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A Mobile Agent-Based Algorithm for Prediction of Inundation Area

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Abstract

Flood is inevitable but can be predicted before time to secure maximum human lives and decrease its impacts. For this purpose, a lot of techniques have been developed to predict the flood like Hydrograph, unsteady Flow River like SPH(Smooth Particle Hydrodynamics), ANFAS, FRICS, DMS and CBC. However these are not efficient to take benefits of uprising concepts for prediction. To overcome the problems, we developed a system based on mobile agent concepts. For mobile agent communication, VSAT (Very Small Aperture Terminal) is used which is useful in any type of critical conditions. For this, we develop a mobile agent based algorithm which can provide communication of server and client agent. This divides the system in two parts server and client agent. The client agent is responsible for calculating the discharge of flood based on water passing through the cross-section area, calculated by Simpson's1/3rd method and its velocity. The responsibility of the server agents to take the decision of inundation area depends on the discharge of water and historical data.

Keywords: Mobile agent, algorithm, communication, velocity, inundation area.

Introduction

The occurrence of flood hazards has increased in many countries like Malaysia[1], China[2], India[3], Japan[4], Turkey[5], Bulgaria[6] and most recently in Saudi Arabia. Saudi Arab is one of the countries that faced a catastrophic disaster of flood in 2010 and 2011, in Jedda and Mecca , that killed over 120 people and caused up to a billion dollars' worth of damages. The fact of flood occurrence in recent years is due to heavy rain in different cities like Jedda, Mecca and Riyadh. Since, the rains were so rarely in Saudi Arabia, Saudi cities lack infrastructure to deal with heavy rain. Mostly the occurrence of flood is actually the overflow of water from waterways and from the river banks[7]. The flood situation can be created due to: the highest discharge in the river, full the channels which overflow through its banks, in mountain areas, land does not absorb all water of heavy rain , consequently the water runs off the land which is not controlled by streaming channels[8].

Flooding can have many factors like heavy rainfall, severe winds over water, unusually high tides, tsunamis, heavy snow and facinghigh melting ratio and failure of dams as shown in the figure 1[3].

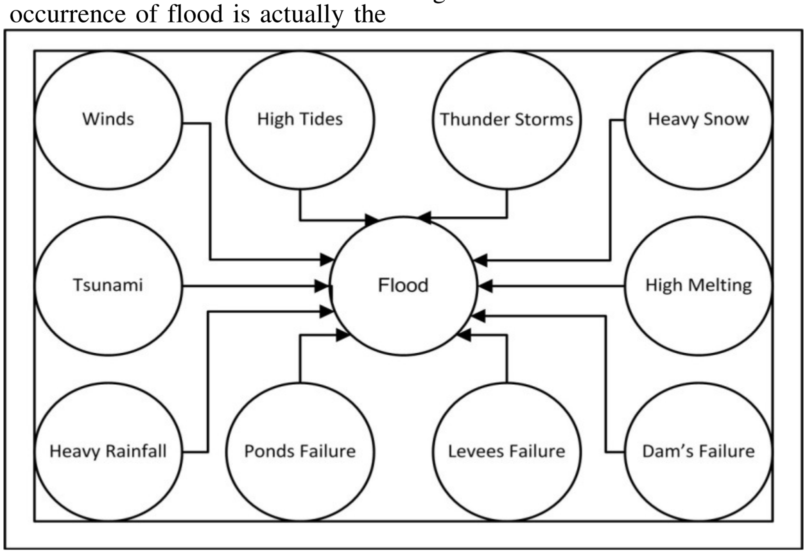

Figure-1
Causes of Flood

Practical experience shows that floods cannot be avoided but can be managed controlled and alleviate its affect by taking appropriate actions[9,10]. It is absolutely imperative to predict flood and make decisions about the forecasting of inundation area to rescue the people[11]. For this purpose, lots of strategies have been developed to nullify the impact of this potential danger. The biggest challenge of flood counterpart is to predict the flood and to save the human lives and their belonging. The Hydrograp his a technique to plot a graph, showing the stage or discharge of the river[8]. It plots graphs of gauging station relative to time. The Unsteady Flow River Model is another approach for the flood prediction. It has many factors such as input flow of water to river; storage capacity and discharge are studied and estimated using computer system[12]. SPH (Smooth Particle Hydrodynamics) is a simulation based model uses GIS (geographical Information System), LIDAR (Light Detection and Ranging), DEM (Digital Elevation Model) and Remote Sensing image to model this study[1]. The ANFAS is another method used for impact assessment of the flood affected area. It develops a simulation to help decision-makers about the flood damage[13]. FRICS (The Foundation of River Basin Integrated Communications) based on cell phones and mobile internet, applied (in Japan) throughout in country on 700 points, it calculates the river flow which is further available through website[4]. Government of India (GOI) and the United States agency for International development (USAID) initiated the Disaster Management Support (DMS) project as a collaborative effort to reduce the vulnerability of the Indian population to a variety of natural hazards[3]. It includes implementation of a flood forecasting and flood inundation mapping system. Turkey and Bulgaria developed three projects: contact information, real time data exchange and flood forecasting warning[6]. They model four remote sensing hydrometric stations are established in Bulgaria records continuously and supply real time data using a GSM communication system between both the countries.

