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Real Time Wireless Sensor Network for Tide Prediction Using Genetic Fuzzy Model

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Abstract—Tide prediction is very much essential for human activities and to reduce the construction cost in marine research environment. Wireless Sensor Network (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 genetic fuzzy system needed that will enable efficient data collection and data aggregation, and the network requirements of the deployed tide detection system. The actual deployment of Gopalpur Port (Latitude: 19°16' N , Longitude: 84°57' E) eastern coast of India, a region popularly known within the tourist circuit, boasts of one of the finest and most popular beaches in Orissa, India.

Keywords – wireless sensor network, Genetic fuzzy system, tide prediction, heterogeneous networks.

I. INTRODUCTION

Accurate tide 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 Wireless Sensor Networks (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].

Environmental disasters are largely unpredictable and occur within very short spans 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 ***Gopalpur 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 tides on the sea coast.

The remainder of the paper is organized as follows. Section II describes Research Background and Related Work. In Section III, we describe the Genetic Programming. Section

IV Mamdani Fuzzy Model. Section V describe Wireless Sensor Test Bed. Section VI Conclusion and Future Work.

II. RESEARCH BACKGROUND AND RELATED WORK

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

A. Definition of Tides

1. *What is Tide:* The periodic vertical movement of water on the Earth's Surface. Tides are the alternating rise and fall of sea level with respect to land, as influenced by the gravitational attraction of the moon and sun.

2. *What causes tides:* Tide-generating forces (TGF) are a result of the gravitational attraction between the earth, the sun, and the moon and the centrifugal force due to the relative motions of the moon around the earth, and the earth around the sun. While these forces exactly balance on average, the local mismatch at the earth's surface creates a horizontal force directed towards the surface points closest and farthest from the moon (the "lunar" TGF) and the sun (the "solar" TGF).

3. *Other factors influence tides:* Coastline configuration, local water depth, sea floor topography, winds, and weather alter the arrival times of tides, their range, and the interval between high and low water. A tide prediction can differ from the actual sea level that will be observed as a result of the tide.

4. *Why do we need tidal predictions:* Knowledge of the times and heights of tides and the speed and direction of tidal streams is important to a variety of people. These include:

a. The *Hydrographic Surveyor* in order to reduce soundings to a common datum. This is very important, as the Navy would not be able to defend our waters without accurate charts.

b. The Navigator particularly in estuarine and coastal waters and the approaches to harbours.

c. Harbor and Coastal Engineers in the construction of harbor works, bridges, locks and dykes.

d. The *Public* to know when to go fishing, sailing, cross rivers on hiking trails

B. 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 [5]; 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 [4], 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.

III. GENETIC PROGRAMMING

Genetic programming is a branch of genetic algorithm. The main difference between genetic programming and genetic algorithm is the representation of the solution. Genetic programming creates computer programs in LISP or scheme computer languages as the solution. Genetic algorithms create a string of numbers that represent the solution.

Genetic programming uses four steps to solve problems:

1. Generate an initial population of random compositions of the functions and terminals of the problem.
2. Execute each program in the population and assign it a fitness value according to how well it solves the problem.
3. Create a new population of computer programs.
   a. Copy the best existing programs.
   b. Create new computer programs by mutation.
   c. Create new computer programs by crossover (sexual reproduction).
4. The best computer program that appeared in any generation, the best-so-far solution, is designated as the result of genetic programming [Koza 1992].

In our proposed system, we choose the cross over operation by choosing parents to produce children.

The variable x, y and z are used for the input for fuzzy inference system and the variable r is used for the output for fuzzy inference system.

