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A Meta Heuristic Approach to Solve Knapsack Problem

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Abstract
A novel fuzzy approach to solve Knapsack Problem (KP). This problem was first formulated as a multilevel programming problem. When there are multiples decision makers (DMs). Then we established the satisfaction level of each DM. Dynamic recursive formulation Programming was used to solve decisions in interrelated steps. overall satisfaction Decisions were achieved through this step-by-step manipulation of the hierarchical structure. Capacity Assignments were developed and step by step solution steps were provided. detailed comparison Coordination was also done between multi-purpose and multi-level KPs.

Keywords--*Knapsack problem, Fuzzy, Multilevel programming, DP, Resource allocation.*

I. INTRODUCTION

The well-known knapsack problem (KP) can be summarized as follows: a hiker must decide,among the i= 1, 2 , . . . , N objects, which objects to include in her or his knapsack on a forthcoming trip. Objective i has weight w_i and utility ci to the hiker. The objective is to maximize thetotal utility of the hiker's trip subject to a weight limitation, W [1]. This problem has been studiedextensively and has been applied to various areas such as capital budgeting, cargo loading,cutting stock, flyaway kit, project selection, etc. [2,3].During the past decades, there has been an increasing realization on the practical needs toidentify and to consider simultaneously several conflicting objectives [4]. This multi-objectiveknapsack problem (MOKP) can be expressed as [5]. Note that the above expression is also classified as the unbounded knapsack problem [6] with one knapsack. If xi 6 {0, 1} (i.e., xi = 1, if the object i is selected; and x~ = 0, otherwise), the problem becomes a 0-1 KP [2]. Furthermore, the decision of these multiple objectives can be made by a team or by two groups of individual decision makers (DMs) [6].In a hierarchical organization with multiple DMs, a multilevel knapsack problem (MLKP) can be formulated with decentralized planning. The simplest case of MLKP is the bilevel programmingproblem, where the top level DM has control over the vector Xl while the bottom level DMcontrols the vector x2. Let the performance functions of zl and z2 for the two planners be linearand bounded, then the new bilevel knapsack problem can be represented as [7]. Equation (2) is a nested optimization model involving two problems, an upper one and a lowerone [9]. Notice that if there exists no hierarchical control feature, equation (2) simplifies to theMOKP of equation (1). Thus, MOKP and MLKP are closely related. And the constraint regionsin two equations are the same, i.e., X = {xi, i = 1 , . . . , N} = {xl, x2}.The usual solution techniques dealing with KPs are dynamic programming (DP) and integerprogramming [3]. We will focus on DP in this study for the ease of extension to the fuzzyenvironment. For crisp MOKPs, recent approaches are concentrated on how to find an efficientsolution in the DP structure. Cho and Kim [10] developed an improved interactive hybrid methodto adjust DM preference information through a scaling constant among objectives. Klamroth andWiecek [11] proposed DP-based approaches to obtain all the nondominated solutions. Most ofother studies can be categorized as integer programming-based approaches. One example is thework of Salman et al. [12].Because of the similar between MOKP and MLKP, these two problems will be imbedded in acommon DP structure. We will first review the related literature of fuzzy MODP.Bellman and Zadeh [13] suggested that fuzzy decisions could be considered as the confluenceor intersection of goals and constraints. Esogbue and Bellman [14] made some extensions andintroduced many applications. At the same time, Kacprzyk offered a genera/view aboutmultistage decision-making under fuzziness and derived a genera/ structure for solving fuzzyDP problems. Kacprzyk and Esogbue made a fairly comprehensive survey of the majordevelopments and applications of fuzzy DP. However, the breadth of theory and applicationsof fuzzy MODP is still limited. This is especially true in the field of decentralized planning of hierarchical systems. Due to the complexity of the multilevel programming (MLP) problems, there exist no efficienttraditional techniques for obtaining the numerical solutions of a reasonable sized problem. Shihet al. suggest a fuzzy approach for MLP to simplify the complex structure, and it was provento be feasible and efficient. In addition, the suggested supervised search procedure can be easilyextended to a k-level hierarchical system, and it is also a flexible structure for further expansion.Consequently, we would like to examine the possibility of unifying the level-wise (hierarchical)operation and stage-wise operation for multilevel DP in a fuzzy environment. Following an extension of the structure of Kacprzyk , the new structure with interrelation among stagesand objectives/levels can be simplified [8,9].In the remaining sections, we will introduce the concept of capacity allocation for KP. Theequations for fuzzy DP and MODM are introduced used to solve the

MOKP and MLKP. Adiscussion on the well-known turnpike theorem with fuzzy approach is also carried out. The finalsection contains some conclusions and remarks.

II. DYNAMIC PROGRAMMING FOR KNAPSACK PROBLEMS

Dynamic programming is an effective algorithm for solving multistage decision problems. Itutilizes a functional equation to circumvent the dimensional explosion for multistage processes [10]and has been applied to solve many real world problems such as optimal control, inventory control,advertising campaign, production planning, equipment replacement, resource allocation, etc. [11].In this study, we only focus on the knapsack problem.

III. Proposed Algorithm

STEP 1. According to the basic information in these tables, we will set up the degree of satisfaction by fuzzifying the objectives through their PIS and NIS of the possible capacity allocated at each stage.

STEP 2. The satisfactory solution of the imbedded bi-objective returns at each stage can beobtained through max-min operation, which means minimizing the satisfactory degree of twoobjectives, and then go to the next step.

STEP 3. The process is for maximizing the satisfactory degree among all possible cases of combinationsunder different inputs and states, and yet the given budget remains a constant constraint.

STEP 4. After all individual problems are solved, i.e., the single stage problems, we will establishthe backward relationship among stages through DP structure. To trace the capacity allocated,we start from the last stage, Stage 4, with the capacity remaining after the previous stage, Stage 3, then go back to the second stage, and to the first stage.

IV. CONCLUSIONS

In this study, we have investigated multi-objective and multilevel knapsack problems in a fuzzyenvironment. An efficient algorithm is developed, and a solution procedure has been proposedthrough Microsoft Excel as well. Although the size of the examples under scrutinizing is small,large size problems are expected to solve through the same procedure.Since different decision variables can be controlled by separated different decision units (orDMs) in a multilevel system, its decision space will be more restricted than that of the MODMproblems'. In general, its solution will no better than that of the MODM's. However, both areefficient solutions.In a general resource allocation problem, the number of decision variables will not always equalthe number of the stages, but the situation will happen in solving KPs. Consequently, we couldthink that the KP is a special case of the resource allocation problems.Notwithstanding only bi-level problems are illustrated; multiple-level dynamic programmingproblems can be solved through the same algorithm. Please see the details of the search algorithmin [13] for simplifying multilevel structures.The efficiency of our fuzzy approach is dependent on the scheme of dynamic programming witha loose structure. We have not discussed the computational problem in this study, and interestedreaders might check some algorithms, e.g., [10], in the literature. And looking for a short-cutalgorithm in DP structure will be the future direction.In this study we have not involved the integer programming-based algorithms for MOKPs andMLKPs. Readers can go through the contents of Shih and Lee seeing a case of multilevelminimum-cost flow problem. This would be another direction for further investigation.

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