Research Internship: Sampling Landscape Features

Host institution: Laboratoire d’informatique de l’École polytechnique (LIX), Palaiseau, Île de France, France.

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Keywords: Heuristic optimization, low-discrepancy point sets, sampling, landscape-aware algorithm configuration, supervised machine learning, artificial intelligence.

Context: Landscape-aware algorithm configuration and low-discrepancy sampling. This internship lies in the intersection of two active research topics. The idea of landscape-aware algorithm configuration is to analyze the problem to be solved by estimating certain characteristics (“features”) and to decide, based on these features and previous experience (supervised machine learning approaches), which of several available algorithms to use for solving the problem and how to configure its hyperparameters [KHNT19, KT19, ELH19].

In continuous optimization, it is often not possible to compute the precise feature values efficiently. One therefore resorts to evaluating the objective function in a small number of sample points and to approximating the feature values from these points. This raises the question which points to use for this approximate computation of the features. The general question how to analyze continuous functions from finite sample sets is a classic problem in discrepancy theory. If the target is to numerically integrate a function, this problem is well-understood [Nie92, DP10] and a large variety of different sample point set constructions has been developed.

Topic of this internship. In our ongoing research on landscape-aware algorithm configuration, we observed that the insights from classic discrepancy theory cannot be transferred to the feature estimation problem. While in classic discrepancy theory random points are known to be less effective than so-called quasi-random point sets, our first experiments show that for the robust estimation of features, random points do a much better job than Latin hypercube samples and are competitive with Sobol’ points. The topic of this internship is to shed more light on this surprising first observation. Possible research questions include the following.

- So far, we only compared random points, Latin hypercube samples, and Sobol’ points. The discrepancy theory literature contains a number of
further prominent sample point set constructions. How do these perform in the feature estimation problem?

- The classic low-discrepancy point sets were constructed with the aim that each axis-parallel rectangle in the domain contains – as good as possible – the number of points which is fair with respect to the volume of the rectangle. This notion of a even distribution is motivated by the fact that standard error estimates in numerical integration, such as the Koksma-Hlawka inequality, build upon it. For the feature estimation problem, it is very likely that other properties of the sample point set are more important. Can we extract such a discrepancy notion from the data we have? How do point sets look like which minimize this discrepancy notion?

Prerequisites: As should be clear from the description above, this is a topic with a strong connection to very recent research. As such, the intern should have an interest in doing actual research, and consequently, a pronounced scientific curiosity. While this is a research and not a programming project, some basic programming skills (for example scripting abilities in Python) are indispensable. A solid background in computer science, mathematics, or applied mathematics is necessary. The working language of our group is English.

Practicalities: We are flexible with respect to the type of internship (M1, M2, other). We are also flexible with respect to the starting date of the internship. The intern will be based at the LIX, École Polytechnique. The intern will receive a salary as regulated by the law (approximately 500 Euros per month). This internship is part of a research project which benefits from the support of the FMJH Program PGMO and from the support of EDF and Thales.

References


