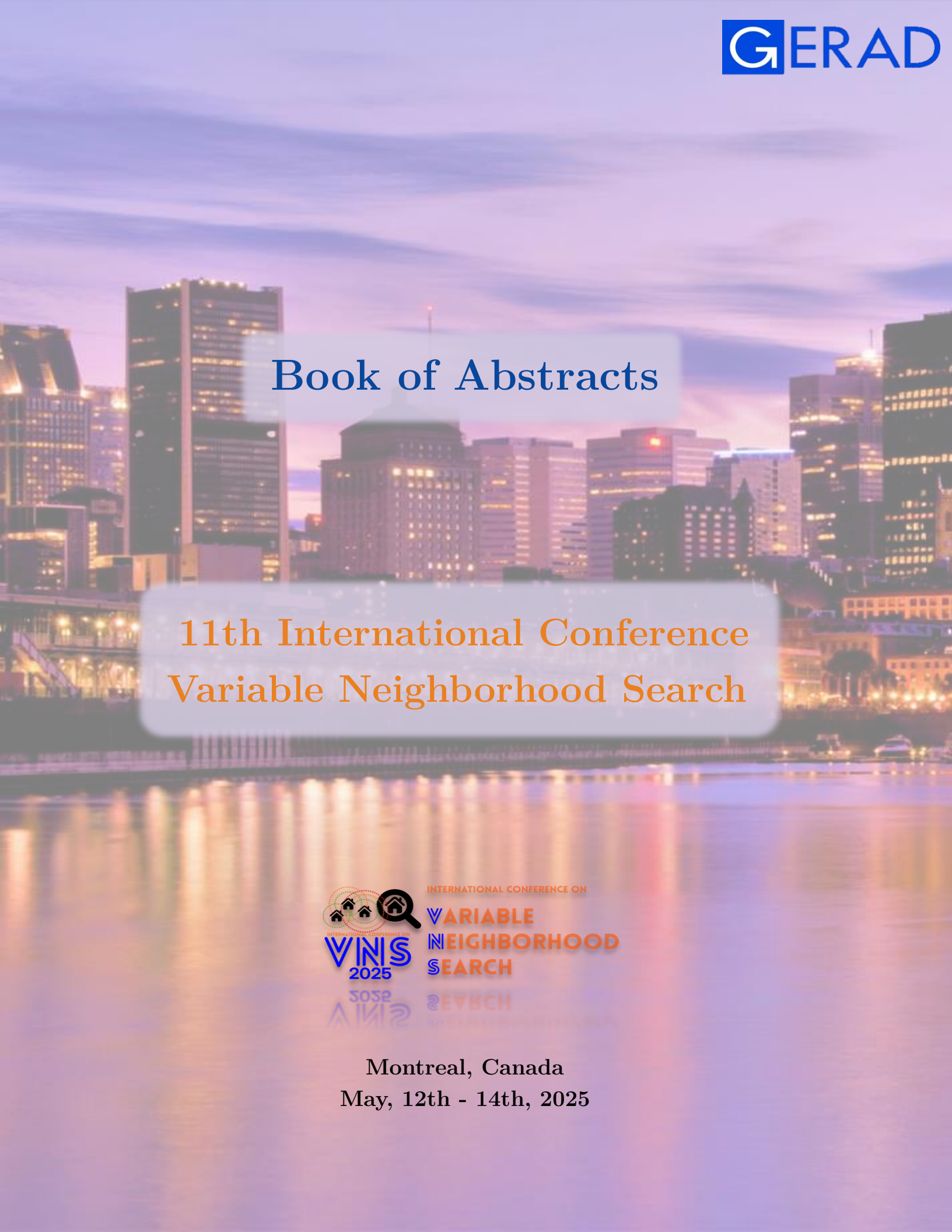

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Book of Abstracts

11th International Conference Variable Neighborhood Search

INTERNATIONAL CONFERENCE ON VARIABLE NEIGHBORHOOD SEARCH

VNS 2025

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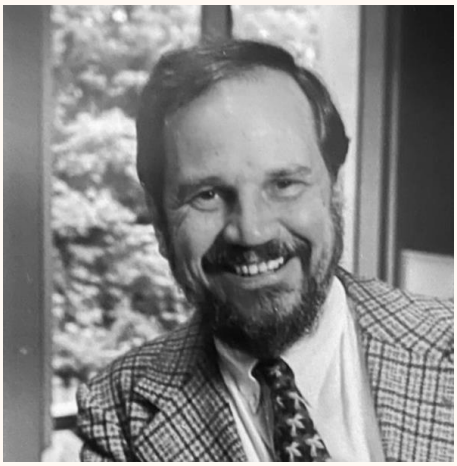

"Some ideas do not merely solve problems; they shape the way we think about solving them."

In memory of ***Pierre Hansen*** *and* ***Nenad Mladenović****,*
whose vision gave rise to Variable Neighborhood Search and
inspired generations of researchers to explore new landscapes of optimization.

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Welcome

We are delighted to welcome you to the 11th International Conference on Variable Neighborhood Search (ICVNS 2025), taking place from May 12 to 14, 2025, at HEC Montréal in Montreal, Canada. This year's conference is held in conjunction with the Journées de l'Optimisation, organized by CIRRELT, offering a dynamic platform for researchers, practitioners, and experts in optimization, heuristics, and metaheuristics to converge and share their latest findings.

ICVNS 2025 continues the tradition of fostering collaboration and innovation in the field of Variable Neighborhood Search (VNS). The conference program features keynote talks from leading experts, technical sessions, and discussions on recent developments in combinatorial and global optimization, machine learning, logistics, scheduling, and more. We are honored to have Dr. Jack Brimberg, a prolific researcher in heuristic methods and VNS, deliver a plenary talk highlighting his significant contributions to the field.

