The research described in this thesis investigates automatic on-line control of the parameters of evolutionary algorithms (EAs).

Evolutionary algorithms are a class of search and optimisation algorithms based on the paradigm of biological evolution in nature. EAs are used to find solutions for difficult problems, i.e. problems of high complexity, high dimensionality and very large search spaces. EAs are population-based algorithms: they maintain a population of possible solutions at all times. Possible (candidate) solutions to a problem are encoded in an appropriate representation that contains all the necessary information. Candidate solutions are combined with each other and are randomly perturbed, a process that corresponds to reproduction in biological organisms. Each candidate solution is assigned a fitness value that expresses how well it solves the problem at hand. Based on these fitness values, candidate solutions compete for a place in the population and a chance for mating; this resembles the selection that organisms go through in nature and the concept of the survival of the fittest. Though EAs are very far from accurately simulating biological evolution, they borrow the basic notions of it and use them to successfully find good solutions to problems.

The core process of an EA consists of a loop with a number of steps involving the creation and selection of candidate solutions. Each such step in the loop may include several parameters, either numeric or nominal. The effectiveness of an EA is very often influenced to a great extent by the specific values of these parameters. Therefore, successfully applying an EA often becomes a matter of properly setting its parameter values. To further complicate things, it has also been shown that changing the values of some parameters during different stages of a single run can also have an impact on the performance of an EA.

This poses a challenge: how to set the value of a parameter at any given time during a run so as to maximize the effectiveness of the EA? Parameter control attempts to meet that challenge with the use of mechanisms that vary the parameters of an EA on-the-fly.
according to an underlying strategy. A parameter controller adds an extra step to the core loop of an EA: at every iteration the controller uses information extracted from the current population of the EA to make a decision about how to subsequently set the values of the parameters of the EA.

However, though the principle is there, parameter control is, practically, still an open problem as there are no standard and widely used solutions. The purpose of this thesis is to contribute to making parameter control more applicable and relevant in practice by (i) providing a theoretical basis that identifies the key elements of parameter control and helps with designing new controllers, and (ii) working towards a one-fits-all solution, i.e. a controller in the form of a readily available plugin that can be applied to any EA.

The text is divided into two parts. The first part examines the basic notion of parameter control and its relation to tuning and the overall parameter setting problem, suggests a framework for parameter control from a component viewpoint as well as in the context of Reinforcement Learning, and presents an extensive literature review of the field of parameter control identifying key trends and challenges. Based on that, the second part presents a number of parameter controllers designed as independent components that can be used as generic plugins for any conventional EA, and experimentally evaluates these control designs with several EA and problem combinations, including real world and dynamic problems. Experimental results show that a generally applicable parameter controller is a viable idea that could be mostly beneficial when controlling evolutionary algorithms that are not extensively refined. This can be especially useful when applying newly developed and ad hoc evolutionary algorithms as is often the case in industrial and commercial environments.