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A research on coupling prediction model for multi-disaster

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The research on disaster prediction and emergency system mainly concentrate on urban emergency management systems and single disaster prediction systems (Levya, 2007 Lu, 2002). But as an integrated system, the theoretical research on the disaster management system itself relatively lags behind and a unified senior management and operation platform need to be developed, on which every department can cooperate and coordinate effectively. Recent years, some research has focused on risk analysis for interdependent infrastructure systems (Guikema, 2009) and risks of multiple natural hazards on these systems (Gu, 2008). Based on the results of previous researches, this paper proposed a framework for multi-disaster coupling prediction model through the introduction of the disaster chain theory.

Disaster-chain refers to a compound system with an array of disaster elements, in which there are a series of consequent interactions among the elements and subsystems. Due to the intensity of the interactions, the system has the characteristic of entirety(Liu, 2006). The progression of many natural disasters will inevitably lead to a series of secondary and derived disasters, which constitute a natural disaster chain. Earthquake disaster-chain, typhoon disaster-chain, cold wave disaster-chain, storm disaster-chain, drought disaster-chain etc.(Gao, 2007), are the most common ones.

Hazard and hazard-affected body are essential elements of the natural disaster prediction models. One hazard will lead to one or more hazard-affected bodies associated with the human society damage. The process is the formation of a natural disaster, and number of interrelated, interacting disasters make up a disaster chain. A single disaster is the basic aspect of a disaster-chain. There is only one hazard and one or more hazard-affected bodies in the process of a single natural disaster. Hazard occurs→the hazard of time, space, strong features of forecasting→a corresponding loss of hazard-affected bodies constitute a single disaster prediction model. And Hazard→ the change of existential state (hazard-affected body damage) the cycle of hazard constitutes a hazard chain process model.

The hazard chain controls the sequence of the disaster chain in the coupling prediction model. In order to simplify the model, the concept of hazard-affected body was extended to such an extent that all the energy transmission media in the process of hazard chain could be defined as this, and dummy hazard-affected body as a new type was added to it. The media which were not well-defined currently were classified as dummy hazard-affected bodies in this model. In this way, the change of intermediate state in the chain can be reflected by the damage of hazard-affected bodies. The coupling prediction process based on disaster chain can be decomposed into multiple single disaster prediction sub-models. The hazard-affected body platform will record the change of the hazard-affected bodies' properties subject to a specific hazard, and the properties will be used in the next single disaster prediction. Finally, the loss of the disasters will be evaluated through the hazard-affected body management platform with the user's assessment model.

The main obstacle for constructing the disaster prediction model lies in the complexity of the chain effect of natural disaster. By the construction of the event chain based on the event trigger mechanism, the self–organization of sub-models has been realized. There are three elements in the event chain: firstly, the initiation of the event; secondly, the occurrence of the event; thirdly, the follow-up events. The event-trigger mechanism means that all the hazards, damage of hazard-affected bodies can be boiled down to incidents, which can be triggered interactively or by corresponding conditions.

Multi-agent technology can be used in designing the elements and event handling mechanism can be used in realization of event trigger mechanism defined in this model. According to the different roles they play in this model, the main intelligent agents in the model can be divided into five types: interface agent, hazard agent, hazard-affected bodies agent, decision support agent and warning assessment agent. Event trigger mechanism can be realized by the event handling mechanism in many Integrated Development Environments(IDE). In order to study the feasibility and effectiveness of the multi-disasters coupling prediction model, this author develops a MDCPS, a prototype system on the basis of the multi-disasters coupling model with C# language in a Visual Studio. NET environment, and uses it as a test platform for research.

Compared with traditional methods of disaster analysis, the multi-disaster coupling prediction model based on natural disaster chain have four advantages: First, based on the disaster-chain theory, the model analyses the genesis and influencing process of the primary and secondary disasters comprehensively. Second, the model introduces module design idea and event-chain method, and effectively solve the complexity of the theoretical analysis of the disaster chain through the single disaster model as the encapsulation and adapter design of the event, making the integrating of every disaster system become possible. Third, the setting-up of the model has offered a unified top management & dispatching platform for natural disaster administration. Fourth, the introduction of the event trigger mechanism make it possible for the coupling among every single disaster in the disaster chain.

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