Paper

A Method of Solving Problems by a Decision Support Agent System

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When we wanted to solve a problem, up to now we have chosen a suitable method for solving problems, and the problem has been solved, using the specified method. The purpose of this paper is to show a decision support agent system composed of an interface agent, a manage agent and thirteen problem solving agents. The interface agent has functions of an exchange of information about a problem to be solved to a user interface and self-study. The manage agent has functions of understanding the feature of the problem and assigning a suitable problem solving agent for a task. The problem solving agents have functions of solving problems, self-improvement and self-evaluation.

1. Introduction

Eight methods of linear programming, object planning, analytical hierarchy process, contribution function, interpretive structural modeling, decision making trial and evaluation laboratory, Markov chain and non-totaling action have been known as the methods for solving problems. When we wanted to solve a problem, so far we have selected a suitable method among them for solving problems in decision making [Kinoshita, 1992]. For example, a problem in a general planned business was decided, using the linear programming method.

In this paper, a decision support agent system composed of an interface agent, a manage agent and problem solving agents is proposed. The functions of these agents are shown in the next section. The problem solving agents involve those using the methods in statistics such as multiple regression analysis, principal component analysis, discriminating analysis, quantification method I, quantification method II agents [Bolch, 1974], [Hawkins, 1982], [Hayashi, 1950], [Takeuchi, 1982], [Tanaka, 1979], in addition to those using the methods such as linear programming, object planning, analytical hierarchy process, contribution function, interpretive structural modeling, decision making trial and evaluation laboratory, Markov chain and non-totaling action. The problem solving agents are explained for the feature and applicable examples in order to make what kinds of problems are solved clear in the next section.

2. The Structure of the Problem Solving Agent System

Figure 1 shows the structure of the problem solving agent system, composed of an interface agent, a manage agent and thirteen problem solving agents.

2.1 Interface Agent

The interface agent has functions of an exchange of information about a problem to be solved to a user interface and self-study. In some cases, the interface agent asks some questions to a user, and give the answers to a problem solving agent.

Structure

Ask questions and give the answers: The interface agent asks questions to a user, and give the answers to a problem solving agent.

Self-study: The interface agent studies several patterns during the exchange of information.

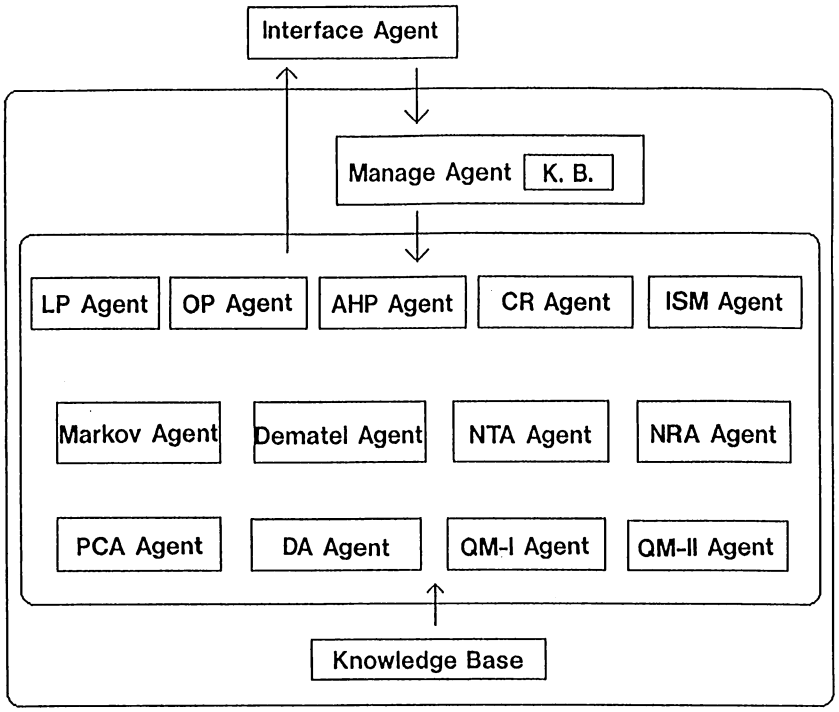

Fig.1 The structure of the problem solving agent system

2.2 Manage Agent

The manage agent has functions of understanding the feature of problems and assigning a suitable problem solving agent for a task. The manage agent also has a knowledge base to understand the feature of inputted problems.

Knowledge Construction

A manage agent has a knowledge base in order to judge thirteen kinds of problem patterns.

Structure

The structure of the manage agent consists of understanding the feature of problems and assigning a suitable problem solving agent for a task.

Understanding the feature of problems: The manage agent understands the feature of the inputted problems.

Judgment: The manage agent judges that an inputted problem belongs to one of those 13 problem patterns, comparing the inputted problem with those problems of the knowledge base.

Giving instruction: The manage agent assigns a suitable problem solving agent for a task.

