

Overview of Evolutionary Computation Theory

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During the last half century of Evolutionary Computation (EC) research, a multitude of algorithms have been developed that fit the very loose rubric of “inspired by natural evolution.” Unsurprisingly, analytical approaches to understanding such systems are similarly diverse. Nevertheless, cursory study of EC typically provides some limited background in *schema theory* for genetic algorithms and successful real-world application of evolutionary algorithms (EAs) are more often justified analogically than by relating to underlying foundational aspects of EC. I believe this has led to a number of common myths about the state of theory for the field: that schema theory and the building block hypothesis is the only EC theory, that there is very little formal basis to these methods, or that EC theory is largely descriptive and has very little utility to practical application of EAs.

In fact, there have been a number of theoretical advances in EC. There are several critical conference and workshop venues that specifically target EC theory, and new advances are frequently published in major journals of the field—including the journal *Theoretical Computer Science*, perhaps the most prestigious journal in all of CS. EC theory incorporates mathematical tools from many disciplines (dynamical systems, probability theory, discrete mathematics, etc.) and considers many aspects of such systems (step-wise algorithm behavior, global algorithm performance, non-linear dynamics, challenges arising from relationships between problem properties and algorithm properties, etc.). The latest *Foundations of Genetic Algorithms* produced 18 papers covering analysis of evolution-inspired methods for continuous optimization, combinatorial optimization, multi-objective optimization, co-optimization, as well as problem analysis. None discussed schema theory and many offered *predictive* analysis of algorithm performance.

I offer a broad perspective in this talk. Like EC itself, EC theory is not at all unified, and I lay out a high-level, math-free organization categorizing existing work. At the top level, these include two different focuses of algorithm analysis (global and local behavior), component analysis and problem analysis. I discuss the famous *No Free Lunch* as a separate category. Within these categories, we find topics such as landscape-oriented Walsh analysis, exact/pressimistic micro/maco schema theory, infinite population dynamical models, runtime analysis, and many more. I will select a handful of examples and provide math-light general discussions of them. The talk targets those with a basic understanding of computer science and optimization, assuming as little EC background knowledge as possible. Goals of the talk include creating a greater awareness of EC theory, providing a (hopefully) more accurate notion of extant strengths and weaknesses in current approaches and results, and stimulating interest in further discussion on these topics.