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Araştırma Makalesi

A REVIEW ON OPTIMIZATION LITERATURE RELATED TO OPERATIONS RESEARCH FIELD

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Abstract

Optimization is an iterative search process aimed at finding the best solution value for an objective function that satisfies constraints or bounded conditions in mathematically expressible problems. There are hundreds of books written in this field, and a new book is added to the list everyday. Since optimization is a very large field, each book is written for different disciplines. If you want to work on any subject related to this field, reaching the related book can be complicated and time consuming. The point to be reached in the research is to do an extensive research on the optimization books and to obtain relevant statistics. For this purpose, available optimization books related to the operations research of the last ten years were searched and examined in detail according to their topics. This work is aiming at leading the people who want to study about this topic by searching the literature about the optimization in the field of operations research.

Keywords: *Optimization, Operations Research, Literature Review.*

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YÖNEYLEM ARAŞTIRMASI ALANINDA OPTİMİZASYON LİTERATÜRÜ KONUSUNDA BİR TARAMA

Öz

Optimizasyon, matematiksel olarak ifade edilebilen problemlerde, belirli kısıt ya da sınırlandırılmış koşulları sağlayan bir amaç fonksiyonu için en iyi çözüm değerinin bulunmasını amaçlayan iteratif bir arama sürecidir. Bu alanda yazılmış yüzlerce kitap bulunmaktadır ve her geçen gün listeye yeni bir kitap daha eklenmektedir. Optimizasyon çok geniş bir alan olduğundan, her kitap farklı disiplinlere yönelik olarak yazılmaktadır. Bu alanla ilgili herhangi bir konuda çalışılmak istenildiğinde ilgili kitaba ulaşmak karmaşık ve zaman alıcı olabilmektedir. Araştırmada ulaşılmak istenen nokta optimizasyon konusundaki kitaplara ve kitapların içerdikleri konulara ilişkin kapsamlı bir araştırma yapmak ve ilgili istatistiklerin elde edilmesidir. Bu amaçla son 10 yıla ait ulaşılabilen optimizasyon kitapları taranmış ve yöneylem araştırması ile ilgili olanlar detaylı olarak konularına göre incelenmiştir. Bu çalışma, uzun süren bir emeğin ürünüdür ve yöneylem araştırması alanında optimizasyon konusu ile ilgili kitaplara yönelik literatür dökümünü çıkararak, bu konuyla ilgili çalışma yapmak isteyenlere yol göstermeyi amaçlamaktadır.

Anahtar Kelimeler: *Optimizasyon, Yöneylem Araştırması, Literatür Araştırması.*

INTRODUCTION

Optimization is an iterative search process that seeks to find the best solution value for an objective function that provides certain constraints or constrained conditions in mathematically expressed problems (Belegundu ve Chandrupatla: 2011, p. 1). It is applied in areas such as science, engineering, medicine, military, and business management.

Modeling is the mathematical expression of the problems encountered in real life. However, sometimes we can encounter complex problems that are difficult to model. In these complex problems, it is sometimes possible to obtain an acceptable approximate solution instead of the exact solution. Researchers were primarily interested in modeling in the development of optimization (Sarker ve Newton: 2008, p. 3).

A general optimization problem can be mathematically expressed as follows:

$$\min f(x) \tag{1}$$

$$g_i(x) \leq 0 \qquad i=1, 2, \ldots, m < n \tag{2}$$

$$h_j(x) = 0 \qquad j=1, 2, \ldots, r < n \tag{3}$$

$$x_l \leq x \leq x_u \tag{4}$$

where x is the decision variable, (1) is the objective function, (2) is the inequality constraint, (3) is the equality constraint and (4) refers to the boundaries of the decision variable.

If an optimization model has only the objective function, this model is called as an unconstrained optimization model. If there are constraints such as equality or inequality besides the objective function, this model is a constrained optimization model (Arora: 2015, p. 4).

There are many books written on optimization up to day. Accessing to a relevant book can be complicated and time consuming. With this study, it is aimed to guide the researchers and students to find the book they need faster and more effectively.

