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Primena softverskih alata u procesu selekcije IT proizvoda

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Apstrakt: Kada je u pitanju donošenje određenih odluka svakodnevnih/rutinskih ili specifičnih, koje često podrazumevaju planiranje, programiranje, izbor najpovoljnije alternative, finansiranje ili realizaciju poslovnog zadatka, ono je uglavnom zasnovano na analizi podataka. Kriterijumi koji se tom prilikom nameću su vrlo raznovrsni i ponekad međusobno suprotstavljeni. Problemi koji se postavljaju pred donosiocem odluka najčešće su nestrukturirani, pa ne postoji matematički algoritam za njihovo rešavanje, a često se postavlja i pitanje objektivnosti pr iizboru optimalnog rešenja.Tema ovog rada je primena Excel Solver-a kod pronalaženja optimalnog izbora proizvoda u preduzeću koje se bavi prometom računarske opreme, uz poštovanje trendova prodaje, raspoloživih skladišnih i ljudskih kapaciteta i finansijskih ograničenja. Na konkretnom primeru prodaje desktop računara, laptop računara i tablet uređaja, predstavljeni su osnovi linearnog programiranja čija implementacija predstavlja osnovu primene Excel Solver-a.

Ključne reči: linearno programiranje, problem optimuma, Excel Solver

Software Tools Application in IT Products Selection

Abstract in English: When it comes to making of certain decisions everyday/routine or specific, which often imply planning, programming, selection of the most favorable alternative, financing or realization of business task, it is mostly based on the data analysis. Criteria which are imposed on that occasion are diverse and sometimes mutually opposed. Problems posed to the decision maker are often unstructured so there is no mathematical algorithm for solving them, and often there is a question of objectivity in choosing the optimal solution.The subject of this work is the use of Excel Solver in finding the optimal choice of products in the company which is engaged in trade of computer equipment, considering sales trends, available storage and human capacities as well as the financial limitations. The fundamentals of linear programming are presented with the concrete example of sales of the desktop computers, laptop computers and tablet appliances, and their implementation presents the base of the use of the Excel Solver.

Keywords: linear programming, problem optimum, Excel Solver

1. Introduction

In the process of managing the company, the manager makes the decisions. Making the decision is not a simple process. It's a process which requires detailed preparation and is based on reliable and relevant information and their interpretation.

Excel is of big help to managers because it allows simple and impressionable graphic review of the results and their interpretation. Program add-ins which can be added by need are the specificity of this software. One of them, the Solver, is especially interesting because it can help to predict the consequences of some decisions and in creating the scenario. Solver can simulate real situation in the sense of the calculation of the best production or marketing mix, resource allocation or making of the business schedule for employees.

In the implementation of this software, it is very important to emphasize the good construction of the mathematical model. Setting the parameters and constraints as well as finely defined relations in the observed system is the key to defining the model, which, by usage of Excel Solver, will offer the solution which will lead to a good business decision.

2. Basis of Linear Programming

The conditions in the business surroundings, as well as in the company, which are often changing, can be studied by using the analytical simulation modeling, and in that way their effect on the final result can be estimated. That means that it can be estimated in which way their change can lead to the change in the development of some business decision phenomena. By analytical simulation modeling it is considered the use of mathematical models for optimization or simulation.

Optimization is usually a mandatory process in a scientific experimentation and in engineering, supported with mathematical tools, from industrial process to new analytical methods. There are different strategies for gaining optimal values for different cases of optimization, simultaneous (example – Gradient or SIMPLEX) (Candioti et al., 2014; Coello, 2000; Deb &Goyal, 1998; Deb, 1991; Dejaegher& Vander Heyden, 2009) or sequential (example – Box Behnken, central composites, Doehlert and fractional programming**)**. Calculation method must be selected according to the given problem (Candioti et al., 2014, Dejaegher& Vander Heyden, 2009, Sánchez et al., 2012). However, most of the optimization problems in engineering are mostly nonlinear and contain mix (of direct and continuous) variables, with very complex constrictions, and therefore they can not be solved with classical mathematical analysis or with basic methods and strategies (Michalewicz, 1994).

