STRUCTURE OF DECISION MAKER FROM THE EVALUATION VIEWPOINTS OF A DECISION-MAKING SOFTWARE

Chen, S .C Pu, E. F. ,and Zhou, Z. Y.

Department of Computer Science
Northwest Teacher's College
Lanzhou, Gansu, China

ABSTRACT

DECISION MAKER is a software system based on the Analytic Hierarchy Process (AHP) suggested by T.L.Saaty. It is designed for IBM PC with a wide range of applications. Having been used by many people in various fields, we would like to draw a checklist for software review and analyse the DECISION MAKER according to it. The evaluation will contribute to improve this software. As a result,a good software will encourage us to make decisions more scientifically and help us to make decisions more conveniently.

1. General

Many softwares based on AHP have been developed, and DECISION MAKER, implemented in the Northwest Teacher's College,is one of them. This has been used by many people in many fields such as teaching quality evaluation, athlete-training, research projects choice and so on. As other decision-making software based on the AHP, DECISION MAKER will help its users to organize factors of a problem into a hierarchical structure and calculate the priorities of the alternatives respective to the top node. After putting it into work for a period of time, we think there is a need to review the program for future development.

Using the DECISION MAKER, we place the goal of our problem analysis at the top of the hierarchy. Elements in the intermediate levels are criteria of the analysis. At the bottom of the hierarchy are either alternatives of the problem-solving or detailed items of the problem analysis [2].

Main features of the DECISION MAKER are:
- editing hierarchical structures,
- printing-out the structures and their relevent data,
- computing local and global weight with consistency check,
- interface to database, and
- sensibility check.

2. Data Structure of a Node

One of the main points in the programming is to store nodes in order to construct a hierarchical structure. Within a hierarchy, a node has at least one parent (except the top one) and at least one child (excl. the leaves). From this point of view a node can generally be defined as following:

```
define NODE record
begin

    char        NODE_NAME;
    real        GLOBAL_WEIGHT;
    int         NUMBER_OF_INFERIOR_NODES;
    array typo of NODE infnode[NUMBER_OF_INFERIOR_NODES];
    real        LOCAL_WEIGHT_OF_INFERIOR_NODES;
    real array ELEMENTS_OF_UPPER_RIGHT_JUDGEMENT_MATRIX;

  end;
```

With the data structure above, we can describe hierarchical structures completely. The number of superior nodes for root is zero and the NUMBER_OF_INFERIOR_NODES for leaves is also zero. The elements of the judgement matrix for a node will only be partly stored, namely, the upper right part of the matrix. Its number is therefore n*(n - 1)/2.

3. Structure of the System

Features of the systems can be divided into following categories:

```
          ┌ cursor: Move the cursor which points to the current node rightward, left-
          │         ward, upward, and downward.
        - │ edit:   These are functions to create, rename, and delete nodes. The re-
          │         lationship with nodes in upper level will be established here.
┌──────┐  │         The "edit" function offers a convenient way to set up a hierar-
│ MAIN │  │         chical structure.
│      ├─ │ compute:This function is used to calculate global or local weight of
│ MENU │  │         nodes. Sensibility analysis is also available after synthesis.
└──────┘  │ mark:   Mark the current node with a number between 1 and 9.
          │ jump:   Jump back to a marked node. Using "mark" and "jump" we can find
          │         a node easily even in a big hierarchical structure.
          └ help:   Help users to see the user manual.
```

4. Guidelines for the Evaluation of a Decision-Making Software

Evaluation of a software concerning a wide range of criteria which in turn can be divided into following categories:

(1). What, why, and for whom?
(2). Program use.
(3). Motivation.
(4). Execution time.
(5). Users' point of view.

4.1 What, Why, and for Whom?

The reason we need a software for making socio-economical or scientific decisions is very clear. Decision-making softwares for scientists, administrators, or managers may be different. Scientists prefer quantitative analysis which can be obtained by massive numerical data. Therefore, these data should be treated in a special way before they are processed by AHP. On another aspect, software for decision makers in administration and management should always have a good menu which are "very" user-friendly. Detailed menus will help them to overcome psycological handicap in order order to make decisions with the software.

