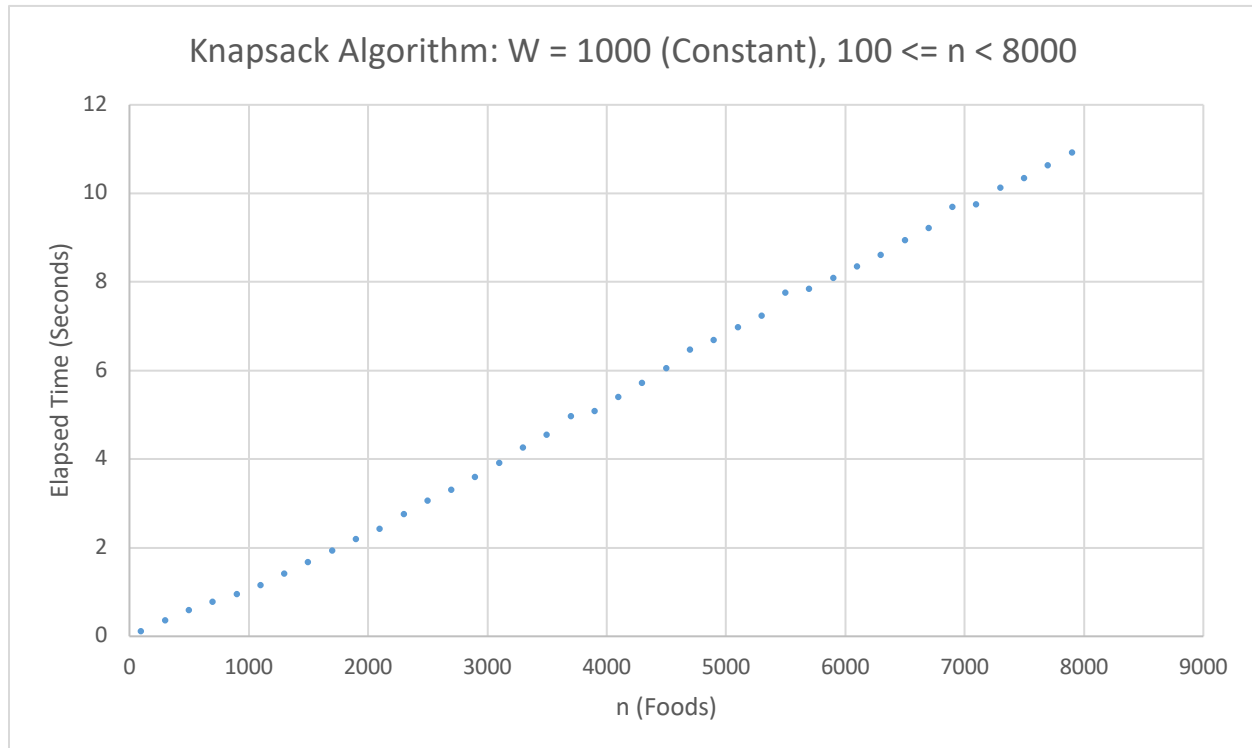


Project 4: Dynamic Programming

by Dion Wayne Pieterse & Michael Lindwall

Empirical Timing Data – Knapsack Algorithm: Fixed W and variables values of n :



Conclusion:

The above scatter plot shows the knapsack algorithm as a function of n . The algorithm displays a $O(n^2)$ behavior. It appears almost linear but this is due to the efficiency of the algorithm. The plot's timing data resembles the predicted $O(n^2)$ trend for the algorithm that we implemented.

Questions Answered:

- **Did you implement backtracking, or not?**

No backtracking was not implemented. We implemented the pseudo-code provided in the project 4 PDF.

- **What is the efficiency class of your algorithm? Does your empirical data support this efficiency class?**

The efficiency class of our algorithm was $O(n^2)$. The algorithm was implemented very efficiently

And the scatter plot shows a result of $O(n^2)$, however it looks very close to a linear curve but that is due to the efficiency of the algorithm.

- Which of the 4 “real-world” instances were you able to solve? Include the output from the run(s) that you completed successfully.

