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A Model of Complexity Measurement for Emergency Decision Support System

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Abstract

Emergency decision-making is the core of emergency management, and directly determines success or failure of emergency disposal activities. This paper introduced the information entropy in the complexity theory. With the combination of qualitative and quantitative methods, the paper proposed a model of evaluation and decision-making for complexity measurement based on information entropy. The model can effectively choose the best decisions in decision-making programs that have been developed and evaluation system. And an example shows its value.

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1. Introduction

Emergency is a typical complex system because of its diversity, randomness, sudden, disorderly and other features. The complexity of emergency refers to the states which are difficult to understand, describe, predict and control, but from the perspective of information theory, it is the state of the system that is expected to take quantity of information. The greater of the degree of complexity, indicates the more uncertainty and unpredictability of the states of incident, and need obtain more information to understand it [1-3]. The complexity characteristics of emergency determine the complexity of decision-making. And the level of understanding the emergency and the program of decision-making will affect its handling and control effects. Generally, there are two ways that respond to decision-making complexity of emergency. One the hand, it is as possible as to minimize or eliminate complexity from the point of management. The strategy is to simplify emergencies in order to improve their manageability, such as the status of the incident process, reducing the amount of resources. On the other hand, trying to understand and measure the complexity from the perspective of theoretical methods. That is to say, according to qualitative and quantitative description and analysis of system complexity, the purpose of effective choice system behaviour will be to achieve. Measurement is the basis for management, and the measure of system complexity is the basis for the studying quantitatively complexity. Based on complexity measure, the specific analysis of the cause for system complexity can quantitatively evaluate different disposal options in order to optimize emergency decision-making [4-6].

The key of emergency decision-making is that how to develop and optimize decision-making program. And the key of program optimization is choice of rational target weight with a certain amount of subjective and arbitrary [7].

How to better determine the target weight and eliminate subjectivity and optimize decision-making from a number of alternatives is main research aim of this paper. With of complexity measurement based on method of complexity theory, the paper proposed a model of evaluation and decision-making for complexity measurement based on information entropy, which can be used to describe quantitatively the complexity of target of emergency decision-making and evaluation.

2. Complexity Measurement

In information theory, entropy reflects the degree of disorder and solves the problem of complexity measure as a measure of the scale of complex information. An indicator in the decision-making programs carry the more information that the index the greater the role of decision-making. The smaller the entropy value, the smaller the degree of disorder in system [2].

2.1. Definition of Information Entropy

Let discrete random variable X with n possible values (x_1, x_2, \dots, x_n) , and their probability are respectively (p_1, p_2, \dots, p_n) , then entropy of X is defined the following [8-10]:

$$E(X) = H(p_1, p_2, \dots, p_n) = -\sum_{i=1}^n [p_i \log p_i] \quad (1)$$

In the formula, $p_i \geq 0$, $\sum_{i=1}^n p_i = 1$. If X denotes a system, x_i and p_i respectively denote n possible states and its occurrence probability in the system, $E(X)$ is information entropy which is the amount of information required for describing the system X . $E(X)$ also describes the degree of uncertainty of the system X . The greater the entropy, the system is more uncertainly, the greater the complexity. Information entropy described equation (1) has the following features:

- ① When only one is 1 and the others are 0 in p_i , the information entropy of the system is minimal. Namely $E(X)=0$, X is a completely deterministic system.
- ② When the states of system are the same probability distribution ($p_i = 1/n$), the information entropy of the system is maximal and $E(X)=\log n$. Because of X is the most uncertainly, the system is in the most complex state.
- ③ The uncertainty, information entropy, and complexity of system will increase if p_i changes by equalization.

2.2. Definition of Information Entropy Weight

According to the concept and features, entropy combines the inherent information of programs to be selected in the multi-attribute decision-making evaluation with quantitative information of decision-makers' subjective experience, which can be more essential to measure the complexity of programs and can create a model of multi-attribute decision-making evaluation based on entropy weight.

It is supposed that there are n programs to be evaluated, and an index system consists of m evaluation indexes, which can indicate by assessment matrix $[Y] = (y_{ij})_{n \times m}$ that normalized is $[X] = (x_{ij})_{n \times m}$. Then the entropy of the j -th index can be defined as follow:

$$e_j = -k \sum_{i=1}^n [f_{ij} \ln f_{ij}] \quad (2)$$

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