

WIRELESS SENSOR NETWORK FOR SUPER CYCLONE PREDICTION USING ARTIFICIAL NEURAL NETWORK

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ABSTRACT

Super cyclone prediction is very much essential for human activities and to reduce the construction cost in marine research environment. Wireless Sensor Network (WSN) is a network of distributed autonomous nodes that can sense or monitor physical or environmental conditions. WSNs are used in various applications such as environmental monitoring, prediction and detection of natural calamities, medical monitoring and structural health monitoring. WSN is one of the research areas in the information world. Which provide platform to researcher with the capability of developing real-time monitoring system. This paper discusses the development of a WSN to detect super cyclone, which includes the design, development and implementation of a WSN for real time monitoring, the development of the artificial neural network system needed that will enable efficient data collection and data aggregation, and the network requirements of the deployed super cyclone detection system. The actual deployment of Paradeep port (Latitude: 20° 16' 60 N, Longitude: 86° 42' 0 E) north east coast of India, a region well-known for deals with bulk cargo apart from other clean cargoes. Government of India declared Paradeep as the Eighth Major Port of India on 18th April 1966 making it the First Major Port in the East Coast commissioned after independence.

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INTRODUCTION

Accurate super cyclone prediction is an important problem for construction activities in coastal and offshore areas. In some coastal areas, the slopes are very gentle and tidal variation makes waterfront distances in the range from hundred meters to a few kilometers. In offshore areas, accurate super cyclone data is helpful for successful and safe operations. The applications of WSN contain a wide variety of scenarios. In most of them, the network is composed of a significant number of nodes deployed in an extensive area in which not all nodes are directly connected. Then, the data exchange is supported by multihop communications. Routing protocols are in charge of discovering and maintaining the routes in the network. However, the correctness of a particular routing protocol mainly depends on the capabilities of the nodes and on the application requirements [1].

Orissa on the East Coast along with Andhra Pradesh and West Bengal has the locational is advantage of being in the path of depression of severe cyclonic storms that occur before the onset of south-west monsoon or after it recedes. The super cyclone and severe cyclone of October 1999 distressed 14 prosperous coastal districts throwing the lives of One Crore of people out of gear. The exceptional cyclonic gale, high flood, tidal doorway and stagnation are the main factors for distress and calamity there. Though relief was pouring in from all parts of the world but it was not reaching the victims due to improper disaster management. Proposal of cyclone shelters, coastal high

way, conservation of declining mangrove and other forests, afforestation and drainage improvements are the main need in the area. Improvements of saline and other embankments, dredging of the mouths of channels and rivers and additional ventage to the roads and cross drainage structures have been advocated. Proper forecasting and other curative measures with proper disaster management programme can alleviate the flood and cyclone to a great extent.

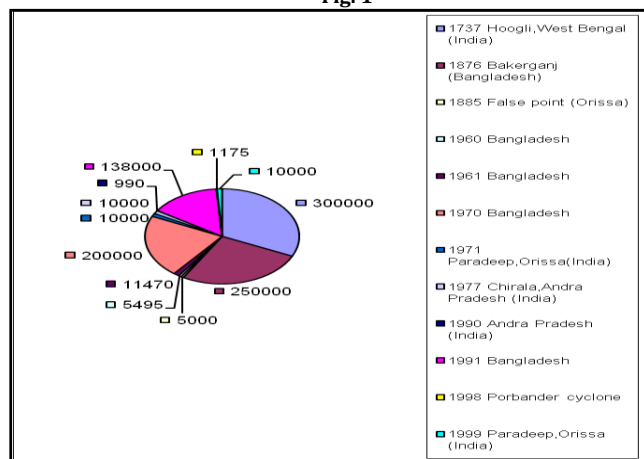
Environmental disasters are largely unpredictable and occur within very short period of time. Therefore technology has to be developed to capture relevant signals with minimum monitoring delay. Wireless sensors are one of the latest technologies that can quickly respond to rapid changes of data and send the sensed data to a data analysis center in areas where cabling is not possible. WSN technology has the capability of quick capturing, processing, and transmission of critical data in real-time with high resolution. However, it has its own limitations such as relatively low amounts of battery power and low memory availability compared to many existing technologies. It does, though, have the advantage of deploying sensors in hostile environments with a bare minimum of maintenance. This fulfills a very important need for any real time monitoring, especially in unsafe or remote scenarios. This paper discusses the design and deployment of super cyclone prediction detection system using a WSN system at **Paradeep port**, Orissa (State), India.

