IT426: ARTIFICIAL INTELLIGENCE SYSTEMS
INFORMATION TECHNOLOGY DEPARTMENT

PROJECT PHASE 2

ASSIGNED: MAR. 22ND 2021
DUE: APRIL 11TH 2021 @ 12:00 PM

SmartDiet: a GA-Based Solution for Optimal Meal Plans.

RULES:

1. You are allowed to work on this assignment in a group of three.
2. The project is supposed to encourage you to read more on the topic taught in class.

You are a CEO of an AI company which builds and sells AI software to different types of clients. A client of yours is Sarah, a dietitian who helps people build customized healthy meal plans that fits their body and preference. Sarah told you that it takes her a long time to build meal plans for her customers since it varies according to the customer *weight, height, age, gender, and food preference*. So, she decided to reach out to your company to see if AI can make her job easier. You told her that she is lucky since this is a common AI problem, known as optimization, and you can help her by building a Genetic algorithm solution.

The code should work as follows; the user enters weight in kg, height in cm, gender, age, and food preference (options include: vegetarian/non-vegetarian). Your GA will then run to find the best dish(es) for each meal (breakfast, lunch, dinner, snack) in the meal plan that maximize your fitness function and output the complete plan. Each main meal (breakfast, lunch, dinner) in the plan may contain minimum one dish and maximum three dishes, while the snack may contain no items or up two items. Further, the meal plan must be balanced such that the calories are distributed among the meals. For instance, below are examples of balanced and unbalanced meal plans.

Balanced plan:
Breakfast: Egg and steak Sandwich (371 Cal)
Lunch: Veggie Quinoa Salad (200 Cal), Chicken Biryani (350 Cal), Carrot and lentil soup (174 Cal)
Dinner: Chicken, Avocado & Red Pepper Pizza (350 Cal), Pesto Pasta Salad (280 Cal)
Snack: A bag of Popcorn (100 Cal)

Unbalanced plan:
Breakfast: Egg and steak Sandwich (371 Cal), Sausage and egg wrap (300 Cal), Buttermilk Pancake (230 Cal)
Lunch: Veggie Quinoa Salad (200 Cal)

Dinner: Chicken, Avocado & Red Pepper Pizza (350 Cal)
Snack: None

To calculate the total number of the needed calories per day: first, you will need to take the gender, height, weight and age from the user. Then, apply the following formulas which will compute the maximum calories per day based on gender type. Finally, your GA will generate a meal plan which must not exceed the maximum allowed calories per day. For example, based on the given formulas, the total calories in the generated daily meal plane for a **31years** old woman with **170cm** height and **75kg** weight shouldn't be over 1634.65 calories.

For men: 66 + (6.2 x weight) + (12.7 x height) – (6.76 x age)

For women: 655.1 + (4.35 x weight) + (4.7 x height) – (4.7 x age)

Your fitness function includes two parameters; total number of calories and food preference, which are equally important. Your fitness function can be designed as *weighted sum* and importance of factors can be encoded as weights w_i in the fitness function, where $\Sigma\, w_i = 1$. Please note that your fitness function value should usually be in the range [0,1], but some solutions (meal plans) may have a value > 1 if the meals total calories is over the suggested calories for the entered input. The optimal meal plan has a fitness value <= 1. Below is sample of the input and output of SmartDiet.

Sample Input/Output of SmartDiet:

```
Welcome to SmartDiet! What is your name?

Muna

Hi Muna! Please enter your weight in kg.

75

Please enter your height in cm.

170

Please enter your age

31

Please enter your gender (M/F)

F

Please enter your food preference (v for vegetarian and nv for non-vegetarian)

Nv

Your maximum allowed calories per day is 1634.65 calories.

We are working on preparing your optimal meal plan. . .
```

Your meal plan is ready! Your plan is presented below with 1545 calories per day.(PS to students: This is a manually-generated plan for illustration for this project)

Breakfast: Egg and steak Sandwich (371 Cal)

Lunch: Veggie Quinoa Salad (200 Cal), Chicken Biryani (350 Cal), Carrot and lentil soup (174 Cal)

Dinner: Chicken, Avocado & Red Pepper Pizza (350 Cal)

Snack: A bag of Popcorn (100 Cal)

Hope you enjoy it!

	Dish	Calories	Category
Breakfast Menu			
1	Buttermilk Pancake	230 Cal	vegetarian
2	Omelette	150 Cal	vegetarian
3	Mixed berries and Greek yogurt	100 Cal	vegetarian
4	Egg & Avocado on Toast	300 Cal	vegetarian
5	Beans on Toast	97 Cal	vegetarian
6	Scrambled egg and mushrooms	91 Cal	vegetarian
7	Banana and honey	99 Cal	vegetarian
8	Egg & steak Sandwich	371 Cal	Non-vegetarian
9	Smoked Salmon Cucumber Wraps	170 Cal	Non-vegetarian
10	Sausage and egg wrap	300 Cal	Non-vegetarian
Lunch Menu			
1	Grilled Salmon Fillet	360 Cal	Non-vegetarian
2	Chicken Biryani	350 Cal	Non-vegetarian
3	Chicken Fajita Wrap	520 Cal	Non-vegetarian
4	Noodles with Prawns	280 Cal	Non-vegetarian
5	Tuna and Chickpea Pita Sandwiches	381 Cal	Non-vegetarian
6	Carrot and lentil soup	174 Cal	vegetarian/ Non-vegetarian
7	Spaghetti with lentil Bolognese	420 Cal	vegetarian
8	Vegetarian noodles with miso	300 Cal	vegetarian

