MM-MINOS - AN INTEGRATED INTERACTIVE DECISION SUPPORT SYSTEM

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PREFACE

The Interactive Decision Analysis Project is concerned, among other things, with the development of software for solving multiple-criteria decision problems.

In this paper the authors describe some recent modifications to an interactive decision-support system previously developed at IIASA: the new package is more user-friendly and more efficient but less portable. All the new options are defined in full in a technical appendix.

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1. Introduction

Some software for solving multiple-criteria decision problems has recently been developed at IIASA. This software, which is highly portable (Lewandowski, 1982; Lewandowski and Grauer, 1982; Grauer and Brillet, 1982), utilizes the reference point approach (or the concept of satisficing decision making) developed by Wierzbicki (1980). It has been tested extensively, in all cases with positive results. The problems solved come from the chemical industry (Grauer et al., 1982b; Dobrowolski et al., 1982), energy modeling (Grauer et al., 1982a) and economics (Grauer and Zalai, 1982).

However, these tests also revealed the weak points of the software. One of the most important of these derives from the fact that the software works at the level of model descriptions--it is actually the preprocessor of the MPS format input file. This means that every modification of the reference point requires preprocessing and generation of the MPS file, which must also be read by the LP package (MINOS in our case). Both operations take a lot of computer time--in our experience, about 75 percent of the total solution time is consumed by these operations.

This problem can be overcome by utilizing the internal representation of the MPS file generated by the MINOS input routine. Fortunately, special routines which simplify access to this internal data structure have recently been made available (Preckel, 1980). Using the existing software, the MINOS package and the subroutines mentioned above, we developed the new software described here, which is in fact a multiple-criteria extension of MINOS.

The basic differences between the existing package and the new one are as follows:

(i) the three programs (lpmod, lpmulti, lpsol) of the original package have been integrated into a single program; this makes the software simpler and more convenient to use, especially for non-computer-specialists;

(ii) the user interface has been redesigned and many new options added;

(iii) the package is MINOS-oriented, i.e., it is not possible to use the software if the MINOS package is not available. Therefore, it is portable only to those centers licensed to use MINOS.

2. Theoretical Background

The general principles of the system are the same as those of the earlier, more portable version (Lewandowski, 1982). The scaling function used in the calculation is as follows:

$$s(w) = \min \{ \delta \min_{i \in [1,p]} w_i , \sum_{i=1}^{p} w_i \} - \varepsilon \sum_{i=1}^{p} w_i , \qquad (1)$$

where $w_i = q_i - \bar{q}_i$ is the distance between the value q_i of objective i and the corresponding reference point value $\bar{q}_i$; δ represents a penalty coefficient and ε is a small number.

The properties of this function have been investigated by Kallio et al. (1980), who also derived the equivalent LP problem.

However, it is also possible to use other scaling functions, e.g., those based on the Tschebyshev norm (Grauer et al., 1982b).

Convergence-forcing mechanisms have not been built into the system mainly because they are not sufficiently well-developed.

3. Preparation of the Input Data

The problem description must be prepared in standard MPS format, as before. This file should be exactly the same as for the standard MINOS system, the only restriction being that "names" cannot begin with the prefix "mm". It is also necessary to prepare the SPECS file containing the control directives for the MINOS package. This should include some new directives describing the objective (which can be a row or a column) as well as an initial guess of the reference point. The structure of this part of the SPECS files is as follows:

OBJECTIVE TYPE (optional)

SEQUENCE OF OBJECTIVE NAMES

where

$$\text{OBJECTIVE TYPE} = \left\{ \begin{array}{l} \text{MAXIMIZE} \\ \text{MINIMIZE} \\ \text{FLOATING} \end{array} \right\}$$

The "objective type" directive determines whether the corresponding group of dependent objectives should be maximized, minimized or considered neutral (FLOATING). The sequence given above can appear in the SPECS file as many times as necessary. The objective name has the following structure:

OBJECTIVE *name* *value*

Here "OBJECTIVE" is a keyword (see Appendix), "*name*" is the name of the objective row or column (which must appear in the ROWS or COLUMNS section of the MPS file) and "*value*" is the initial value of the reference point. By default, the objective type is MINIMIZE; the corresponding default value of "*value*" is zero. It should be pointed out that the objective type as well as the value of the reference point can be changed during the interactive dialogue with the system.

