

An Interactive Multi-Attribute Fuzzy Decision Analysis Package

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ABSTRACT. A new computer code package, Interactive Fuzzy Decision Analysis (IFDA) is developed based on Fuzzy Set theory. The package utilizes, as input, verbal rating and weights for each criteria and subcriteria. IFDA handles problems in which either criteria and subcriteria or only criteria are given. The output is given in a tabulated or graphical form. The IFDA is developed on an HP-3000 Computer and an HP-7221 B plotter. However, the package may be used on any other computer. To use this package, the maximum allowed number of alternatives is 20 and only 20 criteria can be selected, while the maximum number of points of a membership function are 15. The application of IFDA is illustrated by examples to show the capabilities of the package.

Nowadays, most engineers are faced with making choices between different engineering alternatives. A decision problem becomes more complicated if there is a large number of selection criteria and/or large number of different options. Moreover, accommodation for future developments and uncertainties is necessary in the analysis of most decision problems. In fact, whenever there are uncertainties which that may effect the views of decision maker, decision theories offer a procedure for systematic analysis in a rational manner designed to improve the decision-making process. This can be done by breaking up complex decision problems into a number of relatively smaller problems so that quantification of the decision maker's preferences and judgement can be introduced. Fuzzy sets theory is used in this work to solve multiple attribute problems under uncertainty based on verbal judgement. A set of alternatives can be characterized by a number of attributes. By assigning verbal rating and weights to each of these attributes, one can compute weighted final rating for each alternative which can be used to rank the alternatives. The theory of fuzzy sets has been treated and developed by many investigators; Watson *et al.* (1979), Kenarangui *et al.* (1979), Baas and Kwakernaak (1977), Zadeh (1972, 1976), Graines (1976) and, Bellman and Zadeh (1970). The

above mentioned investigations as well as the MAFDA computer code, Kenaran-gui (1980), are used as the basis for developing the current code, IFDA.

IFDA Input Deck Description

The data input consists of three files:

1. The first file is concerned with rating of alternatives, their number (RAF), criteria, subcriteria, ... etc.
2. The second file deals with plotting scale, axes labeling (PLF), curves title, ... etc.
3. The third file is the interactive part of the package (IPF) where the best alternative number is given directly on the CRT. Curve title lettering type and criteria name are also given interactively. The plotter will start drawing only when it is allowed to do so. This is important to give the user the required time to change the plotting sheet.

IFDA File Construction Details

1. First file, RAF

The first line in the first file has the following constructions,

MC, SUBCR, NA, NM
where

MC = number of criteria

SUBCR = logical parameter

SUBCR = TRUE

there are subcriteria

SUBCR = FALSE

No subcriteria

NA = number of alternatives

NM = number of points of membership functions, μ_0 ,

The second line gives values for the membership functions, μ_0 , that is

$$\mu_{0(1)}, \mu_{0(2)} \dots, \mu_{0(NM)}$$

The third line gives the number of subcriteria, NS. If there is no subcriteria, this data line is not required.

The following groups of lines give the rating of each alternative for each criterion or for each alternative for the various criteria or for each subcriterion. The data lines are given in such a way for form a rating matrix R (I,J) where

I = 1,2,...,(NA + 1), where NA is the number of alternatives

and

$J = 1, 2, \dots, MC$ where MC is the number of criteria

or

$J = 1, 2, \dots, NS$ where NS is the number of subcriteria

On the line $J=1$ and $I=1, \dots, NA$, rating of the first alternative for each criterion or subcriterion is given according to the code given in Table 1. The data is given formatless and separated by a comma ',' or simply by an empty space.

The following lines are for the second alternative; that is $J=2$ and the third alternative; that is $J=3, \dots$ etc.

On the line $NA + 1$ the weighing of each criterion with respect to each other or subcriteria with respect to each other is given to the code in Table 2.

If there is no subcriteria, this file will have only one matrix $R((NA + 1), MC)$. If there is subcriteria the file will have MC Matrix for each criterion, $R((NA + 1), NS)$. The last line of this matrix set is a line which gives the weight of criteria with respect to each other as given in Table 2. The best way to explain this data input is a specific example for criteria and another example for subcriteria problems. Two examples are given in Appendix I. Also see our paper appearing in the next volume of this journal.

Table 1. Rating of criteria and subcriteria.

Very good	V
Good	G
Fair to good	T
Fair	F
Poor	P
Very poor	R
Not clear	N

Table 2. Weighting for criteria.

Very important	V
Important	I
Moderately important	M
Rather unimportant	R
Very unimportant	U

2. Second File, PLF

This file consists of four similar data sets. The first line in each data set is the plotting scale factor (SF). The maximum plotting area is 0.25×0.38 m. SF is a reduction of this area to the desired area (SF 1.0).

The second line is the number on letters in the x-axis lable, NX, and y-axis label, NY. The two numbers are unformatted and should be separated as always by a comma ',' or an empty space.

The third line contains three numbers of the letters in the three lines of the curve title (NT1, NT2, NT3).

The fourth line is a drawing mark NO which is equal to zero. The second number is the character sets form NFORM. The available forms are

NFORM = 1; Triplex Roman

NFORM = 2; Script

NFORM = 4; Enhanced stick.

The fifth line gives the starting point of the first letter of the first line of curve text (XT, YT) and the letter height in inches, HL.

The sixth line is the x-axis lable text LX.

The seventh line gives the y-axis lable text LY.

The eight line and ninth line are the first and second lines in the membership function curve text. The third line in the text is given interactively on the screen as will be explained later on.

