DATA EXCHANGE PLATFORM FOR BRIDGE DISASTER PREVENTION USING INTELLIGENT AGENT

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Abstract:

Due to the location and environment of Taiwan, the frequency of nature disaster is high and the caused damages to the human life, properties and transportation facilities are serious. Considering the disaster prevention of bridge structures caused by earthquake, scour, debris flow, corrosion and senescence, literatures involving the developed bridge management information systems and the bridge disaster prevention, alert and prediction systems are collected. This research establishes the bridge disaster emergency procedure for various disasters. Bridge management unit can follow the disaster prevention / action process to reduce the loss caused by nature disasters.

To exchange data between different systems, this research establishes a data exchange platform. The software agent including data retrieval, selection, identification and store is developed to automatically exchange data to / from TBMS (Taiwan Bridge Management System), TELES (Taiwan Earthquake Loss Estimation System), Central Weather Bureau, Water Resources Agency, the Soil and Water Conservation Bureau Council of Agriculture. When disasters occur, the system will be activated and used to collect different information from various resources by agent software to identify the damage conditions of bridges. Also, the appropriate actions provided by the system can assist bridge managers for decision-making.

Keywords: Disaster prevention, Data exchange platform, Agent

1. INTRODUCTION

Taiwan is located within the seismic zone, with frequent earthquake disaster, which mostly mountain and river. In building road system, bridges are often needed to cross nature barriers. In order to link distant area, bridges play a crucial role of maintaining industry and commerce develop. Bridges become the key of supply living consumables and import or export products in sparsely populated region [1]. As bridges are the important conduit of transportation and civil activities, a disaster would cause damage, inevitably cause great impact on post-disaster communication, urgent aid and material transportation, and seriously influence action process [2].

Now government endeavor to get electronic government moving, lots of disaster monitor systems have been established to publicize data in WWW (World Wide Web), though they are primarily displayed in web pages. In order to use these data to exchange with current disaster analysis system, manual manner is usually taken to manual copy web pages, costing time and labor, and being short of timeliness. Probably the alert information of bridge damage cannot be disseminated to various bridge administration agencies or road passers in time, so that the disaster is magnified, and the disaster information of various regions of Taiwan cannot be integrated, delaying authority's decision-making.

Therefore in this research, data exchange platform was developed, where data exchange among sub-systems was automatically made by intelligent agent, including basic bridge data of TBMS (Taiwan Bridge Management System) and earthquake potential analysis result of TELES (Taiwan Earthquake Loss Estimation System); disaster data exchange includes earthquake reports of the Central Weather Bureau, river level monitoring by the Water Resources Agency, red warning zone of debris flow by the Soil and Water Conservation Bureau.

After preliminary analysis of disaster data collected, the system will auto determine the alert level of all bridges, activate reporting system to inform all administration agencies to implement traffic control of risky bridges by means of various communication transfer modes, so as to prevent passers from using the dangerous bridges, and minimize disaster spread.

2. RESEARCH OBJECTIVE

Based on the above discussion, this research determines the following research objective:

1. To determine classification of bridge disaster:

Determine various causes of bridge disaster; fully analyze the root causes of bridge damage: earthquake, typhoon/flood erosion, debris flow or corrosion and senescence, and summarize and sort out the release sources of various disaster data and TELES/TBMS system running modes.

2. To establish bridge disaster emergency procedure:

According to the Disaster Prevention and Rescue Committee of Management Ministry divides the earthquake disaster prevention and rescue measures into three stages such as disaster prevention, disaster contingency emergency and disaster restoration and rehabilitation. Data exchange platform was designed on the main framework of emergency procedure. Emergency procedure primarily

includes pre-disaster prevention and in-disaster emergency stages, disaster data, investigation and evaluation form, potential analysis software and emergency measure constitutes the whole emergency procedure. If classified according to disaster type, there are four kinds of disaster emergency procedures, namely, earthquake, typhoon/flood erosion, debris flow and corrosion/senescence.