Qualitative research: It can be defined as a qualitative data collection method such as observation, interview and document analysis, and a qualitative process to present perceptions and events with a realistic and holistic approach. Based on the collected data, it is a modeling study that explains some previously unknown results in relation to each other. Observation, interview and written documents are the most widely used data collection methods in qualitative research. Within the scope of the study, written documents were considered as data collection method. The study is a qualitative research covering only the books written on optimization related to operations research area. For this purpose, the content review of 1246 books in the area of optimization that can be reached in the last 10 years was made and 172 books in the field of operations research were discussed in detail. Based on the contents of the books, a classification has been made and presented as a table.

HISTORY OF OPTIMIZATION

Although the mathematical analysis of optimization has improved during the 20th century, the roots are based on the studies by Greek mathematician Euclid, who calculated the minimum distance between a point and a line around 300 BC, and that another Greek mathematician Zenedorous showed that the true limited area with a maximum area for a given environment is a semicircle about 200 BC (Arora: 2015, p. 1).

The first study on optimization was carried out by Fermat (1646) and Newton (1670), they obtained the solution of the univariate function by derivation. Euler (1755) obtained the solution of the univariate function by using the vector of variables. Lagrange (1797) obtained the solution of the univariate function under constraints using the vector of variables. The gradient method was proposed by Cauchy in 1847 for the problem of minimization. In 1917 Hancock published his first textbook on optimization. Kantorovick presented the linear programming model and an algorithm to solve it in 1939. Modern optimization methods were pioneered by Courant's study on the penalty functions in 1943, Dantzig's paper on the simplex method for linear programming in 1951; and Karush, Kuhn, and Tucker's study about "KKT" optimality conditions for constrained problems (1939, 1951). Dynamic programming is based on Bellman's work (1952). Geometric programming is based on the work of Duffin, Peterson and Zener (1967). Particularly, numerical methods

were developed for nonlinear optimization in the 1960s. Mixed integer programming improved by the branch and bound technique is developed by Land and Doig (1960) and the cutting plane method by Gomory (1960). For unconstrained optimization, Davidon–Fletcher–Powell used variable measurement methods in 1959, Fletcher and Reeves used the conjugate gradient method in 1964. Rosen's gradient projection method (1960), the appropriate direction method of Zoutendijk (1960), the generalized reduced gradient method of Abadie and Carpenter (1969), Fiacco and McCormick's SUMT technique (1968) were pioneers of constrained optimization methods.

With the development of computers in the 1980s, large-scale problems could be solved. Today's problems in the field of optimization are multidisciplinary and multi-objective. The algorithms used to solve today's complex optimization problems include not only gradient-based algorithms, but also non-traditional methods that mimic natural processes, such as genetic algorithms, particle swarm optimization, ant colony, and simulated annealing.

Thanks to the developed solution methods and the developing technology, computer programs have been developed and solutions have been provided to solve the problems of larger size. Commonly used software for optimization are MATLAB optimization toolbox, EXCEL SOLVER, GAMS, CPLEX. ALTAIR, GENESIS, ISIGHT, modeFRONTIER and FE-Design are structural and simulation-based optimization software (Arora: 2015, p. 2-4; Belegundu ve Chandrupatla: 2011, , p. 2-3; Sarker ve Newton: 2008, p. 4-5).

METHOD AND FINDINGS

The study is a literature review covering the books written on optimization related to operations research area. For this purpose, a detailed survey covering the years 2008-2017 was conducted. The scope of the available optimization books has been narrowed down to the field of Operations Research for a more detailed analysis. Based on the contents of the books, a classification has been made and summarised as a table. Since the table is massive, it is given online as a whole and only an instance of it can be given in the article. The statistics for the books examined in detail are also presented in the study.

