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Disaster Management Information System Framework using Feed Forward Back Propagation Neural Network

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Abstract: It is impossible to prevent natural disasters but the applications of recent technologies can be implemented for reducing their effects by developing disaster early warning strategies, preparing and implementing developmental plans to provide resilience to such disasters, and helping in rehabilitation and post disaster reduction. In all cases the circulation of precise, current and reliable information plays a significant role. An integrated approach using scientific and technological advances should be adopted to mitigate and to manage natural hazards using the proper information system for disaster management should be present to tackle the disaster and to manage it. The proposed study is about Uttarakhand (India) which is devastated by natural disaster (cloudburst and flash flood, 15 – 16 June 2013) before a couple of months and it also can be implemented in another provincial. The proposed study aims preparing an efficient disaster management information system for risk prevention and reduction in time to reach in emergency situations using web based interface and feed forward back propagation neural network.

Keywords: FFBPANN, DMIS, ICT, Cloudburst, NDMA.

I. INTRODUCTION

The upper Himalayan territories of Himachal Pradesh and Uttarakhand are full of forests and snow-covered mountains and thus remain relatively inaccessible to reach. They are home to several major and historic Hindu's and Sikh's pilgrimage sites besides several tourist spots. Heavy rainfall for four consecutive days (15/06/2012 to 18/06/2012) as well as melting snow aggravated the floods. Warnings by the India Meteorological Department (IMD) predicting heavy rains were not given wide publicity beforehand, causing thousands of people to be caught unaware, resulting in huge loss of life and property. The scale of the devastation that has taken place in the state because of flash floods was its lack of preparedness to deal with such disasters. This is also the fact of failure to widespread circulation of warning by IMD regarding heavy rainfall. Even the Uttarakhand has a history of being hit by natural disasters time to time although the state has not even mapped the frequency and intensity various types of disasters it has suffered. The Comptroller and Auditor General of India (CAG) reports in its performance audit report on the disaster management mechanism in the country, submitted to Parliament on April 23, 2012; CAG had highlighted that the Uttarakhand disaster management authority (SDMA), constituted in 2007, had not formulated any rules and policies or guidelines for disaster management in the state.[1][2]

The global average of number of disasters has been rising rapidly; improved warnings and mitigation programmes have reduced significantly the number of human lives lost in the nations those are well from the view point of technology. Advances in Information and Communication Technology (ICT) have made it possible to not only forecast some of the disasters but also to have made available means, for quick and effective rescue and relief operation, thereby minimizing the deadly impacts of some of the worst disasters. For instance, compared to more than 10,000 killed during the cyclone that hit Andhra Pradesh in 1979, improved communication techniques limited the loss to less than 1000 during the May 1990 cyclone of similar intensity in the same state. In the neighboring Bangladesh in the early 1970s, a cyclone killed more than 300,000 people. However, after the country put in an extensive early warning system, a recent cyclone of similar intensity resulted in loss of 3,000 lives. The United States of America has one of the higher rates of natural disasters in the world, but, the number of lives lost every year in that country due to natural disasters has been drastically decreasing over the years, compared to increasing global average. [3]

The Kedarnath[1] Calamity (15-18 June, 2013)

A mock drill organized by the National Disaster Management Authority (NDMA) in May-June 2011 in three districts of Uttarakhand had raised many crucial questions. After the drill, that was conducted in Dehradun (Capital of Uttarakhand State) on May 27, Haridwar on May 30 and Tehri-Garhwal on June 1, many solutions were offered to reduce damage in the state in the event of

[1] Kedarnath is situated in (Uttarakhand State) India, is devastated by landslide and flood.