The increase in depressions during the monsoons over Bay of Bengal is directly related to rise in the temperature of sea surface. It is an impact of global warming. Abnormal behavior of sea surface temperature has started to affect the atmospheric climate over the Bay of Bengal. The increased number of continuous depressions over the Bay of Bengal has also led to increase in the height and velocity of the sea waves, which causes cyclone on the sea coast.

Table. 1 Major Cyclone of India and Neighborhood

YEAR	NAME OF THE COUNTRY	NO. OF DEATHS
1737	Hoogli, West Bengal (India)	3,00,000
1876	Bakerganj (Bangladesh)	2,50,000
1885	False point (Orissa)	5,000
1960	Bangladesh	5,495
1961	Bangladesh	11,470
1970	Bangladesh	2,00,000
1971	Paradeep, Orissa (India)	10,000
1977	Chirala, Andra Pradesh (India)	10,000
1990	Andra Pradesh (India)	990
1991	Bangladesh	1,38,000
1998	Porbander cyclone	1175
1999	Paradeep, Orissa (India)	10,000

Fig. 1



The remainder of the paper is organized as follows. Section II describes Research Background and Related Work. In Section III, we describe the Artificial Neural Network Algorithm. Section IV Wireless Sensor Test Bed. Section V Conclusion and Future Work.

RESEARCH BACKGROUND AND RELATED WORK

The research background and relevant technologies includes: (1) the definition of super cyclone (2) wireless sensor network technology.

Definition of super cyclone (What is super cyclone?)

A Super Cyclone is one whose wind speed encountered in core-area of a tropical cyclone equals or exceeds 226 km/hr.

What causes super cyclone?

A cyclone is a very large mass of air ranging from 800 km to 1600 km diameter with low pressure surrounded by a high pressure air mass. Due to unequal heating of earth surface pressure difference arises and strong wind blow in a spiral motion towards the low pressure centre from all direction because of rotation of earth around its own axis, causing cyclonic gale of more than 50 kmph. The large whirling mass of air at the centre where pressure is low is known as cyclone and acts like a chimney through which air gets lifted, expands, cools and finally gets condensed causing precipitation. If precipitation is caused by cold front it is very intense but for short period, while by warm front it is more continuous. A super cyclone is one whose

wind speed encountered in core-area of a tropical cyclone equals or exceeds 226 km/hr.

Why do we need super cyclone predictions?

Prediction of cyclonic storm in the Bay of Bengal and issuance of timely warning is the task of the Storm Warning Centre (National Weather Forecasting Centre) India. The cyclone information issued by the Storm Warning Centre (SWC) requires detection and monitoring of cyclones from formation until landfall and forecasting the cyclone's future track. Modern technology has provided the means for early detection and constant tracking. The cyclone warning system is well known in India. Warnings include the following information.

- Position of storm centre.
- Direction and rate of movement.
- Area likely to be affected specifying upazillas (administrative unit in India) of the district if possible.
- Approximate time of commencement of gale winds.
- Maximum wind speed expected.
- Approximate height of storm surge/tide and areas likely to be affected

Wireless Sensor Network Technology

WSN technology has generated enthusiasm in computer scientists to learn and understand other domain areas which have helped them to propose or develop real time deployments. One of the major areas of focus is environmental monitoring, detection and prediction. The