This edition of ICVNS holds special significance as we pay tribute to the late Professor Pierre Hansen, who passed away on January 19, 2025. As the pioneer of Variable Neighborhood Search and Honorary Chair of ICVNS, Professor Hansen's profound impact on the field and his intellectual generosity will continue to inspire researchers for years to come.

We extend our heartfelt thanks to all participants, contributors, and organizers who have made ICVNS 2025 possible. We hope this conference serves as a catalyst for new ideas, collaborations, and friendships, all in the vibrant and welcoming city of Montreal.

Warm regards,

Daniel Aloise

Conference Chair, ICVNS 2025.

Polytechnique Montréal, Canada

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  Research Professor, Mathematical Institute, Serbian Academy of Sciences, Serbia
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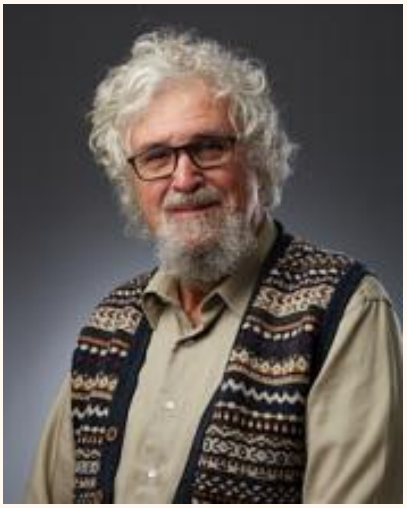
Invited Plenary Speakers

Plenary Talk: Dr. Jack Brimberg



Dr. Jack Brimberg is a prolific researcher who has made significant contributions to the development and analysis of heuristic methods, particularly Variable Neighborhood Search (VNS), for solving complex location and optimization problems. His work spans a wide range of topics, including continuous location-allocation, p-median, p-center, and minimax models, often proposing novel solution approaches and analyzing their properties.

Throughout his career, Dr. Brimberg has collaborated with prominent researchers, notably Pierre Hansen and Nenad Mladenović, publishing numerous influential papers. He has also explored the use of different distance functions and norms in location models and has applied operations research techniques to diverse domains, including water resource management, oil pipeline design, sports analytics, and military/defense problems.