We were able to solve all 4 “real-world” instances. Below is the output for each of the 4 solved:

```
-----  
n_request=10000, n=8490, total_kcal=1500  
-----
```

knapsack solution:

```
SOUP,BF BROTH BOUILLON & CONSOMME,CND,COND (100 g where each .5 cup is 124 g) kcal=11  
protein=3 g  
GRAVY,CAMPBELL'S,AU JUS (100 g where each .25 cup is 59 g) kcal=8 protein=2 g  
FISH,POLLOCK,ALASKA,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)  
kcal=70 protein=17 g  
FISH,POLLOCK,ALASKA,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)  
kcal=80 protein=19 g  
FISH,COD,PACIFIC,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=72  
protein=18 g  
FISH,COD,PACIFIC,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=84  
protein=20 g  
CRUSTACEANS,SHRIMP,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=85  
protein=20 g  
CRUSTACEANS,SHRIMP,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=99  
protein=24 g  
SOY PROTEIN ISOLATE (100 g where each 1 oz is 28 g) kcal=335 protein=88 g  
SOY PROT ISOLATE,K TYPE (100 g where each 1 oz is 28 g) kcal=321 protein=88 g  
GELATINS,DRY PDR,UNSWTND (100 g where each 1 envelope, (1 tbsp) is 7 g) kcal=335  
protein=86 g  
total kcal=1500 total_protein=385 g  
-----
```

```
elapsed time=20.6798 seconds  
-----
```

```
-----  
n_request=10000, n=8490, total_kcal=2000  
-----
```

knapsack solution:

```
EGG,WHITE,DRIED,STABILIZED,GLUCOSE RED (100 g where each 1 cup, sifted is 107 g)  
kcal=357 protein=84 g  
RUFFED GROUSE,BREAST MEAT,SKINLESS,RAW (100 g where each 4 oz is 113 g) kcal=112  
protein=26 g  
SOUP,BF BROTH BOUILLON & CONSOMME,CND,COND (100 g where each .5 cup is 124 g) kcal=11  
protein=3 g  
SOUP,SWANSON CHICK BROTH 99% FAT FREE (100 g where each 1 serving, 1 cup 8 oz is 227  
g) kcal=4 protein=1 g  
GRAVY,CAMPBELL'S,AU JUS (100 g where each .25 cup is 59 g) kcal=8 protein=2 g  
COWPEAS,LEAFY TIPS,CKD,BLD,DRND,WO/SALT (100 g where each 1 cup, chopped is 53 g)  
kcal=22 protein=5 g  
HADDOCK,COOKED,DRY HEAT (100 g where each 1 fillet is 150 g) kcal=90 protein=20 g  
FISH,POLLOCK,ALASKA,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)  
kcal=70 protein=17 g  
FISH,POLLOCK,ALASKA,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)  
kcal=80 protein=19 g  
FISH,COD,PACIFIC,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=72  
protein=18 g  
FISH,COD,PACIFIC,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=84  
protein=20 g  
CRUSTACEANS,SHRIMP,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=99
```

protein=24 g
SOY PROTEIN ISOLATE (100 g where each 1 oz is 28 g) kcal=335 protein=88 g
SOY PROT ISOLATE,K TYPE (100 g where each 1 oz is 28 g) kcal=321 protein=88 g
GELATINS, DRY PDR, UNSWTND (100 g where each 1 envelope, (1 tbsp) is 7 g) kcal=335
protein=86 g
total kcal=2000 total_protein=501 g

elapsed time=31.048 seconds

n_request=10000, n=8490, total_kcal=2500

knapsack solution:

EGG, WHITE, DRIED, STABILIZED, GLUCOSE RED (100 g where each 1 cup, sifted is 107 g)
kcal=357 protein=84 g
RUFFED GROUSE, BREAST MEAT, SKINLESS, RAW (100 g where each 4 oz is 113 g) kcal=112
protein=26 g
EMU, FAN FILLET, RAW (100 g where each 1 serving, (3 oz) is 85 g) kcal=103 protein=23
g
EMU, OUTSIDE DRUM, RAW (100 g where each 3 oz is 85 g) kcal=103 protein=23 g
TURKEY, RTL PARTS, BREAST, MEAT ONLY, CKD, RSTD (100 g where each 1 breast is 863 g)
kcal=136 protein=30 g
SOUP, BF BROTH BOUILLON & CONSOMME, CND, COND (100 g where each .5 cup is 124 g) kcal=11
protein=3 g
SOUP, SWANSON CHICK BROTH 99% FAT FREE (100 g where each 1 serving, 1 cup 8 oz is 227
g) kcal=4 protein=1 g
GRAVY, CAMPBELL'S, AU JUS (100 g where each .25 cup is 59 g) kcal=8 protein=2 g
COWPEAS, LEAFY TIPS, CKD, BLD, DRND, WO/SALT (100 g where each 1 cup, chopped is 53 g)
kcal=22 protein=5 g
COWPEAS, LEAFY TIPS, CKD, BLD, DRND, W/SALT (100 g where each 1 cup, chopped is 53 g)
kcal=22 protein=5 g
FISH, POLLOCK, ALASKA, RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)
kcal=70 protein=17 g
FISH, POLLOCK, ALASKA, CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)
kcal=80 protein=19 g
FISH, COD, PACIFIC, RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=72
protein=18 g
FISH, COD, PACIFIC, CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=84
protein=20 g
CRUSTACEANS, SHRIMP, RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=85
protein=20 g
CRUSTACEANS, SHRIMP, CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=99
protein=24 g
SOY PROTEIN ISOLATE (100 g where each 1 oz is 28 g) kcal=335 protein=88 g
SOY PROT ISOLATE,K TYPE (100 g where each 1 oz is 28 g) kcal=321 protein=88 g
GELATINS, DRY PDR, UNSWTND (100 g where each 1 envelope, (1 tbsp) is 7 g) kcal=335
protein=86 g
CHEESE, MOZZARELLA, NON-FAT (100 g where each 1 cup, shredded is 113 g) kcal=141
protein=32 g
total kcal=2500 total_protein=614 g

elapsed time=44.1327 seconds

n_request=10000, n=8490, total_kcal=4209

knapsack solution:

EGG, WHITE, DRIED, STABILIZED, GLUCOSE RED (100 g where each 1 cup, sifted is 107 g)
kcal=357 protein=84 g
CHEESE, SWISS, NONFAT OR FAT FREE (100 g where each 1 serving is 28 g) kcal=127
protein=28 g
RUFFED GROUSE, BREAST MEAT, SKINLESS, RAW (100 g where each 4 oz is 113 g) kcal=112