3. To build the intelligent agent server:

Usually disaster data are not updated periodically, and are even diversified and scattered. A manual control of disaster data update should have low efficiency and be labor-consuming. In order to determine and collect disaster data more efficiently, this research will build up the server of disaster data update software agent. Upon natural disaster information release, the program will download it from internet, and auto set up the new disaster data according to database rows. With respect to bridge basic data, TBMS database has already included all bridge data in Taiwan, in order to avoid redundant input operation and repeated database creation, the intelligence agent shall be designated by user, who collects basic data of specific bridge for subsequent analysis.

4. To build data exchange platform:

In process of disaster, data exchange platform will automatically collect all disaster data for analysis, show precedence of urgent bridge investigation and bridges to be alerted. This platform is based on intelligent agent program, integrates all sub-system data, and output reliable bridge data.

3. Determine Bridge Disaster Classification

Bridge damage or malfunction was due to multiple causes, in which natural disaster and aged corrosion are the major causes. In natural disaster, the earthquake, typhoon, flood, erosion, debris flow often lead to severe bridge damage, aged corrosion was bridge damage accumulated through long service.

Due to the location and environment of Taiwan, the frequency of nature disaster is high, government agencies will release disaster prediction information in web pages, though the information are scattered at various individual websites and not centralized. This research collects information source of great disaster a bridge would suffer, using data exchange technique to collect for bridge hazard prevention analysis, including data from the Central Weather Bureau (earthquake report), Water Resources Agency (river water level), the Soil and Water Conservation Bureau (debris flow alert zone), TBMS (inspection data of bridge corrosion and senescence), TELES (potential analysis of bridge earthquake hazard) and TBMS(basic bridge data), as detailed below:

1. The Central Weather Bureau, main content is earthquake report.
2. The Water Resources Agency, flood prevention and rescue support system, releasing water level of all monitored rivers.
3. The Soil and Water Conservation Bureau, emergency system, web services is available to get alert forecast information, the feedback is alert area of debris procedure potential rivers.
4. TBMS is the management system of maintenance and inspection records of every bridge administration agency, where U value is the crucial data to determine aged bridge corrosion.
5. TELES is the software about simulated earthquake potential analysis developed by National Center for Research on Earthquake Engineering, which can emulate pre-earthquake and post-earthquake status of bridge, obtain results of bridge damage extent, passage failure probability. It is operated by inputting earthquake data, outputting bridge damage info and passage failure probability, the intelligent agent will collect data in DBF format and update TELES data regularly.
6. TBMS is currently the bridge management system used by all bridge administration agencies nationwide, including Directorate General of Highways, Taiwan Area National Freeway Bureau, Taiwan Railway Administrator and all counties/cities governments. Most of basic bridge data required can be exchanged from TBMS by data exchange technique. So repeated construction is unnecessary, labor of data maintenance can be reduced, and data correctness can be secured.

4. Bridge Disaster Emergency Procedures

In this research, various emergency procedures were selected according to type of disaster, there are bridge earthquake disaster emergency procedure, bridge scouring disaster emergency procedure, bridge debris flow disaster emergency procedure and corrosion and senescence procedure. Aided by data exchange platform, the user can complete every procedure soon.

1. Bridge earthquake disaster emergency procedure:

In accordance with “Basic Plan of Disaster Prevention & Rescue”, this research established the bridge earthquake disaster emergency procedure. It mainly includes four stages such as “disaster prevention”, “disaster emergency response”, “emergency restoration” and “planned rehabilitation”.

In “disaster prevention” stage, the primary job is make pre-disaster (normal time) earthquake hazard potential analysis by TELES, the results are passage failure probability and various damage probabilities during earthquake, which can be the basis for bridge administration agencies to decide precedence of bridge repair.

In “disaster emergency response” stage, TELES is used to make earthquake trend analysis in earthquake, and obtain passage failure probability and various damage probabilities as well, which can be the basis for bridge administration agencies to decide precedence of post-earthquake bridge emergency safety investigation. According to TELES analysis result, each bridge administration agency shall immediately carry out bridge emergency safety investigation, firstly make “disaster info collection” of basic data such as lifeline utility safety in each disaster region, then make “emergency investigation” of rapidly commanding damage status of bridge structure in important sites, and finally implement “emergency

measures" of passage, restricted passage and forbidden passage.

In "emergency restoration" stage, the main job includes "emergency evaluation" which works out the preliminary repair principle and bridge safety level, and rapid and temporal "emergency restoration" remedy in order to prevent further disaster development or secondary disaster and avoid bridge damage or even collapse due to aftershock.