Disadvantages of existing numerical methods have forced researches to rely on heuristic algorithms (Lee & Geem, 2005). The solutions to heuristics, global optimization as well as meta-heuristic method can be found in the literature (Yang et al., 2013). Kannan and Kramer (1994) combine improved Lagrange multiplier method with Powell's and Fletcher - Reeves Conjugate Gradient method for solving optimization problems**,** while Sandgren (1990) proposednonlinear branch and bound algorithms ased on integer programmingto solve the mixed-integer optimization problems.

Heuristic methods are really suitable and powerful way for obtaining solutions for the optimization problem. Heuristic techniques include genetic algorithm (GA), simulated annealing (SA), tabu search (TS), particle swarm optimization (PSO), harmony search (HS), ant colony optimization (ACO), etc. Deb and Goyal (1998), presented the technique of combinedgenetic engineering (GeneAS) which combines binary and real-coded genetic algorithms with the purpose of controlling mixed variables. Coello (2000), Deb (1991), Dimopoulos (2007), Hwang & He (2006) apply genetic algorithms for solving these problems of mixed integer engineering optimization.

Linear programming (LP), however, considers model optimization problem with given constraints. That means that LP is supposed to solve the problem of linear combination of independent random variables in order to achieve maximal and minimal result with gratification of the appointed conditions and/or demands. Optimization includes the choice of variables and determination of their values. LP uses mathematical model to describe the optimization problem which consists only of linear functions. The name "programming" originated before the appearance of the computers as a synonym for careful planning of the activities which would lead to achieving the set goal in the best possible way. The name "linear" comes from the form of the equations which are used.

The entire procedure seems expected and simple. However, formulation (modeling) of the real life problem as the LP problem, firstly requires good knowledge of the problem and great work experience. Although this could be a challenge, the result of model experiment should be the solution which will open the way to a good business decision. Model LP (Ivanović, 2014) should consist of:

- Linear objective function
- Linear constraints
- Allowed set of solutions.

Objective function has a following form:

$$f\left(x_1,\ldots x_n\right)=\sum_{i=1}^{n} a_i \cdot x_i \quad . \tag{1}$$

Conditions/constraints, which should be confirmed by solutions from the allowed set, are given in the form of inequality: $A \cdot x \leq b$ for the problem of maximum, and, $A \cdot x \geq b$ for the problem of minimum. Therefore:

$$a_{11}x_1 + a_{12}x_2 + ... + a_{1n}x_n \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} b_1 , \quad (2)$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \begin{Bmatrix} \geq \\ = \\ \leq \end{Bmatrix} b_m , \quad (3)$$

whereby variables x_1, x_2, …., x_n should meet the requirement of negativity or integer.

$$x_1 \geq 0, x_2 \geq 0, ..., x_n \geq 0 , \quad (4)$$

Here is:

- x – vector variables
- b_i – coefficients,
- A – matrix which contains a_{ij}

Area of the usage of linear programming is diverse: production, procurement, transport and distribution, marketing, telecommunications, financial investment and planning, making the schedule for the employees, etc. All questions which involve the assessment of the maximum profit, minimum risk, assessment of optimality, marketing or product mix, optimal product distribution, assessment of optimal position which will provide minimum cost, are solved by using the LP. However, it is most frequently used to solve the models which are corresponding to profit maximization, as well as cost minimization. Today it is a standard tool which has saved millions of dollars for many companies or smaller firms in industrialized countries all over the world, by which its usage, in all of the sectors of the society, is spreading very fast.

The essence of the manager's activities are the decisions which are made as the function of managing business processes. Decision making implies the usage of specific knowledge, "tools" and knowing the process structure in the purpose of improving its performances. Most of the decisions are made by considering constrained financial and other resources.Management can efficiently use the LP technique in order to gain better business decisions. In practice, with the help of this business approach, general profitability of the companies is increased up to 20%.

