Probability method of reliability for cooperative neural network

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ABSTRACT: Cooperative neural networks have been used for the last few decades in a broad variety of applications. If the application is conclusive or decision based, like in classification or clustering problems, then it is suitable to use. While measuring the reliability or the failure aftermaths, it has been proved that essential constituent which assist in enhancing the reliability is having no unitary point of failure in a cooperative neural network. In this paper we have studied the reliability of any cooperative neural network and made a review of the possibility of implementing probabilistic mathematical model to check whether a cooperative neural network is reliable and few general results are provided for the reliability evaluation.
KEYWORDS: Cooperative Neural Networks, Reliability, Clustering

Introduction

In cooperative network entire nodes can pass along data like hand in glove. All nodes can be either generator or forward-moving clients, which advance data for other nodes in the cooperative networks [LSK09]. The cooperation is based on decode and forward scheme [SM09]. Some time it is difficult to solve some network problems and in that kind of perspective, cooperative neural networks can be effective network solution [AK98]. Cooperative neural network unlike other neural networks, mix changes to individual neural network frameworks to puzzle out complex network problems [CGW99].

Cooperative neural networks have been used for the last few decades in a broad variety of applications [ACK03] [AR09]. If the application is

conclusive or decision based, like in classification or clustering problems, then it is suitable to use. Specifically, areas such as data mining and financial engineering, has lot of use of cooperative neural network [AR09]. Applying neural network proficiency to monitored classification is very much powerful in terms of robustness, adaptively and hardware-implementation plausibility [PB07]. Also it is useful for parameter estimation of autoregressive signals and to decompose complex classification tasks [MD07] into simpler sub-tasks and then puzzle out each sub-task efficiently using a simple module. Decision making is utmost important, that too multi-module-decision-making [PB07] which is usually done utilizing a competitive [AKR94] or a cooperative [AKR94] [Wai89] [BC93] [MD07] technique. For the successful transmission of data on a cooperative neural network, reliability is one of the important factors to be considered [HH93]. If the reliability of the transmission path is more, the probability of successful transmission of data is more.

A variety of well known reliability structures are available to check the reliability of a cooperative neural network. In this paper, we have made a review of the possibility of implementing finite probability model to check whether a cooperative neural network is reliable and few general results are provided for the reliability evaluation.

1 Reliability for cooperative neural network

In the early time effort has been made to estimate the functional reliability by experiments. The soft calculation drew that the neuron like components are characterized by the logical redundancy [Far96]. The failures of some elements do not result in the errors at the neural network output. The preliminary concept of neural network had been given by MuClloch and Pitts (1943) [A+06]. There are two possible states of neurons; one is firing and another is not firing. For t neuron i a predicate that is true when the neuron is firing at a given time t: $N_i(t)$. MuClloch and Pitts (1943) depicted that the solution of a neural network as a set of logical sentences of the form neuron i is firing if and only if a given logical combination of the firing predicates of input neurons at previous times and some constant sentences including firing predicates of these same neurons at t=0 is true. Those logical sentences can be a solution for a network if they are all true for it; those sentences describe what the network computes. Likewise, such an ``if and only if'' sentence is called realizable by a network if it is true for that network; that is, when the net can compute it [SA08]. Some time it is

difficult to solve some network problems and in that kind of perspective, cooperative neural networks can be effective network solution [AK98]. However, suppose, whole neural network is partitioned into sub networks. Considering a task to be completed is assigned to sub network N_1. N_1 sub network may or may not able to accomplish that task on its own [RR07] [Ald99]. N_1 may require the support of another sub network say N_2 to complete the task too. Hence the completion of the task counts on N_2. N_1 is a motivation for N_2 as well as dependent on N_2. We can imagine that the two neuron fields G_m and G_n, have network m and n respectively in them. Consider that m is assigned a job; that means m is the system N_1 depicted above [RR07] .As took for granted earlier, the neurons in the neural network m may not alone end up this job. Very likely m demands some guidance or some technical taking heed from network n. If that not happened then we hypothesize that the task is too large and m allocates some part of it to its subsidiary n. Hence, there is an instituted interconnection between m and n [RR07] .There is a possibility that not all neurons in n sub network have connections with all neurons in m and converse may also be true (Hopfield BAM network). We can articulate that each neuron m_i in M has its own sub network group of neurons $\{m_{kl}\}$, l=1, 2,..,q_i in N($1 \leq i \leq s$, $1 \leq q_i \leq t$ (say)). We can show our network as follow.

