Tutorial

Title
Preference-Based Problem Solving for Combinatorial Applications

Abstract
Combinatorial problems refer to those applications where we either look for the existence of a consistent scenario satisfying a set of constraints (decision problem), or for one or more good/best solutions meeting a set of requirements while optimizing some objectives (optimization problem). These latter objectives include user's preferences that reflect desires and choices that need to be satisfied as much as possible. Moreover, constraints and objectives (in the case of an optimization problem) often come with uncertainty due to lack of knowledge, missing information, or variability caused by events, which are under nature's control. Finally, in some applications such as timetabling, urban planning and robot motion planning, these constraints and objectives can be temporal, spatial or both. In this latter case, we are dealing with entities occupying a given position in time and space.

Because of the importance of these problems in so many fields, a wide variety of techniques and programming languages from artificial intelligence, computational logic, operations research, and discrete mathematics, are being developed to tackle problems of this kind. While these tools have provided very promising results at both the representation and the reasoning levels, they are still impractical to dealing with many real-world applications.

Using the Constraint Satisfaction Problem (CSP) formalism, we will explore several exact and approximate solving techniques to address the challenges and limitations listed above.

Duration
TWO-hours

Motivation -
A large variety of real-world applications can be seen as preference-based constraint optimization problems. The aim of the tutorial is to provide attendees with the necessary tools to tackle these problems in practice. Several examples and case studies in the areas of scheduling, planning, robotics, timetabling, and resource allocation, are investigated.

Expected audience

This is an introductory tutorial to combinatorial optimization. Basic background in Algorithms, Discrete Mathematics, and Artificial Intelligence is necessary.

Outline of contents

In this tutorial, we will show how to overcome the challenges we face when solving a given combinatorial problem under user's preferences. The approach that we will adopt is based on the Constraint Satisfaction Problem (CSP) paradigm and its variants. The latter include extensions of CSPs that have been proposed to deal with both hard and soft constraints. Solving techniques include both exact methods and metaheuristics. Exact methods include the backtracking algorithm and its variants. Constraint propagation and variable/value ordering heuristics are covered, showing how they can be applied to improve the performance of backtracking in practice. Metaheuristics include Stochastic Local Search (SLS) methods and nature-inspired techniques. We will also consider the case where constraint problems occur in dynamic environments, as well as situations where some of the relevant information are incomplete/uncertain.

Key references

Constraint Satisfaction, Combinatorial Optimization, Spatio-Temporal Reasoning, Preference Reasoning, Metaheuristics, Constraint Acquisition, Scheduling, Planning and Timetabling

List of speakers

Dr. Malek Mouhoub
Professor and SaskPower AI Chair
Dept. of Computer Science
University of Regina, Canada

Dr. Malek Mouhoub obtained his MSc and PhD in Computer Science from the University of Nancy in France, in 1996. He is currently Professor and SaskPower Research Chair in Artificial Intelligence at the University of Regina, in Canada. Dr. Mouhoub's research interests include Constraint Solving, Metaheuristics and Nature-Inspired Techniques, Spatial and Temporal Reasoning, Preference Reasoning, Constraint and Preference Learning, with applications to Scheduling and Planning, E-commerce, Online Auctions, Vehicle Routing, Efficient Grid-wide Energy Consumption, Precision Farming, and Geographic Information Systems (GIS). Dr. Mouhoub's research is supported by the Natural Sciences and Engineering Research Council of Canada (NSERC), the Canada Foundation for Innovation (CFI), and the Mathematics of Information Technology and Complex Systems (MITACS) federal grants, SaskPower, in addition to several other funds and awards. Dr. Mouhoub is the past treasurer and member of the executive of the Canadian Artificial Intelligence Association / Association pour l'intelligence artificielle au Canada (CAIAC). CAIAC is the oldest national Artificial Intelligence association in the world. It is the official arm of the Association for the Advancement of Artificial Intelligence (AAAI) in Canada. Dr. Mouhoub received the 2022 CAIAC Distinguished Service Award.