In this research wedevelop a model for implementing distributed behavior of flood prediction using mobile agent concepts. Mobile agent is a particular type of agent having the ability of migration from one host agent to another agent where it can resume its execution[14]. Since, our system is geographically distributed, dynamic ambience and communication essential[15] for such systems the use of the mobile agent approach is documented[16-20]. In this research, we deploy the client agents on critical points to observe water flow and level to calculate discharge of the water through the cross-section. Further, the discharge is communicated to a server agent through a mobile agent to calculate predictions of inundation area. For mobile communication the VSAT (Very Small Aperture Terminals) technology is used. VSAT technology can solve telecommunications issues, enabling organization to focus on their core activities without becoming constrained by infrastructure.

Conceptual Model

In this system we divide our approach in two parts one is the server and another is a client agent. The client is the agent situated on the spot where the flood is passing. The client is responsible to measure the speed, level of water, calculate discharge and send it to the server. Whereas, the server is the agent receives the data, manipulate it and then take a decision about inundation to predict the upcoming flood. The server agent consists of the components: agent execution, user message, alarm, database and security. Whereas the client agent contains the components: agent execution, level of water, speeds of water, discharge and security as shown in the Figure 2 and described as followed:

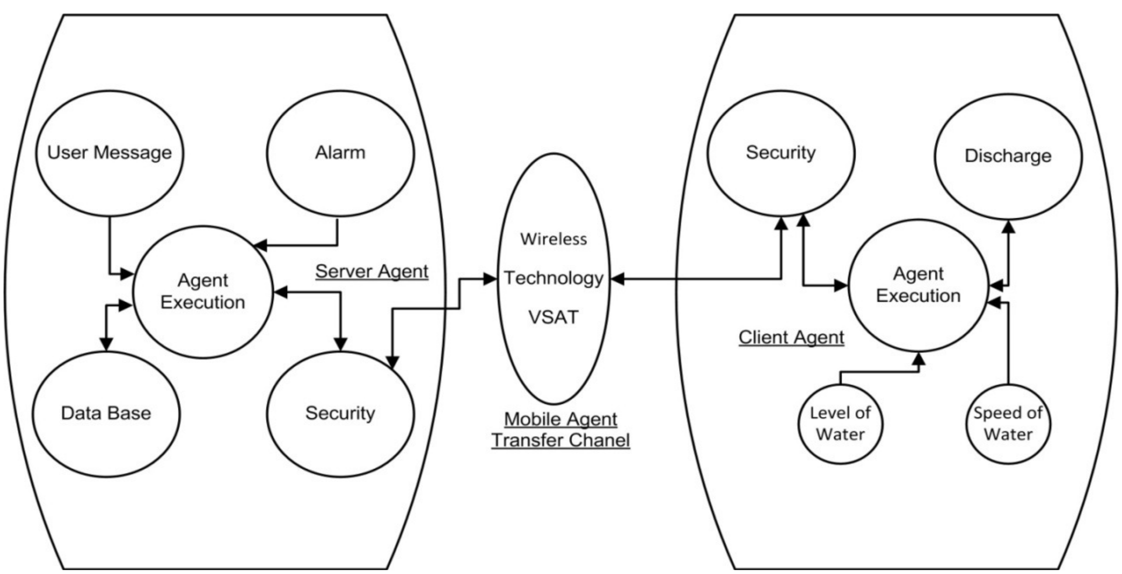

Figure-2
Components of Conceptual Model

Components

Server agents: Agent Execution: This component is responsible for the mobile agent creation, mobility and communication with client agent.

Security: The security component is used for securing the system and protecting it from unnecessary intrusion in both sides of client and server.

Agent execution at client: As the MA resides on the client machine, it starts execution and generates the results. For this purpose it takes help from following components: i. Speed of water: This is a sensor responsible for continuously reading the speed of water and updating the database. ii. Level of water: This sensor reads the level of water and updates the database continuously. iii. Discharge: Client agent uses speed of water passing through the cross-section area to calculate the discharge of water.

Agent execution at server: i. User Messages: This component is an interface for communicating with user. This informs about an inundation area in critical situation. ii. DB: DB contains the records of historical events occurred and its effects. DB support in taking decisions as well for calculating inundation area. iii. Alarm : If discharge reaches to a critical stage, then server agent sends signal to alarm device for prediction of flood for people living along the river bank for safety evacuation.