3. Specific Features of Excel Solver and Construction Problem

Each business system is specific. Today, in order of making the decisions, there is a big amount of data which need to be analyzed. For that purpose, concepts Big Data, Cloud Computing and Internet of Things are used. Given platforms converge into one resulting information system which provides bigger productivity and system efficiency (Langović &Pažun, 2016).

Developing the system for decision support, considering the complexity of one business system and its interactions with business surrounding, would be a complicated process (Grujčić et al., 2010). One of the alternatives which, in those conditions, could simplify and ease the development of less demanding systems for decision support, is the usage of Excel. It is a popular tool for analysis and solving the LP problem, which, with a program add-inSolver, gives the answers to the questions which are necessary in the process of the business deciding. In Excel, there are 4 main groups of model analysis.

- What-if analysis: the user changes one or more independent, input variables and observes the changing of the dependent, output variable. For example, it is used for insurance risk assessment.
- Sensitivity analysis: the user changes only one independent variable and observes its effect on the change of the dependant variable. For example, how it is reflected on the change of profits.
- Goal seek or How can: the user determines the goal value of the dependant variable and requires the change of the value of one of the independent variables until the goal value of the dependant

variable is reached. If the goal profit is determined, it is observed how to determine the product price in order to achieve the projected profit.

- Optimization: one or more variables should be optimized by changing one or more independent variables with the given constrains. In other words, it is a search for the production mix which will provide optimal result, by which product prices, quantities and expenses are defined, and human and equipment capacity or the sale possibility are available as constraints.

Generally speaking, data base can be realized in the form of electronic tables, and its access is possible also by external data bases through SQL inquiry (Sharda et al., 2014). In the case of usage of Excel, data which is entered in the cells of the Excel table, which is the main database, are the system base. The user interface can be realized by using the tables, as forms for data input, and numerous installed graphic possibilities for the review of output results. Excel also gives the possibility of additional functionalities and fulfillment of specific demands, with the help of the installed program language Visual Basic for Applications (VBA). Excel has a big library with approximately 400 installed mathematical, statistical, financial, engineering and other functions which can be used for making different models. It is empirically proven that in the management structure, 90% of the time is spent on the decision making. Solver is a program add-in designed for solving optimization problems in linear, nonlinear and integer programming. The essence of the entire problem is for it to be described using the system of equations or inequalities, by which requested values and constraints are explicitly shown. Model consists of three basic parts which should be noticed and shown separately: decision variables, goal function and constraints**.**

Decision variables are the variables to which unknown values are added, which are the problem solution. The goal function is an equation which shows the model goal, and depending of the problem nature, it can be maximized or minimized or set as a determined, fixed value. Constraints exist in every real problem. They can be limited quantities of resources, work or requirements demand and they are presented in the form of equations or inequalities.

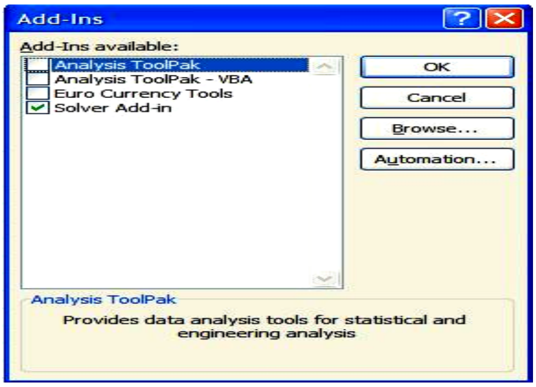

Figure 1. Turning on the option Solver Add-in

Starting the Solver is very simple because it is installed in Excel. It needs to be activated, following the next steps: File→Options→Add Ins→Manage→Excel Add-ins→Solver Add-in→Go. By pushing the button Go, dialog box Add-Ins is opened, like in the Figure 1, the check box Solver Add-in should be confirmed and then the button OK should be clicked on. Once activated, Solver stays available inside the menu Data, from where it can be used by need. Solving the concrete problem, or its mathematical interpretation, begins by entering the data related to the given problem. The goal is to define the problem in the format which will correspond to the given problem.

