Thesis subject: Research on max-min or min-max solutions for algorithmic problems

Location: Laboratoire LAMSAD, université Paris-Dauphine, Paris, France

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Description of the subject:
This thesis is about the so-called ”difficult” combinatorial optimization problems, in which, given an input instance, the goal is to find an optimal solution. However, under widely accepted complexity assumptions (such as $P \neq NP$), it is impossible to decide an exact solution in polynomial number of steps, where the polynomial function depends on the size of the input instance. Nonetheless, it is important to solve those difficult problems and thus, to have an approach to circumvent intractability. The approaches pursued in this thesis will be:

- Approximate guarantee of performance. If it is unlikely to have an exact polynomial algorithm for such problem, it make sense to search for an approximate solution, in polynomial time, whose gap with an optimal solution can be bounded.

- Parameterized complexity. While calculating an exact (optimal) solution would take exponential time, it might be possible to constrain the exponential part of the running time to depend solely on a parameter which is smaller than the size of the input instance.

- Restricting the instances. Even if the problem is intractable in general, there might be a restricted class of instances which become amenable to a polynomial algorithm.

In this thesis, we will focus on classic problems in theoretical computer science such as Maximum Independent Set, Knapsack, Minimum Dominating Set. The originality of our subject lies in the characteristic of a desired solution. For maximization problems, we shall ask for a maximal solution of minimum size, that is a smallest-sized one among all solutions that can not be extended. For example, in the graph depicted in Figure 1, a maximum independent set is of size 2 (with vertices $a$ and $c$), but a maximal independent set of minimum size is size 1, consisting of $b$. It is impossible to extend this solution by adding a vertex while preserving the independence of the set. Note that the independent set consisting of $a$ has size 1, but it is not maximal because you can add $c$ and still keep the set independent. For minimization problems, the solution characteristic can be defined analogously: here, one seeks a minimal solution of maximum size.

Figure 1: Example of a graph with 3 vertices.
This line of research was not studied much in the literature. A few results are known for some graph problems such as Independent Set, Edge Dominating Set or Vertex Cover \[1, 3, 7, 8\] or for scheduling problems \[2, 4, 5, 1, 6\].

References


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- A full-time temporary appointment for a period of 3 years;
- A salary (after social/health insurance deductions) of €1635 per month for 3 years. The doctoral student will be employed as a researcher;
- Support for your personal development and career planning including courses, summer schools, conference visits etc.;
- A research position in an enthusiastic and internationally renowned research group;
Requirements:
The candidates shall satisfy the following requirements:

- Master’s degree in mathematics or computer science, ideally with specialization in algorithms, combinatorial optimization or another relevant area.
- Excellent knowledge in Complexity Theory, Approximation Algorithms, Graph theory.
- Good English skills (writing and speaking). Knowledge of French is welcome because the successful applicant should ensure lectures in English or French.

Application:
Applications, including any attachments, should be submitted by the 23 of May to the following emails: jerome.monnot@dauphine.fr or eunjungkim78@gmail.com or florian.sikora@dauphine.fr.

The following documents must be attached to the application:

- A short cover letter stating the motivation of the candidate to apply, and the reason(s) why they should be selected for the position;
- A curriculum vitae;
- Bachelor and Master grades (and the corresponding transcriptions if necessary) and certificates
- Two reference letters