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Emergency Decision Engineering Model Based on Sequential Games

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Abstract: When emergency breaks out, the problem how to make timely and efficiently the emergency decision is focus issue in emergency management. So an engineering model is established by using dynamic games firstly. Then the process of sequential games between decision maker and emergency is analyzed in detail. The information about emergency is got through finitely sequential games in order to bring forth the optimal relief plan and to provide support for the decision-making when an emergency occurs. Finally, the optimal relief plan that was generated by using the engineering model of sequential games is given by a specific example.

Keywords: emergency decision-making ; sequential games; relief plans

1. Introduction

Although there are few studies on applying game theory in emergency management at present, some research results have been achieved. The game scheduling model of rescue resources to multiple locations is proposed by Shetty, R, and Gupta, U. (2007) in order to discuss the programs of fair and reasonable scheduling resources, which is not consistent with the actual situation because the game model was based on complete information. As far as the scheduling of rescue resources from resource centers to crisis locations is concerned, multiple transportation modes such as air shipment, road shipment and water shipment and so on may be used synchronously to rapidly and efficiently deliver rescue resources to crisis location. A multi-model layer network for rescue resources scheduling is conceived by Yang, J.J, Wu, Q.D., and Cheng, Y. (2008). Yao, J., Ji, L., and Chi, H. (2005) also present the model of dynamic game model, which possesses obvious defect that the optimal scheme is determined on basis of minimum cost. After analyzing the relationship between decision-makers and emergency, an engineering model based on sequential games is established.

2. Analysis of emergency decision based on sequential game

2.1. Basic concept of sequential games

Sequential game is a game which one player chooses his action after the others have chosen theirs. Importantly, the later player must have some information about the first player. Extensive form representation is usually used in sequential games, because it can explicitly illustrate the sequential aspects of a game. One of the hypotheses in

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sequential games is sequential rationality (Kreps ,D, and Wilson R. 1982), which player's choice is the optimality of subsequent play.

Let (δ,μ) be a state of sequential game, where δ represents the set of strategies taken by all players, μ is the probability distribution that each player takes his own action under the given h of the information set.

2.2. Sequential decision-making process in emergency management

The problem of sequential game in emergency management has the following features: ①emergencies are a process of dynamic development and evolution; ② emergency information is imperfect, from obscure to clear, incomplete to complete; ③ with more and more information being obtained, the relief plan enacted under incomplete information should be adjusted at any time; ④ on basis of the states of emergency and stage results of disaster relief, the decision maker should modify his belief in order to lay down a new relief plan. The process of sequential games between decision makers and emergency is as shown in Fig 1.

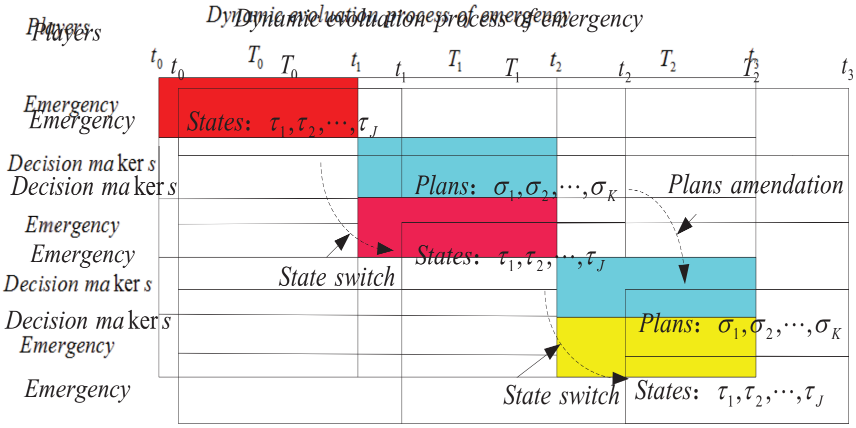

Fig 1. Process of sequential games under incomplete information

Where, $t=\{t_0,t_1,t_2,t_3\}$ is a set of time point that decision-maker adopts a new relief plan; $T=\{T_0,T_1,T_2\}$ denotes a set of stage that the relief plan should be implemented; τ_t refers to the emergency state at t; σ_t is a relief plan that should be used at t.

There exist only two players who are decision makers and emergency in sequential games. The process of sequential games under incomplete information is completely illustrated as follows:

(1) $t_0 \to t_1$ represents T_0. After emergency broke out, casualties and property loss were caused, which would be in their own state.

(2) $t_1 \to t_2$ denotes T_1. According to observing the state of emergency, decision makers are able to judge its probability (i.e. prior probability). Due to extreme lack of information about emergency, decision makers can amend the prior probability of emergency by using the historical data and expert's judgment. The prior probability amended is called the posterior probability. In accordance with the posterior probability and the expected payoff maximization principle, the optimal relief plan is selected.

(3) With the implementation of the relief plan in T_1, emergency would evolve from original state to a new state according to its own evolution.

(4) $t_2 \to t_3$ is T_2. At first, decision makers assess the relief plan adopted .Then decision makers begin to amend the belief of emergency state on basis of the new information collected and the expert's judgment. The posterior probability of emergency state is calculated by using Bayesian formula in order to select a new relief plan.