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a disaster. None were implemented. The report of this drill is not public yet. [6] The CAG report highlighted that the Geological Survey of India had identified 101 of the 233 Uttarakhand villages affected by the disaster of 2008 as vulnerable. But the state did not make any arrangement for relocation of these villages in the past five years. [2]

In 2001 a detailed study was done in this region by Uttarakhand Space Application Centre (USAC) and Physical Research Lab Ahemedabad titled ' Land Slide Induced Floods in the Upper Alakananda Basin' that mapped various sensitive zones in the region and forecasted about heavy flood in near future. [6] USAC accept, during September 2012 flood in Okhimath several lives, as well as property worth crores of rupees wiped out; the loss could have been prevented, had the planners cared to implement the measures suggested by twin scientific studies conducted in Okhimath after 1998 rainstorm". In 1998 there was a huge landslide in Mandakini river that originates from Kedarnath in Rudraprayag district. The number of tourists in the region on 14 June 2013 a total 44591 visited, so they might be around during the rains of 16-17 June 2013. The early warning could have saved thousands of lives, those are dead and reported missing [6] During the rainy season (August and September 2012) two major flash floods in Okhimath and Uttarkashi townships led to death of over 120 people and huge losses. During fall of 2010 floods in North Western part of Indian Himalayan region affected over 3 million people and killed 300, in Pakistan left 14 million homeless and killed 1500, and in China killed at least 1,117 people. One of the scientific studies of 1,317 glaciers by Indian defense research organization in 10 sub-basins since 1962 of Indian Himalayan region finds 16% glaciers shrank during last 50 years. This study finds that in 100 years period there is 1.6°c rise in temperature, the precipitation rate has increased and rate of snowfall decreased, leading to reduced river discharge.[6]

Uttarakhand follows a "seven desk system" during this calamity to deal with a disaster situation. Officers supervising seven areas—operations, logistics, communication, resources, health, services and infrastructure—sit together to make a plan and allot specific responsibilities for efficient management. This also reduces the possibility of gaps in operations due to misunderstanding among various agencies. [6] The use of Information & Communication Technology (ICT) and the rapid advancement and development of various technologies can precisely alarm before the occurrence of such type of disasters.

II. SURVEY OF LITRETURE

Earthquake Disaster Prevention Information System-
The disaster prevention information system which functions surely enables damage reduction of the earthquake disaster. In this study, decentralized independence type disaster prevention information system was proposed. Based on the concept of RARMIS (Risk Adaptive Regional Management Information System), this system consists of "municipality information system" for disaster information processing as a seamless extension of the daily work at local government and "the disaster prevention information centre system" for the disaster responses exclusive processing. Disaster prevention information centre pilot system which realized a series of function based on this concept was developed. [4]

India Disaster Resource Network (IDRN) -
It is experienced that the least developed and developing countries are impacted more severely by large scale natural disasters. The unique geo-climatic conditions have made India highly vulnerable to natural disasters. In India, 54% of landmass is prone to earthquakes, 40 million hectares of landmass is prone to floods, 8000 km of coastline is prone to cyclones and almost 68% of total geographical area is vulnerable to droughts. The last occurrence of massive Tsunami on 26/12/2004 and the occurrence on 15 – 17 June, 2013 Uttarakhand calamities have worsened the situation. Though complete prevention of natural disasters is beyond human capabilities, the adverse impact of any disaster on human lives and their livelihoods can be minimized by taking adequate early warning, preparedness and mitigation measures. The state-of-art Information and Communication Technology (ICT) systems play a crucial role for implementing such preventive measures. [22]

The IDRN is a nation-wide electronic inventory of essential and specialist resources for disaster response, covering specialist equipment, specialist manpower resources and critical supplies. IDRN has been initiated by Ministry of Home Affairs (MHA) in collaboration with United Nations Development Program (UNDP) to systematically build the disaster resource inventory as an organized information system for collection and transmission of information about specific equipments, human expertise and critical supplies database from District level to State level to provide availability of resources for disaster response, so that disaster managers can mobilize the required resources within least response time.

The National disaster management Authority of India (NDMA) accepts that the lives could have been saved if the India Meteorological Department had issued precise forecasts. The India Meteorological Department (IMD) need to develop more precise observational and forecasting capability system. IMD followed a standard format of weather forecast and used certain terminologies like rainfall, heavy rainfall, but "how are we supposed to translate it into action? IMD need to pinpoint where and how much it is going to rain. Even after rainfall started, till date, six days after the event started on June 15, there is no account of how much rainfall occurred at what specific locations, and what was done to alert the populations that were at risk.

