Knapsack Problems

MATH 3220

By Nicole King

Outline

- Introduction
- Components
- Why the Knapsack Problem?
- Techniques
- Solving KP
- Variations

Introduction

Congratulations! You just won a trip to Hawaii!!

- Your Items:

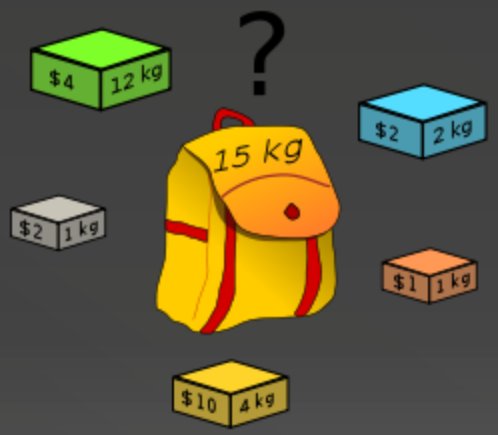
Different Values and

Different Costs

- How will you decide what to pack?

(Jennifer Huls Photography)

Components



(Wikipedia.com)

- Originates : Must fill knapsack with items that are most valuable
- Studied since 1897
- Mathematician Tobias Dantzig (1884-1956)
- Folklore

Components

(Carol Hawkins Studios)

Defining the Problem

The 0-1 Knapsack Problem:

- Need unique objects (one time use)
- Value for each object
- Cost for each object

- Problem Objective: Highest value within cost limit
- Example: Your house is on fire and must save your pets!

Why the Knapsack Problem?

- **Useful to Real Life Problem Solving**
  - Determining least wasteful ways to cut raw materials
  - Selection of capital investments
  - Creation and scoring of tests

Techniques

- Branch and Bound
- Dynamic Programming
- Hybridizations of both

Solving KP

- Using Bounded Knapsack Problem:
  - You were given one suitcase
  - The capacity of this suitcase is 50 pounds
  - You have to choose from the items listed to pack
  - You may pack more than one item only if that item is listed twice

Solving KP

Item	Value	Cost (Weight)
Swim Suit	400	5 lbs.
Flip Flops	200	10 lbs.
Hair Dryer	350	20 lbs.
Camera	500	30 lbs.
Swim Suit	400	5 lbs.
Shorts	200	5 lbs.
High Heels	150	10 lbs.
Snorkel	150	5 lbs
Sunscreen	500	20 lbs.
Hat	300	10 lbs.

The weights listed above are not accurate.

Solving KP

How do we choose what to pack?

Item	Value	Cost (Weight)
Swim Suit	400	5 lbs.
Flip Flops	200	10 lbs.
Hair Dryer	350	20 lbs.
Camera	500	30 lbs.
Swim Suit	400	5 lbs.
Shorts	200	5 lbs.
High Heels	150	10 lbs.
Snorkel	150	5 lbs
Sunscreen	500	20 lbs.
Hat	300	10 lbs.

Greedy Solution

-Choose the highest values within capacity first

-Results:

Cost: 50 lbs.

Value: 1000

Solving KP

- How do we choose what to pack?

Item	Value	Cost (Weight)
Swim Suit	400	5 lbs.
Flip Flops	200	10 lbs.
Hair Dryer	350	20 lbs.
Camera	500	30 lbs.
Swim Suit	400	5 lbs.
Shorts	200	5 lbs.
High Heels	150	10 lbs.
Snorkel	150	5 lbs
Sunscreen	500	20 lbs.
Hat	300	10 lbs.

Optimal Solution

-Results:

Cost: 50 lbs.

Value: 1950

Variations

- 0-1 Knapsack Problem
- Bounded Knapsack Problem
- Unbounded Knapsack Problem
- Subset-sum Problem

Variations

- Change-making Problem
- 0-1 Multiple Knapsack Problem
- Generalized Assignment Problem
- Bin-packing Problem

Review

- Introduction
- Components
- Why the Knapsack Problem?
- Techniques
- Solving KP
- Variations

References

- Carol, H. (Artist). (n.d.). House on fire. [Web Drawing]. Retrieved from http://www.carolhawkins.com/illustration.shtml
- Dantzig, T. (1930). Numbers: The language of science.
- Huls, J. (Photographer). (2012). Vintage suitcase. [Print Photo]. Retrieved from http://www.123rf.com/photo_13942259_packed-vintage-suitcase-full-of-vacation-items.html
- Keller, P. & Pisinger (2004). P. 3
- Knapsack problem. In (2012). Wikipedia. Retrieved from http://en.wikipedia.org/wiki/Knapsack_problem
- Martello, S., & Toth, P. (1990). *Knapsack problems: Algorithms and computer implementations*. West Sussex, England: John Wiley & Sons Ltd.
- Mathews, G. (1897). On the partition of numbers. *Proceedings of the London Mathematical Society, 28,* 486-490.
- Six mistakes when asking questions. (2012). [Print Photo]. Retrieved from http://www.pickthebrain.com/blog/do-you-make-these-6-mistakes-when-asking-questions/

Questions?

(Six Mistakes When Asking Questions)