Mohammed VI Polytechnic University (UM6P)
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# Machine Learning for Constraint Satisfaction and Optimization

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***Keywords***— Constraint Programming, Optimization, Machine Learning, Heuristics, Reinforcement Learning.

## 1 Research motivation

Constraint programming (CP) is used to solve combinatorial problems, stated as a conjunction of constraints. This technology has been successfully applied to solve many real-life industrial and engineering problems such as vehicle routing, maximizing container terminal throughput, scheduling maintenance visits, timetabling, workforce scheduling, ...

In constraint programming, the modeling part is separated from the resolution part. The constraint satisfaction and optimization problems (CSOPs) formalism provides a powerful framework for modeling the problems addressed by constraint programming. The CSOP is a constraint satisfaction problem (CSP) that seeks complete and consistent instantiations optimizing a cost function. CSOPs are often difficult to solve. Most of these problems belong to the class of NP-hard problems and therefore do not currently have efficient algorithmic solutions. Despite the important progress made by constraint programming solvers, the development of solvers capable of handling highly combinatorial problems is a persistent need in several industrial sectors.

## 2 Problem statement

The CSOP resolution algorithms are broadly classified into two large categories: exact methods that ensure the completeness but require exponential time complexity, and local methods that sacrifice completeness to gain in time complexity. In both cases, these algorithms explore the search space by making decisions at each stage of the search. A perfect algorithm would make no mistakes and would guide the search directly to a solution when it exists (a backtrack free search). Machine learning seems to be a natural candidate to help making such decisions in a more reasoned and optimized way. This thesis aims at developing a synergistic integration of machine learning and constraint satisfaction and optimization [3, 1, 2] with the purpose of improving the performance of existing solvers.

## 3 Research scope

The integration of machine learning and constraint programming can be applied to several objectives. First, in the context of solution finding, learning constraints during search will avoid redundant search and thus improve search performance. Secondly, solution prediction is related to the objective of directly applying machine learning to derive a solution for a given constraint satisfaction problem (CSP). Furthermore, satisfiability prediction focuses on predicting the satisfiability of a CSP without the need to activate a solver. Finally, heuristic learning focuses on learning search heuristics that improve the performance of a constraint solver with respect to some criteria such as execution time.

## 4 Admission criteria

The PhD position is proposed by the International Center of Artificial Intelligence of Morocco, of the Mohammed VI Polytechnic University. Applicants must be holders of a Master, an engineering or an equivalent recognized degree in Computer Science or Applied Mathematics. In addition, they should have strong theoretical background in computer science and machine learning, algorithms, programming skills (Python and java). Particular attention will be given to the suitability of this research project with the applicant's background.

## References


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