Introduction to Programming (NF06A)
— **Project** 2022-2023 —

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Portfolio optimization

Instructions

- Work in binome.
- Code + executable files are to be uploaded in the project folder of the TD group in which you will make your presentation. Think about indicating both names.
- The presentation (power point + execution) will take place during the tutorial session.
- The code will have to be fully commented. To do this, you must use the Doxygen tool [1] to manage the documentation.
- Recommendations: The C language is very informative on the internet, do a search before contacting a friend or a professor.
- It is not allowed to take a code from someone otherwise you could be sanctioned.

Required Work

Portfolio optimization is a well-known problem in finance that aims to help investors make decisions on how to allocate their funds across different investment options in order to maximize returns while minimizing risks. In this project, the aim is to design an application that will help the investor solve the portfolio optimization problem for a given set of investment options.

The first step in solving the portfolio optimization problem is to gather data on the potential investment options. This data may include information on historical returns, risks, and correlations between different investment options. The data will be given to the application using an Excel file that should be read in Python. The Excel file must contain all the data necessary to optimize the investor's portfolio.

To illustrate, we take the following example. Suppose an investor has a budget of $1,000,000 to invest in a portfolio consisting of three investment options: stocks, bonds, and commodities. The investor is looking to maximize the expected return on the portfolio while minimizing the risk.

The expected returns and risks for each investment option are as follows:

- Stocks: Expected return of 10% and a risk level of 20%
- Bonds: Expected return of 5% and a risk level of 10%
- Commodities: Expected return of 15% and a risk level of 30%

[1] www.doxygen.org

To solve this portfolio optimization problem, we need to specify the objective function and constraints. The objective function is to maximize the expected return on the portfolio, subject to the following constraints:

- Budget constraint: The total amount invested in the portfolio must not exceed the budget of $1,000,000.
- Investment constraint: The investor must invest a minimum of 20% and a maximum of 50% of the portfolio in stocks, a minimum of 30% and a maximum of 60% in bonds, and a minimum of 10% and a maximum of 40% in commodities.
- Risk constraint: The portfolio must not have a risk level exceeding 25%.
- Return constraint: The portfolio must have an expected return of at least 8%.

The data and the constraints given in the example can be changed. The investor has the possibility to change the risk they take, the amount of money they invest and the options they can invest in.

The optimization algorithm (to be implemented in C) will take the constraints into account and determine the optimal allocation of investments in the portfolio that satisfies the constraints and maximizes the expected return on the portfolio. The Python interface will allow users to input their investment preferences and constraints, and view the optimized portfolio allocation and relevant investment metrics.

Your goal is to build an application that will help the investor to find the best portfolio for their investment. Your application must have the following features:

1. Read data of the problem from an Excel file. All data should be in one file (use sheets for modularity).
2. Allow the user to modify their data if needed
3. Solve the problem using any known algorithm for portfolio optimization
4. Display the solution to the investor

C and Python code separation

1. Data structures used to represent the problem must also be created in C and Python
2. Algorithms and heuristics used to solve the problem must be coded in C (as procedures or functions) (feature 3)
3. All the other features (1, 2 and 4) must be done in Python

4. Once a solution (or multiple solutions are obtained using heuristics), display data analysis about the different solutions (e.g. best option in which one should invest, etc.). Use your creativity to propose statistical analysis

5. Graphical interfaces in Python are a plus

6. Interactions between the C and Python must be done using files or existing libraries for the purpose (Ctypes preferably but other libraries are also accepted)