Software System for Multicriteria Decision Making

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Abstract – **The paper discusses a multicriteria decision support system, called MOLIP, designed to model and solve linear and linear integer problems of multicriteria optimization with the help of an innovative classification-oriented algorithm. The structure, the functions and the user's interface of the system are described.**

Keywords – **multicriteria decision support systems, multicriteria optimization, interactive algorithms**

I. Introduction

The multicriteria decision support systems (MDSS) are interactive computer-based systems, designed to aid the decision maker (DM) in solving multicriteria problems for optimization and analysis [4]. Some well-known MDSS, which solve problems of multicriteria optimization, are the systems VIG [2], NIMBUS [4], DIDAS [3], LBS [1], DINAS [5], MOLP-16 [7], MONP-16 [7], MOIP [8]. In each one of these software systems a well-known interactive algorithm of multicriteria optimization is implemented. The quality of any of these algorithms defines to a great extent the quality of the system as a whole.

An experimental MDSS, called MOLIP, is described in this paper. It is designed to solve linear (continuous and integer) problems of multicriteria optimization. The system operates under MS Windows operating system. The optimization modules of the system realize two new interactive classification-oriented multicriteria algorithm [9] and two single-objective algorithms. The first single-criterion algorithm [6] is designed to solve linear problems, while the second one – linear integer problems [10]. The two single criterion algorithms are realized in LINDO Callable library [www.LINDO.com]. The interactive multicriteria algorithms allows the DM define at each iteration not only the aspiration level, as it is usual in most of the interactive algorithms known up to now, but also set the desired or acceptable intervals and directions of change in the values of the separate criteria. In this way the DM can describe his/her wishes and preferences with greater precision, flexibility and reliability.

II. Function and Structure of the System

MOLIP system is designed to solve linear and linear integer problems of multicriteria optimization (MO).

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The linear integer problems of MO and the linear problems of MO have not a mathematically well-defined optimal solution. That is why it is necessary to choose one of the (weak) non-dominated solutions, which is most appropriate with reference to DM's global preferences. This choice is subjective and it depends entirely on the DM.

The software realizations of two innovative classification-oriented interactive algorithms [9] are built in with the purpose to solve these multicriteria problems. The two interactive algorithms are oriented towards learning, which means that the existence of an implicit utility function of the DM is not presumed. These algorithms give the DM wide capacities to describe his/her local preferences with the help of desired or acceptable levels, directions and intervals of change in the values of a part or of all the criteria.

A software system for multicriteria decision making MOLIP is realized in MS Visual Basic. It consists of the following three main modules: a control program, optimization modules and interface modules.

The control program is an integrated software environment for creating, processing and saving of files associated with MOLIP system (ending by ".mlp" extension) and also for linking and executing different types of software modules. The basic functional possibilities of the control program can be divided in three groups. The first group includes possibilities to use the standard for MS Windows applications menus and system functions – "File", "Edit", "View", "Window", "Help" and others in MDSS own environment. The second group of control program facilities includes the control of the interaction between the modules realizing:

– creating, modification and saving of ".mlp" files associated with MOLIP system, which contain input data and data concerning the process and the results from solving MO linear and linear integer problems;

– interactive solution of the linear and linear integer MO problems which have been entered;

– localization and identification of errors occurring during MDSS operation.

The third group of control program functional features consists of possibilities for visualization of important information concerning the DM and the system operation as a whole.

The control program is developed on the principle of Multiple Document Interface (MDI) in MS Visual Basic software environment. In its main form it has a menu containing the standard for MS Windows applications drop-down menus for control of files, editing, windows control and Help. The main functions of the system are realized with the help of several daughter forms and context menus.

The optimization module realizes the two classification-

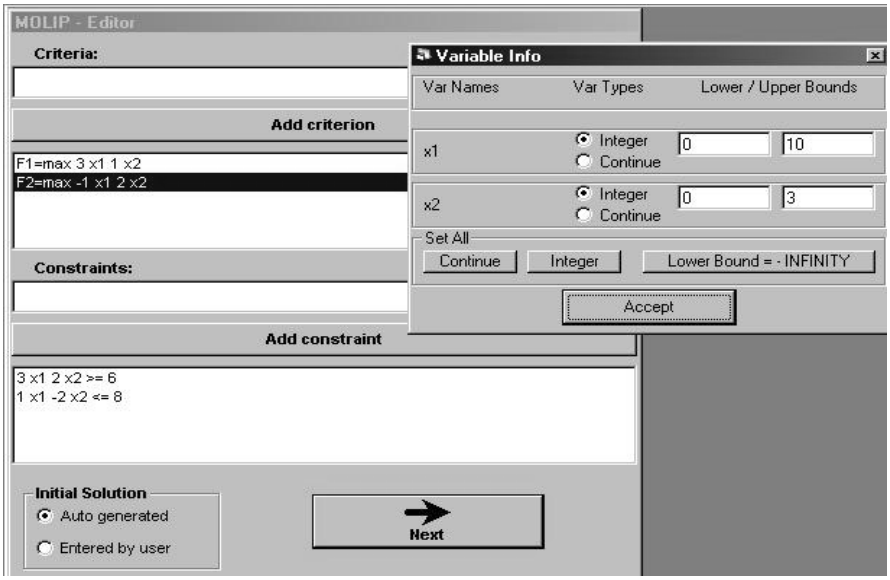

Fig. 1. The "MOLIP Editor" window

oriented interactive algorithms and two single criterion algorithms of linear [6] and mixed integer [10] programming. The single criterion algorithms are generated by LINDO Callable library.

