

Artificial Intelligence Fundamentals

Project:

Evolutionary algorithm for solving the Knapsack Problem

Aleksander Kuśmierczyk

Mikołaj Słoń

Mateusz Szperna

Kornel Żaba

Computer Science

22 March 2017

|  |  |  |
| --- | --- | --- |
| **Date** | **Author of change** | **Description** |
| 22.03.2017 | Mikołaj Słoń | Created documentation file |
| 22.03.2017 | Kornel Żaba | Added problem description |
| 23.03.2017 | Mateusz Szperna | Added existing solutions |
| 29.03.2017 | Aleksander Kuśmierczyk | Added detailed solution |
| 13.04.2017 | Mikołaj Słoń | Implemented Evolve logic |
| 13.04.2017 | Kornel Żaba | Implemented mutation and crossover |
| 21.04.2017 | Mateusz Szperna | Added interface design |
| 11.05.2017 | Kornel Żaba | Implemented fitness function |
| 11.05.2017 | Aleksander Kuśmierczyk | Added dataset handling and fixed player creation |
| 18.05.2017 | Mateusz Szperna | Implemented interface |
| 24.05.2017 | Mikołaj Słoń | Connected interface and logic |
| 24.05.2017 | Mateusz Szperna | Implemented bindings |
| 01.06.2017 | Mikołaj Słoń | Added video and minor fixes |
| 06.06.2017 | Kornel Żaba | Added presentation |
| 06.06.2017 | Aleksander Kuśmierczyk | Updated documentation |
| 13.06.2017 | Mateusz Szperna | Improved interface |

Table of Contents

1. Description of a problem..…………………………………………......4

2. An analysis of a problem...……………………………………...…….5

3. Some existing solutions.……………………………………………....6

4. Description of a preferred solution……………………………………8

5. Some implementation problems……………………………………...9

6. End results of the application………………………………………..10

7. Conclusion……………………………………………………………..10

### **1.** **Description of a problem**

The aim of our project is to provide a solution to so called ‘**Knapsack Problem’**. If we have a set of items, each with a weight and a value, determine the number of each item to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible (Figure 1.).

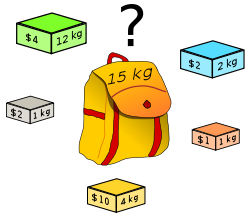


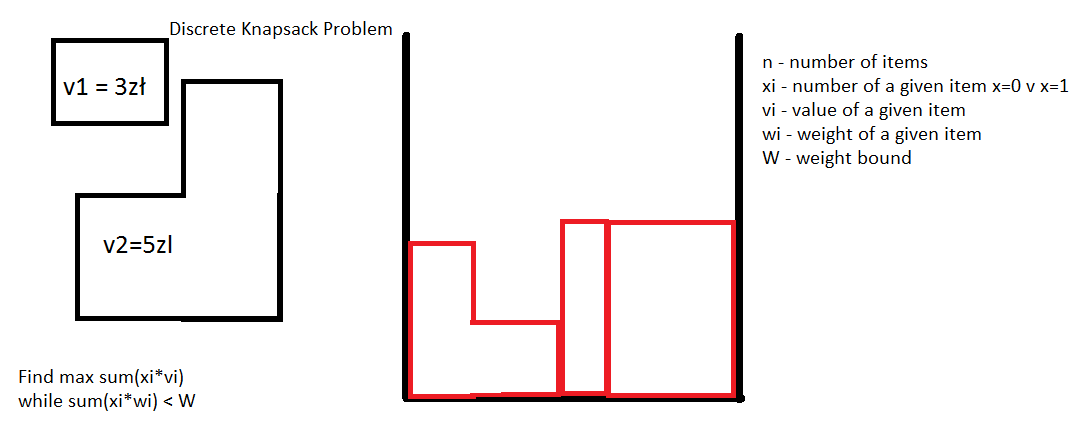
Figure 1. Visualization od Knapsack Problem

### **2.** **An analysis of a problem**

Our project will discuss the **0-1 Knapsack Problem**. In which the number *xi* of copies of each kind of item is restricted to zero or one. Given a set of *n* items numbered from *1* up to *n*, each with a weight *wi* and a value *vi*, along with a maximum weight capacity *W.*