Figure 1: A Part Of The Classification Results

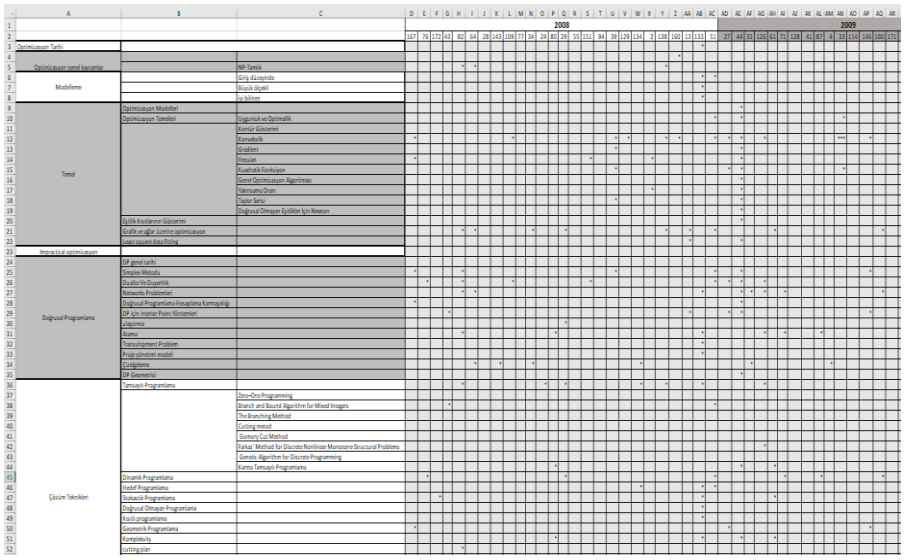


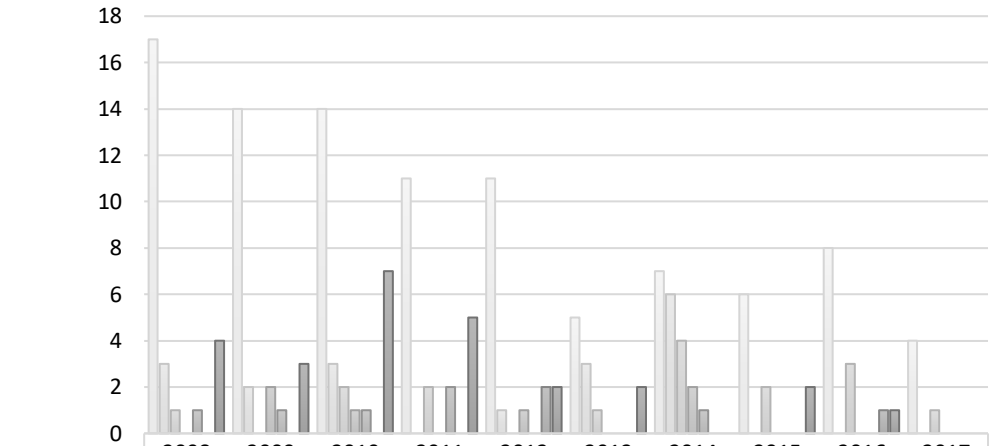
Figure 1 shows an instance of the table generated based on the subject classification.

Table 1: Books That Are Reviewed By Years

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Books on Optimization	132	122	158	91	126	121	152	133	124	87
Books on Optimization in Operations Research	26	22	28	20	17	11	20	10	13	5
Examined %	19,70	18,03	17,72	21,98	13,49	9,09	13,16	7,52	10,48	5,75

Figure 1 shows an instance of the table generated based on the subject classification. Entire table is available at https://tinyurl.com/ycwu7kws. Table 1 shows the number of books that have been reached and examined in detail according to the years. In the first line, the number of books reached in the optimization field, and in the second line, the number of books that are in the operations research field among these books. For example, of the 132 optimization books reached in 2008, 26 were in the field of operations research and were examined in detail. In other words, 19,70% of the books reached in 2008 are examined in detail.

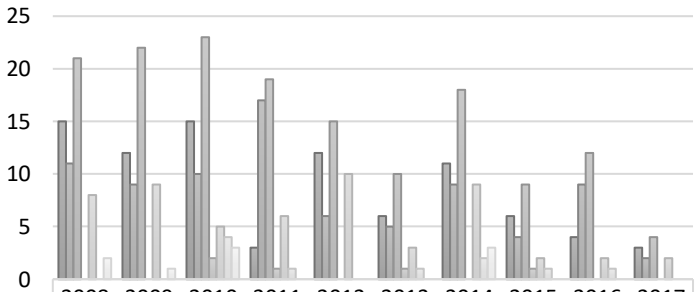
Figure 2: Number of Books Examined According to Publishers



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Springer	17	14	14	11	11	5	7	6	8	4
Wiley	3	2	3	0	1	3	6	0	0	0
Crc	1	0	2	2	0	1	4	2	3	1
Siam	0	2	1	0	1	0	2	0	0	0
Cambridge	1	1	1	2	0	0	1	0	0	0
Birkhauser	0	0	0	0	2	0	0	0	1	0
Others	4	3	7	5	2	2	0	2	1	0

When examined books are classified according to the publishers, the books of Springer Publishing House are the most as shown in Figure 2 and this is due to ease of access.