The interface modules accomplish the dialogue between the DM and MDSS during the entry and correction of the input data of the multicriteria problems being solved, during the interactive process of these problems solution, and also in dynamic digital and graphic visualization of the process main parameters. The editing module enables the entry, alteration and storing of the descriptions of the criteria, the constraints, and also the variables type and limits of alteration. Two types of graphic representation of the information about the criteria values at different steps and some possibilities for comparison are provided by another interface module. Dynamic Help is also available, which shows information about the purpose and way of use of each one of the GUI elements.

III. Operation with MOLIP System

MOLIP system is working under MS Windows. It can be added to *Programs* group and/or with a *Desktop* icon, from where it is started. The system registers the ".mlp" extension and associates it. Thus at double clicking on a valid ".mlp" file, the system will be started and this file will be loaded. There is a menu in the main window with the standard for MS Windows drop-down menus and commands.

With their help the operation of a new file is started or an existing ".mlp" file is loaded and the operation may continue with the information stored in it.

The entry and correction of the problem criteria and constraints is realized in "MOLIP Editor" window. Every criterion and every constraint is entered separately in the respective text field for edition. Syntax check is accomplished when they are added to the data already entered. The syntax accepted is similar to the mathematic record of this class of optimization problems. The type of the optimum looked for is entered first – "min" or "max". After that the digital coefficient with its sign is entered, followed by the variable name it refers to. The variables names can be an arbitrary set of letters and numbers. Each one of these elements is separated by a space. The constraints have similar syntax – digital coefficients and variables names are successively entered. The type of the constraints is defined by some of the symbols "<=", ">=" or "=". By double clicking on the constraint or criterion already entered, they are transferred to the editing field again, if subsequent corrections are necessary.

Variable Info form can be opened in this window, where information concerning variables type and limits of alteration is entered. All the variables are by default of "Integer" type, with "Lower Bound"=0 and "Upper Bound"=1E+30, which is considered as ∞. The information about all the variables can be automatically altered with the help of two buttons – Continue and Lower Bound = INFINITY. The closing of "Variable Info" window and the corrections made are saved pressing Accept button.

Fig. 1 shows the windows of "MOLIP Editor" and "Variable Info" with the following illustrative example entered:

$$\mathrm{F}_1 = \max(3\mathrm{x}_1 + \mathrm{x}_2);\ \mathrm{F}_2 = \max(-\mathrm{x}_1 + 2\mathrm{x}_2);$$
$$\text{subject to}: 3\mathrm{x}_1 + 2\mathrm{x}2) \le 6;\ \mathrm{x}_1 - 2\mathrm{x}_2) \le 8;$$
$$\mathrm{x}_1 \le 10;\ \mathrm{x}_2) \le 3.$$

With the help of "Accept" button "MOLIP Solving" window is called, where the generated initial solution is output.

The "MOLIP Solving" window is divided into several zones. Its upper part contains a band with buttons that realize the main functions of the process for interactive solution of MO linear and linear integer problems. These are the buttons:

Solve – for starting the optimization module in order to find a new current solution of MOLIP, solving the scalarizing problem generated at this iteration;

Info – for visualization of the variables values at the current solution in a separate window;

