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The Inductive Constraint Programming Loop

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1 Research motivation

Constraint programming (CP) is a paradigm that is used to describe and solve combinatorial problems that arise in various domains. Its main advantage is its ability to declaratively and accurately describe a problem using constraints which are mathematical relations that define how variables relate to each other. Constraint programming has a strong theoretical basis and a broad practical scope. Examples of constraint programming applications include but are not limited to vehicle routing, maximising container terminal throughput, scheduling maintenance visits, planning waste collection, timetabling, workforce scheduling,...

Machine learning (ML) is concerned with providing machines with the ability to automatically learn from data and past experiences to identify functions/patterns and make predictions with minimal human intervention.

The Inductive Constraint Programming loop [2] is an interaction between a machine learning component (ML) and a constraint programming component (CP). The ML component observes the world and extracts patterns. The CP component solves a constraint satisfaction or optimization problem using these patterns. The solution is applied to the world that changes over time, possibly due to the impact of applying the solution. This process is repeated in a loop.

Several interesting problems can be described using the inductive constraint programming loop [2]. Examples include bus schedules, carpooling, energy-aware data centers,...

2 Problem statement

The problem with current technology is that data analysis and constraint satisfaction/optimization have almost always been studied independently [2]. There are several successful approaches to data analysis in the ML field, and at the same time, the CP community developed advanced techniques for solving constraint satisfaction and optimisation problems. However, a limited number of isolated studies on specific cases have tried to leverage the benefits that can be obtained by linking these two fields. The Inductive Constraint Programming loop, an integrated and interdisciplinary approach, aims to fill this gap.

3 Research scope

Two objectives can be pursued in this thesis. The first one has a practical interest in that it consists of solving industrial problems using the Inductive Constraint Satisfaction Problem Loop. The second objective is theoretical in that much remains to be done to improve the current inductive constraint programming based systems. For example, constraint acquisition systems [1, 5, 3, 4] that aim to assist non-expert users in the modeling task, are still far from being usable in practice. That is, state-of-the-art interactive constraint acquisition systems such as QuAcq need to ask the user more than 8000 queries to acquire Sudoko. This thesis aims to leverage the advances made in deep learning with the goal of contributing to bridge the gap between the current state- of-the-art acquisition systems and an expert-level Artificial Intelligence.

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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