Figure 3: Number of Books by Content



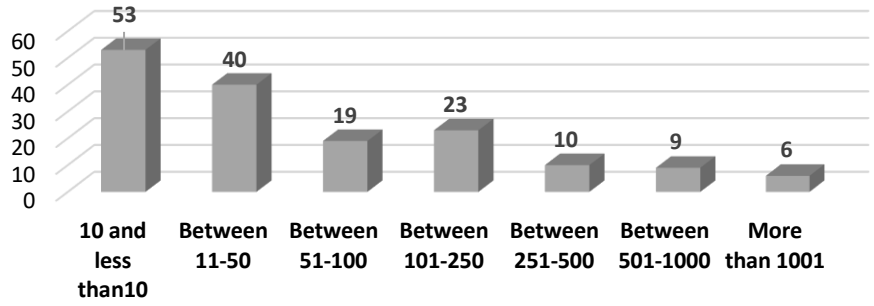
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Fully related to optimization	15	12	15	3	12	6	11	6	4	3
Partially related to optimization	11	9	10	17	6	5	9	4	9	2
Narrow-scoped	21	22	23	19	15	10	18	9	12	4
Comprehensive	0	0	2	1	0	1	0	1	0	0
Theoretical	8	9	5	6	10	3	9	2	2	2
Containing Matlab	0	0	4	1	0	1	2	1	1	0
Containing computercode/ program	2	1	3	0	0	0	3	0	0	0

From a different point of view, the examined books are classified as in Figure 3 based on whether they are ‘fully related to optimization’, ‘partially related to optimization’, ‘narrow-scoped’, ‘comprehensive’, ‘theoretical’, ‘containing Matlab’, and ‘containing computer code/program'. The classes are created as a result of the evaluation of the contents of the books. For example, books containing most of the optimization topics are included in the ‘comprehensive’ class, and books containing some of the optimization topics are included in the ‘narrow-scoped’ class. Since MATLAB is one of the most frequently used software in optimization, in addition to the class ‘containing computer code/program’, the class ‘containing Matlab’ has been created. In Table 2, the books are given according to the classes they are included in. In addition, a book may enter more than one class in this classification.

Table 2: Books According To Content

Classes	Books
Fully Related To Optimization	[4],[7], [8], [9], [10], [11],[13], [15], [16],[17], [20], [22] ,[23] , [24], [25], [27], [28], [34], [35], [36], [39], [40], [42], [44], [45], [46], [47], [49], [50], [51], [52], [53], [54], [59], [60], [63], [64], [65], [67], [70], [72], [74], [76], [80], [82], [86], [88], [89], [90], [91], [92], [93], [96], [97], [99], [100], [102], [104], [106], [113], [114], [116], [119], [121], [123], [124], [127], [128], [133], [136], [138], [141], [142], [143], [144], [150], [153], [154], [155], [160], [161], [162], [165], [166], [167], [168], [171]
Partially Related To Optimization	[1], [2],[3], [5], [6], [12], [18], [19], [21], [29], [30], [31], [32], [33], [37], [38], [41], [43], [48], [57], [58], [61], [62], [66], [68], [69], [71], [73], [75], [76], [77], [78], [79], [81], [83], [84], [85], [87], [94], [95], [98], [101], [103], [105], [107], [108], [109], [110], [111], [112], [115], [117], [118], [120], [122], [125], [126], [129], [130], [131], [132], [134], [135], [137], [139], [140], [142], [145], [146], [147], [148], [149], [151], [152], [156], [157], [158], [159], [164], [169], [170], [172]
Narrow-Scoped	[1], [2], [3], [4], [5], [6], [7], [8], [9], [11], [12], [14], [15], [18], [19], [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [31], [32], [33], [34], [35], [36], [37], [38], [41], [42], [43], [44], [45], [46], [47], [49], [50], [51], [52], [53], [54], [57], [58], [59], [60], [61], [62], [63], [64], [65], [66], [67], [68], [69], [71], [73], [74], [75], [76], [77], [78], [79], [80], [81], [82], [83], [84], [85], [86], [87], [88], [89], [90], [91], [92], [93], [94], [95], [96], [97], [98], [99], [100], [101], [102], [103], [104], [105], [107], [108], [109], [110], [111], [112], [113], [114], [115], [116], [117], [118], [119], [120], [121], [122], [123], [124], [125], [126], [127], [128], [129], [130], [132], [134], [135], [136], [137], [138], [139], [140], [141], [143], [144], [145], [146], [147], [148], [149], [150], [151], [152], [153], [154], [155], [156], [158], [159], [160], [161], [162], [163], [164], [165], [166], [169], [170], [171], [172]
Comprehensive	[10], [17], [40], [70], [168]
Theoretical	[6], [9], [12], [13], [16], [19], [20], [26], [30], [31], [32], [33], [36], [37], [40], [44], [50], [52], [53], [55], [59], [65], [67], [69], [72], [75], [77], [78], [80], [82], [83], [87], [90], [91], [97], [100], [103], [104], [107], [108], [109], [112], [116], [119], [125], [126], [128], [137], [138], [142], [150], [156], [157], [162], [170], [172]
Containing Matlab	[17], [22], [49], [59], [89], [98], [148], [152], [161], [168]
Containing Computer Code/Program	[11], [28], [45], [46], [59], [70], [73], [86], [133]