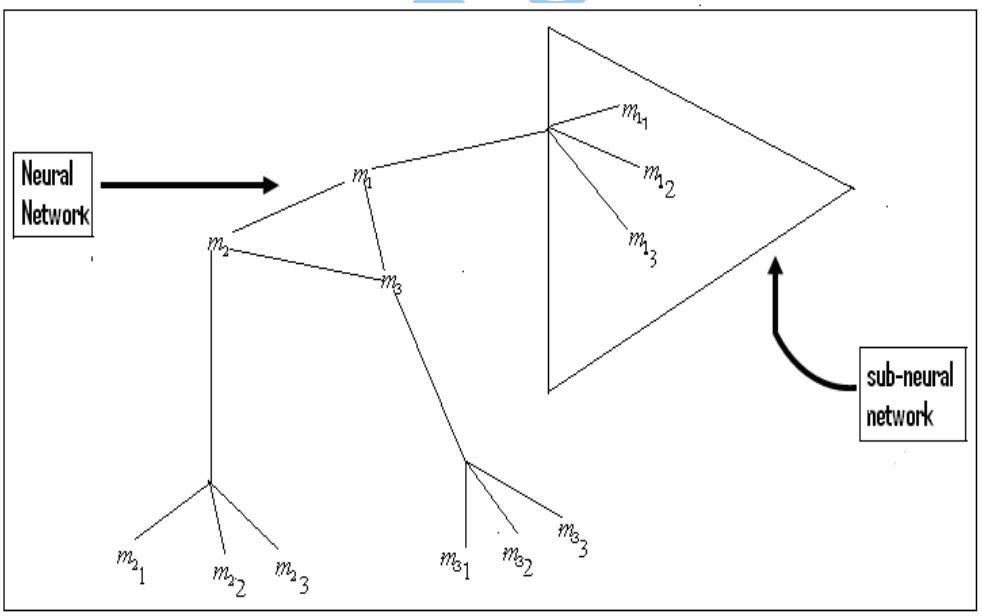

Figure 1. A distinctive figure of neural network which has been partitioned in to sub networks

In figure 1 we have depicted each node as m_i (0<i <4, i=integer) and their corresponding sub network as m_{ik} (where 0<i <4,0<k<4; i,k=integer). For any neural network's node, higher value of i and k also possible. Next stage, we have discussed a simplified a mathematical model.

