Abstract Booklet

3rd Metaheuristics Summer School

~ AutoDL meets HPC ~

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MESS 2024

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Optimized tabu search algorithm

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The performance and behaviour of any metaheuristic algorithm largely depends on its hyperparameters. Their impact is even more important in large and real-world size problems. The best values for these hyperparameters cannot be identified with trial and error and efficient methods are required for hyperparameters tuning to obtain the best possible results. We present how blackbox optimization can help choose the parameters of tabu search efficiently in a physician scheduling problem. The experiments have been conducted through a Mesh Adaptive Direct Search (MADS) algorithm and the results will be presented.

Enhancing Multivariate Time-Series Forecasting Accuracy through Automated Machine Learning

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Multivariate time-series forecasting is a challenging task that requires expertise in both statistical modelling and domain knowledge. In recent years, the use of deep learning techniques has gained popularity due to their ability to extract patterns from data and generate valuable knowledge for decision-making. However, the increasing amount of data to be processed in such applications presents a significant challenge. Deep neural networks are becoming more complex, requiring numerous hidden layers to process the data. Moreover, existing models in the literature require ad-hoc tuning of hyperparameters to maximize accuracy.

Automated machine learning (AutoML) has emerged as a promising approach to address this challenge by automating the process of model selection, hyperparameter tuning, and feature engineering. All these techniques are denoted as Automated Machine Learning (AutoML) [1] and can be categorized into two types: Neural Architecture Search (NAS) and Hyperparameter Optimization (HPO). Neural Architecture Search methods are based on an optimization algorithm to select the best neural network architecture that fits the dataset and avoids overfitting to achieve the best model accuracy. On the other hand, Hyperparameter Optimization selects the best hyperparameters of neural network architectures that maximize the performance of such a network.

In [2], it has been demonstrated how variables can affect each other in multivariate time series forecasting, and the use of metaheuristic algorithms can help to select the best predictors for each variable, improving the accuracy of the prediction. In this research work, we employ our algorithm of Automated Machine Learning, denoted as GP-NAS (General-Purpose Neural Architecture Search), published in [3], to design neural network architectures that maximizes the performance in multivariate time-series forecasting applications. We demonstrate the effectiveness of our approach on several real-world datasets and show that it outperforms traditional methods in terms of accuracy and efficiency.

References:

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Gasslip: A Multistage Stochastic Linepack Optimization Model under Steady-StateConditions

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A multistage stochastic optimization model, Gasslip, is being proposed for linepack optimization in natural gas transportation. Linepack refers to the ability of pipelines to store natural gas by controlling pressure values, providing flexibility to handle uncertain events. The trade-off between linepack storage and compressor power consumption is crucial for efficient gas transport. The proposed model operates under steady-state flow conditions and addresses the nonlinear and nonconvex nature of compressor performance and pipeline pressure equations. Gasslip offers a comprehensive solution for optimizing gas network performance, aiming to enhance efficiency and reliability in the transportation of natural gas. This research is particularly relevant for Norway, which supplies a significant portion of Europe's gas demand through Gassco's responsible gas transport from the Norwegian continental shelf.

DeepRL for Assembly Scheduling Problems

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The Job Scheduling Problem and its extensions have been extensively investigated in the past decade, utilizing various solving methods such as heuristics, metaheuristics, and even deep reinforcement learning (DeepRL). Unfortunately, the real-world scheduling problems are difficult to solve efficiently, leading to significant time consumption when attempting to solve large industrial instances. While heuristic-based dispatching methods offer a way to compute schedules within a reasonable time frame, creating effective

heuristics that produce satisfactory solutions is a challenging and laborious task.

In this presentation, we will present the current stage in solving the Assembly Scheduling Problems (ASP) by using DeepRL, according to the needs of a manufacturer involved in an academic-industry collaborative project. The starting point of our work is the schlably framework (C. Waubert de Puiseau et all, schlably: A Python Framework for Deep Reinforcement Learning Based Scheduling Experiments, 2023). Our aim was to extend its capabilities to accommodate in-tree precedence relations characteristic of ASP. Additionally, we are implementing several other dispatching rules, further enriching the framework's versatility. Our presentation will also include an in-depth evaluation of these enhancements, shedding light on their effectiveness.

Our experience with solving ASP started during the master studies, where we adapted and analyzed three different approaches of a heuristic used to schedule operations corresponding to ASP: batch splitting heuristic, flexible batch splitting heuristic and parallel batch splitting heuristic according to requirements/ characteristics of real-world problems (same collaborative project mentioned above). All these variants are based on an existing heuristic called LETSA (A. Agrawali et all. 'just-in-time' production of large assemblies. IIE Transactions, 28(8):653–667, 1996). Compared to LETSA, these approaches considered preventive maintenance operations for machines, the possibility of batch splitting, and a single work center with several machines with different execution times.

