to obtain a quantum computational complexity that is logarithmic in the dimension of the data. They also present an application of our method as a genetic sequence recognizer.

Wang, H., *et al.* (2015) present the global stability analysis of fractional-order Hopfield neural networks with time delay is investigated. A stability theorem for linear fractional order systems with time delay is presented. And, a comparison theorem for a class of fractional-order systems with time delay is shown. The existence and uniqueness of the equilibrium point for fractional-order Hopfield neural networks with time delay are proved. Furthermore, the global asymptotic stability conditions of fractional-order neural networks with time delay are obtained. Finally, a numerical example is given to illustrate the effectiveness of the theoretical results.

Xu, Q., *et al.* (2018) investigates twin attractors in a two-neuron- based non-autonomous Hopfield neural network (HNN) through numerical analyses and hardware experiments. Stability analysis of the DC equilibrium point is executed and an unstable saddle-focus is found in the parameter region of interest. The stimulus-associated dynamical behaviors are numerically explored by bifurcation diagrams and dynamical map in two-dimensional parameter-space, from which coexisting twin attractor's behavior can be observed with the variations of two stimulus-associated parameters. Moreover, breadboard experiment investigations are carried out, which effectively verify the numerical simulations.

Duan, S., *et al.* (2016) present novel systematic design of associative memory networks is addressed in this paper, by incorporating both the biological small-world effect and the recently acclaimed memristor into the conventional Hopfield neural network. More specifically, the original fully connected Hopfield network is diluted by considering the small-world effect, based on a preferential connection removal criteria, i.e., weight salience priority. The generated sparse network exhibits comparable performance in associative memory but with much less connections. Furthermore, a hardware implementation scheme of the small world Hopfield network is proposed using the experimental threshold adaptive memristor (TEAM) synaptic-based circuits. Finally, performance of the proposed network is validated by illustrative examples of digit recognition.

Cabeza, R. T., *et al.* (2016) Most of the existing artificial neural network models use a significant amount of information for their training. The need for such information could be an inconvenience for its application in fault diagnosis in industrial systems, where the information, due to different factors such as data losses in the data acquisition systems, is scarce or not verified. In this chapter, a diagnostic system based on a Hopfield neural network is proposed to overcome this inconvenience. The proposal is tested using the development and application of methods for the actuator diagnostic in industrial control systems (DAMADICS) benchmark, with successful performance.

Wang, Q., *et al.* (2015) present a new subpixel resolution land cover change detection (LCCD) method based on the Hopfield neural network (HNN) is proposed. The new method borrows information from a known fine spatial resolution land cover map (FSRM) representing one date for subpixel mapping (SPM) from a coarse spatial resolution image on another, closer date. It is implemented by using the thematic information in the FSRM to modify the initialization of neuron values in the original HNN. The predicted SPM result was compared to the original FSRM to achieve subpixel resolution LCCD. The proposed method was compared with the original unmodified HNN method as well as six state-of-the-art methods for LCCD. To explore the effect of uncertainty in spectral unmixing, which mainly originates from spectral separability in the input, coarse image, and the point spread function (PSF) of the sensor, a set of synthetic multispectral images with different class separabilities and PSFs was used in experiments. It was found that the proposed LCCD method (i.e., HNN with an FSRM) can separate more real changes from noise and produce more accurate LCCD results than the state-of-the-art methods. The advantage of the proposed method is more evident when the class separability is small and the variance in the PSF is large, that is, the uncertainty in spectral unmixing is large. Furthermore, the utilization of an FSRM can expedite the HNN-based processing required for LCCD. The advantage of the proposed method was also validated by applying to a set of real Landsat-Moderate Resolution Imaging Spectroradiometer (MODIS) images.