The data from the model should be presented in the table, on the Excel work sheet. The table can also be filled with textual comments. The company “Monitor System” from Belgrade is engaged in trade of computers and computer equipment, as well as in the consulting services in this area. The model, by which the calculation of the company “Monitor System” is done, includes 3 decision variables and 11 functional constraints. Decision variables are marked with x_1, x_2 and x_3, and they are the number of desktop computer, the number of laptop computer and the number of tablet appliances which should be studied in the purpose of further sales. They are products of average performances and prices which have the highest demand on the market, regardless the manufacturer.

The problem is in the assessment of the number of products which should be ordered from the supplier, with consideration of available storage space, observed sales trend and the number of working hours which servicers, who install the software and assemble the parts, in the case of the desktop computers can realize in one month. The profit should be maximal with the condition that the amount of the ordered merchandise can not be larger than 100000 €. The company profit, whose turnover is under consideration, doesn't depend only of three products. However, because these three products are dominating, provide the biggest profit and are sold the most, the calculation is done only based on them. These are the reasons for setting the constraints on the number of computers which are ordered from the supplier: 150 pieces for desktop and laptop computers and 80 for tablet appliances, as well as 720 hours needed for servicers (4 servicers at 180 working hours a month) for montage and product testing. Tablet appliances are obviously not the problem in terms of storage space, but demand for them is smaller. On the other hand, demand for desktop and laptop computers is approximately the same, but because of the insufficient storage space/warehouse in the company, this constriction is set.

The time needed for servicers to order the computer, enter it in the database, install it, configure it and at the end, sell it, is 3.5 hours for desktop, 1.5 hours for laptop and 0.5 hours for tablet. These data are used as constant. Average computer prices are 436.00 € for desktop computer, 270.00 € for laptop computer and 117.50 € for tablet computer. These values are also taken as constants. According to that, constraints can mathematically be presented in the following manner:

1. $3.5 \cdot x_1 + 1.5 \cdot x_2 + 0.5 \cdot x_3 \leq 720$,
2. $436 \cdot x_1 + 270 \cdot x_2 + 117.5 \cdot x_3 \leq 100000$,
3. $x_1 \leq 150$,
4. $x_2 \leq 150$,
5. $x_3 \leq 80$,
6. $x_1 \geq 0$,
7. $x_2 \geq 0$,
8. $x_3 \geq 0$,
9. $x_1 \in$ integer,
10. $x_2 \in$ integer,
11. $x_3 \in$ integer.

Constraint 1 defines the time used by 4 servicers per month for configuring and testing of desktop and laptop computers and tablet appliances. Constraint 2 defines the amount of the order which can not be bigger than the approved credit of the supplier, respectively not more than 100000.00 €. The conditions from observed sales trends and available storage space impose constraints 3-5, by which it can be ordered at the most 150 desktop computers, 150 laptop computers and 80 tablet appliances. By constraints 6-8, it is required that the variables are nonnegative, and by constraints 9-11 the integer condition for all three variables is set. In this way, the mathematical base for the usage of the Solver is prepared.

4. Application of Excel Solver and Analysis of Results

Before the usage of the Solver it is necessary to create the table with data on the Excel work sheet which will be the base of the budget. It should include:

- Information about the number of hours needed for configuration and testing of the products, which are spent during the ordering, installation, sale preparation and the sale itself of different products,
- Information about the purchase/input price,
- Information about additional servicers' expenses for the price/work on the configuration and testing of the devices,
- Information about retail product price,
- Defined maximal quantities which can be ordered because of the limited storage space and observed sales trends.

