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The use of the brute-force method for solving the knapsack problem

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Abstract. In this paper we propose the brute-force method as a suitable method for solving the knapsack problem in high schools and colleges.

Keywords: brute-force method, knapsack problem

The (0,k)-knapsack problem is as follows. Given n items, denoted by Item #1, Item #2,…,Item #n, with weights w1,w2,…,wn and prices c1,c2,…,cn, where wi and xi are integers, wi, xi $\geq$ 1, i = 0,1,…,n. Let W = w1 + w2 + … + wn. Find the maximum of the function F(x1,x2….,xn) = x1.c1 + x2.c2 + … + xn.cn subject to x1.w1 + x2.w2 + … xn.wn $\leq$ w, where w $\leq$ k.W, x1,x2,…,xn$\in$ {0,1,…,k}, k is an integer, k $\geq$ 1. If we have to solve the (0,k)-knapsack problem for all w = 0,1,2,…,W, we call the problem the extended (0,k)-knapsack problem.

The brute-force solution of the (0,k)-knapsack problem is as follows. We select all sequences (x1,x2,..,xn) such that x1.w1 + x2.w2 + … xn.wn $\leq$ w and then we calculate the sums x1.c1 + x2.c2 + … + xn.cn for each of the selected sequences. Let c is the maximal of the calculated sums. Then we select as answer all sequences (x1,x2,..,xn) whose sums are equal to c. In the answer (x1,x2,..,xn), if xi = 0 for some i, it means that the Item #i is not selected, if xi = p, where 1 $\leq$ p $\leq$ k, it means that p copies of Item #i are selected, 1 $\leq$ i $\leq$ n.

Since the brute-force method is simple, it allows simple implementation. I have created a simple computer program by using the programming language PHP. The computer program is used in examples given below.

If the (0,1)-knapsack problem is defined for n items, where n $\leq$ 15, the computer program displays the answer without any delay, that is for less than 0.1 second. Hence, we could use the brute-force method as suitable method for solving the (0,1)-knapsack problem in high schools and colleges. Also, for the extended (0,1)-knapsack problem we obtain the answer without delay. The university students have to study more fast and sophisticated methods, but in the high schools and colleges, we could prefer the brute-force method, since it is simple and the students could easily understand and use it.

Example 1. Solve the extended (0,1)-knapsack problem given by the following table:

Item	#1	#2	#3	#4	#5
weight	6	3	10	7	4
price	5	3	7	1	2

Solution. The record of the output of the computer program is available for download as supplementary material.

Example 2. Solve the extended (0,5)-knapsack problem given by the same table as in example 1.

Solution. The record of the output of the computer program is available for download as supplementary material.

Example 3. Solve the extended (0,1)-knapsack problem given by the following table.

Item	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
weight	6	3	10	7	4	8	9	13	5	11
price	5	3	7	1	2	7	1	2	3	1

Solution. The record of the output of the computer program is available for download as supplementary material.

Example 4. Solve the extended (0,2)-knapsack problem given by the same table as in example 3.

Solution. The record of the output of the computer program is available for download as supplementary material.

Example 5. Solve the extended (0,1)-knapsack problem given by the following table.

Item	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11	#12	#13	#14	#15
weight	6	3	10	7	4	8	9	13	5	11	4	8	6	5	9
price	5	3	7	1	2	7	1	2	3	1	2	7	1	7	3

Solution. The record of the output of the computer program is available for download as supplementary material.

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