Algorithm of the Conceptual Model

This algorithm describes the mobile communication between the server and client agent. It initiated at server LOC= "SERVER", which creates a mobile agent at server. The mobile agent is then move toward the client agent using connection established() function. At client agent, it executes the mobile agent; calculate speed of water by Current meter and level of water using a linear array LW which store sublevels of water calculated with Bubble Tube[21]. Further, an area of a cross-section is calculated by using the data stored in array LW by Simpson's 1/3rd rule. Moreover, the client uses speed and area of the cross-section to calculate the discharge of water through the area. Finally, the client dispatches the mobile agent contains the discharge towards the server. It executes at the server, calculates the inundation area based on the current discharge and the historical values of the previous floods. It also issues warning to the area about the time and intensity of the upcoming flood to the community. The algorithm is divided in three parts: Server module, client module and the area of the cross-section as follows.

Server Module:

```
1  Initialize: set LOC= "SERVER"
2  bolean connectionestablished();
   //attach client 1 information
3  if(connectionisestablished()) Then
   // client 1  information passes as parameter
        LOC="CLIENT1"
        go ("newmethod");
   else
                    //connectionerror
   End of if Structure.
Initialize Serverbasecal()
4. If(Discharge > D1  && Discharge < D2)  Then
                    FloodType = "Medium"
4.1  Connectiondb();//Database connection to Server
4.2  Readdb();// Read history of flood at this point from Database

4.3  ALERT  //Server calculate the inundation area and alert the Management for taking  appropriate actions to secure people of critical region.
        Else
5.  If(Discharge > D2  && Discharge < D3)  Then
                    FloodType = "High"
5.1  Connectiondb();//Database connection to Server
5.2  Readdb();// Read history of flood at this point from Database
5.3  ALERT  //Server calculate the inundation area and alert the Management for taking appropriate actions to secure people of critical region.
   Else
6. If(Discharge > D3 )  Then
                    FloodType = "Very High"
6.1  Connectiondb();//Database connection to Server
6.2  Readdb();// Read history of flood at this point from Database
6.3  ALERT  //Server calculate the inundation area and alert the Management for  taking appropriate actions to secure people of critical region.
7. Else
        FloodType =  " Normal "
7.1  Connectiondb();//database Connection to Server
7.2  Readdb();//Read history of flood at this point from Database
   // take no actions on Normal flowing.
End of If Structure
Exit
```

Client Module:

```
1   Initialize  newmethod()

1.1 o→read speed of water through sensor (FW) using Current Meter
1.2 Repeat for k=1 to MAX(No. of width parts)
1.3 o→read level of water through sensor using Bubble Tube and stored in array LW[k]
        [End of Loop.]
1.4 AREA =  AREACAL(); // Call the sub module of Simpson's 1/3 formula
1.5  Discharge = AREA * Speed
```

1.6 if(connectionestablished()) Then // back to SERVER
1.6.1 //Send Discharge of flood to SERVER
1.6.3 LOC = "SERVER"
1.6.4 go("Serverbasecal()");
End of if Structure

Area of the Cross-Section:

Initialize AREACAL();
1, AREA = LW[0] + LW[N]
2. [Initialize counter.] Set k= 0
3. Repeat for k=1 to n-1
4. If k mod 2 = 0
AREA = AREA + 2* LW[K]
Else
AREA = AREA + 4* LW[K]
End of If structure
[End of Step 3 loop]
6. AREA = h/3 * AREA
7. End

Area of River Using Simpson's 1/3 Formula

Different methods are used to read depth of water which varies with the passage of time due to their natural shapes or sedimentation. This difference causes error in calculation of the area through which the water passes. Consequently, it creates an error in the discharge and hence wrong prediction of inundation area. In this work to calculate the area we divide the cross-section area into n- subintervals with n+1 digital bubble tubes as shown in the figure 5.2. The bottom curve of the cross-section generated by the lower ends of digital bubble tubes for any three points is almost parabolic shape. As Simpson's 1/3rd has parabolic approach, it is best suited to calculate the area as follows.

$$\text{Area(Cross-Section)} \approx \frac{h}{3}\left[LW(0) + 2\sum_{i=1}^{\frac{n}{2}-1} LW(2i) + 4\sum_{i=1}^{\frac{n}{2}} LW(2i-1) + LW(n) \right]$$

Where $LW(0)$ to $LW(n)$ are---------.

Since the parabolic curve makes 2nd degree function, hence its 3rd and higher derivatives are zero i.e., $LW^{(4)}(\xi) = 0$ where ξ is some number between 0 and n. Hence, the error in calculating the area by Simpson's 1/3rd is given by the equation is zero.

$$Error = \frac{1}{90}\left(\frac{b-a}{2}\right)^5 \left| LW^{(4)}(\xi) \right| = 0$$

Where ξ is some number between 0 and n.

