The Strategic Analysis, Optimizing Control, Sick Treatment, Harmonious Simulation of Intelligent Transportation Decision Support System Based on Set Pair Analysis

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Abstract: - Intelligent Transportation System (ITS) is the combination of artificial intelligent and transportation. This article mainly discusses the applications of SPA in ITS in terms of management and decision-making. Taking advantage of Set Pair Analysis (SPA), Four-Variable Connection Number, Set Pair Control (SPC) and Set Pair Matching (SPM), and combining other subjects such as Cybernetics and Extenics Theory together, we propose a general architecture of Set Pair-Intelligent Transportation Decision Support System (SP-ITDSS), which solve the management problems of ITS like strategic analysis, optimizing control, sick treatment, optimizing dispatch and harmonious simulation etc. And the discussion of SP-ITDSS paves the way for the development of SP-ITDSS Software.

Key-Words: - Intelligent Transportation System (ITS), Set Pair Analysis (SPA), Four-Variable Connection Number, Set Pair Control (SPC), Set Pair Matching (SPM), Set Pair-Intelligent Transportation Decision Support System (SP-ITDSS)

1 Introduction

Intelligent transportation system (ITS) has been more and more confirmed to be vital for world transportation development. However, it is a large-scale and complex system, whose complicacy and uncertainty make traditional control and management method fail to do its justice. Fortunately, intelligent mathematics could successfully solve these problems. C.P. Pappis and E. H. Mamdani (1977), for example, applied Fuzzy sets in transportation control, and proposed a solution for mono-phase intersection traffic—Pappis method (C.P. Pappis et al, 1977). One problem of previous researches, however, was that the application of intelligent mathematics in ITS was limited to the application of Fuzzy set(Zadeh L A, 1965) and Vague set (Gau Wen-Lung, Daniel J.Buehrer, 1993), which unfairly neglected the application of Set Pair Analysis (SPA)(Zhao Keqin, 2000). Actually, SPA, which extend and develop of Fuzzy set and Vague Set, is more general and synthetic. Therefore, combining SPA with other disciplinary like Cybernetics and Extenics Theory, this paper will propose a general architecture of Intelligent Transportation Decision Support System based on SPA (SP-ITDSS) and its programming flow charts. This SP-ITDSS will provide solutions for strategic analysis, optimizing control, sick treatment, optimizing dispatch, harmonious simulation etc.

2 SPA, Multi-variable Connection Number and SPA's latest development

2.1 SPA

SPA [15] is an effective analysis tool to solve problem of uncertainty, whose main idea of this method is to describe the relation between two sets in three angles: identity, discrepancy and contrary (IDC). This method has extended the Fuzzy Set which discusses just one angle--identity and Vague Set which discusses two angles--identity and contrary, and has been applied to many fields like science, industry, agriculture etc.

2.2 Connection number (μ)

It is a mathematical description of IDC in a Set Pair (A, B), see as follows:

$\mu = a + bi + cj$, $a, b, c \in [0,1]$, $a + b + c = 1$, $i \in [-1,1]$, $j = -1$

a represents the identity, b represents the discrepancy, c represents the contrary.

2.3. SPV

Set weight ratio α, β, γ to a, b, c, we can ascertain a SPV(υ): $\upsilon = \alpha a + \beta bi + \gamma cj$

2.4. Multi-variable Connection Number

If we carry on a further discussion with regard to the value of i in bi, then Four-variable Connection Number or even Multi-variable Connection Number could be formed, which could discuss the problem of uncertainty from more than three dimensions[16].

2.5. SPA's latest development

On the basis of SPA, Set Pair Control (SPC) [12] and Set Pair Matching(SPM) [3] have been founded to satisfy different practical demand.

SPC is a theory applying SPA in the domain of Cybernetics, whose fundamental idea is Set Pair Reasoning (SPR). The general form of SPR is the statement: if x then a and b and c (a, b, c stand for IDC). After bargain and control, we could build a

$$R^{+} = \bigcup_{i=1}^{n} R_i$$

Controller of for optimizing control.

SPM is intelligent matching based on SPA, which mainly uses SPV, Kaufmann Measure [3] and relation matrix of relation chart in order to accomplish an optimal matching between n set pairs.

3. Extenics theory and Fault Elimination theory

Extenics theory and Fault Elimination Theory are effective tools to describe the changeability of thing and be used to deal with contradiction problem. Here we introduce five common-used methods.

3.1. Extenics theory and Matter-Element Transform

The Extenics theory [2] is consisted of two braches: matter-element analysis theory and extension set theory, which can describe the changeability of thing and be used to deal with contradiction problem.

The extensibility of matter-element provide several orientations to deal with incompatible problem, and matter-element transform [2] is the technology to achieve that goal, which includes four fundamental transforms—replacement, adding and deleting, expanding and confining, and dispensing.

