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# CUTTING AND PACKING PROBLEMS: AN UPDATED LITERATURE REVIEW

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Cutting and Packing Problems: An Updated Literature Review

by Paul E. Sweeney and Elizabeth Ridenour Paternoster

## Abstract

More than 400 books, articles, dissertations, and working papers are included in this bibliography on cutting and packing problems. The list of published articles and dissertations is a nearly exhaustive compilation of the English language references on the subject. The list of working papers, although extensive, presents only a sample of the recent work in this field. All of the books and journal articles listed in the bibliography have been categorized according to the dimensionality of the problems studied and the solution methodologies employed.

Key Words:

Cutting Stock Problems

Trim Loss Problems

Packing

Bin Packing

Linear Programming Applications

Heuristic Problem Solving

# Cutting and Packing Problems: An Updated Literature Review

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## Introduction

Although several English language articles on cutting and packing problems appeared in the 1950's [2-12], Gilmore and Gomory's later articles on linear programming approaches to one-dimensional cutting stock problems [15, 20, 24, and 30] were the first to present techniques which could be practically applied to difficult real-world problems. Since then, articles have been published every year on the original one-dimensional problem and, increasingly, on its two- and three-dimensional extensions (see Figure 1). This bibliography has been compiled in response to the increasing diversity and complexity of research on these problems. Its purposes are to:

1) provide the most exhaustive, categorized bibliography ever published on these problems,

2) provide a listing of the large number of articles published since the last similar bibliography appeared (see Dyckhoff, et.al. [251]),

3) facilitate access to publications pertaining to distinct problem types, and

4) facilitate access to publications pertaining to distinct solution methodologies.

We assume the reader is familiar with cutting and packing problems, but those who require a basic introduction to the field should refer to the following:

Brown [52]

Salkin and de Kluyver [80]

Golden [88]

Berge [119]

Gilmore [124]

Hinxman [147]

Garey and Johnson [162]

Israni and Sanders [187]

Sarin [210]

Coffman, Garey, and Johnson [220]

Dowsland [250]

Dyckhoff, Kruse, Abel, and Gal [251]

Dyckhoff [347]

Because this bibliography is concerned with application-oriented research, some articles of a more theoretical nature have been intentionally omitted. That is particularly true for articles on knapsack and bin packing algorithms, where a great deal of research has been done on computational complexity and worst-case analysis (see Johnson, [68]). To find other articles on those topics, refer to the literature reviews cited above (i.e., see [80], [162], or [220]).

