Xavier Rixhon's PhD thesis - Answers to jury members

Exploration of uncertainty-aware energy transition pathways - Reinforcement learning and principal component analysis-based methods

I would like to thank the jury members for the comments, which significantly helped improving the manuscript and substantiating the novelty of my work. Based on the notes taken during the private defense, I hereby transcribed, as accurately as possible, the jury's comments.

I believe I have addressed all the issues raised in the following answers. Some of them required adaptations of the text. These adaptations are either directly in the thesis manuscript or left for further developments in subsequent papers. For each comment, I have first highlighted the issue, then provided an answer, and finally described how the manuscript was adjusted, if needed.

When a comment explicitly came from specific members of the jury, they are listed at the beginning of the comment with the following color code: **Stefano** Moret, **Stefan** Pfenninger, **Sylvain** Quoilin and **Christophe** De Vleeschouwer. Here is how an answer to a comment is structured:

> Text of the comment.

The answer provided to the comment and, based on this, where the potential modification brought to the manuscript is located in the thesis manuscript using blue font.

New version of the text in the manuscript.

INTRODUCTION

LITERATURE REVIEW

REINFORCEMENT LEARNING

BINDING

> **Christophe** - The concept of binding constraint was not clear.

Besides the information given in Section 4.2.3 of the manuscript (and reminded here below), I do not see further explanations that could clarify the concept of binding constraint in a Linear Programming (LP) problem. Consequently, regarding this comment, there has not been further modification brought to the manuscript.

To identify the actions that have an actual impact on the environment, we can check if they are binding or not. In a LP problem, constraints represent hyperplanes in the domain of variables. In a two-dimension space, these are straight lines (see Figure 1). When the problem is bounded and feasible, these lines are the edges of a convex polygon: the domain of feasibility. The optimal solution, $\mathbf{x}^*$, is the combination of variables leading to the optimal value of the objective function. Besides being within the domain of feasibility, it is proven that this optimal solution, when unique[a], locates on a vertex of the domain [1]. The constraints intersecting at this vertex are considered as binding, actually limiting the objective function to be more optimal. In other words, binding constraints, when tightened, aggravate the objective value function. If these are inequality constraints, as represented in Figure 1, it means that their left and right sides of the equation are equal.

[a]There are cases where the objective function has the same optimal value along an entire edge. In this case, there is an infinity of solutions and the problem is indeterminate.

PRINCIPAL COMPONENT ANALYSIS

CONFUSION WITH THE WORD PC

> **Christophe** When using the word "component", there seems to be a confusion and it is not always easy to understand if you refer to the vector or the coefficient related to one of the original variable.

The confusion probably comes from the fact a Principal Component (PC) actually represents an eigenvector of the covariance matrix. This vector is, by definition, composed of **components**, each of them being a coefficient related to a specific original
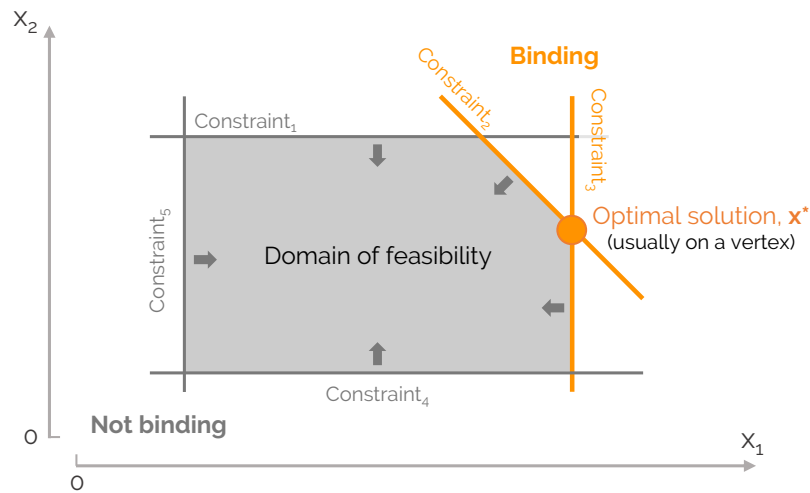
Figure 1: Binding versus non-binding constraints. In LP where the feasibility domain is non-empty and bounded, the constraints defined a convex feasibility domain in the space of variables (here, x_1 and x_2). The optimal solution usually locates on a vertex of this domain, i.e., the intersection of several constraints (here, constraints 2 and 3) limiting the solution. These constraints are considered as binding, i.e., having a limiting impact on the optimal solution.

variable. Here below are listed the parts where there could have been misleading confusion and, potentially, modifications have been brought to the manuscript:

End of second paragraph of section 1.4.1 - no modification:

Moreover, this means that α_{ki}, i.e., the **component** of α_k related to the ith original variable, x_i, gives its weight in the kth PC, i.e., z_k.

BIBLIOGRAPHY

[1]   D. Bertsimas, J. N. Tsitsiklis, Introduction to linear optimization, volume 6, Athena Scientific Belmont, MA, 1997.