Thesis Topic: Parameterized Approximation
Advisor: Vangelis Paschos
http://www.lamsade.dauphine.fr/~paschos/
Coadvisor: Michael Lampis
http://www.lamsade.dauphine.fr/~mlampis/

Thesis Description

The proposed area of research for this thesis is **Parameterized Approximation Algorithms and Complexity**, a promising new approach for designing algorithms for NP-hard optimization problems.

Finding ways to deal with NP-hard optimization problems is one of the central challenges of theoretical computer science today. The reason for this is that NP-hardness is a common characteristic of the vast majority of interesting optimization problems, ruling out the existence of polynomial-time exact algorithms (unless P=NP).

Two of the most prominent ways for dealing with this situation that have been offered so far in the literature are Approximation algorithms and Parameterized Complexity. In approximation algorithms, we try to attack a hard optimization problem with a polynomial-time algorithm that produces a "good-enough" approximate solution. This approach has produced a rich field of algorithmic techniques which, for many problems, can produce solutions guaranteed to be comparable to the optimal value in the worst case (see the standard textbooks [7, 8]). In parameterized complexity on the other hand, we are usually still interested in an algorithm that finds exactly the optimal solution, but is allowed to do so in super-polynomial time. Here, we want to confine the inevitable combinatorial explosion of the problem to a small parameter, that usually takes moderate values in most instances of interest. This allows us to design an algorithm which "often" runs efficiently (see the standard textbooks [6, 3]).

By now, both of the above approaches have matured to a point where it is relatively clear what can and what cannot be achieved with them. For example, thanks to the famous PCP theorem we know that many problems are not just NP-hard, but are also inapproximable in polynomial time. At the same time, we know that if we could design efficient parameterized algorithms for some others, this would imply the existence of sub-exponential algorithms for 3-SAT, disproving the so-called Exponential Time Hypothesis (ETH). It is thus a natural question, whether problems which are intractable for these two approaches, and therefore do not admit neither approximation nor parameterized algorithms, become tractable if one tries to design a **Parameterized Approximation** algorithm.

Parameterized Approximation is a hot new area of research that is at the moment attracting renewed interest [5, 2, 1]. The goal of this thesis will be to

advance the state of the art in parameterized approximation both by focusing on the parameterized approximability of specific problems and by trying to build a general, coherent theory of this emerging field. The approach proposed is two-pronged.

- Working on algorithms that borrow and combine ideas from both approximation and parameterized algorithmics. This is a wide-open and very promising field and the problems to be considered are essentially limitless. We expect to begin this work with optimization problems on graphs, perhaps building on recent work on this topic ([4]).
- Building a theory of parameterized inapproximability. Concretely, one of the questions that one may want to answer here is: "Does there exist a non-trivial parameterized approximation algorithm for Clique?". Since this is a major open problem, one could also consider investigating whether other problems can be proved inapproximable, while conditinoally assuming that Clique is hard (as is often conjectured).

Position Description and Research Environment

The successful candidate will work on a thesis supervised by Vangelis Paschos and Michael Lampis, as a member of LAMSADE, Universite Paris Dauphine. The two supervisors have a track record of internationally recognized research in both approximation algorithms and parameterized complexity and are strongly interested in developing the ideas of parameterized approximation. LAMSADE, a CNRS lab attached to Paris Dauphine, is a world-class research center in theoretical computer science, with a vibrant and international research environment. Universite Paris Dauphine is one of the leading universities in Paris, located in the 16th district, a few minutes away from the Arc de Triomphe.

She/he will be offered a competitive 3-year fellowship, through which she/he will be hired as a full-time temporary employee of the university. This entitles her/him to all basic benefits given to french public employees (such as health insurance). Net salary is expected to be around 1600 Euros/month. A light teaching load (such as, for example tutoring programming labs) is expected, with a salary complement.

Candidate Profile

The successful candidate will possess a Master's (or equivalent) degree in Computer Science or a related field. Her/his main characteristic will be a **strong interest** in related areas of theoretical computer science, such as discrete algorithms, computational complexity, graph theory, etc, as well as a **strong ambition** to do high-quality research. Good abilities in spoken and written scientific english are expected. An ability to speak french is a plus, but is **not** required.

Interested candidates are invited to send informal inquiries to Vangelis Paschos `paschos@lamsade.dauphine.fr` and Michael Lampis `michail.lampis@dauphine.fr` before submitting a full application.

References

[1] Edouard Bonnet, Bruno Escoffier, Eun Jung Kim, and Vangelis Th. Paschos. On subexponential and fpt-time inapproximability. In Gregory Gutin and Stefan Szeider, editors, *Parameterized and Exact Computation - 8th International Symposium, IPEC 2013, Sophia Antipolis, France, September 4-6, 2013, Revised Selected Papers*, volume 8246 of *Lecture Notes in Computer Science*, pages 54–65. Springer, 2013.

[2] Erik D. Demaine, MohammadTaghi Hajiaghayi, and Dániel Marx. 09511 abstracts collection – parameterized complexity and approximation algorithms. In Erik D. Demaine, MohammadTaghi Hajiaghayi, and Dániel Marx, editors, *Parameterized complexity and approximation algorithms*, number 09511 in Dagstuhl Seminar Proceedings, Dagstuhl, Germany, 2010. Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik, Germany.

[3] J Flum and M Grohe. *Parameterized Complexity Theory*. Springer, 2006.

[4] Michael Lampis. Parameterized approximation schemes using graph widths. In Javier Esparza, Pierre Fraigniaud, Thore Husfeldt, and Elias Koutsoupias, editors, *Automata, Languages, and Programming - 41st International Colloquium, ICALP 2014, Copenhagen, Denmark, July 8-11, 2014, Proceedings, Part I*, volume 8572 of *Lecture Notes in Computer Science*, pages 775–786. Springer, 2014.

[5] Dániel Marx. Parameterized complexity and approximation algorithms. *Comput. J.*, 51(1):60–78, 2008.

[6] Rolf Niedermeier. *Invitation to fixed-parameter algorithms*. Oxford University Press, 2006.

[7] Vijay V Vazirani. *Approximation algorithms*. Springer Science & Business Media, 2001.

[8] David P Williamson and David B Shmoys. *The design of approximation algorithms*. Cambridge University Press, 2011.