List of Abstracts

A variable neighborhood search heuristic for semi-supervised minimum sum-of-squares clustering

Mahuton Hugues Midingoyi, André Meneses, Daniel Aloise

Polytechnique Montréal, Universidade Federal do Rio Grande do Norte

Semi-supervised clustering is an unsupervised learning model that incorporates prior information to enhance the learning process. Among various clustering objectives, the minimum sum-of-squares clustering (MSSC) is widely used to partition data by minimizing intra-cluster variances. In our work, we propose a Variable Neighborhood Search (VNS) heuristic for MSSC, where prior information is given in the form of pairwise must-link and cannot-link constraints. Our approach relies on the efficient evaluation of data points reassignments among the clusters after the model reformulation. Computational experiments indicate that, in most cases, our proposed VNS heuristic outperforms the solutions produced by the state-of-the-art heuristic algorithms within a similar computational time.

Keywords: Semi-supervised clustering · minimum sum-of-squares clustering · MSSC · Variable Neighborhood Search · VNS · pairwise must-link and cannot-link constraints

An efficient implementation of a VNS heuristic for the weighted fair sequences problem

Caroline Rocha, Bruno Jefferson de Sousa, Daniel Aloise, Lucidio Cabral

Ivado Labs, Universidade Federal da Para ba, Polytechnique Montréal

In the Weighted Fair Sequences Problem (WFSP), one aims to schedule a set of tasks or activities so that the maximum product between the largest temporal distance between two consecutive executions of a task and its priority is minimized. The WFSP covers a large number of applications in different areas, ranging from automobile production on a mixed-model assembly line to the sequencing of interactive applications to be aired in a Digital TV environment. This paper proposes an iterative heuristic method for the WFSP centered on an efficient implementation of a variable neighborhood search heuristic. Computational experiments on benchmark instances show that the proposed metaheuristic outperforms the state-of-the-art method proposed to the problem, obtaining comparable solution values in much less computational time.

Keywords: Weighted Fair Sequences Problem · WFSP · scheduling · iterative heuristic · Variable Neighborhood Search · VNS

Analyzing shake strategies for the CMMSA

Marcos Robles, Sergio Cavero, Eduardo G. Pardo

Universidad Rey Juan Carlos

The Cyclic Min-Max Sitting Arrangement problem (CMMSA) is a graph layout optimization problem where vertices of an input signed graph must be embedded on a cyclic host graph. The input graph contains weighted edges, either +1 or -1, representing positive and negative relationships between vertices. For each vertex, a penalty occurs when vertices connected by negative edges are positioned closer than those connected by positive edges. The goal is to minimize the maximum number of such penalties occurring at any single vertex. By focusing on minimizing the maximum penalties, the CMMSA ensures a more balanced distribution of conflicts compared to the classical Cyclic Minimum Sitting Arrangement problem, which minimizes the sum of penalties across all vertices. This paper presents a comprehensive study based on Variable Neighborhood Search (VNS) methodologies for solving the CMMSA. Building upon successful applications of VNS in related problems, we analyze multiple algorithmic variants and strategies. Specifically, our investigation focuses on two main components: a Variable Neighborhood Descent (VND) scheme that combines two specialized local search procedures, and a Basic VNS (BVNS) framework incorporating five distinct shake procedures. We evaluate these approaches using established benchmark instances from the literature. Our computational experiments demonstrate the effectiveness of the proposed VNS methods in solving the CMMSA and provide insights into which combinations of components yield the best results for different instance characteristics. The findings not only highlight the efficacy of the proposed approach but also provide a foundation for future research on the CMMSA and related graph layout optimization problems.