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protein=26 g
EMU,FAN FILLET,RAW (100 g where each 1 serving, ( 3 oz ) is 85 g) kcal=103 protein=23
g
EMU,OUTSIDE DRUM,RAW (100 g where each 3 oz is 85 g) kcal=103 protein=23 g
TURKEY,RTL PARTS,BREAST,MEAT ONLY,CKD,RSTD (100 g where each 1 breast is 863 g)
kcal=136 protein=30 g
TURKEY,DRUMSTK,FROM WHL BIRD,MEAT ONLY,RAW (100 g where each 3 oz is 85 g) kcal=109
protein=24 g
SOUP,BF BROTH BOUILLON & CONSOMME,CND,COND (100 g where each .5 cup is 124 g) kcal=11
protein=3 g
SOUP,SWANSON CHICK BROTH 99% FAT FREE (100 g where each 1 serving, 1 cup 8 oz is 227
g) kcal=4 protein=1 g
GRAVY,CAMPBELL'S,AU JUS (100 g where each .25 cup is 59 g) kcal=8 protein=2 g
TURKEY,BREAST,SMOKED,LEMON PEPPER FLAVOR,97% FAT-FREE (100 g where each 1 slice is 28
g) kcal=95 protein=21 g
COWPEAS,LEAFY TIPS,CKD,BLD,DRND,W/SALT (100 g where each 1 cup, chopped is 53 g)
kcal=22 protein=5 g
COWPEAS,LEAFY TIPS,CKD,BLD,DRND,W/SALT (100 g where each 1 cup, chopped is 53 g)
kcal=22 protein=5 g
BEVERAGES,PROT PDR WHEY BSD (100 g where each .33 cup is 32 g) kcal=352 protein=78 g
COD,ATLANTIC,RAW (100 g where each 3 oz is 85 g) kcal=82 protein=18 g
FISH,MAHIMAH,RAW (100 g where each 3 oz is 85 g) kcal=85 protein=19 g
HADDOCK,COOKED,DRY HEAT (100 g where each 1 fillet is 150 g) kcal=90 protein=20 g
PIKE,NORTHERN,CKD,DRY HEAT (100 g where each 3 oz is 85 g) kcal=113 protein=25 g
FISH,TUNA,LT,CND IN H2O,DRND SOL (100 g where each 1 oz is 28 g) kcal=86 protein=19 g
LOBSTER,NORTHERN,RAW (100 g where each 1 lobster is 150 g) kcal=77 protein=17 g
TUNA,LT,CND IN H2O,W/SALT,DRND SOL (100 g where each 3 oz is 85 g) kcal=116
protein=26 g
FISH,COD,PACIFIC,CKD,DRY HEAT (MAYBE PREVIOUSLY FROZEN) (100 g where each 1 fillet is
90 g) kcal=85 protein=19 g
TUNA,YELLOWFIN,FRSH,CKD,DRY HEAT (100 g where each 3 oz is 85 g) kcal=130 protein=29 g
FISH,POLLOCK,ALASKA,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)
kcal=70 protein=17 g
FISH,POLLOCK,ALASKA,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g)
kcal=80 protein=19 g
FISH,COD,PACIFIC,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=72
protein=18 g
FISH,COD,PACIFIC,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=84
protein=20 g
CRUSTACEANS,SHRIMP,RAW (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=85
protein=20 g
CRUSTACEANS,SHRIMP,CKD (NOT PREVIOUSLY FROZEN) (100 g where each 3 oz is 85 g) kcal=99
protein=24 g
SOY PROTEIN ISOLATE (100 g where each 1 oz is 28 g) kcal=335 protein=88 g
SOY PROT ISOLATE,K TYPE (100 g where each 1 oz is 28 g) kcal=321 protein=88 g
GELATINS,DRY PDR,UNSWTND (100 g where each 1 envelope, (1 tbsp) is 7 g) kcal=335
protein=86 g
CHEESE,MOZZARELLA,NON-FAT (100 g where each 1 cup, shredded is 113 g) kcal=141
protein=32 g
FROG LEGS,RAW (100 g where each 1 leg is 45 g) kcal=73 protein=16 g
TURTLE,GREEN,RAW (100 g where each 3 oz is 85 g) kcal=89 protein=20 g
total kcal=4209 total_protein=993 g
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elapsed time=106.03 seconds
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```

- What measures, if any, did you take to help your code solve more real-world problems?

We did not take any additional measures to help us solve more real-world problems. We implemented the pseudo-code provided in the project and were able to solve all four “real-world” problems without any issues at all.

- **Did you find implementing this algorithm to be easy, difficult, or in between? What was the hardest part, and why? How does the difficulty level compare to the two algorithms from project 2?**

Initially understanding how the algorithm worked took quite a few hours. We ended up dissecting each line and analyzing how everything worked step by step, which led us to a complete understanding of how to implement the algorithm. The hardest part was getting the indexes working correctly. We had a lot of out of bounds issues and segmentation faults as we worked through solving it. The difficulty was much more for project 4 when compared to project 2.

- **How does the performance of this algorithm compare to the exhaustive search algorithm from project 2? Would the exhaustive algorithm be faster, or slower, for the real-world problems? Do you think this dynamic programming algorithm is more useful in practice than the exhaustive algorithm?**

The performance of this algorithm is much better. It is significantly faster than the exhaustive search algorithm from project 2. The exhaustive search would be slower by a massive factor for the real-world problems. Yes, we think this dynamic programming algorithm is more useful in practice than the exhaustive search.