Main job of "planned rehabilitation" stage includes "detailed safety test" which acquires bridge status quo, earthquake cause, damage scope and all relevant test data needed for final planned rehabilitation, and "permanent rehabilitation" which dismantle and rebuild the damaged bridges or take remedy measure to enhance bridge earthquake resistance.

2. Bridge scouring disaster emergency procedure:

The bridge scouring disaster emergency procedure primarily consists of two stages, i.e., "disaster prevention" and "disaster emergency response". "Disaster prevention" stage uses flood resistance evaluation form to estimate flood resistance of bridges, the result can be the basis for bridge administration agencies to make bridge remedy plan; besides, water level of rivers and brooks is the important parameter to influence bridge safety, thus a continuous monitoring of water level is indispensable, the Water Resources Agency, Ministry of Economic Affairs has set up water level monitor stations in all important rivers and brooks nationwide, and releases water level monitoring data in website in time, this research will synchronize it for bridge safety monitoring use.

When bridge water level exceeds alert level, this indicates uncertainty of bridge usage safety, and this prompts "disaster emergency response stage", the involved bridge administration agencies shall dispatch engineering staff to site inspect the bridge water level status, according to current domestic bridge lockout criterion, if the distance between water level and bridge surface is below 1.5m, then the bridge has to be blocked for any passage.

3. Bridge debris flow disaster emergency procedure:

The Soil and Water Conservation Bureau marked totally 1420 potential debris flow rivers in the whole province, distributed in 19 counties/cities, 159 townships, 625 villages/neighborhoods, and constructed as GIS chart. When the coming of typhoon or storm, The Soil and Water Conservation Bureau relies on rainfall forecast by the Central Weather Bureau and accumulated rainfall values measured by each region, labels the rivers with debris flow probability from 1420 potential debris flow rivers, and releases "Red Alert List of Potential Debris Flow Rivers" in website of "Debris Flow Disaster Prevention Emergency System".

This research has acquired nationwide bridge location chart and potential debris flow river chart. Overlay these two charts can find out which bridge located within potential debris flow region. When the Soil and Water Conservation Bureau releases Red Alert List of Potential Debris Flow Rivers, this system can extract it into our database by means of data exchange platform, and immediately compare all bridges located in potential debris flow region, mark the bridges in red alert area of debris flow, send out the alert, so that bridge administration can instantly lock out the bridge or implement traffic control.

4. Corrosion and senescence procedure:

Corrosion and senescence normally hurts bridges over a long time, so it does not induce damage so drastic and severe as earthquake, typhoon/storm scouring and debris flow. It has to be solved by regular inspection and maintenance. Most of local bridge inspection and evaluation systems use D.E.R.U. structure deterioration evaluation method, the so-called D.E.R.U. grading method which is dividing bridge deterioration into three parts: severe Degree, Extension, and Relevancy of this deterioration or phenomenon with bridge structure safety and serviceability, and inspectors make disposition suggestions according to Urgency of deteriorated structure repair.

D.E.R.U. grading method classifies 1~4 levels, though in case of "no such item" or "unable to be measured" or "unable to be graded", 0 will be marked. If urgency of deteriorated structure repair (U) is 1, routine maintenance suffices; if U=2, then it can be maintained in 3 years; if U=3, it shall be maintained in 1; if U=4, urgent repair is needed.

In TBMS, the data module is built in D.E.R.U. mode, all bridge data are recorded in detail. Therefore this research will not repeat building inspection system, and will exchange data with TBMS by means of data exchange platform technique, pick up U values of bridges, or urgency evaluation if the bridge needs repair.

5. INTELLIGENT AGENT

5.1 Architecture of Agent

The intelligent agent technique has been used in various domains such as itinerary arrangement and information retrieval, its application can reduce work loading, user may assign a specific task to the agent or collaborate with the agent to reach a common target [5]. Design of software agent differs from conventional program design and Object-Oriented program design, it's a new type of program design [6]. Main features of agent are [7-9]:

1. Autonomy: after the work is assigned to the agent program, no labor need be introduced in its work flow, it can complete its work independently.
2. Social ability: agents can communicate and coordinate each other by means of unique manner. And the agent has interactive ability similar to natural human.
3. Pre-activeness: the agent adopts goal-directed manner in work, and adapts to external ambience influence on its goal.
4. Reactivity: the agent is able to respond properly after ambience changes.
5. Mobility: the agent is able to migrate between various computers along with its data, and work between various computers.
6. Temporal continuity: after job assignment, the agent is able to learn self processes or threads in order to complete the job.