Keywords: CMMSA · graph layout · metaheuristics · Variable Neighborhood Search · VNS · shake strategies

A Variable Neighborhood Search Heuristic for the Electric Dial-A-Ride Problem

Mohammad Karimi, Guy Desaulniers, Michel Gendreau

Polytechnique Montréal, GERAD, CIRRELT

This paper addresses the Electric Dial-A-Ride Problem, which involves scheduling a fleet of electric vehicles (EVs) to provide ride-sharing services for customers with specified origins and destinations. The problem incorporates several key features: (1) the use of EVs and consideration of partial charging strategies, (2) a concave piecewise linear charging function, (3) time-dependent charging pricing policies, (4) multiple types of charging infrastructure, and (5) capacity constraints for charging stations. To solve this problem, we propose a variable neighborhood search heuristic with various neighborhood classes, combined with a mixed-integer programming technique to optimize the fleet s charging strategy. The performance of the proposed algorithm is evaluated using large and very large datasets, including instances with up to 10,000 requests adapted from the literature and real-world data. The results demonstrate that the algorithm delivers highly competitive solutions compared to existing approaches in the literature.

Keywords: Electric Dial-A-Ride Problem · Variable Neighborhood Search · metaheuristics · electric vehicles · charging strategy · mixed integer programming

A Machine Learning enhanced Variable Neighborhood Search approach for the Uncapacitated Facility Location problem

Lucas Martín-García, Isaac Lozano-Osorio, J. Manuel Colmenar, Belén Melián-Batista

Universidad Rey Juan Carlos, Universidad de La Laguna

The Uncapacitated Facility Location Problem (UFLP) is widely recognized as a relevant problem in logistics, resource distribution, and telecommunications network planning. Given a set of potential facility locations and a set of customers, the goal is to determine which facilities to open in order to serve all customers while minimizing both opening and assignment costs. Since this problem is classified as NP-hard, obtaining exact solutions at large scales could not be possible, thereby motivating the use of approximation techniques and metaheuristics. Although early studies used exact formulations derived from the UFLP model, recent research has emphasized the efficacy of approximate and metaheuristic algorithms, which achieve high-quality solutions with substantially reduced computational effort. This work introduces a Variable Neighborhood Search approach to tackle this problem. In order to guide the search toward higher-quality solutions, machine learning techniques have been incorporated to this process. Experimental results on well-known benchmark datasets demonstrate that our method reaches solutions very close to the optimal values, with significantly shorter execution times, which makes it competitive with the state-of-the-art algorithms.

Keywords: Uncapacitated Facility Location Problem · UFLP · Variable Neighborhood Search · metaheuristics · machine learning

Parallel Variable Neighborhood Search: A Thematic Survey

Tatjana Davidovic, Teodor Gabriel Crainic, Tatjana Jaksic-Kruger

Mathematical Institute of the Serbian Academy of Sciences and Arts, UQAM, CIRRELT

The main focus of this study is on the survey of parallelization strategies for the Variable Neighborhood Search (VNS) metaheuristic. Parallelization is a widely-used tool for increasing the efficiency of many algorithms. For deterministic algorithms, the main goal is to speed up the execution of all required computations by distributing them among the available processing units. When stochastic algorithms (like metaheuristics) are considered, the expectations are increased: by engaging multiple processing units, one can hope to improve the quality of the resulting solution, if possible, within the reduced running time. However, usually this is not easy to achieve. Various aspects of parallel computing should be examined, such as identification of parallelizable parts, distribution granularity, balancing the computational effort of various processing units, synchronizing their work, optimizing communication (data exchange) delays, etc. In addition, the compatibility between the available hardware resources and the required computational requirements should also be taken into account. Last, but not least, characteristics of the optimization problem in hand and it's suitability for parallel and distributed treatment should not be neglected. Parallel metaheuristic is actually a completely new algorithm that may significantly differ from the original, sequential variant. In some cases, this property may be preferable, however, in many others the authors are trying to preserve the good characteristics of the original algorithm. This survey analyses the existing results related to the parallelization of VNS considering all mentioned aspects. We try to derive some useful recommendations how to address various optimization problems taking into account the available multiprocessor architecture and the existing sequential VNS implementations.