Figure 4: Number of books by citation numbers



The number of citations of a book can also be an important criterion for researchers. Therefore, the number of citations of the books were also taken into consideration. In Figure 4, the number of books according to the number of citations is given and books cited over 250 are listed in Table 3.

Table 3: Books cited over 250

Citation Numbers	Books
251- 500 arası	[20], [23], [41], [51], [52], [64], [76], [121]
501-1000 arası	[17], [28], [44], [48], [75], [94], [110], [157], [168]
1001 ve üzeri	[12], [27], [39], [40], [82], [153]

Table 4 has been created in order to guide the researchers who want to work on optimization in specific areas. The books corresponding to the fields specified in Table 4 are classified in terms of their contents.

Table 4: Books For Specific Areas

Areas	Books
Supply Chain	[35], [92], [141], [145]
Portfolio Optimization	[144]
Fuzzy Optimization	[29], [99], [162]
Robust	[4]
Financial Optimization	[45]

Optimization is a very large area and some of the books have been written entirely for a specific topic. Table 5 presents only the books written for a specific topic of optimization.

Table 5: Books On A Specific Topic Of Optimization

Topics	Books
Combinatorial Optimization	[125]
Multi-Objective Optimization	[15], [28], [63], [144]
Nonsmooth Optimization	[9], [11], [142]
Particle Swarm Optimization	[78], [93], [121]
Semi-İnfinite Optimization	[65]
Stochastic Optimization	[162]
Integer Programming	[7]
Evolutionary Optimization	[15], [34], [47], [63], [171]
Metaheuristic	[54], [160], [168]
Hybrid Method	[24], [158]
Network Problems	[60], [64], [81], [100], [104], [106], [118], [127], [137], [150], [153], [156]
Scheduling Problems	[154]
Convex Optimization	[12], [20], [48], [50], [67]
Duality	[29], [109], [113]

CONCLUSION AND FUTURE STUDIES

In this study, literature research has been done for optimization, which is an important subject in Operations Research and the books and contents in this field have been examined in detail. For this purpose, 1246 optimization books which can be reached in 2008-2017 years were scanned and 172 books related to operations research were examined in detail. The books reviewed were classified with different perspectives. In addition, the topics which were created by examining the contents were associated with the books and included as a table.

Statistics generated to the books examined in detail were also obtained. These statistics are prepared according to years, custom-generated classification, publications and number of citations. In addition to these statistics, books according to certain characteristics are given in detail in tables.

In the study, a literature review covering the last 10 years was used. As a continuation of the study, it is aimed to expand the scope and make a more detailed research including the last 30 years.

It is aimed to prepare a course content for optimization courses at the undergraduate, graduate and doctorate levels taught in universities based on the topic breakdown and the classification of books.

When it comes to working on any subject related to optimization, accessing to a relevant book can be complicated and time consuming. With this study, it is aimed to guide the researchers working on optimization in the field of operations research.

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