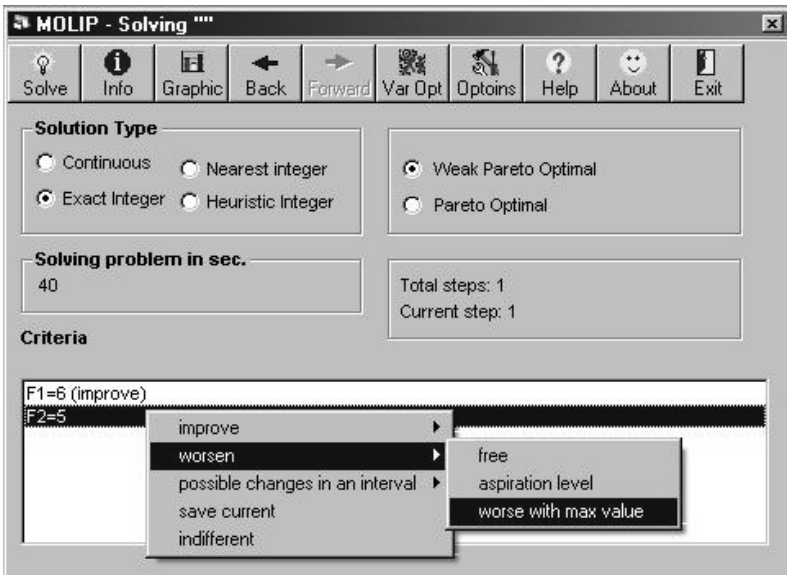

Fig. 2. The "MOLIP Solving" window

Graphic – for opening the window for graphic comparison of the results obtained at the separate steps. The upper bar-graphics gives the possibility for visual comparison of the solutions found at two iterations, selected by the rotating fields below it. The low graphics can trace the alteration of the values of the different criteria at different steps of the interactive process for better solution search. The buttons for rotation enable the selection of an initial and final step of the interval, in which the values of all the criteria are observed;

Back and Forward – buttons for navigation. They allow the DM go back to preceding steps and reconsider the solutions found. In case the DM wishes, he/she can change his own preferences concerning the criteria alteration at any of the previous steps and start the process for better solution search from there on;

Options – for opening different system setups: of the data file, which is active at the moment – it can be associated with ".mlp" extension; changing the names of the system variables if "alfa" and "beta" have another user's meaning in the problem being solved; changing the values of the default parameters of the scalarizing problems solved;

Help – for output of help information with basic directions about entry, editing and solving of MO linear and linear integer problems in MDSS environment;

About – for providing information about the team and system information about the computer system used;

Exit – for MOLIP system exiting with or without storing of the data and the results from the recent work in a file.

The next field of MOLIP Solver window contains radio buttons for setup of the MOLIP solution looked for: continuous, integer, approximate integer, the closest integer, as well as Weak Pareto optimal or Pareto optimal.

Below them information is found about the time of MDSS operation for the current problem in seconds, the number of the step being currently considered and the total number of the executed steps.

Two text fields follow. The first one outputs successively the values of the criteria obtained at the current step. It is an operating field where DM's preferences relating to the search of the next solution are set. After marking each one of the criteria, a context field is opened with the help of the mouse right button, where the DM sets the desired alteration in the value of this criterion at a following iteration. In case the selection is connected with the necessity to enter a particular value, MOLIP system opens an additional dialogue window and waits for the entry of the corresponding digital information.

The solution of the illustrative example found after the second iteration is shown in Fig. 2. For the next iteration the DM sets his/her preferences for improvement of the first criterion F_1 and worsen by a maximally feasible value 1 for criterion F_2. After that the new nondominated solution $F_1 = 9; F_2 = 4$ is output. The graphic presentation in Fig. 3 enables the DM to consider the alteration of the criteria values in the process of search for the best compromise solution.

When interactive algorithms are used for MO problems solving, it is an advantage to present information not only about the last solution found, but also about the process of search, about all the previous steps. Given that some significant solutions are made on the basis of these results. It is important for the DM to be able to "testify" how he has reached this solution. That is why the information about the interactive process of MO problem considered, which consists of the problem input data, the solutions obtained at each step, the preferences set by the DM for a new search and the constructed scalarizing problems, saved in *.mlp files associated with MOLIP system serves not only for restarting an interrupted solution process, but also for documentation. "*Print*" command from the main menu can be used for selective print of the type of information chosen by the DM.

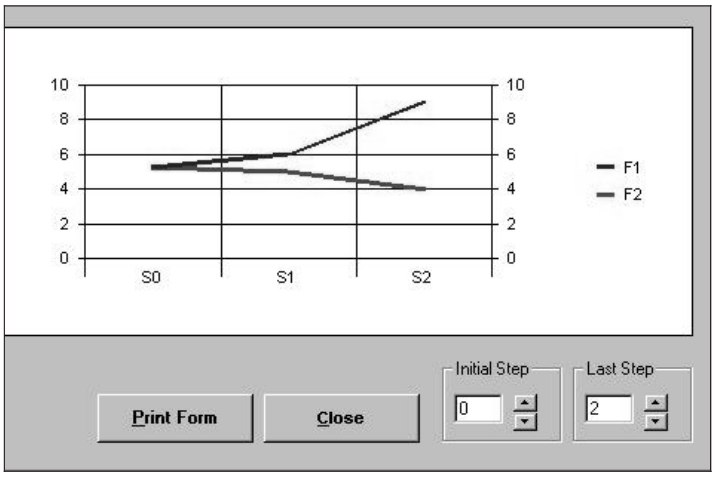

Fig. 3. The "MOLIP Graphic of results" window

IV. Conclusion

A software system for multicriteria decision making MOLIP is developed on the basis of two new classification-oriented interactive algorithms. These algorithms enabled the design of a system with a very user-friendly interface. The experiments recently accomplished prove that MOLIP is a convenient and reliable software tool supporting the solution of linear multicriteria problems. The applied software tools enable its future development for operation in a network.

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