Drought Forecast and Alert System (DFAS) has been proposed and developed in [3]; it uses mobile communication to alert the users, whereas the deployed system uses real time data collection and transmission using the wireless sensor nodes, Wi-Fi, satellite network and also through internet. The real streaming of data through broadband connectivity provides connectivity to wider audience. An experimental soil monitoring network using a WSN is presented in reference [2], which explores realtime measurements at temporal and spatial granularities. In this paper, real time deployment of a heterogeneous network for super cyclone prediction detection has been discussed. This study incorporates both theoretical and practical knowledge from diverse domains such as super cyclone prediction and geomechanics, wireless sensor, Wi-Fi, and satellite networks, power saving solutions, and electronic interface and design, among others, which covered the design, development and deployment of a real-time super cyclone system using a WSN.

NEURAL NETWORK ALGORITHM

A neural network is a powerful data modeling tool that is able to capture and represent complex input/output relationships. The motivation for the development of neural network technology is to develop an artificial system that could perform "intelligent" tasks similar to those performed by the human brain. Neural networks resemble the human brain in the following two ways:

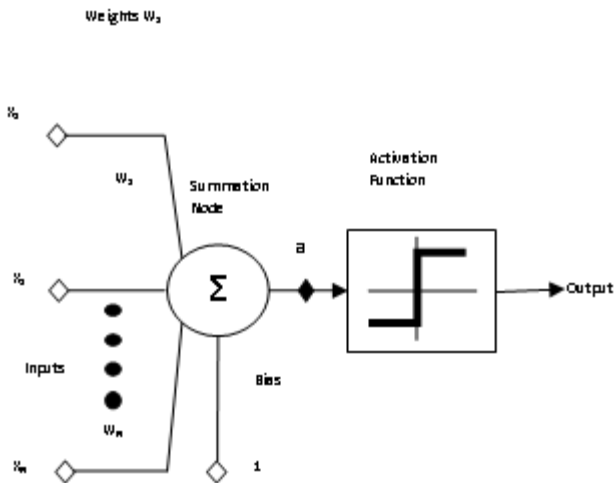
- A neural network acquires knowledge through learning.
- A neural network's knowledge is stored within inter-neuron connection strengths known as synaptic weights.

Fig-2 depicts the neuron model of the neural network and describes as follows.

- X_i = Input of a neuron i .

2. W_i = Synaptic weight to represent the linkages strength of neuron i .
- The high synaptic weight highly effects the operation of the neural network. On the other hand, the low synaptic weight has lightly effects on the neural network. The low synaptic weights usually are removed to reduce the computing time of the neural network. The operation of the neural network is to adjust the synaptic weights of neuron linkages and determine the suitable synaptic weights to have accuracy results.
3. S is responsible for the summation of each neuron's Synaptic weight.
4. $\vartheta()$ is the activation function, which is the nonlinear type to convert the summation value into the output.
5. Y_j = Output of the neural network.

Fig. 2: The Neuron Model of Neural Network



$$a = w_1x_1 + w_2x_2 + \dots + w_nx_n + \text{Bias}$$

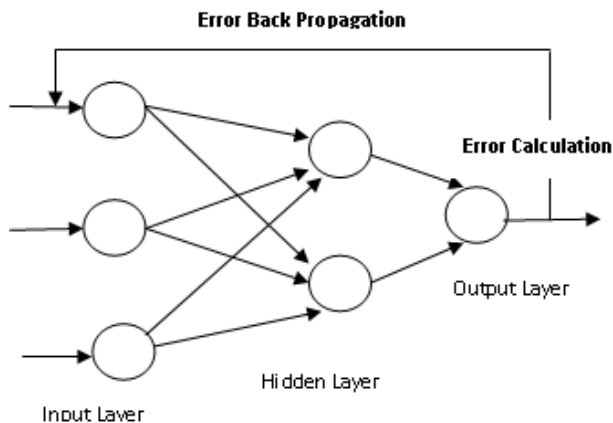
Output = Threshold [a]

Where Threshold [a] = $\begin{cases} -1, & \text{for all } a \leq 0 \\ 1, & \text{for all } a > 0 \end{cases}$

