CHOOSING THE BEST OPTIMIZATION SOFTWARE WITH THE MULTI-CRITERIA DECISION-MAKING APPROACHES

Zahra Izadpanah Mohamadabadi [1], Roya Azari[2], Elham Shadkam[3*]

[1,2] Industrial Engineer, Khayyam University,

[3] * Corresponding Author, Department of Industrial Engineering, Faculty of Eng.; Khayyam University, Mashhad, Iran,

ABSTRACT

In this paper, the rankings of famous optimization soft wares are discussed and the best software will be selected. AHP and TOPSIS methods are used to prioritize software, which have been utilized from the best Multiple Attribute Decision Making approaches. Criteria have been identified to choose the best software to optimize the functionality listed by the software vendors as well as experts' opinion. The decision matrix and the related decision criteria were created using these software products in this field. Then, the best optimization software was chosen by implementing AHP and TOPSIS methods. Finally, the results of both methods are compared. According to the results of paper, GAMS identifies as the best software product.

KEYWORDS

Multiple Criteria Decision Making, AHP, TOPSIS, optimization, software.

1. INTRODUCTION

Optimization is a science originated of mathematical techniques and helps managers in decision-making. There are numerous optimization software and decision-making methods, but each of these software has different possibilities and capabilities to solve optimization problems. The purpose of this paper is selecting the best and most complete optimization software for solving various optimization problems and rankings these optimization software. For this purpose, two multi-criteria decision-making methods (TOPSIS and AHP) have been used for ranking

.

Rezainik and Mirkarimi carried out a study in the form of a thesis to evaluate and classify non-linear software [1]. However, the conducted studies in this field are very narrow. This paper entirely deals with this issue. It can be said this study is the first done work in this field. It is hoped it be used by researchers.

Following, in the second part of paper, various optimization soft wares and their capabilities are discussed by vendors and experts' opinion. The decision matrix is created in the third part. In the fourth part, the implementation of multi-criteria decision-making methods of TOPSIS and AHP has been provided.

2. INTRODUCTION OF OPTIMIZATION SOFTWARE

In the following, the famous optimization software are discussed, each of them is studied in this paper.

GAMS software is built in GAMS Company. It has a high speed in solving large scale models. In fact, it can be named as the best software to solve very large and complex optimization problems. GAMS software can easily communicate with databases. Supported models in GAMS software are NLP, LP, MIP, MCP, MPEC, CNS and etc.

LINDO and LINGO software are built in Lindo Company. LINDO software has a high efficiency in solving LP, NLP, QP, QCP, and stochastic problems. The important features of this software are simple programming, the capability of data entry from database and spreadsheets software products such as Access and Excel, the capability to extract and send the results to Access and Excel software, high power for solving problems by utilizing the most optimal method [2], [3], [4].

Lingo software does not require a strong system, and it is installed and run on a conventional system and it is very light. The software is similar to LINDO, but it has more capabilities including the production of large models with low input, high power to exchange information with other software. According to experts, it is the most powerful software after GAMS [5], [6].
WIN QSB software was released named QSB by WIN QSB Company in 1995. The most recent version of this software is marketed by Yih-long Change & Kira Desani. Each field covers most problems and shows the solving process visually.

CPLEX software is built by IBM Company. It is used to solve linear programming integer, network planning, squared scheduling. The number of constraints for the problem is unlimited. In addition, it identifies and solves programming models with GAMS, AMPL, and MPL format [7], [8].

MINOS software is built by SOFTWARE INC STANFORD BUSINESS Company to solve linear and non-linear problems and to manage thousands of design variables and constraints. It is able to solve large problems. AMPL software is named after its founder company. It has a high speed and it is used to solve large, linear, nonlinear, and integer problems. Microsoft Office was introduced in 1989 for Mac OS X. In the next year, i.e. 1990 the version of Windows is released. The first version of Microsoft Office includes Microsoft Word, Microsoft Excel, and Microsoft PowerPoint.