Our goal will be:

Maximize while and



### **3.** **Some existing solutions**

Naive solution

int knapSack(int W, int wt[], int val[], int n)

{

int i, w;

int K[n+1][W+1];

// Build table K[][] in bottom up manner

for (i = 0; i <= n; i++)

{

for (w = 0; w <= W; w++)

{

if (i==0 || w==0)

K[i][w] = 0;

else if (wt[i-1] <= w)

K[i][w] = max(val[i-1] + K[i-1][w-wt[i-1]], K[i-1][w]);

else

K[i][w] = K[i-1][w];

}

}

return K[n][W];

}

Improved solution using Dynamic programming

// Returns the maximum value that can be put in a knapsack of capacity W

int knapSack(int W, int wt[], int val[], int n)

{

// Base Case

if (n == 0 || W == 0)

return 0;

// If weight of the nth item is more than Knapsack capacity W, then

// this item cannot be included in the optimal solution

if (wt[n-1] > W)

return knapSack(W, wt, val, n-1);

// Return the maximum of two cases:

// (1) nth item included

// (2) not included

else return max( val[n-1] + knapSack(W-wt[n-1], wt, val, n-1),

knapSack(W, wt, val, n-1)

);

}

All existing solutions presented here are taken from the article **“Dynamic Programming ( 0-1 Knapsack Problem)”** on the website www.geeksforgeeks.org.

“

**An idea for solving it using evolutionary algorithm.**

* We create a set of random items with sum of weights less than W. We will call this set teams.
* We define a team as good if the sum of values of its elements is high.
* Each of the teams should be able to mutate. Mutation is used to randomly shake up some teams. This prevents us from getting stuck at a local maximum.
* We should be able to breed. A function that takes two teams and creates a better one.
* At each iteration of the algorithm Weakest teams will be discarded and strongest ones bread
* At each iteration we randomly add other individuals to promote genetic diversity.

This solution gets better results the more iterations we make.

### **4.** **Description of preferred solution**

We have chosen **C#** programming language for development of our project, as the whole group has already had experience with it, additionally it provides useful functionalities. As our project is focused on solving the problem rather than visualizing it, our presentation layer will not include additional frameworks. Main IDE for the project is set to be **Visual Studio 2015**. It is a very powerful C# development environment, with integrated **Visual Studio Unit Testing Framework**, that will be used for testing phase of the project.

As we chose the Evolutionary approach, the solutions of the initial problem will take the role of the candidate solutions and subsequent computations using the fitness function and with the application of some random changes will gradually evolve the population reaching the optimal solution.

Our problem is to be data driven therefore we will use the pre prepared player datasets available at (for testing).Testing and running the program shall be performed using this sample, as it provide all necessary data for our problem. Additionally we will use a random knapsack problem generator (self implemented) for the sake of testing. The results will be compared with the expected ones.

Project will be structured into 3 distinctive parts:

1. Back-end application:

* back-end functionalities.

1. Front-end application:

* User friendly interface.
* Adjustable settings.

