Decision makers often have to consider multiple criteria, possibly conflicting ones at once, when choosing a solution to a problem. For example, to reach an optimal design of an aircraft, engineers need to satisfy multiple objectives such as maximising passenger volume and cruise speed, and at the same time minimising fuel consumption and lifecycle cost. Trying to satisfy these objectives can result in a potentially large number of candidate solutions to be considered. Within this solution space, there exists a set of nondominated solutions, known as a pareto frontier (e.g. Figure 1), where no objective can be improved without sacrificing at least one other objective (tradeoff). Visualizing pareto solutions for more than three objectives has long been a significant challenge for multi-objective optimization problems. The classical approach attempts to transform the multidimensional problem so that it can be mapped to a 2D or 3D visual space. One of the best-known methods within this category is the scatter plot matrix, where all the bivariate projections of the solution space are presented in a table.

**Description:**

Decision makers often have to consider multiple criteria, possibly conflicting ones at once, when choosing a solution to a problem. For example, to reach an optimal design of an aircraft, engineers need to satisfy multiple objectives such as maximising passenger volume and cruise speed, and at the same time minimising fuel consumption and lifecycle cost. Trying to satisfy these objectives can result in a potentially large number of candidate solutions to be considered. Within this solution space, there exists a set of nondominated solutions, known as a pareto frontier (e.g.
Figure 1), where no objective can be improved without sacrificing at least one other objective (tradeoff).

Visualizing pareto solutions for more than three objectives has long been a significant challenge for multi-objective optimization problems. The classical approach attempts to transform the multidimensional problem so that it can be mapped to a 2D or 3D visual space. One of the best-known methods within this category is the scatter plot matrix, where all the bivariate projections of the solution space are presented in a table.

The aim of this project is to design and implement novel visual-interactive techniques to facilitate and guide users in the exploration of multi-objective pareto frontiers using scatterplot matrices. The proposed methods could be various “constrained” brushing and linking techniques of 2D regions of interests with smooth transitions between them, in order to allow easy comparison of alternative trade-off scenarios. The student will have the opportunity to work on real datasets from live sciences and work with domain experts.

Figure 1: Example of a Pareto frontier [1]. The boxed points represent feasible choices, and smaller values are preferred to larger ones. Point C is not on the Pareto Frontier because it is dominated by both point A and point B. Points A and B are not strictly dominated by any other, and hence do lie on the frontier.

**Objectives:**

- Requirement analysis from recorded videos and meetings with domain experts: we have video recordings showing domain experts collaboratively exploring the results of a multi-objective optimisation model for a wine dataset. The experts used a multidimensional visualization tool [2] based on a scatterplot matrix and simple lasso selections. These videos can be used to extract design requirements. Meetings with experts (biologists and agronomists from INRA) could be envisaged for further design requirements analysis and evaluation.

- Design and development of interactive visualization techniques for pareto frontiers exploration using linked 2D scatterplots: to design interactive visualization techniques to support the tasks and exploration strategies identified in the requirements analysis (i.e. with the overall aim to improve the exploration of tradeoffs between multiple objectives).

**Requirements:**

- Good programming skills (Java, C++ and/or Matlab)
- Interest and/or experience in multi-objective optimisation is a plus but not required.

**Location:**
The successful candidate will work at INRA (UMR GMPA, Grignon centre). Part-time work at Universite Paris-Sud can also be arranged.

**Supervision:**

INRA: Nadia Boukhelifa nadia.boukhelifa@inra.fr, Evelyne Lutton evelyne.lutton@inra.fr

Universite Paris-Sud: Anastasia Bezerianos anastasia.bezerianos@lri.fr

**References**