An important observation following the drill (by NDMA, India) noted the gaps in communication between

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government agencies in the event of collapsed roads and linkages. It also noted that the coordination between various agencies at state and district level was better than at the local level—tehsil, block or town. This, in effect, meant that practical implementation of disaster management would have gaping holes. [6]

This shows how agencies like IMD, CWC, NDMA and SDMA have failed to put in place basic systems of warning, forecasting, monitoring and information dissemination that can greatly reduce disaster potential of any area. There have been seven similar flood-related disasters in Rudraprayag in the last 34 years. When we analyze about this disaster we found that, there was no specific and timely warning of impending disaster from the India Meteorological Department (IMD), NDMA, SDMA or any other governmental or non governmental body.

Forecasting the behaviour of complex systems has been a broad application domain for neural networks. In particular, ANN models have been used in applications such as electric load forecasting [8, 9], economic forecasting[10], natural physical phenomena [11], river flow forecasting [12], prediction of lactation yield based on partial lactation records [13], forecasting student admission in colleges [14], empirical comparisons of feed-forward connectionist and conventional regression models for prediction of first lactation 305-day milk yield in Karan Fries Dairy Cows [15], forecasting sugar cane production [16], short-term load forecasting [17,18], forecasting the Saudi Arabia stock prices [19], short term electricity price forecasting[20], and improve forecasting sea level [21].

ANN is an information-processing paradigm that is inspired by the way biological nervous systems, such as the brain, process information. ANNs, like people, learn by example. An ANN is configured for a specific application, such as pattern recognition, function approximation or data classification, through a learning process.

Neural networks, with their amazing ability to derive meaning from complicated or loose data, can be used to mine patterns and identify trends that are too complex to be noticed either by humans or by computer techniques. The objective of the neural network is to transform the inputs into meaningful outputs. ANN can be used where no mathematical model (f (x) = x2) is available for example, Weather forecasting.

Back- Propagation of errors or back –propagation is a learning algorithm that can be implemented under supervision. The delta rule may be described as implementation of back-propagation. The method facilities the calculation of the desired output for a given input. The methodology is significant for networks with feedback (feed-forward networks). The pre-requisite for back-propagation is differentiability in the activation function used by artificial neurons. Back-propagation neural network (BPNN) is used to predict the weather.

It is evident from the foregoing analysis of literature that a significant study on weather forecasting in India using ANN does not exist. Even though there are statistical methods, ANN models report significant result for forecasting. Hence, this study is undertaken and *back-propagation neural networks* (BPNNs) have been used to predict weather.

III. METHODOLOGY AND RESULTS

This complete study is divided in two frame works. The frame work I, is about ANN model development. It uses some selected meteorological parameters for the purpose of training the model. The frame work II, is about wide spread circulation of information forecasted by proposed ANN model.

Data collection- The data is collected from WWW.IMDAWS.COM and ARIES Nainital for weather parameter. The sample data is as follows-

Meteorological Data - Sample Parameters

S. No.	Rain Sum (mm)	Avg Temperature (Deg C)	Wind Speed (Km)	Wind Direction (Deg)	Dew Point (Deg C)	Sea Level Pressure (HPA)	Pressure Tendency in Last 24 Hours in HPA
1	0	4.4	4	190	0.6	797.3	0.4
2	0	9.2	2	260	2	833.3	-0.6
3	0	15.4	5	270	11.4	953.8	1.3
4	0	12.1	1	40	2.6	882.1	-1
5	0	6.7	2	320	6.6	808.9	1.3
6	0	11	1	300	10.8	850.2	-0.8
7	0	16.7	1	280	7.8	993.7	1.4
8	0	5.1	5	230	4.2	804.2	2.8
9	0	4.6	4	235	4.5	817	0.7
10	0	15.4	1	280	11.4	940	0.5
11	0	5.4	4	210	9.21	797.2	-0.8
12	0	11.9	3	210	5.1	833.3	0.3
13	0	17.3	6	260	11.4	953.8	-0.6
14	0	5.9	5	135	5.8	817.1	3.4
15	0	16.4	1	120	7.7	881.8	1.8
16	0	7.7	1	320	7.6	808.8	-0.8
17	0	13.6	3	240	13.4	850	1.5
18	0	19.6	3	280	12.9	993.6	-1
19	0	7.5	3	240	6.8	804.4	0.7
20	0	10.3	1	245	0.5	813.8	3.5
21	0	12	5	140	3.5	833.5	1.2
22	0	18.1	6	280	9.8	986.8	0.3
23	0	18.6	5	260	10.7	953.8	0.4
24	0	6.3	3	250	9	817.2	-0.1
25	0	18	0	240	9.7	882.1	2.4
26	0	8.5	1	230	6	809.4	1.4
27	0	15.6	2	190	15.4	850	-0.3
28	0	21	2	290	13	993.8	1.3
29	0	18.3	2	280	9.9	940	0
30	0	7.8	6	280	4	804.4	1.9
31	0	7.7	2	170	1	797.3	2