2.3 Problem Solving Agents

Outline and applied examples are shown for the problem solving agents such as LP, OP, AHP, CR, ISM, Dematel, Markov and NTA. An analysis method, feature and applicable examples are shown for five problem solving agents such as MRA, PCA, DA, QM-I and QM-II, which are added for decision making.

(1) LP Agent (Linear Programming Agent)

Relative deviations of an object function are calculated from an ideal value which is obtained by solving linear programming equations. An optimum solution is obtained by solving linear equations of which coefficients are calculated relative deviations.

Example

A profit, production cost and production amount are decided under the given limitation of economics, production activity, resources and transportation.

(2) OP Agent

An object planning (OP) agent can obtain an optimum solution which is able to raise the level of the goal of the objects, by considering that several objects are attained as much as possible.

Example

A person spends for ten days in a resort, and plays tennis, mount climbing and fishing. The spending time, costs and the degree of satisfaction for each play are 3 hours, 20$, 2 for tennis, 5 hours, 40$, 5 for mount climbing, and 2 hours, 10$, 3 for fishing. The total leisure time is 60 hours, and the total cost is 500$. Does the person get the maximum degree of satisfaction when the person spends how many hours for each play?

(3) AHP Agent

An analytical hierarchy process (AHP) agent solves a problem by three steps.

Step 1: A complicated problem is decomposed into a stratified structure by a decision maker.

Step 2: A suitable weight is added for each component of the stratified levels.

Step 3: A suitable weight is added for the all stratified structure. Priority of each substitute is decided for a general object.

Example

The priority of four candidate is decided under the given components of action, one's background, actual results, personality, etc.

(4) CR Agent (Contribution Function Agent)

The general evaluation of a community / a society is performed in connection with the contribution function of each people in a contribution function method.

Example

In a piano competition, the first prize, the second prize and the third prize are decided in ten persons who got through the last preliminary, under marking on the basis of 10 points of each fifteen judge.

(5) ISM Agent (Interpretive Structural Modeling Agent)

A complicated problem is objectively decomposed into a stratified structure, using a mathematical model, in Step 1 of the AHP agent in an interpretive structural modeling method.

Example

A stratified structure related to the order of priority of the purchase of a house is decided, under the components of traffic convenience, shopping convenience, resident area, garden area, scene and environment.

(6) Dematel Agent

A Decision Making Trial and Evaluation Laboratory (Dematel) agent makes the structure of a problem clear, by collecting specialized knowledge by means of a questionnaire to experts..

Example

A problem of the crisis of the Earth / mankind is analyzed structurally in relation to the components of nuclear war, the destruction of an ozonosphere, lack of food, population, environmental pollution, limitation of natural resources, sickness and the increase of crimes.

(7) Markov Agent

A phenomenon at a stage is affected by the previous phenomenon, and is not affected by the past phenomenon in a Markov chain method. Such a structure is mathematically described.

Example

Let 0.6 the probability that crops in the next year in an area are rich when crops in a year are rich. Let 0.3 the probability that crops in the next year in the area are poor when crops in a year are poor. If the crops this year were rich, calculate the probability of a rich crop and a poor crop after t years in such a situation.

(8) NTA Agent (Non-Totaling Action Agent)

When a model of a personal action is made and a utility function is considered, personal selectivity of a method is calculated in a non-totaling action method.

Example

The general evaluation of image of a railway company is performed, under grading on the basis of 10 points of several components related to the image of the company.

(9) MRA Agent (Multiple Regression Analysis Agent)

Results are predicted / the cause is controlled, by using the data of an object variable and several explanation variables in a multiple regression analysis method.

A linear multiple regression model for the data of n is described as

$$y_i = A_0 + A_1X_{1i} + A_2X_{2i} + ... + A_qX_{qi} + \delta_i$$

$$(i = 1,2, ... ,n) \qquad (1)$$

where y_i are predicted values, X_{1i}, X_{2i}, ... , X_{qi} the values of explanation variables, A_0, A_1, ... , A_q the constants, δ_i the predicted errors, respectively. The constants of A_0, A_1, ... , A_q are calculated as minimizing the sum of square of the predicted errors

$$\sum_{i=1}^{n} \delta_i^2.$$

A result y is predicted by the following multiple regression equation.

$$y = A_{0'} + A_{1'}X_1 + A_{2'}X_2 + ... + A_{q'}X_p \qquad (2)$$

where partial regression coefficients $A_{0'}$, $A_{1'}$, ... , $A_{q'}$ are the constants calculated as minimizing

$$\sum_{i=1}^{n} \delta_i^2.$$

Feature

1. The multiple regression equation is decided as the combination of the explanation variable is selected optimally after the validation of each partial regression coefficients.

2. The MRA agent can evaluate whether the multiple regression equation is useful or not by the magnitude of the coefficient of determination.