3.2. Extenics3-4-4 method

It is an application of Extenics in originating and creating, which uses 3 orientations, 4 innovational transforms, 4 combinations to create a series of original solutions, and to choose feasible and optimal solutions [2].

3.3. Extensional forces and Transforming Bridge

Extensional forces including practical and virtual forces are mainly used to achieve a matter-element transform. Through adequate programming and planning, we can use extensional forces to achieve transforms like replacement, adding and deleting, expanding and confining, and dispensing in order to set up optimal strategy [1]. Transforming Bridge is a method to deal with contradictory problem, the main idea of which is setting up a 'bridge' to transform a contradictory problem into a coexist problem [7].

3.4. Fault Elimination 15-6-3 method

This method [6] uses 15 orientations to maintain 6 fundamental transforms and 3 combination methods, which could find the faults, identify the faults and eliminate the faults.

3.5. Dissatisfaction 7-4-3 Method

This method mainly uses 7 orientations to maintain 4 transforms and 3 combination methods to deal with condition of dissatisfaction [9],

4. The general architecture of SP-ITDSS

Combining SPA with Cybernetics and Extenics theory, we propose a general architecture of SP-ITDSS, dividing it into four subsystems: strategic analysis subsystem, optimizing control and sick treatment subsystem, harmonious simulation sub system and intelligent matching system, as in figure 1.

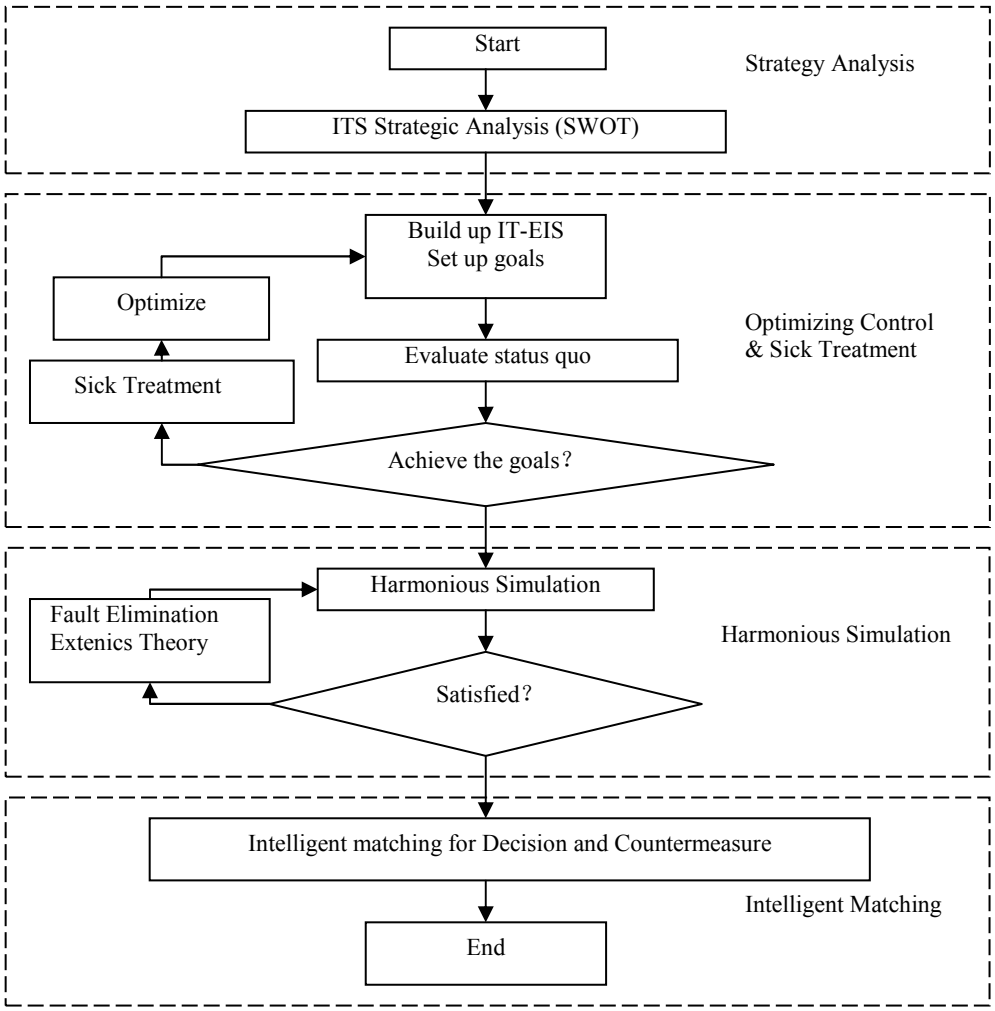

Fig.1. General architecture of SP-ITDSS

Firstly, strategic analysis subsystem makes strategic analysis in terms of ITS's strength, weakness, opportunity and threatens, and then points out a orientation for strategic optimizing; Secondly, according to the results of strategic analysis, experience of experts and practical situation, the optimizing control and sick treatment subsystem will build up evaluation index system(IT-EIS) , set up goals for certain problem in ITS, and apply measures of sick treatment and optimizing control in case that status quo does not match the goals; Thirdly, harmonious simulation system tests the optimizing results, and applies Fault Elimination and Extenics theory to optimize simulation courses; According to the results of simulation, intelligent matching subsystem seeks optimal matching of decision and countermeasure for ITS.