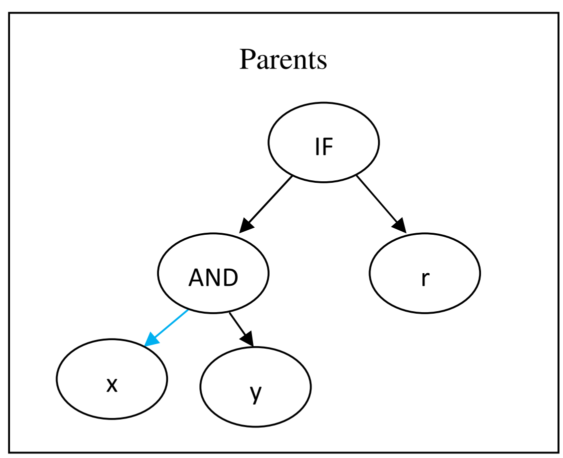

Figure 1

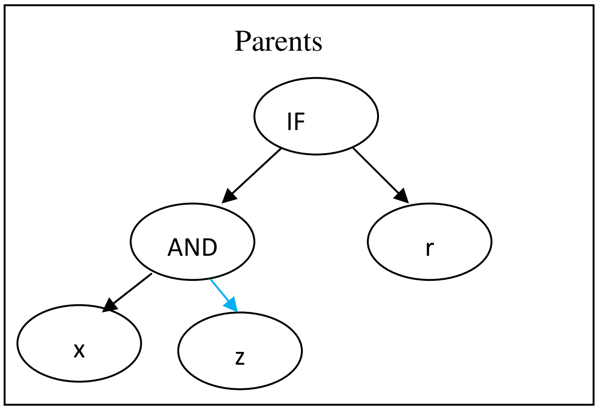

Figure 2

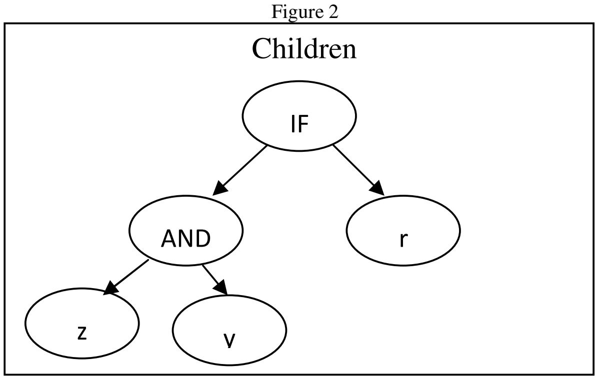

Figure 3

The following two parental LISP S-expressions:

(IF (AND(x y))

(r))

(IF (AND(x z))

(r))

The children resulting from crossover is shown below:

(IF (AND(z y))

(r))

IV. MAMDANI FUZZY MODEL

There are 3 types of fuzzy control system/model used.

1. Mamdani Fuzzy model
2. Sugeno Fuzzy model
3. Tsukamoto Fuzzy model

The most commonly used fuzzy inference technique is the so-called **Mamdani** method [2]. In 1975, Professor Ebrahim Mamdani of London University built one of the first fuzzy systems to control a steam engine and boiler combination. He applied a set of fuzzy rules supplied by experienced human operators. The Mamdani-style fuzzy inference process is performed in four steps:

1. Fuzzification of the input variables
2. Rule evaluation (inference)
3. Aggregation of the rule outputs
4. Defuzzification

Step 1: Fuzzification

The first step is to take the crisp inputs, x1, y1 and z1 (depression over sea, temperature over sea and velocity of wind), and determine the degree to which these inputs belong to each of the appropriate fuzzy sets. We examine a simple three-input one-output problem that includes two rules:

Rule: 1 IF x is A2 AND y is B2 THEN r is O2

Rule: 2 IF x is A2 AND z is C2 THEN r is O2

The Reality for these kinds of rules:

Rule:1 IF depression over sea is more AND temperature over sea is more THEN tide over the sea is more.

Rule:2 IF depression over sea is more AND velocity of wind is more THEN tide over the sea is more.