	A	B	C	D	E
1		desktop	laptop	tablet	
2	Hours for product configuration [h]	3.50	1.50	0.50	A)
3	Average purchase price [€]	436.00 €	270.00 €	117.50 €	B)
4	Following expenses [€]	11.67 €	5.00 €	1.67 €	C)
5	Price per piece [€]	447.67 €	275.00 €	119.17 €	D)
6	Retail price + 10% [€]	479.60 €	297.00 €	129.25 €	E)
7	Profit [€]	31.93 €	22.00 €	10.08 €	F)
8	Maximum quantities [pieces]	150.00	150.00	80.00	G)
9	Final orders [pieces]	0.00	0.00	0.00	H)
10					
11	Usage of working hours [h]	0			I)
12	Usage of credit €	0.00 €			J)
13	Amount of following expenses [€]	0.00 €			K)
14	Total expense €	0.00 €			L)
15	Profit €	0.00 €			M)

Figure 2. Example of the table for the usage of Excel Solver

The example of the table for the usage of the Solver is shown in the Figure 2, although the design of the table is individual. Other values from the table are obtained by specific calculation using available functions in the Excel.It is important that the cells in the table are interconnected and that adequate functions in Excel are used. The process of obtaining the values in the cells is shown in the continuation.

- **Step 1: Construction of the table for the usage of Excel Solver**

A) Amount of hours needed for appliances to be entered into database, configured, tested and prepared for the sale. These data are entered as constants.
B) These are average prices of the appliances which are sold the most on the market. These data are also entered as constants.
C) Servicer's working hour in the company is 3.33 €/h, therefore the values are obtained in the following way: 3.5· 3.33 = 11.67 € for desktop computer, 1.5· 3.33 = 5 € for laptop and 0.5· 3.33 = 1.67 € for tablet.
D) The values are obtained by adding the cells: B3+B4, C3+C4 and D3+D4.
E) Considering that the profit is limited to 10% of the purchase price, the values are obtained as: 1.1· B3, 1.1· C3 and 1.1· D3 for some appliances.
F) Values in the cells B7, C7 and D8 are obtained by subtracting the cells B6-B5, C6-C5 and D6-D5.
G) Maximal quantities, considering storage space, credit limit and servicers work, are set to 150 for desktop and laptop computers and 80 for tablet appliances. These data are entered as constants.
H) These are the requested values which are set to 0, and Solver should find the optimal solution regarding the appliances which should be ordered.
I) Data in the rows 11-13 are gained by using the function SUMPRODUCT. By activating this function it is needed to select cells B2, C2 and D2 in the first row, and in the second row, cells B9, C9 and D9. At the beginning the value will be 0, because the values in cells B9-D9 are set to 0, but the Solver will offer adequate solution in the cell B11.
J) By using SUMPRODUCT it is needed to select cells B3, C3 and D3 in the first row, and in the second row, cells B9, C9 and D9. The initial value is 0, but with the usage of the Solver the optimal solution will be obtained considering the use of the credit in the cell B12.
K) The values are obtained by using the function SUMPRODUCT in the way that cells B4, C4 and D4 are selected in the first row, and in the second row, cells B9, C9, D9.
L) Values in the row 14, the cell B14, are obtained as the sum of cells B12 and B13.
M) The data in the row 15, respectively the cell B15, is obtained by using the function SUMPRODUCT in the way that cells B7, C7 and D7 are selected in the first row, and in the second row, cells B9, C9 and D9, like in the Figure 3.

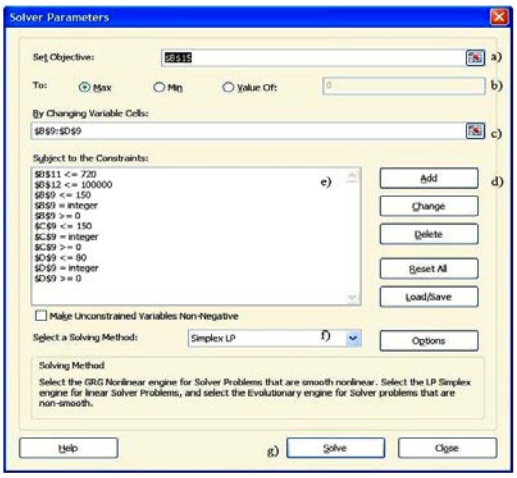

Figure 3. Dialog box of Excel Solver

Step 2: The closing solution

Table with the final solution is given by clicking on the worksheet Sheet 1. All the cells which had the value 0 in the table, and those are cells B9, C9, D9, B11, B12, B13, B14 and B15, which can be seen in the Figure 4., now have new values. These values represent optimal solution of the given problem which is obtained by using Excel Solver, like in the Figure 4. If we look at the constraints which are given and the solutions which Solver has offered, it can be deduced that the obtained values give space for result analysis.