The second data set is completely similar to the first. The only addition is that the third line in curve text is given. The third data set is similar to the first except in adding the word final to curve text title, since it will lable the final membership function of the best alternative over the others. The fourth data set is similar to the second except in adding the word final to the preferability of the best alternative over the others.

It is worth mentioning here that the curves are colored and each line will be drawn with a new color of maximum four; which are available on the plotter.

3. Third File, IPF

While running the IFDA Package, an interactive dialogue exists. The first question is about the test run. If one is satisfied, the package will continue to the tabulated form of the results. The second question is about if you need these tables as a print out or not. The third question gives you plottings, if desired.

During the plotting phase the decision-maker will be asked to give the name of each criteria or subcriteria. This text will be written on the third line in member-

ship functions' curve title. The last interactive data input is that of the best alternative for each criteria. The last two input data will repeat for each criteria if there are subcriteria.

The IFDA Outputs

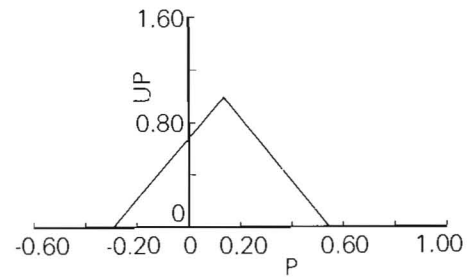
The IFDA output consists of five forms given on three devices; namely: Cathode Ray Tube (CRT), a line printer (LP) and a plotter.

The five forms of output are as follows:

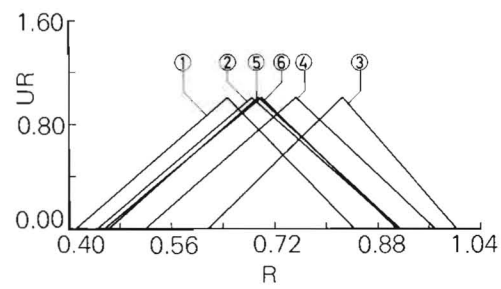
1. After running the package with starting order IFDA, the first output is given on the CRT, which gives complete details of the solution as a test output.
2. If needed you dump this result, second output, on the line printer. Such hard copy is needed in order to facilitate the debugging process.
3. When the decision-maker is satisfied with the test run, he may proceed for the third output. This output is the analysis summary in a tabulated form, namely the final membership, the final rating and the ranking of each criteria for all alternatives. Also, a final membership, rating and ranking of the alternatives is given in a final decision table.
4. The fourth output is simply a dump, if desired, of these tables on the printer.
5. At this point, the plotter should be prepared to execute the drawings. A 'Hellow' word is given and a password should be given in reponse to start drawing. This password is originally required in the plotting library, however, it is needed here to give us the required time to pick up the finished drawing and recharge the plotter with new sheet for the next plot.

References

- Baas, S.M. and Kwakernaak, H.** (1977) Rating and ranking of multiple-aspect alternatives using fuzzy sets, *Automatica* **13** (1): 47-58.
- Bellman, R.E. and Zadeh, L.A.** (1970) Decision-making in a fuzzy environment, *Management Science*, **17**, No. 4, B-141-151.
- Graines, B.R.** (1976) Foundations of Fuzzy Reasoning, *International Journal Man-Machine Studies*, **8**: 623-632.
- Kenarangui, R., Hussein, A.A. and Daniels, K.** (1979) Verbal rating of alternate sites using fuzzy multiple-criteria weights, *Trans. Am. Nucl. Soc.* **33**: 617-619.
- Kenarangui, R.** (1980) *MAFDA, User's Manual, Decision Analysis and Advanced Systems Division*, Technology International, Inc., 125 S. Third; Ames, Iowa, 50010 (U.S.A.).
- Watson, S.R., Weiss, J.J. and Donnell, M.L.** (1979) Fuzzy decision analysis, *IEEE Transactions on Systems, Man, and Cybernetics*, **SMC-9**, No. 1.



Member. func. of the preferability of alternative 3 over the others



Membership functions of final rating for cooling systems

برنامج حوارى لاتخاذ القرارات باستخدام النظرية ذات العوامل المبهمة

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يصف هذا البحث برنامج حوارى لاتخاذ القرارات وذلك باستخدام النظرية ذات العوامل المبهمة. ويمتاز هذا البرنامج باستخدامه لمقاييس وصفية وليست عددية عند تحديد قيم المعايير الأساسية أو الجانبية مثل جيد جدا وجيد، وكذلك عند تحديد لأهمية معيار من المعايير حيث يحدد ثقله بمقياس وصفى مثل هام جدا وهام وهكذا.

وللبرنامج القدرة على التعامل مع المشاكل ذات المعايير الأساسية فقط أو تلك التى تحتوى على معايير أساسية وأخرى جانبية بحد أقصى عشرون معيار وعشرون معيار جانبى.

ويعطى هذا البرنامج النتائج النهائية فى صورة جداول وكذلك فى صورة رسومات بيانية ملونه.

وبالرغم من أن البرنامج قد تم تطويره على حاسب هيلت باكر ٣٠٠٠ (HP-3000) ورسام (HP-7221 B) الا أنه يمكن استخدامه على أى حاسب آخر بعد ادخال التعديلات اللازمة.

كما يحتوى البحث على صورة من المعلومات المعطاه
والمنحنيات الناتجة لمثالين مختلفين أحدهما ذو معيار أساسى
والثانى ذو معيار أساسى وآخر جانبى .