7. Adaptability: the agent is able to learn from evaluation result, and hence adjust its status along with time and ambience changes.

Based on the above characteristics, the agent can be classified according to different behavior patterns. The agent is classified as below:

1. Static and mobile agents: from agent behavior ability, there are static and mobile agents. The static agent is fixed in one computer to execute its specific job, communicating with external world in traditional information exchange manner; while mobile agent migrates to other computers through internet to execute its job, and finally returns to the home computer, mainly used for internet information collection.
2. Interface agents: main function of interface agent is to lower interface complexity so as to increase its usability. It provides smart user interface, help user to solve operation problem in time.
3. Collaborative agents: this type of agent is able to collaborate with other agents, to finish its individual specified job, and then integrate the result.
4. information/internet agents: it helps the user to filter huge internet information, and provide only information useful to the user.
5. Learning agents: this type of agent has machine learning ability, it keeps learning external information so as to change work manner and improve work efficiency.

Based on literature review, the software agent shall have ability to help people to solve problems of different levels. Regarding the topic of "disaster information automatic update", the following important issues are to be solved:

1. The system does not know the source of disaster information.
2. The system cannot distinguish which information is useful disaster data.
3. The system cannot determine the update date of disaster information.
4. The system cannot automatically converse the disaster information into database in items.

Thus, the research determines functions of disaster information automatic update software agent as follows:

1. The agent is able to accept user assignment to search a goal.
2. The agent is able to find the required content from target website (disaster information, bridge information).
3. The agent is able to decide it the website content has been saved in database.
4. The agent is able to automatically download latest disaster information from database column and build the history database, and save both new and old disaster information, provide history record query service.
5. After the agent is assigned, no labor is needed to finish the job in time.

5.2 Develop software agent

In order to attain the above five requirements, this research developed "Disaster Data Automatic Update Software Agent System" which includes four types of agents:

1. Data collection agent: it collects website content of user designated target websites.
2. Data filter agent: it automatically filter contents collected by data collection agent, and leave the required content.
3. Data version determination agent: it verifies if the version of collected data differs from that of database data.
4. Database construction agent: it builds the databases in items from latest disaster data according to database columns.

Besides, the agent system allows the user to input assigned target and work frequency, so that the agent can collect data from assigned target in designated frequency.

The agents built in this research have three attributes: 1.autonomy, 2.reactivity, 3.temporal continuity. And relationships between agents are shown in Table 1 detailed below.

Table1 Summary of agent attributes

Agent	Attribute complied
Data collection agent	autonomy, temporal continuity
Data filter agent	autonomy, reactivity, temporal continuity
Data version determination agent	autonomy, reactivity, temporal continuity
Database construction agent	autonomy, temporal continuity

1. Data collection agent:

After starting the agent program, the data collection agent will automatically collect data from user designated target websites, which complies with autonomy; it has independent thread, able to repeat working, which complies with temporal continuity.

2. Data filter agent:

The data filter agent will automatically receive data collected by data collection agent, which complies with autonomy; it is able to filter diversified data amid various source codes, which complies with reactivity; it has independent thread, able to repeat working, which complies with temporal continuity.

3. Data version determination agent:

The data version determination agent can automatically determine if the disaster data is of the latest version, which complies with autonomy; after determination, it can deliver proper response to the database construction agent as reference of building a database, which complies with reactivity; it has independent thread to repeat working, which complies with temporal continuity.

4. Database construction agent:

The database construction agent can automatically receive data delivered by data version determination agent so as to decide to update database or not, which complies with autonomy; it has independent thread to repeat working, which complies with temporal continuity.

Agents built by the research conform to three agent attributes, which overlap to generate the software agent program. In future, it can advance toward meeting other agent attributes so as to enrich the program function. The

flow chart of disaster data automatic update software agent is shown in the figure below; next we will describe the flow steps.