GINO Software has been built by LINDO Company in 1984 and then, LINGO software has been replaced. TORA software is built by TORA Company. MATLAB software is built by the MATH WORK INC.

3. DECISION MATRIX

In this part, the decision matrix is created according to the mentioned software products in the previous section, as well as the criteria to be considered in solving optimization problems. This decision matrix will be used in the next section and in Table 1. Some of the criteria definitions used in this decision matrix are given in Table 2.

Table 1. Optimization software Decision Matrix

	Price	Quickly resolved	Easily work with	The number of Variables	The number of constraints	LP	NLP	MIP	MINLP	QCP	MIQCP	GLOBAL	MCP	MPES	CNS	DNLP	STOCH	Repeatability	The possibility of extending application	Solubility models	Ability to send results to ACCESS,EXCLE	LICENSE
GAMS	Very high	Very high	Easy	unlimited	unlimited	1	1	1	1	1	1	1	1	1	1	1	1	1	0		EXCLE	1
LINDO		Relatively high	Easy	Relatively limited	Relatively limited	1	0	1	1	1	1	1	1	1	1	1	1		0		EXCLE, ACCESS	1
LINGO		Relatively high	Easy	Much	Much	1	1	1	1	1	1	1							0		EXCLE, ACCESS	1
WINQSB		Top	Very easy	Relatively limited	Relatively limited	1	1	0	0	0	0	1						1	0			0
CPLEX	Very high	Top	Easy	unlimited	unlimited	1	0	1	0	1	1	0	0	0	0	0	0		0			1
MINOS		Top	Easy	Limited	Limited	1	1	0	0	1	0	0	0	0	0	1	0		0			1
AMPL		Top	Easy	Limited	Limited	1	1	1	1	1	1	1	1	1	1	1	1				EXCLE	1
TORA		Top	Very easy	Limited	Limited	1	0	1	0	0	0	1	0	0	0	0	0	0	0			0

Table 2. The definitions of the symbols

Abbreviation	Full form
LP	Linear Programming
NLP	Non-Linear Programming
MIP	Mix Integer Programming
MINLP	Mixed-Integer Non-Linear Programming
MCP	Mixed Complementarity Problems
MPEC	Mathematical Programs with Equilibrium Constraints
CNS	Constrained Nonlinear Systems
DNLP	Non-Linear Programming with Discontinuous Derivatives
QCP	Quad radically Constrained Programs
MIQCP	Mixed Integer Quad radically Constrained Programs
STOCH	Stochastic programming

4. IMPLEMENTATION OF TOPSIS AND AHP METHODS TO CHOOSE THE BEST SOFTWARE:

4.1. TOPSIS implementation

TOPSIS stands for Technique for Order Preference by Similarity to Ideal Solution means the preferred methods based on similarity to the ideal solution. This model was proposed in 1981 by Huang and Ions. In this method, m options are evaluated by index n. The underlying logic of this model defines the negative ideal solution and the (positive) ideal solution. The ideal solution (positive) is the solution that increases the profit criterion and decreases the cost criterion. The optimum option is the option that has the least distance from the ideal solution, and the furthest distance from the negative ideal solution. In other words, in TOPSIS method for ranking options, the options that have the greatest similarity with the ideal solution gain higher ranks [9], [10], [11].

In the decision matrix of Table 1, options are optimization options, and criteria are the capabilities in the software and the capabilities that are necessary for a software in terms of decision maker.
Matrix elements have been created according to information from the manufacturer's site and other sites. For some of these elements, which were failed to gain information, the experts' opinion has been used.

However, some of the matrix elements were not perfect and inevitably, some of these criteria were excluded, and they were not considered in the subsequent calculations. The extending possibility criterion of the software is deleted and it is not considered due to being the same for all options because they did not have any effect on the calculation for TOPSIS. Some of the qualitative matrix elements are normalized in Table 3 and the quantitative matrix elements are normalized in Table 4. The results are given in Table 5. Criteria in Tables 4 and 3, respectively, from left to right are:

Solving speed, easiness of working with the software, the number of variables, the number of constraints, LP, NLP, MIP, MINLP, QCP, MIQCP, GLOBAL, ability to solve models, LICENSE.