A commonly used non linear activation function is sigmoid function, which is defined as The sigmoidal function, $\text{sigmf}(x, [a \ c])$, as given in the following equation by $f(x, a, c)$ is a mapping on a vector x , and depends on two parameters a and c .

$$f(x, a, c) = \frac{1}{1 + e^{-a(x-c)}}$$

Fig. 2: The Back-Propagation Network Model



This paper utilizes the most popular Back-Propagation Network (BPN) algorithm to analyze the potential super cyclone degrees. The BPN algorithm is a typical Supervised Learning Network, which is to learn the internal reflection and regulations between inputs and outputs? The regulations are the synaptic weights of

network neurons. For analyzing any new cases, the input values or independent variables are inputted into the neural network and get the inferential related output values quickly.

Fig-2 depicts the Back-Propagation Network model, which have three system layers and described as follows.

1. Input Layer comprises the inputs of the BPN and represents the initial values of decision.
2. Hidden Layer comprises the neurons, which are responsible for adjusting the synaptic weights of neuron linkages and determining the suitable synaptic weights. To have accuracy results, the hidden layer is composed of several sub-layers to learn the internal reflection and regulations between inputs and outputs.
3. Output Layer comprises the outputs of the BPN and represents the final decision results at this training operation.

The control procedure of the BPN algorithm divides into the following operation:-

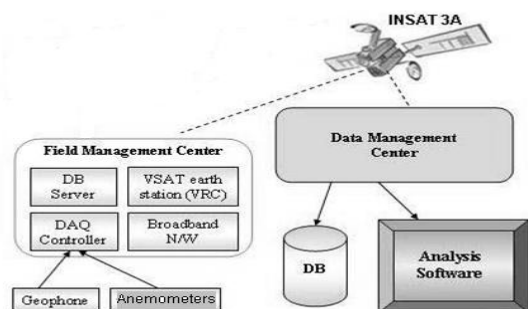
Two phases of computation:

- **Forward Pass:** Run the NN and compute the error for each neuron of the output layer.
- **Backward Pass:** Start at the output layer, and pass the errors backwards through the network, layer by layer, by recursively computing the local gradient of each neuron.

WIRELESS SENSOR TEST BED

The WSN follows a two-layer hierarchy, with lower layer wireless sensor nodes, sample and collect the heterogeneous data from the sensor column and the data packets are transmitted to the upper layer. The upper layer aggregates the data and forwards it to the sink node (gateway) kept at the deployment site. Data received at the gateway has to be transmitted to the Field Management Center (FMC) which is approximately 400 mt away from the gateway. A Wi-Fi network is used between the gateway and FMC to establish the connection. The FMC incorporates facilities such as a VSAT satellite earth station and a broadband network for long distant data transmission. The VSAT satellite earth station is used for data transmission from the field deployment site at paradeep sea beach, Orissa, India to the Data Management Center (DMC), situated within the state. The DMC consists of the database server and an analysis station, which performs data analysis and super cyclone modeling and simulation on the field data to determine the cyclone probability. The wireless sensor network architecture for super cyclone detection is as shown in Fig given below.

Fig 3: Wireless Sensor Network Architecture for CycloneDetection



CONCLUSION AND FUTURE WORK

Real time monitoring of super cyclone prediction is one of the research areas available today in the field of geophysical research. This paper discusses the

development of an actual field deployment of a WSN based super cyclone prediction detection system. This system uses a heterogeneous network composed of WSN, Wi-Fi, and satellite terminals for efficient delivery of real time data to the DMC, to enable sophisticated analysis of the data and to provide cyclone warnings and risk assessments to the inhabitants of the region. In the future, this work will be extended to a full deployment by using the lessons learned from the existing network. This network will be used for understanding the capability and usability of WSN for critical and emergency application. In the future, we plan to experiment with this method, including a simulation and implementation, to evaluate its performance and usability in a real sensor network application.

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