	A	B	C	D	E
1		desktop	laptop	tablet	
2	Hours for product configuration [h]	3.50	1.50	0.50	A)
3	Average purchase price [€]	436.00 €	270.00 €	117.50 €	B)
4	Following expenses [€]	11.67 €	5.00 €	1.67 €	C)
5	Price per piece [€]	447.67 €	275.00 €	119.17 €	D)
6	Retail price + 10% [€]	479.60 €	297.00 €	129.25 €	E)
7	Profit [€]	31.93 €	22.00 €	10.08 €	F)
8	Maximum quantities [pieces]	150.00	150.00	80.00	G)
9	Final orders [pieces]	114.91	150.00	80.00	H)
10					
11	Usage of working hours [h]	667.1788991			I)
12	Usage of credit €	100,000.00 €			J)
13	Amount of following expenses [€]	2,224.58 €			K)
14	Total expense €	102,224.58 €			L)
15	Profit €	7,775.42 €			M)

Figure 4. Optimal solution obtained by using the Excel Solver

The company "Monitor System", respecting the given constraints of the market, financial situation and available storage space, will maximize the result if it can procure, install and prepare for sale 114 desktop computers, x_1=114, 150 laptop computers, x_2=150 and 80 tablet appliances, x_3=80. Considering the result per product unit, the company will gain maximal profit in the amount of 7,746.42€. With this result, theinitial constraints are fulfilled at the satisfactory level.

Attainable capacity, which implies hiring employees for 720 working hours, is quite exploited. For optimal solution, 664 hours are used, and that is 92.22%. Considering that the employees also have other similar jobs beside this one, in smaller extent, the conclusion is that with this work division, production capacities are being used very efficiently.

Second constraint refers to supplier credit. The company has a 100000€ credit for a month. Optimal division which Solver suggests, implies that 99,604.00€ of this amount should be used, which is 99.6% of the approved sum, which can be seen in the Figure 4.

Third constraint regards the number of products from the category desktop, laptop or tablet appliances, which are sold per month, and the availability of storage capacity. The number of sold products from one of the categories can be increased by stocks or similar procedures which increase the sale.

However, the constraint regarding the storage space, firstly for desktop computers, dictates constraints of quantity. In the same way, the sales of laptop computers are more profitable than the sales of desktop computers. However, the sales analysis suggests that no more than 140 laptop computers are sold per month. Setting the constraint to 150 pieces, the data about conditions on the market is complied, although, elimination of this constraint, for tablet and laptop appliances, would significantly increase the profit with smaller number of employees. The constraint on the number of desktop computers is set to 150, although with them, the situation in practice is slightly more complicated than with other appliances. This constraint in fact is not natural, because the combination of the parts can vary, and it is not necessary to install all of the parts which are ordered from the supplier as computer assembly. However, with all of the ordered components in one month, the number of sold desktop computers per month is not bigger than 115.

It is seen that the number of desktop computers did not reach the maximum possible value, while the other two products gain maximum, limit values. If there were no constraints regarding the appliance quantity, it would be seen that the calculation shows that the most profitable way for the company is to sell tablet appliances, but it would be hard for the company to stay on the market by selling only one type of appliance. With constraints in the number of certain products, it is necessary to also set the integer constraints and negativity constraints, which means that it is impossible to sell 12.6 laptop appliances or -4 tablets.

Thus, the problem solution implies that the company profit will be maximal if 114 desktop computers, 150 laptop and 80 tablet computers are sold. In that case, the company profit would be 7,746.42€. At the same time, 664 working hours of possible 720 would be used, while the credit with supplier, in the amount of 99,604.00€ would be almost entirely used.

