# TOWARD INTELLIGENT WEB MONITORING: PERFORMANCE OF COMMITTEE NEURAL NETWORKS VS SINGLE NEURAL NETWORK

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## ABSTRACT:

**Development of communication technologies has created opportunities for Web monitoring and home care in medical practice. Due to voluminous data involved in web based home care, intelligent systems are needed to identify if physician alert is needed and to identify the data that needs to be transmitted. Neural networks are generally used as intelligent tools, but the reliability of a single network may be questionable. In the present study, the technique of committee neural networks for intelligent web monitoring was developed, and the reliability of the committee neural networks was evaluated in relation to single networks. The committee neural networks based on a majority opinion of its member networks provided 100% correct results. On the other hand, individual networks proved to be less reliable and provided less than 100% correct results. Committee neural networks with a majority voting offer powerful potential tools for intelligent web monitoring using home care devices.**

## INTRODUCTION:

Statistics denote that by the year 2015, one third of the US population will be between the ages 50-69 [1]. 76.6 million baby boomers will be in the 50-to-69-year-old age group. Thus we expect the one third of the population to be in greater need of sophisticated health care.

With the advent of e-commerce, facilitation of instant access to information via the internet will be inherent in every system used in day to day life. A miniature cell phone with web accessing capabilities is one such envisioned product. The medical device industry is also outputting highly sophisticated, miniature products which are used for continuous daily monitoring thereby stressing on the factor of preventive care. Most of these devices thus produce detailed albeit voluminous individual patient records. Examples are wrist blood pressure monitors, heart rate monitors etc. Increasing number of sport equipment have in-built/external devices which record important physiological parameters. Hospitals will also gear up towards meeting the demands of such a technologically savvy world with maintaining patient records over the internet such that physicians can easily and instantly access detailed patient medical history from any location whenever needed. Some home monitoring devices already provide web transmission of the data to the physician. Such exponential growth to make data readily available requires the assistance of software which can reliably and accurately process the data, present the data in a flexible format and load quickly.

The transmission and processing of medical data over the internet poses a few basic problems as shown in fig 1.

1. The system should be able to compress large volumes of medical data without any loss.
2. The data cannot be slow to access. In other words the ability to transmit quickly over the internet subject to bandwidth limitations. The data also has to be highly secure and confidential
3. The vast amount of data collected per person has to be intensely processed at the physicians end for valuable alarm conditions and diagnosis.
4. The voluminous data would also call for storage considerations

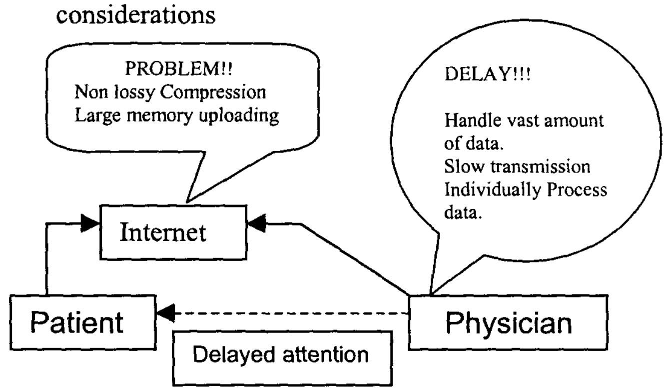


Figure 1: Present situation in web monitoring

Security over the internet is a highly evolving concept and also very complex [2]. However, the other problems can be resolved in a rather simple manner. The use of an intelligent software which can automatically process the data for various conditions before it is uploaded on to the internet thereby transmitting only limited amount of data which can reflect the patient status. This also would do away with the need for large amounts of data compression and transmission. The software could also process data for alarm conditions and automatically inform the concerned physician and provide data in a format which can be easily read and assimilated.

***Issues in the development of intelligent systems:***
The major requirement in the development of an intelligent decision making software is the ability to reliably differentiate between a normal and an abnormal case while reporting an alarm condition or while even deciding on what data is worth uploading. This software in a well evolved form should also be able to predict emergency situations and annotate the incidence of subtle irregular trends in the patient data which may not be alarm worthy but typical for future reference. Artificial neural network offers a potential tool for the development of such intelligent software. Neural networks (NN) have been used in clinical decision support systems, and in classification and detection of abnormalities and artifacts. NN can be developed to handle data specifically from each individual patient.