Keywords: Variable Neighborhood Search · VNS · parallel computing · metaheuristics · synchronization · cooperation

Solving the Minimum Positive Influence Dominating Set Problem in Social Networks Using Metaheuristics

Iván Penedo, Isaac Lozano-Osorio, Jesús Sánchez-Oro, Óscar Cordón

Universidad Rey Juan Carlos; Universidad de Granada

The rise of the internet and social networks has posed new challenges in studying people's behavior on these platforms. People tend to trust or align with a small group of users, leading to the development of viral marketing techniques to effectively propagate information about products or services. This has led to the definition of problems related to social influence maximization/minimization and dominance sets. The Minimum Positive Influence Dominating Sets (MPIDS) problem involves finding a minimum cardinality dominance set to influence an entire social network. For a node to be influenced, at least half of its neighbors must be in the dominance set. Considering that MPIDS is an NP-hard problem, where exact approximations are impractical due to the size of social networks, this work proposes using the Basic Variable Neighborhood Search (BVNS). Given an initial solution, this metaheuristic consists of two phases: a shaking and an improvement phase. In the shaking phase, the solution is modified by removing and reconstructing it using a greedy approach. The improvement phase involves an innovative local search strategy based on generating holes, which removes the delta-neighborhood of a node to facilitate an greedy solution reconstruction.

Keywords: Minimum Positive Influence Dominating Set · MPIDS · Variable Neighborhood Search · VNS · Social Networks

Adaptive Variable Neighborhood Search for Tourist Trip Recommendation

Cristina González Navasa, José Andrés Moreno Pérez, Helí Alonso Afonso, Julio Brito Santana

Universidad de La Laguna

Tourists use information about their preferences and the points of interest to select their itinerary at destinations. Generally, they plan their routes in advance, selecting the points to visit and the order in which they are visited, taking into account information that is often imprecise and changing. Intelligent tourist recommendation systems are capable of selecting the optimal route, taking into account the corresponding constraints, and providing the user with detailed information about the selected points of interest and the amount of time on each visit and during the travel between them. However, changes or unforeseen events occur during the tour, which force the route to be modified dynamically. The Tourist Trip Design Problems (TTDP) are formulated as versions of the Team Orienteering Problem (TOP) with the modifications that each case determines. When any of these changes occur, the new situation can also be modeled as a similar problem, with the additional constraints. Several metaheuristics have been used to address TTDP, including VNS. In this work we experiment with Adaptive VNS that dynamically determines which are the best neighbourhoods to use and how, in each type of situation in which it is necessary to modify the route. We review previous works on applying AVNS to routing problems and VNS to TTDP to select which types of moves are considered and the techniques to assess their performance and select them. The characteristics of the problems that arise in the most frequent circumstances that motivate the change in the route are studied: environmental events, unavailables point of interest, lengthened or shortened visit times or journey times between points. This work is aimed to use VNS into a tool for recommending tourist routes that is being developed and designed in collaboration with a technology company with experience in the tourism sector.

Keywords: Adaptive Variable Neighborhood Search · AVNS · Tourist Trip Design Problem · TTDP · Intelligent Tourist Trip Recommender · ITTR

Multi-Objective VNS Tourism Planning: Optimizing Weekend Itineraries in Montreal

Filipe Pessoa Sousa, Augusto Magalhães Pinto de Mendonça, Igor Machado Coelho

Universidade do Estado do Rio de Janeiro; Universidade Federal Fluminense

This research presents a multi-objective optimization approach for planning weekend tourist routes in Montreal. The problem addresses four conflicting objectives: minimizing costs and travel time while maximizing the number of visited attractions and attraction quality based on public ratings. We compare a Multi-Objective Variable Neighborhood Search (MOVNS) algorithm against NSGA-II, both generating itineraries that respect practical constraints including operation hours and transportation limitations. Our approach incorporates walking, metro, and car transportation modes between hotels and attractions over a two-day period. Using real data from Montreal's top attractions and travel information from OSRM, we evaluate both methods through multi-objective metrics such as Pareto coverage.