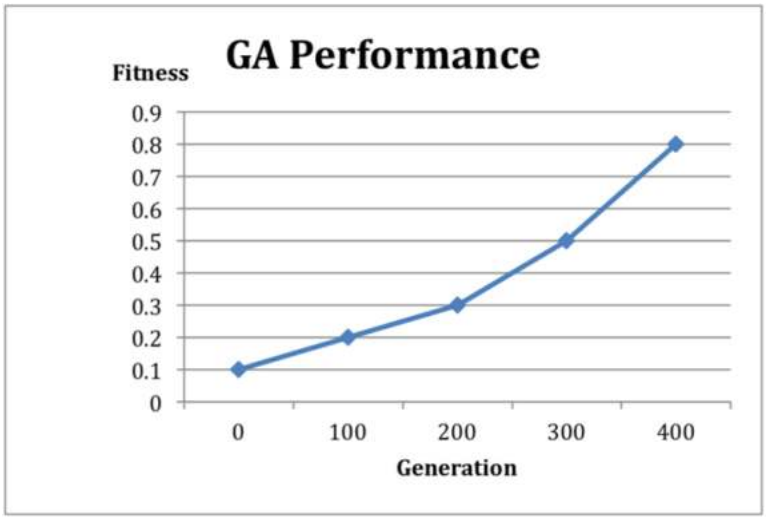
9	Sweet potato curry	344 Cal	vegetarian
10	Vegetable biryani with cauliflower	310 Cal	vegetarian
11	Veggie Quinoa Salad	200 Cal	Vegetarian/ Non-vegetarian
Dinner Menu			
1	Beef Burger	540 Cal	Non-vegetarian
2	Chicken Caesar Salad	230 Cal	Non-vegetarian
3	Grilled Chicken & Hummus Sandwich	400 Cal	Non-vegetarian
4	Chicken, Avocado & Red Pepper Pizza	350 Cal	Non-vegetarian
5	Grilled Halloumi Melt with Pesto & Sun-Dried Tomato	380 Cal	vegetarian
6	Pesto Pasta Salad	280 Cal	vegetarian
7	Turkey Meatball wrap	400 Cal	Non-vegetarian
8	Veggie Quinoa Salad	200 Cal	Vegetarian/ Non-vegetarian
9	Shrimp Tempura Rolls	500 Cal	Non-vegetarian
10	Macaroni and cheese	257 Cal	vegetarian
Snack Menu			
1	Strawberry Cupcake	240 Cal	vegetarian
2	Cheesecake slice	510 Cal	vegetarian
3	Edamame	200 Cal	vegetarian
4	Milk chocolate bar	100 Cal	vegetarian
5	A Cup of granola	200 Cal	vegetarian
6	A Cup of raisins	100 Cal	vegetarian
7	5 pieces of Dates	250 Cal	vegetarian
8	A bag of Popcorn	100 Cal	vegetarian
9	Tortilla Chips with Salsa	100 Cal	vegetarian
10	Cup of nuts	215 Cal	Vegetarian
11	5 Prawns Crackers	500	Non-vegetarian
12	5 Fish Fingers	250	Non-vegetarian
13	2 pieces Beef Samosa	300	Non-vegetarian
14	5 Crumb Fried Prawns	500	Non-vegetarian
15	Chicken Pie Slice	300	Non-vegetarian

Phase 1 deliverables:

1. Written: solution representation and fitness function
2. Code (a language of your choice): Search space (table above), Create_Initial_Population() function, and Compute_Fitness() function.

Phase 2 deliverables:

1. Python Code of the whole project.
2. Report, which consists explanation of:
    a. Solution representation.
    b. Fitness function.
    c. Genetic operators:
        i. Crossover.
        ii. Mutation.
        iii. Selection by roulette wheel selection (See below).
        iv. Replacement.
    d. Termination condition
    e. Result: Graph of GA performance containing the generation vs fitness function as shown in the figure below for each combination of parameter setting in the table below (Total of 3^3 combinations). Your report should have nine graphs.
    f. Analysis of your results: Analyze your nine graphs (similar to the one below). Explain which parameter combination/graph gives the best solution and explain the solution itself.



Experimental Settings:

1. Runs: Run your GA 20 times and report the average fitness.
2. Initialize your first generation randomly in the search range.

GA Parameter	Value	Number of combinations to try
Population size	variable (multiples of 10)	3
Selection method	Roulette wheel selection	-
Crossover type	Random one point	-
Crossover rate, c	Variable 0<c<1, the higher the better	3
Mutation rate, m	Variable 0<m<1 The lower the better	3
Termination Condition	1. Try different conditions and choose the best. For example, terminate when the error value is less than 10^{-8}, or after 20000 generations. (The error value is the difference between the objective function value and the optimal solution)	-

Helpful links (Please do your own research too):

GA Explanation:

http://www.cs.ucc.ie/~dgb/courses/tai/notes/handout12.pdf
https://www.doc.ic.ac.uk/~nd/surprise_96/journal/vol1/hmw/article1.html
https://www.slideshare.net/pbpimpale/genetic-algorithms-200688

Roulette wheel Selection:

https://en.wikipedia.org/wiki/Fitness_proportionate_selection
http://www.edc.ncl.ac.uk/highlight/rhjanuary2007g02.php
https://www.youtube.com/watch?v=9JzFcGdpT8E