There are a number of restrictions which should be taken into account when preparing the SPECS file. The following keywords *cannot* be used; their presence will cause the system to crash;

CYCLE
PHANTOM
NONLINEAR
OLD BASIS FILE
NEW BASIS FILE
DUMP FILE
LOAD FILE

The file number defined in the INPUT file (or MPS file) directive should not be greater than 10. Both the SPECS file and the MPS file are read by the MINOS system and transformed into internal representations.

After each iteration cycle (i.e., MINOS run) the user is given some results--the last MINOS output file is saved in the PRINT file and information concerning the rows or columns specified in the SPECS file as objectives is displayed on the screen. (This information can be appended to the RESULTS file using the SEND command.) The information comprises:

-- name of the objective row or column with a prefix specifying whether the objective was maximized or minimized (if the prefix is missing, the objective type was FLOATING)
-- optimal solution (VALUE) of the objective
-- components of the reference point (RFP)
-- components of the utopia point (UTP)
-- components of the nadir point (NAD)
-- lower and upper bounds for the objectives (LOWER, UPPER)
-- dual variables corresponding to the objective (DUAL)

The columns VALUE, UTP, NAD and DUAL may be marked with an asterisk. This means that the numbers in these columns have no meaning because of changes in the problem data, e.g., when the reference point components have been changed an

asterisk appears after VALUE and DUAL. If the solution obtained in a particular iteration is of interest to the decision maker he can save this solution in the RESULTS file. It is also possible to display more detailed information about selected objectives.

The driver program monitors the MINOS system, paying special attention to information concerning infeasible or unbounded solutions. Such situations will not cause the system to crash; rather, the user is informed about the non-existence of the solution and should take the necessary action himself.

4. Conclusions

The system described here has a number of advantages over its predecessor, lpmulti--it is more efficient, faster and easier to operate, especially for the inexperienced user. However, this system should still be viewed as a prototype: an improved version with a much more sophisticated and informative user-machine interface is being developed.

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APPENDIX

In order to start the system it is necessary to type in the command

MM5 = *specsfile name*

where *specsfile name* is the name of the MINOS specification file containing definitions of the objectives. The following interactive commands are available:

UTOPIA (or UTP) - this command computes utopia and nadir points for the current problem.

EPS *value* - this sets a new value of ε (here and elsewhere, *value* is a standard FORTRAN number).

RO *value* - this sets a new value of the δ parameter.

MINIMIZE (or MIN) *name*, MAXIMIZE (or MAX) *name*, FLOATING (or FLO) *name* - these directives change the objective type; they specify whether the objective function should be minimized, maximized or considered neutral. Here *name* must be the name of a row or column defined in the SPECS file as an objective row (or column).

FORCE *name* UP, FORCE *name* DOWN - these commands result in maximization (UP) or minimization (DOWN) of the row or column specified by *name*. In this case a single-criterion problem is solved, with *name* specifying the performance function.

UPPER *name value*, LOWER *name value* - these directives set upper and lower limits for the objectives specified by *name*.

FIX *name value* - this fixes both upper and lower limits of a given objective or column to the same value.

SEND *text* - this directive sends the current solution (only the information displayed on the screen) to the file RESULTS with *text* as the comment on the first line. The current contents of the file are not lost; the information is appended to the existing material.

PRINT - this command causes full information about the current solution to be displayed on the screen.

PRINT *name* - this directive causes information about the objective or column specified by *name* to be displayed in a more convenient and accurate fashion.

GO - this command initiates a standard run of MINOS. Information about the success or failure of the run is displayed on the screen.

RESET - this resets the problem if a MINOS error occurs during execution of the FORCE or UTOPIA commands.

STOP - if "endrun" is detected in the specification file the program is terminated; otherwise the next problem is solved.

REFERENCE *name value* (or RFP *name value*) - this directive changes the reference point corresponding to the objective specified by *name*.

In the commands UPPER, LOWER, FIX, REFERENCE, the following special symbols can be used instead of *name*:

! - objective name referred to most recently

* - all objectives

$ - all objectives which are not FLOATING (those which are minimized or maximized)

% - all FLOATING objectives.

In these commands (UPPER, LOWER, FIX, REFERENCE), *value* can be replaced by a number, a keyword, a keyword plus a number, or a keyword minus a number, where the "keyword" is one of the following:

UPPER - actual value of the upper bound

LOWER - actual value of the lower bound

VALUE - actual value of the objective

REFERENCE (RFP) - actual value of the reference point

UTOPIA (UTP) - actual value of the utopia point

NADIR - actual value of the nadir point.

The last three keywords are valid only for non-floating objectives (i.e., of max or min type).