Neural networks or any software used in a medical decision process, diagnosis, treatment, therapy etc may be considered as a medical device and could be subjected to FDA regulations [3,4]. Reliability of a NN depends on its performance. In turn, the performance of a NN depends upon various factors such as initial weights, training data, structure of the network and incidence of local minima. A single network may not be reliable enough to make a reliable decision. Moreover, the training data from specific patients might be limited. Recently, Reddy et al [4,5] and Das et al [6] have used committee neural networks to improve the diagnosis of swallowing disorders. However, the training data was sufficient. Therefore, the question arises if the performance of committee networks is more reliable than a single network particularly in cases of limited training data set. The hypothesis of the present study was: Committee networks are more reliable than single neural networks.

**METHODOLOGY:**
Since most common home monitoring devices measure blood pressure, wrist blood pressure monitor was taken as the subject of investigation. Three parameters were chosen: systolic pressure, diastolic pressure and heart rate. We developed the technique of committee neural networks to classify the data into normal (not needing physician to be alerted) and diseased. (condition needing physician intimation and data transmission.)

The technique was to train several networks with the three above mentioned parameters and recruit the best performing five networks into a committee based on initial testing. The committee decision fusion was by majority opinion of its member networks. The committee decision was evaluated in a more rigorous final testing.

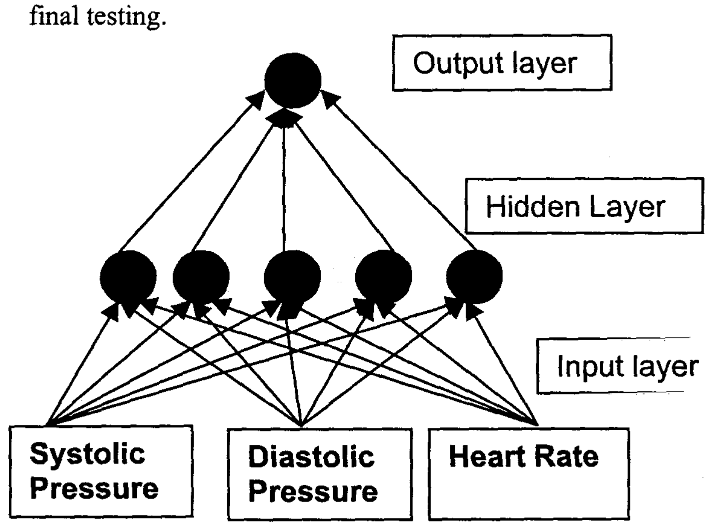


Figure 2: Model of the neural network.

**TRAINING:**
Several different networks were trained using the training data. Each NN was a three layer fully connected feed forward network. All networks had three input nodes corresponding to the three input parameters and had one output layer node (Fig.2). Each of the networks produces an output of either 1 (Abnormal) or 0 (Normal). There are five hidden layer neurons which have weights associated with each of the input parameters and feed the output layer having one node.

Different NN had different initial weights and different training algorithms. The goal of the networks was to minimize the sum squared error between network outputs and desired output to an acceptable level. All networks had the same training data.

***Recruitment of the committee & decision fusion:***
All the NN were tested with initial testing data. Five best performing NN were recruited into the committee. The decision fusion was by majority voting. The majority opinion of three or more members of the committee formed the committee decision. (Fig. 3)

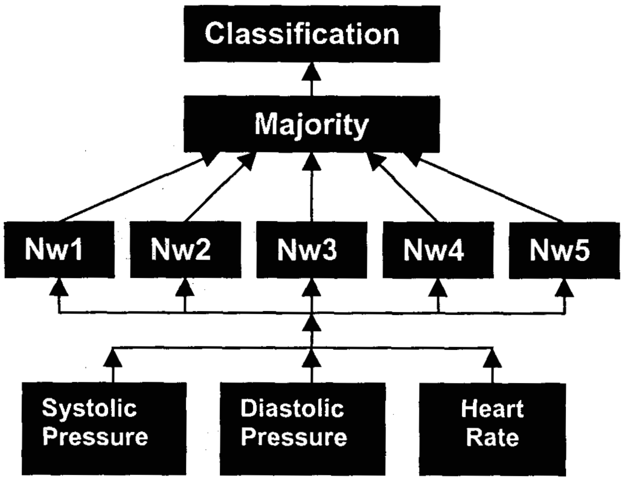


Figure 3: Structure of the committee neural network.

***Final testing*:**
The committee was then rigorously tested with a larger data set. The majority decision was the common decision supported by three or more networks.

