Gwen MAUDET, Post Doctoral Researcher

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Introduction

Gwen Maudet is currently a postdoctoral researcher at the University of Luxembourg, working on the integration of machine learning techniques to enhance the performance of solvers for Mixed Integer Linear Programming problems. His research focuses on the development of methods based on genetic programming, with the goal of producing human-readable algorithms, as well as on defining structural representations (such as distance measures and clustering) within the space of MILP instances.
Previously, he completed his PhD at IMT Atlantique in Rennes, where he worked on data transmission strategies in highly constrained sensor networks with large numbers of nodes. His work involved designing similarity measures for sensors using sparse and noisy data, developing dynamic clustering methods, and proposing adaptive management strategies for sensor fleets.

Professional Experience

December 2023 – Present

- At *University of Luxembourg, Esch-sur-Alzette, Luxembourg. Postdoctoral Researcher* in **Machine Learning for Mixed Integer Linear Programming (MILP)**. This research focuses on the development of machine learning-based methods to design solving strategies within the branch-and-bound framework for MILP problems, a class of techniques referred to as *MLMILP*. The primary objective is to build generalizable strategies that are effective across the entire MILP instance space and suitable for integration into general-purpose MILP solvers. However, current MLMILP approaches tend to perform well only on homogeneous sets of instances and struggle to generalize to more diverse or heterogeneous cases.
  To overcome this limitation, we propose a portfolio-based solving strategy. The idea is to partition the MILP instance space into structurally homogeneous groups and train a dedicated MLMILP method for each group. When presented with a new instance, its closest group is identified, and the corresponding method is applied. This framework involves several key contributions: (i) the design of new MLMILP methods based on genetic programming, which produces lightweight and human-readable solving strategies; (ii) the definition of mathematical distance measures between MILP instances, capturing their structural similarities; and (iii) the development of clustering techniques to effectively partition the MILP space—similar to class definitions, but extended to the full complexity of MILP instances.

April - September 2020

- At *INRIA, Rennes, France. Internship* in **Detecting Bias in Search Engines**. Contributed to the design and implementation of techniques to detect biases between search engines, including the definition of inter-engine distance measures, outlier detection methods, and the development of meta-search engines. Participated in the writing of a journal article and developed a public-facing web platform to demonstrate and allow experimentation with the tools: `https://snide.irisa.fr`.

Professional Experience (continued)

June - August 2019

- At *Acklio, Rennes, France*. *Internship* in **Header Compression for IoT Networks Using Clustering**. Focused on the reduction of IoT protocol header sizes using rule-based compression mechanisms as defined in RFC 8724. Applied hierarchical clustering and genetic algorithms to identify groups of similar headers (e.g., IP, UDP, CoAP), enabling the generation of efficient compression rules tailored to each group. This approach leveraged the redundancy in protocol fields commonly observed in constrained IoT scenarios.

Education

2020 - 2023

- **PhD** at *IMT Atlantique, Rennes, France*.
  Thesis title: Exploiting Sensor Similarity to Enhance Data Collection in Massive IoT Networks.
  This thesis focuses on efficient monitoring of physical phenomena in environments equipped with a large number of low-power sensors characterized by limited memory, minimal computational capabilities, and finite battery life. These sensors operate within a highly constrained star network and are deployed at scale. The primary objective is to design energy-efficient communication strategies that extend the operational lifetime of the sensor network.
  The proposed approach leverages the concept of sensor similarity: if two sensors consistently produce similar data, only one may be required to transmit, thus reducing communication load and conserving energy. The methodology is structured into three main components: (i) Similarity Estimation — a resilient method for quantifying sensor similarity, designed to operate effectively under sparse and noisy data conditions, and without requiring precise sensor localization; (ii) Coverage Set Construction — leveraging the similarity measures, representative subsets of sensors are selected such that their transmissions can approximate the observations of the entire network; and (iii) Transmission Scheduling — a dynamic and adaptive mechanism for assigning transmission periods, tailored to stringent network constraints, including enforced sleep cycles. This component ensures that data quality is preserved while minimizing energy consumption.
  A video presentation of the thesis is available here: `https://www.youtube.com/watch?v=0p3jmufFM1k`.
  Defense Date: November 23, 2023
  Jury Composition: **Laurent Toutain** – IMT Atlantique (*Director*) **Mireille Batton-Hubert** – École des Mines de Saint-Étienne (*Co-director*) **Patrick Maillé** – IMT Atlantique (*Advisor*) **Alexandre Guitton** – Université Clermont Auvergne (*Reviewer*) **Julien Montavont** – Université de Strasbourg (*Reviewer*) **Kinda Khawam** – Université de Versailles