As the AHP, the DECISION MAKER is a tool for solving quantitative and/or qualitative problems for either decision makers or scientists.

4.2 Program Use [1]
Classification of programs by their uses is difficult.Careful analysis notwithstanding, definitions seem doomed to fuzziness, and a given program may seem to fit in more than one categories. Moreover, the use of a given program may vary from person to person. A program written with a special use in mind may be used in completely different ways by each of the users. Despite the difficulties just noted, following definitions are proffered as an aid to the classification.

Educational vs. Practical:
An educational program based on the AHP is designed for persons to learn the AHP. Sufficient hints and detailed menus should be given. For the practical use, it is often required to handle with large-scale matrices in order to meet the demands of the real world[4].

Managerial, Administrative, and Scientific:
AHP has been used for decision-making in a wide range of fields, but they are mainly managerial, administrative, and scientific. Scientific decision is quantitative rather than qualitative while an administrative decision is more qualitative. Characteristics of managerial decisions are between the both above. A software should care these difference and individual speciality.

The DECISION MAKER is a software developed for both educational and practical purpose. It is able to handle with large scale matrices, especially to select the best from over one hundred alternatives that is sometimes necessary for the decision making in the real world. Not only can the DECISION MAKER do qualitative analysis, it can also achieve exact numerical analysis. From this point of view, it is a software for decision-making in administrative, managerial as well as scientific problems.

4.3 Motivation [4]
There should be options that increase user's motivation in order to reach a "better" decision. Some of these options is a function of hardware being used. Important options can be imagined are:

User Involvement: The proper degree of involvement should be adequate. Decision software, being dialogues, will achieve nothing without user involvement.

User Control: Several concepts may be involved here. Options available to the users at the beginning of the program may include different types of data entry, response, test, and provision of help (at the user's request) at any point in the program.

Output Formatting: Output of the system may be on the monitor or on the printer.They should be easily understandable.

Graphics, Animation, and Color: The functional use of one or more of these features can enhance decision-making. The use of graphics, animation, or color must be examined carefully to ensure that they support concept development. One might begin that examination by asking what would be lost if the features were omitted.

Voice and Nonvoice Audio: The use of voice for warning and output has considerable potential. Be aware that misuse of voice may be distracting a terminal room.

The DECISION MAKER asks its user for intensive involvement. Other motive functions are print-out, help function, graphics in color, and beep for warning.

4.4 Execution Time

The time required for the use of a program will vary considerably. Load time depends on the complexity of the program and media (eg. floppy disk or disk). An important time factor is the matrix handling which is often used in the AHP to evaluate eigenvalues and vectors. Scale of matrix influences the computation time significantly. Quick algorithms should be used in order to shorten the computation time. Level number and element number are other factors. Execution time is a synthetic estimate of these factors. Performance of the DECISION MAKER in calculating the eigenvalues and eigenvectors is listed in Fig.1.

Dimension of Matrix	Average Time (sec.)
3	1.533
5	2.8
10	5.2
15	8.867
20	14.33

Fig.1 Execution time of eigenvalues and eigenvectors of a n-dimensional matrix

4.5 Users' Point of View [5, 6]

Following key words are often used by users to view a program:

(1) Flexibility: A decision-making program should be used to accomodate a range of criteria levels, or elements within a level with respect to a given problem. In the DECISION MAKER, input dealing with setting up hierarchical structures might offer up to 10 levels or up to 10 inferiors under a criteria, and over 100 alternatives as leaves.

(2) Screen Formatting: Formatting refers to the physical layout of text and graphics presented on the screen. Some good examples are centering of data, a few items on the screen under the user's control when the next items appear, and reverse-field printing of key items. In the DECISION MAKER, poor formatting including a full screen of text with single spacing, too many graphics, continually flashing displays, and text scrolling off the screen is avoided.

(3) Need for External Information: Generally speaking, the more self-contained a program is, the better. However, certain things require the use of external materials, for example, it often happens when one wants to get started with the decision-making software. The DECISION MAKER contains a brief manual, no additional printed matters are needed except the introductory book[1] of AHP from Saaty.

