Parameterized Analysis of Complexity

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Complexity can have many forms, yet there is no single mathematical definition of complexity that they all adhere to. In this thesis, we introduce a mathematical framework for the analysis of multiple forms of complexity. Our framework is a continuation of the parameterized approach to computational complexity pioneered by Downey and Fellows. Correspondingly, this thesis is not only concerned with the analysis of complexity, but also with the theory of parameterized computational complexity. There are two types of results in this thesis: results on the application of a unified analysis of complexity using our framework, and results on the class of fixed-parameter tractable sets, FPT.

Two concrete domains in which we analyze complexity using our framework are statistical inference and algorithm design. For statistical inference, our framework provides guidelines for balancing underfitting and overfitting of statistical models. For algorithm design, our framework offers indicators that can be used in deciding how much computation to perform when and where, for minimal overall resource usage.

Regarding the nature of FPT, we obtain three results. Using an order on parameterizations derived from FPT, we show that there is often no best parameterization among those that put a set in FPT. Secondly, we show that there is a strict hierarchy below FPT based on polynomial kernelizations. Lastly, we find evidence for an alternative characterization of FPT as the quotient group $D/P$ with respect to symmetric difference. Here, $D$ is the class of decidable sets.