5. Strategy Analysis Subsystem

This subsystem uses SWOT analysis, and provides decision support for ITS strategy programming. A four-variable connection number was introduced in order to make a quantitative analysis of SWOT as follows:

$\mu = a + bi + cj + dk$

$a, b, c, d \in [0,1]$; i $\in$ [0,1] ; j $\in$ [-1,0] ; k $\equiv$ -1 ; $a + b + c + d = 1$

a stands for identity, b stands for difference of positive perspective

c stands for difference of positive perspective, d stands for contradictory

The implementation procedures are as follows:

(1) Referring to index system and relevant standards [11], we build up evaluation index system of strategy analysis $X = \{X_1, X_2, ...X_n\}$;

(2) In accordance with S, W, O, T, we set up a SPA between status quo set and goal set.

(3)According to the different cognitions from several experts, we uses WAS[12] system to allocate

different weights-- $\alpha, \beta, \gamma, \delta$ for S,W, O,T, and these weights should meet a equation;

$\alpha + \beta + \gamma + \delta = 1$

(4). Ascertain the SPV:

$A = \alpha a \rightarrow S$ S

$B = \beta b \rightarrow O$ O

$C = \gamma c \rightarrow T$ T

$D = \delta d \rightarrow W$ W

$M = A + Bi + Cj + Dk$

(5) Using WAS system or Genetic Algorithm，we calculate the value of i, j , then get a quantitative result of SWOT analysis.

(6) Using relevant methods in Extenics and Fault Elimination theory, we could optimize the analysis results and propose adequate strategic programming. The detailed programming flow chart is in [8].

6. Optimizing control and sick treatment subsystem

This subsystem mainly uses SPA and SPC to treat the sick transportation system and propose a optimize model. The implementation procedures are as follows:

(1)according to the results of strategy analysis, experts set up a development goal, put foreword index system and index's weight, and finally establish goal set A .

(2)Analyze status quo, and establish a status quo set B ,.Carry on SPR to deduce status quo set's possible develop trend, and obtain a trend set B^+ .

(3)Take $SPA(A, B^+)$, use WAS to ascertain α, β, γ , and then calculate the value of SPV-- $V \in [0,1]$.

(4)Using WAS, determine the healthy and dead transportation 's membership λ_1, λ_2 , $\lambda_1 > \lambda_2$ $\lambda_1, \lambda_2 \in [0,1]$, as in Figure 2:

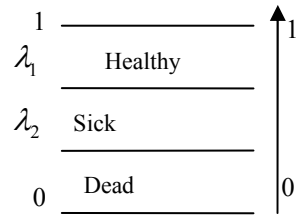

Fig.2: Transportation's health membership

(5) If $V > \lambda_1$, then it is a healthy transportation, and if $\lambda_1 < V < \lambda_2$, then it is a sick transportation which need a sick treatment

(6)Use Fault Elimination 15-6-3 method, Extenics3-4-4 method, Extensional forces and Transforming Bridge to make sick treatment and optimizing control, and establish a controller $R^+ = \bigcup_{i=1}^{n} R_i$ until $V > \lambda_1$. The detailed programming flow chart is in figure 3