**RESULTS:**

The committee correctly classified in 100% of the cases tested. On the other hand, no individual network made 100% correct decision. A sample of the outputs of the different neural network is presented in Table 1 As we can see, network 1 incorrectly classified decision of data set 1. Similarly, other individual networks also did not classify all decisions correctly in 100% of the cases over the final testing data. However the committee took a majority decision of the 5 networks and thus performed well identifying all the cases correctly.

| Data Sets | Nw 1 | Nw 2 | Nw 3 | Nw 4 | Nw 5 | Committee Decision Majority Opinion | Correct Decision |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| 1 | D | D | N | N | N | N | N |
| 2 | D | D | D | N | D | D | D |
| 3 | D | D | D | D | N | D | D |
| 4 | N | N | N | N | N | N | N |
| 5 | N | N | N | D | N | N | N |

Table 1: Decision made the committee matches the correct decision. Key: D =Disease, N= Normal.

**DISCUSSION*:***
The concept of committee networks in decision making using neural networks arises from an underlying analogy observed in most fields of decision making. A good example would be professional discussion groups in the medical industry. These consist of expert physicians who unite to make decisions on cases which do not follow regular patterns of pathology, are rare or pose some ambiguity in course of treatment to be followed.

Each expert physician's decision depends upon the nature of his/her training and the sum of his/her experiences. Similarly each individual neural network decision depends upon the initial weights, learning algorithm etc. which have been different in each case. The decision of a member network in the committee is therefore independent of the decision of other member networks of the committee. It is important to note that all the neural networks trained were trained using the same data set.

Although decision fusion by majority opinion was used in the present study, other methods like weighted fusion could be investigated. In order to reach a majority decision, the committee should consist of an odd number of networks. In the initial testing phase, many individual networks gave excellent results but not 100% correct (Table 1). Therefore, an odd number is necessary to arrive at a firm decision.

The structure of the network used in this study consisted of a single output node. However, NNs could be developed with two output nodes. For example an output of 1,0 denoting abnormal and 0,1 denoting normal [3,5,6] But in such cases, there could be decisions which could lead to ambiguity. To expand, if we are interested only in results 0,1 and 1,0 from each network, there still are the possible 0,0 and 1,1 results which cannot be understood to make a majority decision.

The data used in the study was data at one instant. However, data monitored in future will be continuous. While talking of the above parameters, other factors like interval periods, manner of change in heart rate etc will change from time to time. The neural network architecture should also be able to assimilate these changes in the form of some memory and then use that in the decision making process.

Reliability of a decision may increase with increasing number of recruited member networks. But if the decisions have to made online on continuous data, then a large number of member networks in decision making may induce computational time lags.

The present results have shown that the performance of committee neural networks is more reliable than a single network. Committee networks can be developed and used with with home care devices and web based monitoring for initial data screening needing physician alert, and judgement regarding data transmission.

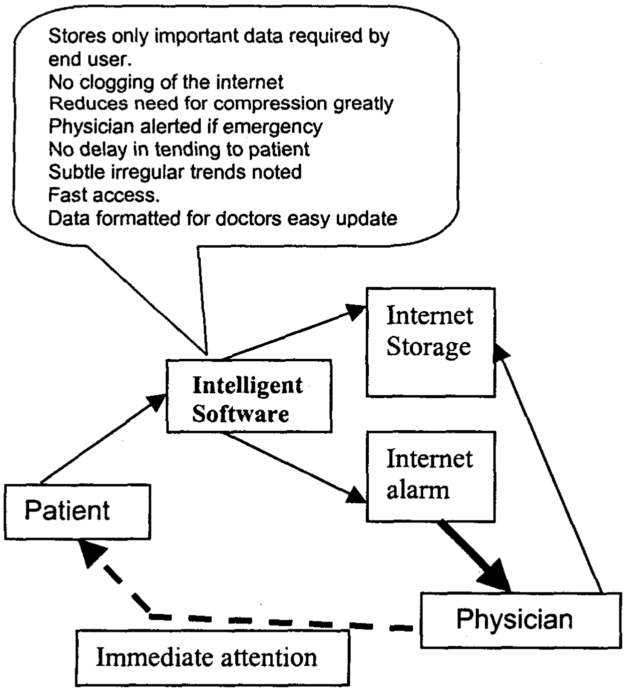


Figure 4: Proposed model of Web Monitoring.

Thus committee networks can be used to monitor the data generated and alert the physician in case of an alarm condition. By deciding what data needs to be transmitted, these also could reduce the amount of data transmitted. Hence these would make the access to data fast, place lesser demands on bandwidth requirements and do away with the need for compression of voluminous data.

## CONCLUSION:

The committee neural networks were developed based on majority voting. The committee decision produced 100% correct results. On the other hand, individual networks were unable to identify all the cases correctly.

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