Framework – I

ANN Model Development- ANN models can be tested experimentally with different number of neurons, learning rate, training tolerance. Training of ANN models been done using back-propagation algorithm. The stepwise procedure for neural network forecasting model is as follows:

Step 1: Define the input meteorological parameter (viz. those(X1, X2, X3 …., Xn) must be defined. These parameters directly influencing the weather prediction strategy.

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Step 2: The data for time period t and preceding time period should be collected.

Step 3: Develop an ANN model with taking into consideration different layer, number of neurons, learning rate and training tolerance or error goal in a particular layer.

Step 4: Evaluate and choose the most appropriate training algorithm of ANN.

Step 5: Select the programming tool to write the simulator for the proposed neural network.

Step 6: Develop ANN model with the help of collected data of chosen parameter selected parameters (X1, X2 , X3 …., Xn [as - Rain Sum (mm), Avg Temperature (Deg C), Wind Speed (Km), Wind Direction (Deg), Humidity (%), Sea Level Pressure (HPA), Pressure Tendency in Last 24 Hours in HPA]) and actual data (O(t-1), O(t-2), O(t-3),…….., O(t-m))

Step 7: Develop the test pattern from the trained network for t + 1, t + 2, t+ 3 ……. t+p , for which we want to forecast the weather. The result of ANN would represent the forecasted figures for the corresponding time periods

Step 8: Perform the error analysis. Calculate Root mean sum of error (RMSE).

The RMSE gives relatively high weights to large errors. This means RMSE is most useful when large errors are undesirable. The other techniques for finding prediction accuracy are mean sum of error (MSE) and mean absolute percentage error (MAPE). The minimum are these MSE, RMSE and MAPE, higher is the prediction accuracy. Confusion matrix is also prepared to forecast the prediction accuracy.

In the figure (Training ANN using Back Propagation Architecture) the process of training ANN model based on past meteorological data is showing. The forecasted results of will be in the form of alarming disaster situations due to past experience. Sample data is represented using the diagram. As-

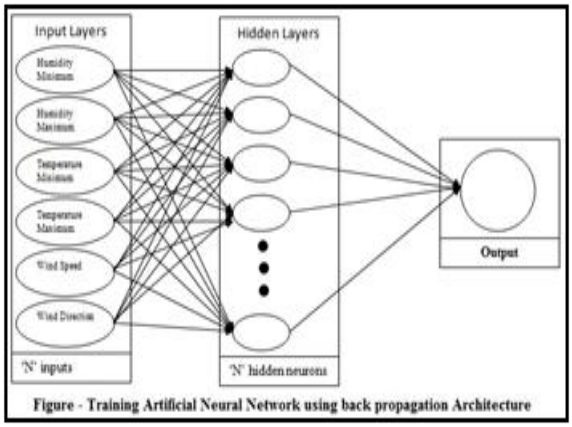

Figure - Training Artificial Neural Network using back propagation Architecture

Framework – II

Disaster Information/ Alert Circulation- The results obtained in frame work I, are circulated in disaster prone areas using various communication mediums. Such as- Mobile SMS, Radio, Television, Police Wireless System, Social media, Intranet, and web based interfaces. The head quarters of different authorities on local level or on above level, the information is also provided using web based interface.

IV. CONCLUSION

Information and Communication Technologies in form of Internet and warning systems are indispensable in planning and successful implementation of most Disaster Risk Reduction initiatives. The potential of most advanced technologies is required to be harnessed in early warning, preparedness and response systems along with adequate emphasis on circulation of information to the responsible authorities such as head quarters at different levels.

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