Keywords: Multi-Objective Optimization · Variable Neighborhood Search · VNS · Tourism Planning · NSGA-II

Efficient Big Data Clustering via VNS-Accelerated Optimization

Rustam Mussabayev, Ravil Mussabayev, Alymzhan Toleu, Ainur Ibraimova

Satbayev University

K-means clustering is a fundamental technique in data mining, yet its performance degrades significantly when applied to massive datasets. To address this limitation, we previously proposed a simple and effective big data clustering algorithm called Big-means. In line with the Less is More approach (LIMA), Big-means was designed to be as simple as possible and did not incorporate any metaheuristics. In the present work, we aim to improve the performance of Big-means by integrating it into the Variable Neighborhood Search (VNS) framework. The core idea is to perform a simultaneous search along two dimensions: 1. Exploring partial solution landscapes created from random samples of the original massive dataset, and 2. Cycling through increasingly broader neighborhoods within these landscapes to refine the current best solution. A special neighborhood structure was defined where two solutions are considered neighbors if they differ in only a fixed number of centroids. Navigating this structure according to VNS methodology provides a more progressive and strategic search through the solution space. The dual-modality approach, combined with the integration of the VNS metaheuristic, enables effective perturbation of the incumbent solution, allowing the algorithm to escape local minima through deeper exploration of each solution landscape. Controlling the sample size in each iteration reduces time complexity and ensures scalability to large datasets. Extensive testing on real-world datasets shows that integrating VNS into Big-means significantly boosts both clustering accuracy and computational efficiency. The proposed method outperforms existing techniques and the original Big-means, establishing a new state-of-the-art for K-means clustering in big data environments.

Keywords: Big Data Clustering · Variable Neighborhood Search · VNS · K-means · BiModalClust

Improved Multi-Objective Variable Neighborhood Search procedure for the optimization of software modularity

Javier Yuste Moure, Eduardo G. Pardo, Manuel López-Ibáñez

Universidad Rey Juan Carlos; Alliance Manchester Business School, University of Manchester

The Software Module Clustering Problem (SMCP) is an optimization problem aimed at enhancing software modularity, a crucial aspect of code maintainability. In 2024, an algorithm based on the Multi-Objective Variable Neighborhood Search (MO-VNS) scheme was developed for the SMCP, addressing a variant of the problem with five different objectives. However, the study identified some weaknesses in the MO-VNS scheme. This work proposes some improvements to the MO-VNS procedure to address previously identified weaknesses. Specifically, it focuses on the Multi-Objective Variable Neighborhood Descent (MO-VND) scheme. The proposed alternative enhances the anytime behavior of the classic MO-VND scheme by (i) uniformly distributing efforts across different objectives and (ii) exploring different acceptance criteria during the search process. Fourteen instances were randomly selected from a widely studied SMCP dataset. To ensure fairness, all methods were coded by the same programmer using the same programming language and optimization framework and executed on the same computing server. Moreover, they started from the same initial solution (built by a random constructive heuristic) for each instance. The proposed methods were run with a maximum computing time of fifteen minutes. To evaluate the behavior of the methods under comparison, one hundred snapshots of the solutions found were taken at different times. The results were evaluated using quality indicators recommended by the literature: Hypervolume (HV), Modified Inverted Generational Distance (IGD+) and the number of non-dominated solutions found (PFS). The proposed variant obtains better solutions on average than the classic scheme at any moment during the execution time according to every quality indicator evaluated: HV, IGD+, and PFS.

Keywords: Software Modularity · Multi-Objective Optimization · Variable Neighborhood Search · MO-VNS · Multi-Objective Variable Neighborhood Descent · SMCP

Exact methods and a variable neighborhood search for the robust capacitated p-median problem