Step 2: Rule Evaluation

The second step is to take the fuzzified inputs, $\mu_{(x=A1)} = 0.3$, $\mu_{(x=A2)} = 0.7$, $\mu_{(y=B1)} = 0.3$, $\mu_{(y=B2)} = 0.7$ and $\mu_{(z=C1)} = 0.3$, $\mu_{(z=C2)} = 0.7$. Apply them to the antecedents of the fuzzy rules. If a given fuzzy rule has multiple antecedents, the fuzzy operator (AND or OR) is used to obtain a single number that represents the result of the antecedent evaluation.

RECALL: To evaluate the disjunction of the rule antecedents, we use the **OR** fuzzy operation. Typically, fuzzy expert systems make use of the classical fuzzy operation union:

$$\mu_{A\cup B}(x) = \max\,[\mu_A(x), \mu_B(x)]$$

Similarly, in order to evaluate the conjunction of the rule antecedents, we apply the **AND** fuzzy operation intersection:

$$\mu_{A\cap B}(x) = \min\,[\mu_A(x), \mu_B(x)]$$

Rule: 1 IF x is A2 (0.7) AND y is B2 (0.7) THEN r is O2 (0.7)

Rule: 2 IF x is A2 (0.7) AND z is C2 (0.7) THEN r is O2 (0.7)

Step 3: Aggregation of the Rule Outputs

Aggregation is the process of unification of the outputs of all rules. We take the membership functions of all rule consequents previously clipped or scaled and combine them into a single fuzzy set. The input of the aggregation process is the list of clipped or scaled consequent membership functions, and the output is one fuzzy set for each output variable.

r is O2 (0.7) → r is O2 (0.7)=Σ

Step 4: Defuzzification

The last step in the fuzzy inference process is Defuzzification. Fuzziness helps us to evaluate the rules, but the final output of a fuzzy system has to be a crisp number. The input for the defuzzification process is the aggregate output fuzzy set and the output is a single number. There are several defuzzification methods, but probably the most popular one is the **centroid technique**. It finds the point where a vertical line would slice the aggregate set into two equal masses. Mathematically this **centre of gravity** (**COG**) can be expressed as:

$$COG = \frac{\sum_{x=a}^{b} x.m(x)}{\sum_{x=a}^{b} m(x)}$$

The final output of the system will be the tide degree.

V. WIRELESS SENSOR TEST BED

The WSN follows a two-layer hierarchy [3], 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.

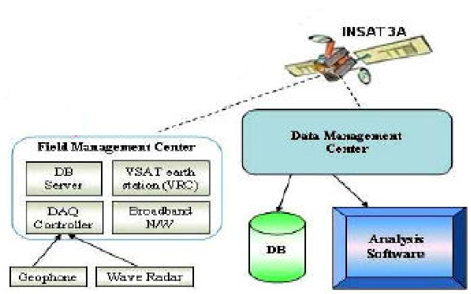

Figure 2: Wireless Sensor Network Architecture for Tide Detection

VI. 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 tide 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.

VII. REFERENCES

[1] A. Nanda, A. K. Rath, B. Dinda, R.K. Rath, "Genetic Fuzzy Approach for Prediction of Coastal Erosion": International Journal of Computer Information Systems, Vol. 2, No. 2, 2011, pp. 80-93

[2] A. Nanda,O. Pattanaik,B. Mohanty, "Wireless Sensor Network for Prediction of Tides using Mamdani Fuzzy Inference System": International Journal of Computer Information Systems,Vol.I, No.2,2010, pp. 33-37.

[3] M.V Ramesh," Real-time Wireless Sensor Network for Landslide Detection": Third International Conference on Sensor Technologies and Applications,IEEE 2009, pp 405-408

[4] E.R.Musaloiu, A. Terzis, K. Szlavecz,A.Szalay, J.Cogan, and J. Gray, "Life under your feet: A wireless soil ecology sensor network",2006.

[5] H. Kung, J. Hua, and C. Chen, "Drought forecast model and framework using wireless sensor networks": Journal of Information Science and Engineering, vol. 22, 2006, pp. 751-769.