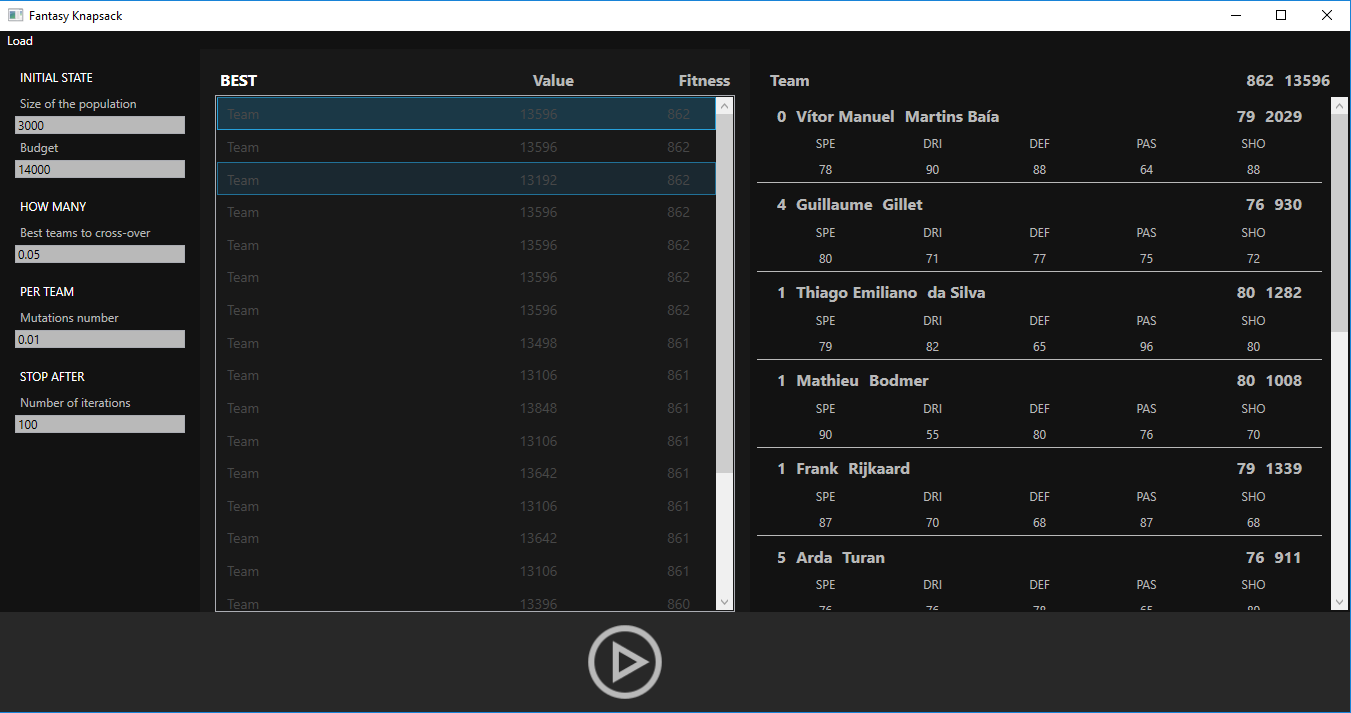
1. Evolutionary algorithm for Knapsack problem.

* Problem is adjusted to create the best soccer team within the budget constraints.

1) All of the backend functionalities are accessible through the code manipulation, as most of them are already strapped into the user interface operating in the program. Some of them are: Use of the random sample, change the number of players, modification of weighting algorithm.

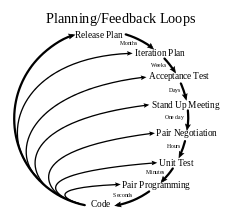
2)User friendly interface provides the simple and intuitive panels and controls in order to adjust the problem to the needs. Player database is imported from the .csv file in the directory and transformed for our needs in order to support the running of the program. The number of iterations as well as the population of teams is also possible to adjust through the user interface.

3) The approach we took in order to solve this problem was the evolutionary approach, therefore we allow to set both the mutation and crossover rate between the teams created randomly. When finished the program will return the “winning” team meaning the team with the best average score of the players on their respective roles (all weighted differently) and with the cumulative price (of players) within the budget constraints. All of the players are split into the categories – Goalkeeper, defense, midfield, attack. All of the respective roles have different weighting function determining their fitness.



Screenshot of the Fantasy Knapsack program running.

### **5.** **Some implementation problems**

To avoid implementation problems we chose the extreme programming approach.

Workflow represented by extreme programming methodology.

During the implementation we have encountered the following problems:

* Integration of User interface with the backend algorithm
* Initial design of the application had minor flaws
* We didn’t make satisfactory number of unit tests.
* Adaptation of player statistics to our problem has proven difficult due to the share number of them.
* Adjusting the weighting function for the algorithm.

### **6.** **End results of the application.**

Screenshot of the running application listing the best team achieved with 200 iterations, mutation rate of 0.01, cross-over rate of 0.05 budget of 12000 and the initial population of 3000.

### **7.** **Conclusion**

With the application as the end result of this project we have achieved a usable tool that can be used for the “fantasy league” championships. Such possibility gives not only interesting conclusions about the creation of football teams but also allows the user to compete with other players in the “fantasy league” for monetary rewards. Further expansion of the algorithm may improve the results by reducing the speed of the computation as well as the better adjustment of the program to the real life sports matches scores.