Example

Annual sales in a supermarket are predicted from the data of annual sales, parking capacity of cars, floor spaces and advertisement of twenty supermarkets.

(10) PCA Agent (Principal Component Analysis Agent)

A few principal components (general barometer) are obtained as minimizing the loss of information about several kinds of variables in a principal component analysis method.

A composite variable z expressed as Eq.(3) is decided as maximizing the variance of z.

$$z = a_1x_1 + a_2x_2 + ... + a_px_p \qquad (3)$$

where x_1, x_2, ... , x_p are the explanation variables and a_1, a_2, ... , a_p the constants, respectively.

Feature

1. The order of priority of general barometer is decided by the score of the principal components.

2. An adequate correlation between the principal components and the explanation variables is evaluated by load factors.

3. How well each principal components reflect the original information is known by accumulative magnitude of the coefficient of determination.

Example

The general barometer of symptoms of the liver is obtained by tests of GOT, GPT, albumin, cholesterol, ZTT, TTT, ChE, ICG. The order of the condition of the disease is evaluated.

(11) DA Agent (Discriminating Analysis Agent)

Which group a new sample belongs is estimated by the past data which are given dividedly to the k groups ($k > 2$) in a discriminating analysis method.

A discriminating analysis using linear discriminating function is carried out when the covariance matrices of two groups coincide. A discriminating analysis using the Mahalanobis generalized distance is carried out when the covariance matrices of two groups do not coincide.

Feature

1. The DA agent can evaluate whether each explanation variable is useful or not by the validation.

2. How well discrimination is done is known by the magnitude of the coefficient of determination.

Example 1

Whether a company is a blue chip one or not is evaluated by management barometer.

Example 2

The cause of imperfect products is examined by the data of perfect products and imperfect products.

(12) QM-I Agent (Quantification Method I Agent)

A property in quantity are predicted on basis of factors in quality in a quantification method I.

Whether n categories for each m item interact with external standards $y_1, y_2, \ldots, y_N$ or not is examined for N samples. Planning quantity Y_S is described as follows.

$$Y_S = \sum_{i=1}^{m} \sum_{j=1}^{ni} a_{ij} \delta_{ij}^{S} \quad (s = 1,2, \ldots, N) \qquad (4)$$

$\delta_{ij}^{S} = 1$ (if samples of s interact with category of j in item of i)

$= 0$ (otherwise)

Category quantity aij is decided as minimizing

$$\sum_{s=1}^{N} (y_S - Y_S)^2.$$

Feature

1. The accuracy of analyzed results can be evaluated by coefficients of correlation between observed values and estimated values of external standards.

2. The degrees of correlation between the external standards and each item are expressed by partial correlation coefficients.

Example

When a new book is planned to be published, m items which will affect sales, such as authors, the contents of planning and the design of book jackets pick out, and furthermore ni categories in item of i such as a mystery, a nonfiction novel, a love story, a historical novel for the contents of planning pick out. How many books will sell is predicted by the analysis.

(13) QM-II Agent (Quantification Method II Agent)

A property in quality is predicted on basis of factors in quality in a quantification method II.

Whether n categories for each m item interact with external standards, that is, s samples for each k group or not is examined. Planning quality Yks is described as follows,

$$Y_{ks} = \sum_{i=1}^{m} \sum_{j=1}^{ni} A_{ij} d_{ij}^{ks} \qquad (5)$$

$\delta_{ij}^{ks} = 1$ (if the s-th sample for the k-th group interacts with category of j in item of i.)

$= 0$ (otherwise)

Category quantity A_{ij} is decided as maximizing the correlation ratio $\eta^2 = S_B^2/(S_B^2 + S_W^2)$, where

$$S_B^2 = \sum_{i=1}^{m} N_i(X_i - X)^2/N \qquad (6)$$

$$S_W^2 = \sum_{i=1}^{m} \sum_{j=1}^{ni} (X_{ij} - X_i)^2 /N \qquad (7)$$

where X_{ij} is the observed values of category of j in item of i, and Xi the average of X_{ij} in relation to j.

Feature

1. The accuracy of analyzed results can be evaluated by multiple correlation coefficients.

2. The degrees of correlation between the external standards and each item are expressed by partial correlation coefficients.

Example

A blood group of a person is predicted by putting into the data of several kinds of personalities, by using the results of the analysis of the data for personalities and blood groups.

3. Summary

We explained a decision support agent system composed of a interface agent which has functions of an exchange of information to a user interface and

self-study, a manage agent which has functions of understanding the feature of problems and assigning a suitable problem solving agent for a task, and thirteen problem solving agents which have functions of solving problems, self-improvement and self-evaluation.

The problem solving agents have the ability of solving by thirteen methods such as linear programming, object planning, analytical hierarchy process, contribution function, interpretive structural modeling, decision making trial and evaluation laboratory, Markov chain and non-totaling action, multiple regression analysis, principal component analysis, discriminating analysis, quantification method I, quantification method II.

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