Bao, B., *et al.* (2017) present simplifying connection topology of Hopfield neural network (HNN) with three neurons, a kind of HNN-based nonlinear system is proposed. Taking a coupling-connection weight as unique adjusting parameter and utilizing conventional dynamical analysis methods, dynamical behaviors with the variation of the adjusting parameter are discussed and coexisting multiple attractors' behavior under different state initial values are investigated. The results imply that the HNN-based system displays point, periodic, and chaotic behaviors as well as period-doubling and tangent bifurcation routes; particularly, this system exhibits some striking phenomena of coexisting multiple attractors, such as, a pair of single-scroll chaotic attractors accompanied with a pair of periodic attractors, a pair of periodic attractors with two periodicities, and so on. Of particular interest, it should be highly significant that a hardware circuit of the HNN-based system is developed by using commercially available electronic components and many kinds of coexisting multiple attractors are captured from the hardware experiments. The results of the experimental measurements have well consistency to those of MATLAB and P-Spice simulations.

3. Problem Formulation and Methodology

3.1 How Collision Occur in WSN:

Collision occurs when two or more nodes attempt to transmit a packet across the network at the same time. The transmitted packets must be discarded and then retransmitted, thus the retransmission of those packets increases the energy consumption and the latency. Collision attack is a type of DOS attack which occurs on Data Link Layer. Packet Collision occurs when two or more close stations attempt to transmit a packet at the same time. This can result in packet loss and impede network performance. Many CSMA based MAC protocols are proposed in Wireless Sensor Network (WSNs) to avoid collisions, such as B-MAC. These protocols can efficiently reduce collisions, but intrinsically cannot eliminate all collisions, because of hidden terminal problems, as well as collisions when multiple nodes sense the medium free at the same time. Furthermore, the consequences of packet collisions are serious to WSNs. Collisions can cause the loss of critical control information from base stations, and applications may fail.

3.2 Role of Neural Network in WSN:

Although neural network and sensor network are normally viewed as two radically different subjects, they do share one thing in common. The most fundamental way of exchanging information in both kinds of networks is one-to-many communication, i.e., the broadcast. In a biological neural network, a firing neuron sends an action potential to all neurons that are connected to it by synapses, each of which may impose different delay and amplification to the transmitted signal. Similarly, a communication node in a sensor network broadcasts its signal to all nodes within its transmission range. The proposed computing with time paradigm applies to networks in which a broadcast is a Communication primitive, such as neural networks in biology or wireless networks in telecommunication. Another example of such a paradigm is computing with action potentials proposed by Hopfield et al.

3.3 Feed Forward Back Propagation:

ANN's are biologically inspired computer programs to simulate the way in which the human brain process information. It is a very powerful approach for building complex and nonlinear relationship between a set of input and output data. The power of computation comes from connection in a network. Each neuron has weighted inputs, simulation function, transfer function and output. The weighted sum of inputs constitutes the activation function of the neurons. The activation signal is passed through a transfer function which introduces non-linearity and produces the output. During training process, the inter-unit connections are optimized. Once the network is trained, new unseen input information is entered to the network to calculate the test output. There are many back propagation algorithm are used in the neural network but mostly used feed forward back propagation neural network (FBNN).

3.4 Hopfield Neural Network:

The Hopfield neural network is a simple artificial network which is able to store certain memories or patterns. Hopfield neural network model is a fully interconnected network of binary units with symmetric connection weights between the units. The nodes in the network are vast simplifications of real neurons - they can only exist in one of two possible states - firing or not firing. At any instant of time a node will change its state depending on the inputs it receives from itself and the other nodes. The dynamics of the Hopfield network can be described formally in mathematical terms. The activation levels of binary units are set to zero and one for "off" and "on," respectively. Starting from some initial configuration ($V_0, V_1, V_2 \ldots V_i$) where is number of units and is the activation level of unit. The behavior of network is determined by an appropriate energy function. This function is based on neuron states, weights and bias value derived from problem data. Update rule of neurons is defined based on energy function.

4. Expected Outcome

In this section, the performance of each classifier in terms of packet delivery ratio, end2end delay, and throughput was compared. For better understanding of results comparison, we introduce these criteria.

a) Packet delivery ratio- It expresses the ratio of the total number of publication messages received by each subscriber node, up to the total number of publication messages generated by all publisher nodes of the events to which the subscriber node has subscribed.