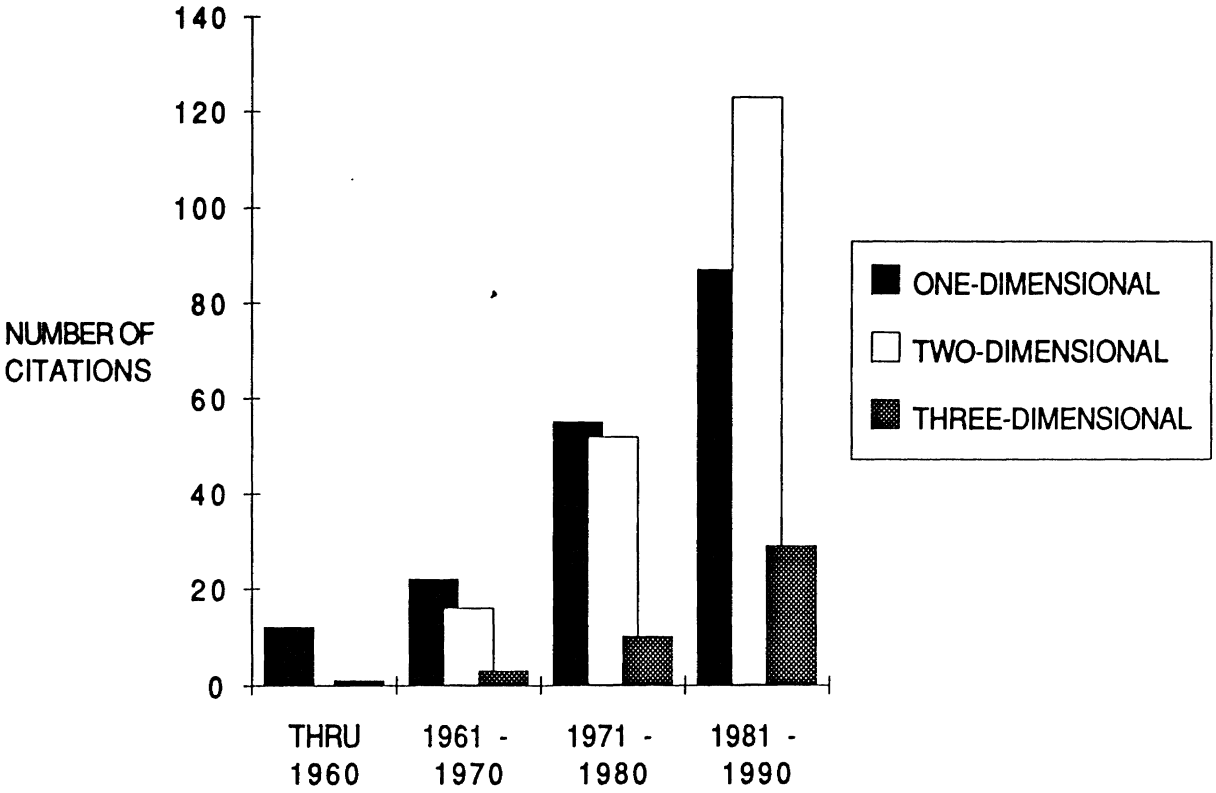
## Organization

More than 400 books, articles, dissertations, and working papers are included in this bibliography on cutting and packing problems. The list of published articles and dissertations is a nearly exhaustive compilation of the English language references on the subject. The list of working papers, although extensive, presents only a sample of the recent work in this field.

While the task of categorizing such a large number of apparently diverse publications is formidable, cutting and packing problems do share a common underlying structure which can be exploited in their classification. Both types of problems focus on the division of some stock resource into smaller pieces (e.g., demanded items) in a way which minimizes the volume or quantity of the resource required. In traditional cutting stock problems, the resource is generally some type

Figure 1

Number of Publications by Year and by Dimension of Problem*




*Publications which cover more than one problem type are double counted.

of physical material (e.g., a large roll of paper or sheet of glass). For packing problems, the resource is an empty space (e.g., a pallet or truck). In either case, classification of the problems according to the dimensionality of the decision regarding resource division is relatively straightforward, and we have followed that convention in our categorization.

In addition to physical dimensionality, we have also grouped the publications according to the solution methodologies employed. Three categories have been used:

- sequential assignment heuristics
- single-pattern generating procedures
- multiple-pattern generating procedures

Sequential heuristic techniques group demanded items into a cutting or packing pattern by using an assignment rule (e.g., first-fit decreasing in bin packing). These procedures (e.g., dynamic programming based algorithms) generate a single "optimal" pattern that can be used once or many times, but they do not consider subsequent patterns for residual demand items. Multiple pattern procedures (e.g., LP-based algorithms) consider interactions between patterns, but they require solutions to be rounded and are, therefore, also heuristic in nature.

By combining these two methods of categorization, we have generated a 3 x 3 matrix to which the publications have been assigned (see Table 1). Articles which discuss more than one kind of problem may appear in more than one cell. Such will be the case, for example, with articles on multi-dimensional problems which are approached by solving one- or two-dimensional sub-problems. Also, publications often cannot be clearly categorized as belonging to only one of the above three groups of solution procedures. All such articles will either be placed where they fit best or, in some cases, will appear more than once in our categorization.

The citations in Table 1 refer to the entries in the main bibliography which immediately follows it. The bibliography is arranged chronologically by year and alphabetically by author within each year. Immediately following the it are two supplementary lists. The first contains dissertations and theses. The second provides a list of recent (1986 to 1990) proceedings, presentations, and working papers. The entries in the supplementary bibliographies have not been categorized with the other books and journal articles because of the inherent difficulties in obtaining and reviewing these more informal works in process.

## Special Topics

For those with an interest in various special topics in cutting and packing, the citations listed below refer to the main bibliography which follows Table 1:

Assortment Problems:

12-13, 20, 25-27, 42, 52, 70, 78, 85, 93, 95-96, 104, 109, 138, 147, 187, 217, 222, 230, 243, 253, 259-260, 274, 297, 311, 314, 327, 332, 339, 347-348, 352

Corrugator Trim Problems:

21, 24, 36-37, 39, 52, 106, 117, 202, 253, 262, 306, 322

Cutting or Packing Items with Irregular Shapes:

49, 56-57, 67, 75, 79, 83, 97, 120, 125, 129, 132, 135, 140, 187, 210, 215, 223, 234, 239, 251, 293, 303, 310, 329, 344, 347

Cutting Material with Defects or Quality Variations:

24, 43, 47, 49, 51, 59, 98, 173, 206, 228, 233, 236, 263, 270, 316, 318, 342, 357, 359

Multi-Stage Problems:

24, 29, 43, 49, 52, 55, 59, 66, 78, 82-83, 85, 87, 99, 101, 107, 124, 130, 140, 146-147, 150, 167, 187, 194, 199-200, 206, 210, 216, 245, 250-251, 253, 279, 297, 305-306, 314, 317-318, 335, 337-339, 348-350, 355-357

Rounding:

3-4, 6, 15, 29, 41, 46, 59, 76, 89, 94, 115, 119, 124, 138, 145, 147, 160, 184, 192, 194, 231, 251, 253, 256, 269, 271, 273, 292, 305, 318, 347, 353, 356

1-1/2 Dimensional Problems:

24, 36-37, 39, 47, 51-52, 61, 101, 113, 115, 117, 128, 130, 136, 141, 148, 155, 162, 178, 181, 195-197, 220, 247, 250-251, 262, 264, 282, 312, 321, 325-327, 336, 347

4 or More Dimensional Problems:

3, 9, 41, 52, 54, 59, 80, 103, 105, 111, 147, 158, 162, 177, 220-221, 291, 311, 347

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We would also like to bring to your attentioon the existence of a Special Interest Group on Cutting and Packing Problems (SICUP) which was formed in conjunction with the EURO IX / TIMS XXVIII Joint International Conference (Paris, July 1988). For information regarding this organization, contact either the authors or Professor Dyckhoff.

Table 1
Categorization of Articles by
Problem Dimension and Solution Approach

| SOLUTION APPROACH: | PROBLEM DIMENSION | | |
|---|---|---|---|
| | One | Two | Three |
| Sequential Heuristics | 45, 52, 54, 58, 62, 68-69, 73, 88, 103, 105, 111-113, 137, 142-143, 156, 162, 168, 171-172, 187, 193, 198, 208, 220-221, 227, 230, 233, 238, 247, 264-268, 274, 284, 290, 292, 300-301, 306-307, 315, 327-328, 331, 347, 350, 356-357 | 47, 52, 54, 84, 103, 106, 111, 120, 129, 132, 136, 139, 141, 143, 148-149, 153, 155, 162-163, 178, 181-182, 187, 189, 195-198, 208, 220-221, 230, 247, 250, 254-255, 258, 262-263, 268, 274, 281, 283, 289, 293, 295, 298, 313-314, 322, 324-326, 332, 335-336, 343-347, 354 | 54, 84, 103, 106, 111, 144, 162, 187, 220-221, 250, 253, 291, 311, 320, 324, 333-334, 341, 347, 351, 354 |
| Single Pattern Oriented | 3, 12, 14, 26-28, 41, 44, 50, 52, 54, 60, 70-71, 77, 80, 88, 91, 93, 95-96, 100, 102, 104, 108-110, 116, 121, 124, 131, 137, 147, 151, 157, 169, 173, 176, 187, 207, 218, 233, 236-237, 241, 251, 257, 260, 270, 274, 288, 306, 347, 352 | 1, 19, 25, 33, 41, 43, 49, 52, 54, 57, 59, 65, 67, 72, 74-75, 78-80, 82-83, 97-99, 114, 118-119, 122, 125, 133-135, 138, 140, 147, 154, 159, 161, 166, 177, 179, 183, 186-187, 190-191, 204, 206, 210, 212, 214-216, 219, 223-225, 228, 234, 240, 242-246, 248-251, 258, 260-261, 274-275, 286-287, 310, 314, 318-319, 329-330, 335, 337-338, 340, 344, 346-348, 352 | 1, 9, 41, 54, 65, 80, 92, 122, 215, 228, 236, 250, 310, 319, 329-330, 333, 347 |
| Multiple Pattern Oriented | 2-8, 10-11, 13, 15-18, 20-23, 29, 34-35, 38, 40, 42, 46, 52, 55, 61, 64, 76, 85-90, 94, 102, 107, 109, 115, 123-124, 126-128, 131, 137, 145-147, 160, 164-165, 174-175, 185, 187-188, 192, 194, 201-202, 205, 213, 217-218, 231, 233, 251-253, 256, 259, 269, 271-274, 276-278, 280, 288, 302, 304-306, 308, 312, 316, 321, 347, 353, 356-357 | 16, 24, 30, 32, 36-38, 48, 51-53, 56, 63, 66, 81, 101, 117, 130, 147, 150, 152, 167, 170, 174, 180, 184, 187, 199-200, 203, 209-211, 222, 226, 229, 232, 235, 239, 250-251, 274, 279, 282, 285, 294, 296, 299, 303, 309, 317, 319, 323, 342, 347-349, 355, 358-359 | 24, 31, 158, 170, 180, 250, 297, 299, 319, 339, 347 |

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