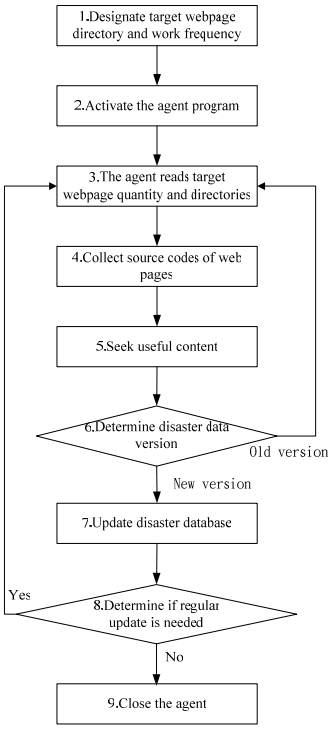

Fig1. Flow chart of software agent working

Step 1: Designate target webpage directory and work frequency: the user start up the agent, and may first appoint target webpage directory and work frequency, the designated data will be saved in database.

Step 2: Activate the agent program: the user manually activates the agent program. The manual disturbance of agent behavior shall end here (except closing the agent program).

Step 3: The agent reads target webpage quantity and directories: after activated, the agent will automatically read user designated webpage directories and quantity, as the basis of data collection.

Step 4: Collect source codes of web pages: the agent program collects webpage source codes according to target webpage directories. Data collected here include webpage marks and scripts.

Step 5: Seek useful content: in this step, the agent will analyze and determine which are disaster data content amid source codes, and discard non-disaster data.

Step 6: Determine disaster data version: in this step, the agent compares the collected disaster data with current disaster content in database, and verifies if the collected disaster data are of the latest version. If yes, then the database will be updated; if not, it will repeat working according to user designated time.

Step 7: Update disaster database: after the agent verifies the collected disaster data is in the latest version, it will list the latest version disaster data in database according to disaster database column design.

Step 8: Determine if regular update is needed: once the database is established, the system will repeat the job in user defined frequency. And the formal version database will be saved as history for queries.

Step 9: Close the agent: if the user does not wish to permanently run the agent program in computer, he can manually close it.

5.3 Definitions of agents

In order to attain expected performance of disaster data automatic update software agent system, the research establishes four types of agents: (1) data collection agent, (2) data filter agent, (3) data version determination agent, (4) database construction agent. Their definitions are shown in the figure below. Their jobs will be detailed as follows.

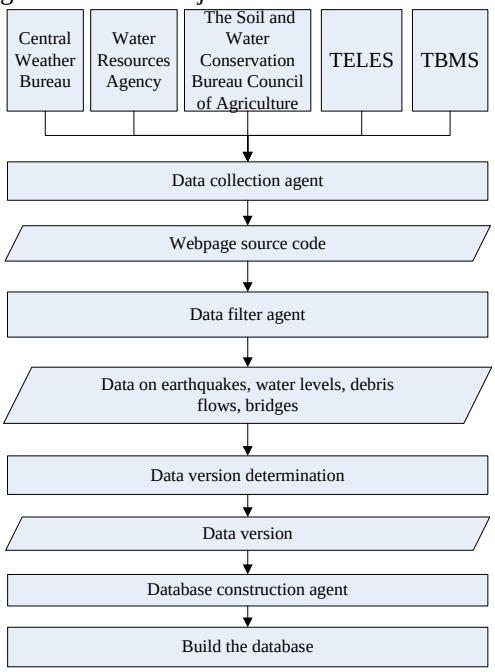

Fig2. Job definition of each agent

1. Data collection agent:

The data collection agent's job is to collect source codes of user designated website contents for future use.

Take " earthquake disaster information" of the Central Weather Bureau for example, the data collection agent will read amid target website database URL of "Special report of latest earthquake" in global info web of the Central Weather Bureau, and connect via the URL to the webpage to collect its source code. The resulted source code is as follows.