It can be calculated by the following formula:

PDR= ((total packets-loss)/total packets)*100

b) End2End Delay- The delay of a packet in a network is the time it takes the packet to reach the destination after it leaves the source.

c) Throughput – Throughput is the number of packet that is passing through the channel in a particular a unit of time. This performance metric show the total number of packets that have been successfully delivered from source node to destination node and it can be improved with increasing node density.

The amount of samples generated by the network as response to a given query is equal to the number of sensors, k, that are present and active when the query is received.
It can be calculated by the following formula:

Throughput=total packets/End2EndDelay.

5. Conclusion

Wireless Sensor Network (WSN) is an innovative large-scale wireless network consisting of distributed, autonomous, low-power, low-cost, small-sized devices that use sensors to collaboratively collect information through unstructured ad-hoc wireless networks. The development of wireless sensor networks was initially driven by military applications such as battlefield surveillance. However, wireless sensor networks are now used in many residential applications, including environmental and habitat monitoring, healthcare applications, home automation and traffic control. Security plays an important role in many wireless sensor network applications. Due to the unique challenges posed by sensor networks, the security technologies used in traditional networks cannot be directly applied to wireless sensor networks due to their unique characteristics. First, sensor nodes are very sensitive to production costs because the sensor network consists of a large number of sensor nodes, and the cost of the sensor nodes should be considered to be well below $1 to make the sensor network feasible. Therefore, most sensor nodes are resource limited in terms of energy, memory, computing, and communication capabilities.

References

[1] Hu, S. G., Liu, Y., Liu, Z., Chen, T. P., Wang, J. J., Yu, Q., & Hosaka, S. (2015). Associative memory realized by a reconfigurable memristive Hopfield neural network. *Nature communications*, *6*, 7522.

[2] Zhang, S., Yu, Y., & Wang, H. (2015). Mittag-Leffler stability of fractional-order Hopfield neural networks. *Nonlinear Analysis: Hybrid Systems*, *16*, 104-121.

[3] Yang, J., Wang, L., Wang, Y., & Guo, T. (2017). A novel memristive Hopfield neural network with application in associative memory. *Neurocomputing*, *227*, 142-148.

[4] Rebentrost, P., Bromley, T. R., Weedbrook, C., & Lloyd, S. (2018). Quantum Hopfield neural network. *Physical Review A*, *98*(4), 042308.

[5] Wang, H., Yu, Y., Wen, G., Zhang, S., & Yu, J. (2015). Global stability analysis of fractional-order Hopfield neural networks with time delay. *Neurocomputing*, *154*, 15-23.

[6] Xu, Q., Song, Z., Qian, H., Chen, M., Wu, P., & Bao, B. (2018). Numerical analyses and breadboard experiments of twin attractors in two-neuron-based non-autonomous Hopfield neural network. *The European Physical Journal Special Topics*, *227*(7-9), 777-786.

[7] Duan, S., Dong, Z., Hu, X., Wang, L., & Li, H. (2016). Small-world Hopfield neural networks with weight salience priority and memristor synapses for digit recognition. *Neural Computing and Applications*, *27*(4), 837-844.

[8] Cabeza, R. T., Viciedo, E. B., Prieto-Moreno, A., & Vega, V. M. (2016). Fault Diagnosis with Missing Data Based on Hopfield Neural Networks. In *Mathematical Modeling and Computational Intelligence in Engineering Applications* (pp. 37-46). Springer, Cham.

[9] Wang, Q., Shi, W., Atkinson, P. M., & Li, Z. (2015). Land cover change detection at subpixel resolution with a Hopfield neural network. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, *8*(3), 1339-1352.

[10] Bao, B., Qian, H., Wang, J., Xu, Q., Chen, M., Wu, H., & Yu, Y. (2017). Numerical analyses and experimental validations of coexisting multiple attractors in Hopfield neural network. *Nonlinear Dynamics*, *90*(4), 2359-2369.