5. Conclusion

Because of the big significance of information in the process of business decision, the management expects disposal of relevant, accurate and quality information, in order to create adequate company actions based on those information.

Program add-in Solver which is a part of Excel package is compact and powerful tool which could help the manager in making the business decisions. What is really interesting for Excel Solver is that this approach to problem solving is interactive. After the optimal solution to one model version is obtained, it is possible to ask series of questions and get instant answers. By examining series of different scenarios, many questions could be answered.

By using this model, real life situation can be simulated, and based on the results which Excel Solver provides, it can be estimated how much the business decision would actually be correct and payable**.** Interactivity of Excel Solver makes it not only reliable, but also a fast collaborator in making of the business decisions.

Literature

1. Candioti, L. V., De Zan, M. M., Cámara, M. S., & Goicoechea, H. C. (2014). Experimental design and multiple response optimization. Using the desirability function in analytical methods development. *Talanta*, 123-138.https://doi.org/10.1016/j.talanta.2014.01.034
2. Coello, C. A. C.(2000). Use of a self -adaptive penalty approach for engineering optimization problems,*Computers in Industry*, 41, 113–127.
3. Deb, K., Goyal, M. (1998). A Flexible Optimization Procedure for Mechanical Component Design Based on Genetic Adaptive Search, *Journal of Mechanical Design*, 120 (2), 162-164.https://doi.org/10.1115/1.2826954
4. Deb, K. (1991). Optimal design of a welded beam via genetic algorithms. *AIAA journal*, *29*(11), 2013-2015.
5. Dejaegher, B., & Vander Heyden, Y. (2021). Sequential optimization methods. In *In Comprehensive Chemometrics: Chemical and Biochemical Data Analysis*, 553-572.
6. Dimopoulos, G. G. (2007). Mixed-variable engineering optimization based on evolutionary and social metaphors. *Computer methods in applied mechanics and engineering*, *196*(4-6), 803-817.

7. Grujčić, Ž., Cvijanović, J. M., & Lazić, J. (2010). Efikasnost Beogradskih mašinskih tehničkih škola. Industrija, 38(4), 95-112.
8. Hwang, S. F., & He, R. S. (2006). A hybrid real-parameter genetic algorithm for function optimization. *Advanced Engineering Informatics*, *20*(1), 7-21.
9. Ivanović, M. (2014).*Exercises form the subject Operations research*, Faculty of Mathematics, Belgrade, 1–55.
10. Kannan, B. K., & Kramer, S. N. (1994). An augmented Lagrange multiplier based method for mixed integer discrete continuous optimization and its applications to mechanical design.
11. Langović, Z., Pažun, B., (2016). Virtualization of information resources in tourism organizations, 1th International Scientific Conference, Tourism in Function of Development of the Republic of Serbia, Spa Tourism in Serbia and Experiences of Other Countries, Vrnjačka Banja, Serbia, 536-552,
12. Lee, K. S., & Geem, Z. W. (2005). A new meta-heuristic algorithm for continuous engineering optimization: harmony search theory and practice. *Computer methods in applied mechanics and engineering*, *194*(36-38), 3902-3933.
13. Michalewicz, Z. (1996). GAs: Why Do They Work?. In *Genetic Algorithms+ Data Structures= Evolution Programs* (pp. 45-55). Springer, Berlin, Heidelberg.
14. Sandgren, E. (1990). Nonlinear integer and discrete programming in mechanical design optimization.
15. Sánchez, M. S., Sarabia, L. A., & Ortiz, M. C. (2012). On the construction of experimental designs for a given task by jointly optimizing several quality criteria: Pareto-optimal experimental designs. *Analytica chimica acta*, *754*, 39-46.
16. Sharda, R., Delen, D., Turban, E., Aronson, J., & Liang, T. (2014). Business intelligence and analytics. *System for Decesion Support*.
17. Yang, X. S., Huyck, C., Karamanoglu, M., & Khan, N. (2013). True global optimality of the pressure vessel design problem: a benchmark for bio-inspired optimisation algorithms. *International Journal of Bio-Inspired Computation*, *5*(6), 329-335.