(4) System Robust: System errors may be introduced by improper calculations, errors in the logic of programs, or input that is conceptually correct but does not meet the form required by the program.The DECISION MAKER has a special input routine, and is intended to prevent all system errors --syntactic errors and improper input - in order to prevent from unexpected disruption.

(5) Simplicity of Input: A program should ensure that a user knows when and in what form input is needed. In the DECISION MAKER, characters with special meaning are avoided. Input location is standardized throughout the program. Typing requirements are minimal, especially by setting up a judgement matrix.
(6) Quality of Response: Response to users of the DECISION MAKER is easily understandable. Response to incorrect input is neutral and no system disruption will be aroused from it.
(7) Tutorial: Ideally, tutorial programs should be fidelity simulations of the best teaching behavior for the people who want to get started. In the DECISION MAKER, a tutorial is included in the program.
(8) Whistles-and-Bell: programs designed to acquaint the user with those characteristics of a computer system that may have effects of warning and and stimulating.
(9) Documentation: In the DECISION MAKER, no printed materials is needed. All descriptions concerning the software are written in the diskette.
(10) Possible Modification: For the easy maintenance, modification of the DECISION MAKER is not possible.

5. Set up a Hierarchical Structure
After entering the name of an application model, we may use the editing function to set up a hierarchical structure. Except the root, relationship among a node and its superiors will be established. Its global weight is the mean value of the nodes in the same level by default. The leaves have no descendents.

Great efforts have been made to form the structure into a hierarchy. We generate all elements within a layer first, then ascertain its relationship with all elements in upper level one by one. Similarly, if a node is deleted, its relationship with all fathers and descendents will be cut. This will be done automatically.

Theoretically, no restriction of element number and level number should be made. But taking the limitation of physical memory capacity and the computation time into consideration, it is impossible. Furthermore, only part of the structure can be seen on the display monitor.

6. Some Remarks of the Software [3]
(1) The DECISION MAKER can represent not only structures shown in Fig.2a, but also those in Fig.2b in an intuitive way.

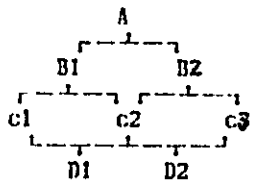

Fig.2a

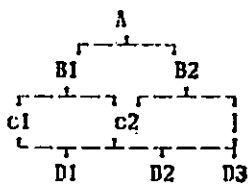

Fig.2b

(2) A quick mode is provided. Sometimes, detailed menus are cumbersome for experienced users. The quick mode without all hints except those are necessary, will speedup data entry.

(3) To enhance the numerical analysis, some easy statistical routines are added to the program.
(4) Interface with database is provided. The database has an unique relation:

Structure:	NODE ————	RELATION ————	NODE
Example :	Tree	needs	water

where RELATION is a verbal description of the relationship between the upper and lower nodes. Viewing from the example "Tree needs water", we will know that the database has the function of storing explanatory information which can be used by expert systems. Toward an inference engine of expert systems is the next stage development of this software[7].
(5) For the sake of more powerful decision-making and faster computation, a new version of this software which will run under VMS operating system on VAX machines, is being developed.

[Acknowledgement]

This project is supported by the National Science Funds of China.

REFERENCES

[1] Saaty, T. L. "The Analytic Hierarchy Process", McGraw-Hill Company, 1980
[2] "Expert Choice" Software and User Manual, Decision Support Software Inc. McLean, VA, 1985
[3] Gou, P. Z. and Wang, Z. H. "Software for the AHP", Graduate Essay in the Northwest Teacher's College, 1987
[4] Dennis, J. R. and Kansky, R. J. "Instructional Computing", Scott, Foresman, and Company, pp.45-78, Illinois, 1984
[5] Micro ... Publications in Review (Vogeler Publishing Inc., Illinois), 1984
[6] Inworld Report Card on Microcomputer Software, Inworld Pub., MA., 1983
[7] Chen,S.C. "On Structured Knowledge Base and Computational Reasoning", Ensembles of System Engineering, Gansu, China, 1988