A Multi-Agent System to Explore Pathfinding Strategies

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The planning of paths in complex, interconnected, and unknown structures, such as mazes, is a crucial topic in various fields, including artificial intelligence and robotics. Intelligent agents, capable of making independent decisions, require efficient navigation through mazes, and their performance can be influenced by various characteristics. Understanding these factors is essential not only for developing more efficient and robust navigation algorithms but also for gaining deeper insights into which attributes to prioritize in the design and implementation of autonomous agents.

In this article, we analyze different multi-agent systems, focusing particularly on the analysis of various navigation strategies based on the concepts of memory and visibility. Our goal is to identify the parameters that impact the agents' performance the most and how variations in agent parameters influence maze-solving efficiency.

Intelligent Gradient Boosting methods for investigation of object interaction dynamics in Mixed Reality

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This research endeavors to address the challenge of inferring object interaction dynamics in Mixed Reality (MR) environments by proposing an alternative approach to the regression forest method previously employed. We introduce an investigation into the application of Intelligent Gradient Boosting methods—LightGBM, XGBoost, and CatBoost—individually and in various combined iterations. These methods are tailored to predict correspondences between image pixels and a scene's world space, facilitating the estimation of each pixel's correspondence to 3D points in the scene's world coordinate frame and enabling the prediction of the pose of an RGB-D camera relative to a known 3D scene. Utilizing straightforward depth and RGB pixel comparison features, we aim to refine camera pose inference without the need for complex feature descriptors or interest point detectors. Our approach involves assembling initial camera pose hypotheses and iteratively refining them through Preemptive RANSAC sampling. Through meticulous evaluation on diverse MR scenes, we aim to demonstrate the efficacy of our proposed technique in relocalization compared to existing state-of-the-art baselines. This investigation contributes to advancing the understanding and application of Intelligent Gradient Boosting methods in the context of MR, thereby contributing to the refinement of object interaction dynamics prediction in immersive environments.

Comparison of Python Metaheuristic Packages

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Metaheuristic approaches are utilized to find suboptimal solutions within a reasonable timeframe. This is crucial for NP-hard problems such as the traveling salesman problem, vehicle routing problem and knapsack problem. However, identifying the appropriate software to execute such algorithms is not straightforward. This paper presents a comprehensive study aimed at identifying a suitable package in the programming language Python. Python is one of the most widely used programming languages worldwide and is employed daily in numerous companies. The sheer number of packages available can be over whelming, making it challenging to select the right tool for a given problem.

The objective of this paper is to locate and compare such packages, preselect suitable ones and determine the best package or packages. The criteria for decision-making include firstly number of algorithms implemented, secondly flexibility, customization and tuning capabilities, thirdly performance and following items: quality of documentation, learning curve in relation to the knowledge of AI, maintenance, community support and overall health of the package.

Efficient Heuristics for Finding Minimal Feedback Arc Sets in Big Data Challenges

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Minimum Feedback Arc Set Problem is a well-known NP-hard challenge, specifically NP-complete. The problem can be defined as follows: given a directed graph G, identify a subset of its arcs of minimum cardinality such that removing these arcs from G, the graph results acyclic. The literature on this problem is extensive, with numerous heuristics and approximation algorithms developed for both theoretical and practical applications, such as Big Data and large-scale biological systems. This problem can also be referred to as the Vertex Linear Arrangement problem.

In collaboration with my research team, we tested new heuristics to identify effective level 1 and 2 linear orderings of vertices in directed graphs to achieve minimal Feedback Arc Sets (FAS). We demonstrated that the newly proposed algorithm for reinserting removed arcs, which has a favorable polynomial upper bound, produces in most cases a minimum FAS. We compared the results of our proposed heuristics against established benchmarks and state-of-the-art algorithms.

Dynamic Metaheuristics: Enhancing Real-Time Problem Solving with Machine Learning Integration

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This research investigates the integration of run-time metaheuristics with machine learning (ML) techniques to address combinatorial optimization problems with dynamic inputs (COPDIs). The primary focus is on enhancing the adaptability and efficiency of optimization algorithms in real-time scenarios.
A case study is presented utilizing a Tabu Search algorithm specifically designed for dynamic map labeling problems, which adeptly handles zoom in and zoom out actions. The innovative aspect of this study lies in two key points: the real-time handling of user-initiated zoom actions and the integration of ML to forecast future labels during zoom out actions. This predictive capability enables the algorithm to preemptively adapt to changing conditions, significantly enhancing its performance. This methodology aims to demonstrate substantial improvements in computational efficiency and solution quality, validated through rigorous case studies and empirical evaluations.

Metaheuristics Summer School

15-18 July 2024 – Catania, Italy

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