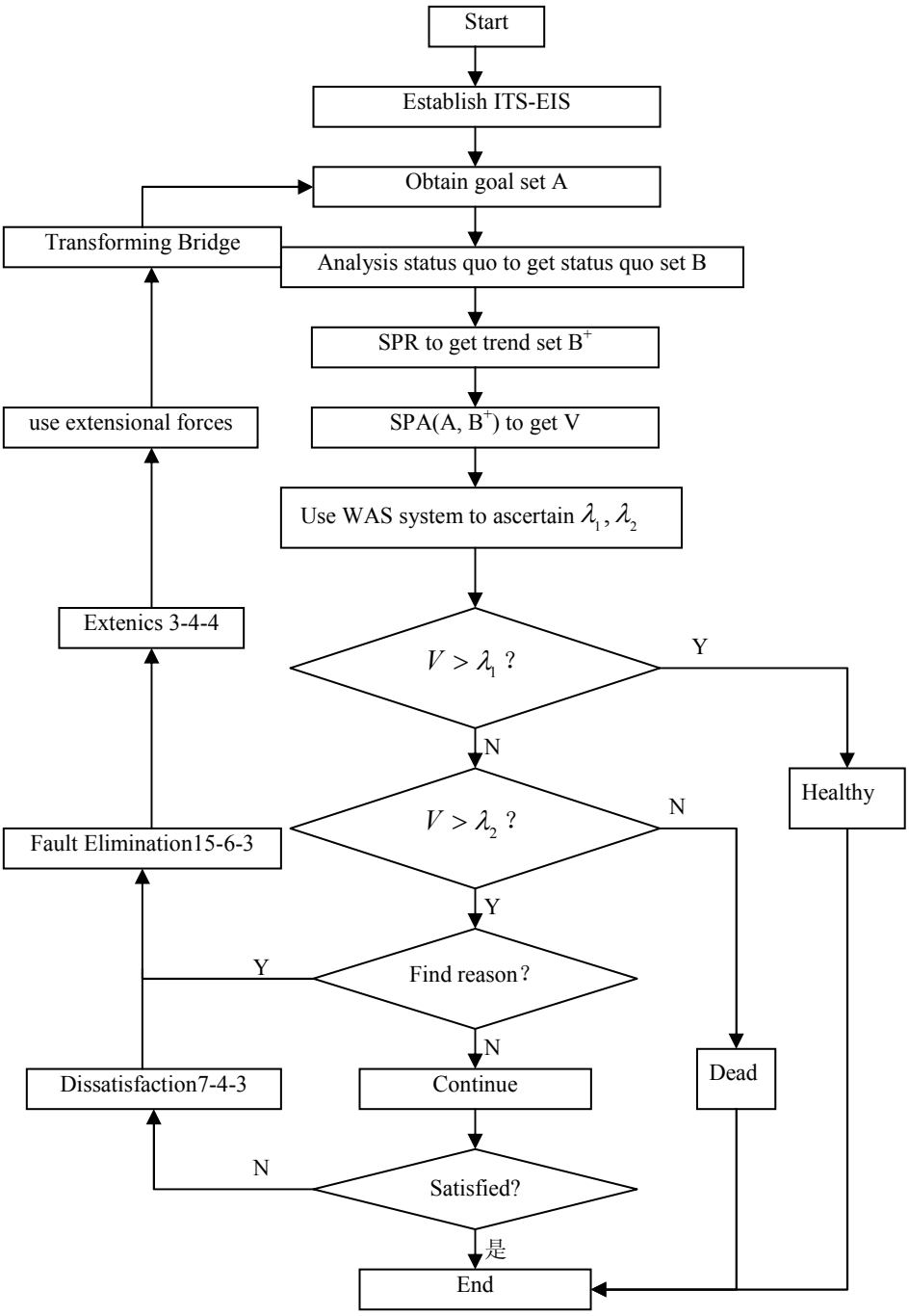

Fig.3: Sick treatment and optimizing Control

7. Harmonious Simulation subsystem

This subsystem is mainly used as a tester of optimizing solutions and results, which regards the transportations system as a man-machine-environment system, and divides ITS into three parts: man—drivers, machine—vehicles and environment—roads. Employing the method of SPM and technology of simulation, this system seeks to achieve a compatibility and optimism of those three parts, so that obtain a final optimum solution of certain transportation problem.

Referring to [5], this system firstly establishes a multi-Agent system which includes man agent, machine agent and environment agent, and then makes use of SPM so as to accomplish a harmonious matching among different agents. Since ITS is a large-scale and sophisticated system, every agent is also complex and has several of interaction rules. It is possible that the result of simulation could not be satisfactory. Given that situation, we could employ theories of Extenics and fault elimination, and use matter-element transform, transforming bridge,

extensional forces to establish a general model for every agent and then achieve a better result.

8. Intelligent matching subsystem

This system uses the final results of harmonious simulation system, and employs the method of SPM. Utilizing SPA to evaluate the matching condition among man, machine and environment, then apply Kaufmann method, relation matrix and relation chart to figure out the best matching among them, and finally provide reasonable decisions and countermeasures for the problems in transportation system [3].

9. Conclusions

This paper offers an application of SPA in ITS in terms of management and decision-making, proposes a general architecture of SP-ITDSS and discusses its function in solving the management problems of ITS like strategic analysis, optimizing control, sick treatment, intelligent matching between the vehicle optimizing operation dispatching and the drivers, the vehicles and the roads, harmonious simulation etc. The advantages of SP-ITDSS could be summarized as: (1) It is a powerful tool to transform uncertainty in ITS into certainty; (2) it offers several methods to extend the complex problem into simple and general problem. However, it is in need of more concrete and practical implementation methods like develop SP-ITDSS software so as to test and perfect its functions.

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