<Title>latest earthquake info </Title>……
<table columnspacing="2" border=0 columnpadding="7" class="NewsTable" summary="earthquake summary table, is a 5-cloumn designed form, the columns are latest info, ,time, scale, Ref. No., and location ">……
2006/05/0906:14 </td><td align="center" bgcolor=#3586FF class=seismicTable>
<a Href=Data/local/ECL0509061440.html>4.0 </td><td align="center" bgcolor=#3586FF class=seismicTable>
small area </td><td align="left" bgcolor=#3586FF class=seismicTable>

Hualien Earthquake Station northwest 18.5km
</td></tr>…….. </body></html>

2. Data filter agent:

The job of data filter agent is to filter the webpage source codes collected by data collection agent, leave the information related with disaster content, hence it can be regarded as an analyzer.

Take "special report of latest earthquakes" for example, the webpage source codes obtained by data collection agent are filtered by data collection agent, and resulted in the following data: (Special report of latest earthquakes, Time, Scale, Ref. No., Location, 2006/05/09, 06:14, 4.0, small area, Hualien Earthquake Station northwest 18.5km.)

3. Data version determination agent:

The job of data version determination agent is to compare disaster data version filtered by data filter agent with the original disaster data version, and determine if disaster database update is necessary.

4. Database construction agent:

After data version determination agent verifies the disaster data version, if update is necessary, the disaster data will be transferred to database construction agent to build the disaster database. The database construction agent will build the disaster database by steps according to database columns.

6. DATA EXCHANGE PLATFORM

The intelligent agents, coupled with data exchange platform and computer-aided decision support system for hazard prevention of bridges, can get various disaster information, and further analyze the bridge status and send it out by reporting system.

The system includes five parts such as user interface, data management, mode management, data exchange platform and reporting system. User interface is the user's operation interface, data management is the system database management function, data exchange platform is collecting data with the agent as the core, reporting system is automatic report release function, informing road user and road administration agencies by E-Mails, SMS (Short Messaging Service) or broadcasts. The system structure of this research is shown in the figure below.

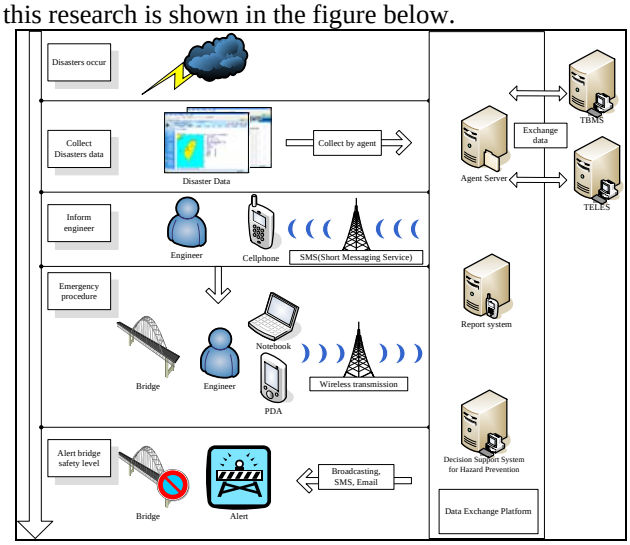

Fig3.System structure

7. CONCLUSIONS AND SUGGESTIONS

This research determined the data parameters needed by prevention system, and obtained them by exchanging via data exchange platform, so that data of various systems and agencies could be shared and integrated to meet the goal of bridge disaster prevention and pre-alert.

The internet data exchange platform technique was utilized to get disaster data of all agencies, such as earthquake information, river water levels, debris warning zones, which acted as the basis of hazard prevention system. All disaster data came from monitored data and analysis result of government agencies, with promptness and accuracy.

Establishment of all disaster emergency procedures assists bridge administrations and engineering staff in performing bridge safety investigation and evaluation following the procedures upon disaster occurrence, and deciding which emergency measure to choose on the basis of investigation and evaluation.

The TELE connection in this system can be used to retrieve earthquake data from the Central Weather Bureau when earthquake occurs, analyze the bridge passage failure probability and bridge damage degree probability and sort them, so that the bridge administration agency can carry out disaster emergency investigation according to the precedence, prioritize the bridge with biggest damage hazard, and reduce the probability of secondary disaster and casualties.

In future it is recommended to use XML (eXtensible Markup Language) format and web service as communication channel, so as to enhance data exchange speed and accuracy.

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