Table 3. Quantitative decision matrix for optimization software

9	3	10	10	1	1	1	1	1	1	1	5	1
5	3	5	5	1	0	1	1	1	1	1	5	1
5	3	9	9	1	1	1	1	1	1	1	5	1
7	5	5	5	1	1	0	0	0	0	1	5	0
7	3	10	10	1	0	1	0	1	1	0	3	1
7	3	3	3	1	1	0	0	1	0	0	5	1
7	3	5	5	1	1	1	1	1	1	1	5	1
7	5	3	3	1	0	1	0	0	0	1	3	0
3	3	5	5	1	1	1	0	1	1	1	3	1
5	3	3	3	1	1	0	0	0	0	0	3	1
7	3	3	3	1	1	1	1	1	1	1	3	1

Table 4. Normalized Matrix

0.42	0.26	0.48	0.48	1	1	1	1	1	1	1	0.35	1
0.23	0.26	0.24	0.24	1	0	1	1	1	1	1	0.35	1
0.23	0.26	0.44	0.44	1	1	1	1	1	1	1	0.35	1
0.33	0.44	0.24	0.24	1	1	0	0	0	0	1	0.35	0
0.33	0.26	0.48	0.48	1	0	1	0	1	1	0	0.21	1
0.33	0.26	0.14	0.14	1	1	0	0	1	0	0	0.35	1
0.33	0.26	0.24	0.24	1	1	1	1	1	1	1	0.35	1
0.33	0.44	0.14	0.14	1	0	1	0	0	0	1	0.21	0
0.14	0.26	0.24	0.24	1	1	1	0	1	1	1	0.21	1
0.23	0.26	0.14	0.14	1	1	0	0	0	0	0	0.21	1
0.33	0.26	0.14	0.14	1	1	1	1	1	1	1	0.21	1

Table 5. TOPSIS implementation results

Optimization software	S_i^+	S_i^-	C_i
GAMS	0.014	0.19	0.93
LINDO	0.072	0.17	0.7
LINGO	0.022	0.18	0.89
WIN QSB	0.16	0.09	0.36
CPLEX	0.11	0.148	0.57
MINOS	0.12	0.117	0.49
AMPL	0.037	0.183	0.82
TORA	0.16	0.1	0.384
EXCLE	0.083	0.169	0.67
GINO	0.161	0.1	0.383
MATLAB	0.051	0.182	0.78

Table 6. Ranking of optimization software using TOPSIS method

Rank	1	2	3	4	5	6	7	8	9	10	11
Software	GAMS	LINGO	AMPL	MATLAB	LINDO	EXCLE	CPLEX	MINOS	GINO	TORA	WIN QSB

According to the results of software ranking using TOPSIS method can be seen in Table 6. According to this method, the best software is GAMS software.

4.2. AHP method implementation

This method was introduced in 1980 by Saaty, and the problems related to decision-making problems, caused by ambiguity in understanding and the relativity of concepts is eliminated in it. This method is one of the most comprehensive MADM models. One of the advantages of this method is the ability to formulize the problem in the form of a multilevel hierarchical structure. AHP makes the decision-making process easy by providing a structure for organizing and evaluating the importance of different criteria and preferences of options for decision-makers. In addition, Expert choice software has been used to support this method. As mentioned above, in order to implement AHP, a proper hierarchical structure must be created. In the first phase, choosing the best software is given. At the second level, criteria are divided into three categories: general criteria of convenient access for the user, the ability to solve large problems, the ability to solve a variety of problems. In the third level, the minor criteria LP, NLP, etc. are given [12], [13], [14]. In the fourth level, the soft wares (options) are given. This structure can be seen in Figure 1. EXPERT CHOICE software is used to implement AHP. The results are presented in Figure 2 and 3.