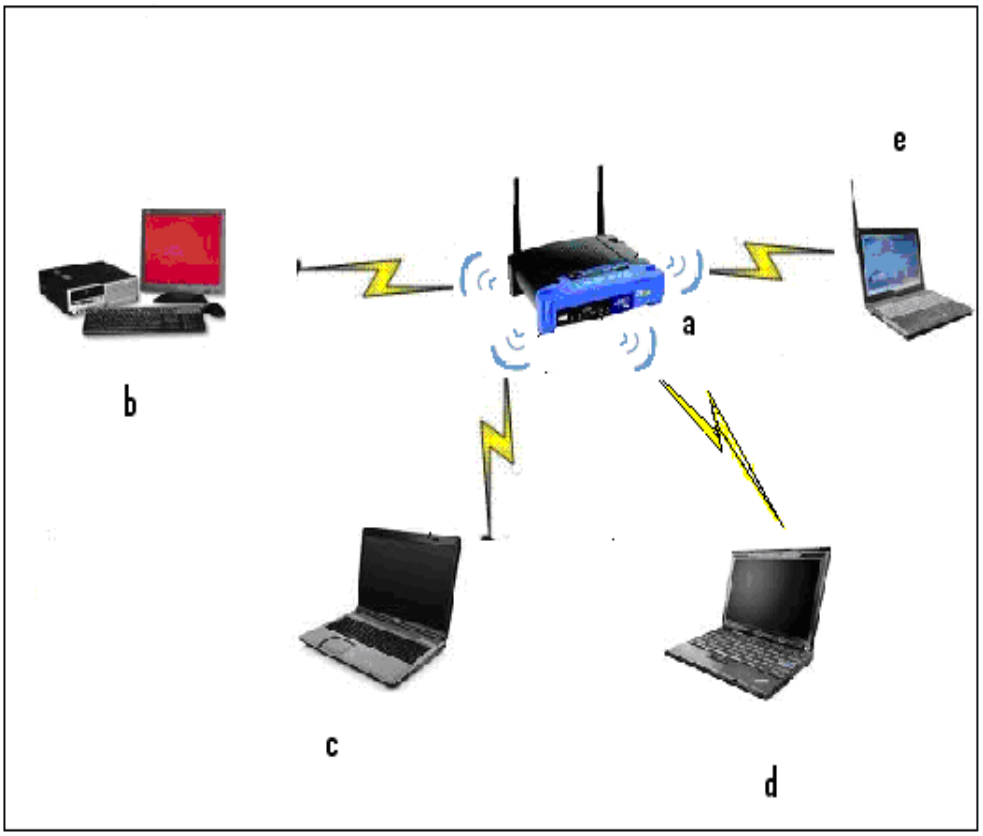

Figure 2. The above figure performs a wireless communication, where signal transferring is done using cooperative neural network technique. (a)-wireless router; (b)-desktop computer; (c, d, e)-laptops

2 Probabilistic model for the cooperative neural network

Functional reliability of a neural network can be classified as following three points

a. Functional reliability condition;
b. Analyzing probabilistic form of cooperative neural network's performance;

Neural network's functional probability and out put signal probability distribution function represents functional reliability criterion. In case of functional reliability of cooperative neural network, deterministic method of neural network design involves the selection of design loadings which are unlikely to be exceeded, together with a low competence of the concern network [CB73]. While analyzing the reliability, neural network capacity exceeds the effects of loadings by a definite amount. It is necessary for ratio of the loading to realize the structural capacity to the design loading is a measure of safety or reliability, named the load factor [CB73]. The stress factor is defined by the strength as a measure of structural capacity divided by the maximum stress caused by the design loads. There is a probabilistic chance of these concerned design loads being exceeded and lower load values of neural network capacities occurring in practices [CB73]. Obviously, in general some chance of this neural event exists. So, little chance of the actual loadings exceeding the neural capacity network may also subsist. In this situation, it is enviable to reflect on the chance of failure.

The reliability of any cooperative network is nothing but the probability of failure of a node in that network [CB73], [FGS66], [Bro60]. The canonical formulation of probability of failure has been proposed by Asplund [CB73], Cornell [Cor67], Yao [YY67]. The basic formula of probability of failure of a node in a cooperative neural network can be defined as:

$P_f = P(R \le \delta)$ where R is failure strength in a member nodes among all nodes and δ is the load effect on all member nodes in the concerned cooperative neural network. When density function $f_\delta(t)$ and distribution function $F_R(t)$ are defined as follows

$$P(t \le \delta \le t + dt) = f_\delta(t)dt, \quad (1)$$

$$P(R \le t) = F_R(t) = \int_{-\infty}^{t} f_R(S)dS \quad (2)$$

then P_f can be expressed as (4)

$$P_f = \int_{-\infty}^{+\infty} F_R(t).f_\delta \quad (3)$$

With n failure nodes in the cooperative neural network and m kind of loading, and intermediate network structure can be given as

$$\max_{i,j}^{n,m} p_{fi,j} \le P_f \le \prod_{i,j}^{n,m} (1-P_{fi,j})^{i=1,\ldots,n}_{j=1,\ldots,m} \qquad (4)$$

$p_{fi,j}$ = probability of failure of mode i having loading j.

It is true that a cooperative neural structure may break down due to an arbitrary combination of many factors, such as static loadings for any nodes across the network, dynamic loadings, instability, corrosion, fatigue or fracture. So, actual collapse of any node across a cooperative neural network depends on many factors.

Conclusion

In this paper, we have studied the reliability of cooperative neural network and shown how partitioned sub neural network dependency causes the failure of nodes. All essential constituent which assist in enhancing the reliability is having no unitary point of failure in a cooperative neural network. A cooperative neural structure may break down due to an arbitrary combination of many factors, such as static loadings for any nodes across the network, dynamic loadings, instability, corrosion, fatigue or fracture. Here, we have shown a possible probability failure mathematical model for nodes in the cooperative network with loading. We hope, this paper will help to do further research on probabilistic chance of failure of nodes for any cooperative neural network.

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