To calculate the area of the cross-section through which the water passes are shown in the last part of the given algorithm

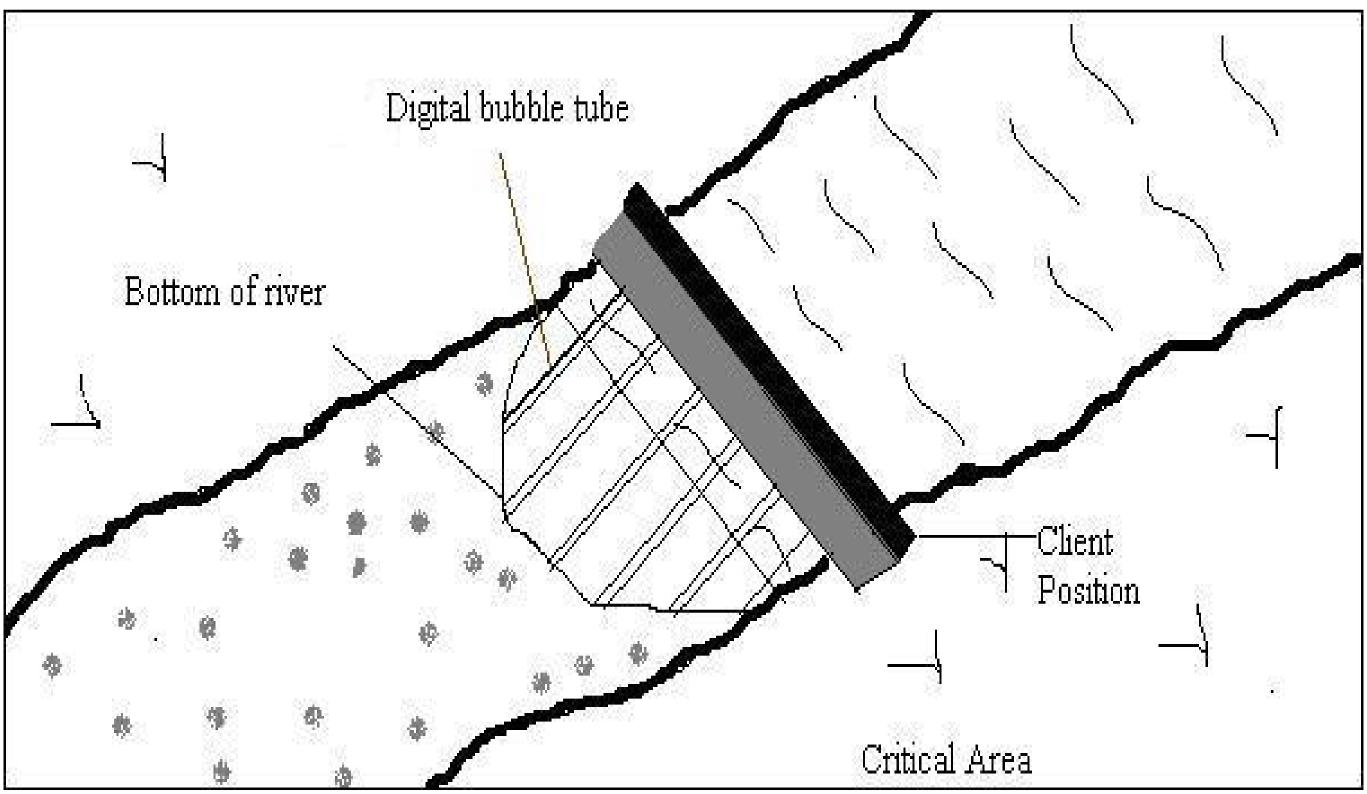

Figure-5.2
Calculating Area using Simpson's 1/3

Conclusion

Flood is a natural hazard and threat for the inhabitant in inundation area. Only prediction can support to rescue the people living in critical region. To overcome the flaws, found in existing technology, we proposed a model using mobile agent technology via VSAT (very Small Aperture Technology). The system is divided in two parts server and client agent. The client agent calculates the discharge of flood based on water passing through the cross-section area and its velocity. The cross-section area is calculated uses Simpson 1/3rd due the parabolic shape of water base to achieve the best results. The server agent takes the decision of inundation area based on the discharge of water and historical data. For this a mobile agent based algorithm is developed which can provide communication of server and client agent. The generic parameter D1, D2 and D3 are used in the algorithm for the nonspecific discharge through different locations. In future, we plan to use formal modeling with mathematical approaches, use in many applications[22-27] to develop a specified and verified system.

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