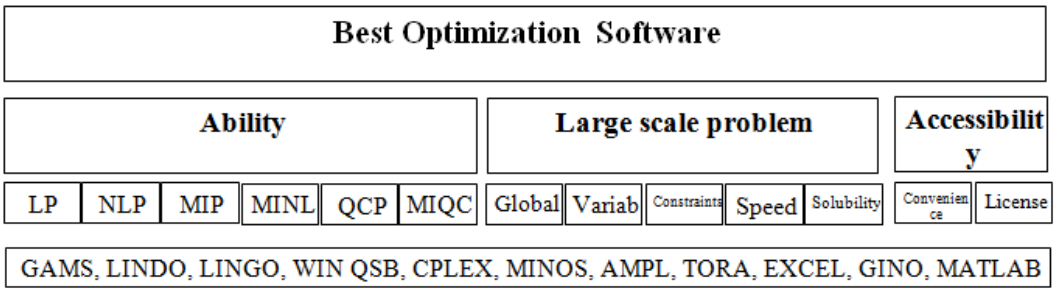

Figure 1. The hierarchical structure of decision matrix

Table 7. Ranking optimization software using AHP

Rank	1	2	3	4	5	6	7	8	9	10	11
Software	WIN QSB	CPLEX	GAMS	MATLAB	TORA	LINDO	LINGO	MINOS	AMPL	EXCLE	GINO

Thus, according to the results of Table 7, the best software products were identified that WIN QSB is in the first place.

5. CONCLUSION

In this paper, the applied optimization software products were investigated and identified. Then, they were ranked using multi-criteria decision-making methods include TOPSIS and AHP. According to the results of TOPSIS, GAMS software was selected as the best software, which can solve all models, but according to the results of AHP, WIN QSB software has been selected as the best software. Therefore, the two software products can be suggested for optimization according to the familiarity and working with each of these two software products and their availability.
In order to further researches in this regard, other multi-criteria decision-making methods can be used and ranked and their results can be compared with the results of this paper. Multivariate statistical methods such as principal component or factor analysis also can be used for clustering and classification of optimization software.

REFERENCES

1. Rezainik, E., Mirkarimi, R. Evaluate and classify non-linear software. BSc. Thesis on Industrial Engineering, sadjad University, 2007, 120 Pages.
2. http://mosamam.ir/
3. http://asreilam.ir
4. http://sharifyar.com
5. http:// tanbakoochi.com
6. http://webneshin.ir
7. http://ampl.com
8. http://gams.com
9. Mao, N., Song, M., Deng, Sh., Application of TOPSIS method in evaluating the effects of supply vane angle of a task/ambient air conditioning system on energy utilization and thermal comfort, Applied Energy, Volume 180, 2016, Pages 536-545.

10. Chen, S. M., Cheng, S. H., Lan, T. C. Multi criteria decision making based on the TOPSIS method and similarity measures between intuitionistic fuzzy values, Information Sciences, Volumes 367–368, 2016, Pages 279-295.
11. Cihat Onat, N., Gumus, S., Kucukvar, M., Tatari, O., Application of the TOPSIS and intuitionistic fuzzy set approaches for ranking the life cycle sustainability performance of alternative vehicle technologies, Sustainable Production and Consumption, Volume 6, 2016, Pages 12-25.
12. Dweiri, F., Kumar, S., Ahmed Khan, Sh., Jain, V., Designing an integrated AHP based decision support system for supplier selection in automotive industry, Expert Systems with Applications, Volume 62, 2016, Pages 273-283.
13. Bal Beşikçi, E., Kececi, T., Arslan, O., Turan, O., An application of fuzzy-AHP to ship operational energy efficiency measures, Ocean Engineering, Volume 121, 15 July 2016, Pages 392-402.
14. Singh,R. P., Nachtnebel, H. P., Analytical hierarchy process (AHP) application for reinforcement of hydropower strategy in Nepal, Renewable and Sustainable Energy Reviews, Volume 55, March 2016, Pages 43-58.