Rafael Ajudarte de Campos, Guilherme O. Chagas, Leandro C. Coelho, Pedro Munari

Université Laval; CIRRELT; Federal University of S o Carlos

The capacitated p-median problem (CPMP) involves placing p identical facilities in a network and assigning customer nodes to these facilities to satisfy all customer demands with minimal transportation costs. In practical applications, demand and distance parameters are often uncertain during the planning process, leading to infeasible or excessively costly solutions if these uncertainties are disregarded. This paper addresses the robust CPMP (RCPMP), which incorporates demand uncertainty into the problem using the robust optimization paradigm. We propose a general framework to model and solve the RCPMP, considering different polyhedral uncertainty sets, namely the cardinality-constrained and the knapsack sets. We develop exact approaches encompassing compact models, different families of valid inequalities, and branch-and-cut and branch-and-price algorithms, exploring both implemented uncertainty sets and problem structure. Furthermore, we implement an efficient Variable Neighborhood Search (VNS) heuristic to solve these robust variants, which incorporates state-of-the-art algorithms, parallelization techniques, and optimized data structures. Computational experiments using adapted benchmark instances with up to 400 nodes indicate the effectiveness of the proposed approaches. The results show that using parallelization and hash tables within the VNS heuristic promotes significant performance improvements and yields near-optimal solutions for most instances, as well as outperforming the exact approaches in several instances where the optimal solution was not found. Moreover, these results highlight the benefits of using robust solutions in practical settings, especially when considering different uncertainty sets to generate solutions with advantageous trade-offs between cost and risk.

Keywords: Capacitated p-Median Problem · Robust Optimization · Variable Neighborhood Search · RCPMP · Uncertainty Sets

PyCommend VNS: A Multi-Objective Python Library Recommendation Framework

Augusto Magalhães Pinto de Mendonça, Filipe Pessoa Sousa, Igor Machado Coelho

Universidade Federal Fluminense; Universidade do Estado do Rio de Janeiro

We introduce PyCommend VNS, a multi-objective framework for recommending Python libraries using Variable Neighborhood Search. The method optimizes linked usage, semantic similarity, and recommendation set size without using arbitrary weights. Experiments on 10,000 top-downloaded Python projects and GitHub data show that PyCommend VNS effectively balances quality and diversity, helping developers discover non-obvious but highly relevant libraries.

Keywords: Library Recommendation · Multi-Objective Optimization · Variable Neighborhood Search · VNS · PyCommend

The Importance of Being Interpretable: Generative AI capabilities and Metaheuristic Research

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College of Charleston; école Polytechnique de Montréal; Universidad Rey Juan Carlos

Building on our seminal exploration of the topic, we present an updated assessment of the evolving relationship between Generative AI and metaheuristics, emphasizing recent advancements in large language models (LLMs) and their implications for optimization research. Over the past year, LLMs have demonstrated remarkable progress in handling unstructured data and performing complex tasks associated with reasoning, emphasizing the importance of interpretability in both AI and metaheuristics. We first review key breakthroughs in LLM capabilities relevant to optimization, including programming, mathematical problem-solving, and scientific knowledge representation. Next, we showcase practical applications of Generative AI in metaheuristic research, such as automated code generation (demonstrating the creation of local search code with comparable execution time and solution quality), literature reviews, and the design of neighborhood structures for Variable Neighborhood Search. Finally, we examine the growing field of LLM interpretability research and discuss how principles from interpretable metaheuristics might contribute valuable insights to understanding these increasingly complex AI systems.

Keywords: Interpretability · Generative AI · Metaheuristics · Large Language Models · Variable Neighborhood Search

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GERAD is an inter-university research centre created in 1979 and bringing together specialists in data and decision sciences, computer scientists, applied mathematicians and mathematical engineers, mainly from HEC Montréal, Polytechnique Montréal, McGill University and the Université du Québec à Montréal. The team comprises more than 70 researchers from Quebec university departments, more than 30 associate researchers from various institutions or industry, nearly 20 research professionals and nearly 500 students at the Master's, Doctorate and Postdoctorate levels. Our Vision

GERAD aims to contribute to future developments in digital intelligence, and to maintain a world leadership role in prescriptive analysis. To make this happen, GERAD's objectives are: to integrate artificial intelligence methods into mathematical decision sciences in order to improve modelling and accelerate solution algorithms; and, conversely, to improve machine learning techniques using mathematical optimization methods. GERAD also aims to increase its influence on the national and international scenes in line with its scientific achievements, in order to promote the use of mathematical decision support methods among all its potential users, thereby helping organizations address major environmental and social challenges.