2016 - 2020

- **Engineering School** at *IMT Atlantique, Nantes, France*.
  Specialization in computer science for decision support, including courses in Machine Learning, Operational Research, and mathematical objects such as graphs and Turing machines. Completed an applied exploratory project for solving TSP using neural networks, implementing GAN, Hopfield NN, Q-DL (50h). Also completed a MILP project to find nurse schedules (20h) and developed a scalable TSP solver using heuristics (10h). Also participated in a one-semester academic exchange at Universiti Teknologi Petronas (Malaysia), where he studied database management methods and programming in C.

2014 - 2016

- **Classes préparatoires aux grandes écoles** at *Rabelais, Saint-Brieuc, France*.
  Completed a two-year intensive program in mathematics and physics to prepare for the national competitive exam for entry into highly ranked engineering schools.

Research Writings

International Journals

- P. Maillé, **G. Maudet**, M. Simon, and B. Tuffin, "Are Search Engines Biased? Detecting and Reducing Bias using Meta Search Engines," en, *Electronic Commerce Research and Applications*, p. 101 132, Feb. 2022, issn: 1567-4223.
  Abstract: The search neutrality debate stems from content or service providers complaining about being discriminated and ranked unfairly low by search engines, raising the need for methodologies and tools to verify bias in search engine rankings. For that purpose, we propose in this paper a simple yet effective framework based on the comparison of the results provided by several search engines, and build the corresponding tool to carry out a campaign of tests. The main objectives are to develop an interpretable model of search engine behaviors and to design statistical tests pointing out suspicious instances as possible bias, without knowing the detailed ranking algorithms implemented by search engines. Our approach consists in reasoning in terms of the visibility that search engines give webpages when ranking them among their results; different types of possible bias can then be detected using statistical tests for outlier detection. We apply this methodology to a test campaign over the most searched terms, which highlights some similarities and discrepancies among search engines, and possible instances of bias. Our approach can be of interest to regulators or any actor in the Internet, and is directly applicable to any search term through a publicly-available tool performing extensive comparisons and bias investigations, and offering two (bias-reducing) meta rankings.

International Conferences

- **G. Maudet**, G. Danoy, "Search Strategy Generation for Branch and Bound Using Genetic Programming," en, in *Proceedings of the AAAI Conference on Artificial Intelligence 39,* 2025.
  Abstract: Branch-and-Bound (BB) is an exact method in integer programming that recursively divides the search space into a tree. During the resolution process, determining the next subproblem to explore within the tree—known as the search strategy—is crucial. Hand-crafted heuristics are commonly used, but none are effective over all problem classes. Recent approaches utilizing neural networks claim to make more intelligent decisions but are computationally expensive. In this paper, we introduce GP2S (Genetic Programming for Search Strategy), a novel machine learning approach that automatically generates a BB search strategy heuristic, aiming to make intelligent decisions while being computationally lightweight. We define a policy as a function that evaluates the quality of a BB node by combining features from the node and the problem; the search strategy policy is then defined by a best-first search based on this node ranking. The policy space is explored using a genetic programming algorithm, and the policy that achieves the best performance on a training set is selected. We compare our approach with the standard method of the SCIP solver, a recent graph neural network-based method, and hand-crafted heuristics. Our first evaluation includes three types of primal hard problems, tested on instances similar to the training set and on larger instances. Our method is at most 2 percents slower than the best baseline and consistently outperforms SCIP, achieving an average speedup of 11.3 percents. Additionally, GP2S is tested on the MIPLIB 2017 dataset, generating multiple heuristics from different subsets of instances. It exceeds SCIP's average performance in 7 out of 10 cases across 15 times more instances and under a time limit 15 times longer, with some GP2S methods leading on most experiments in terms of the number of feasible solutions or optimality gap.

Research Writings (continued)

- **G. Maudet**, M. Batton-Hubert, P. Maille, and L. Toutain, "Energy Efficient Message Scheduling with Redundancy Control for Massive IoT Monitoring," en, in *IEEE Wireless Communications and Networking*, 2023.
  Abstract: In current sensor-based monitoring solutions, each application involves a specified deployment and requires significant configuration efforts to adapt to changes in the sensor field. In this paper, we propose a generic solution that relies on the massive deployment of battery-powered sensors. More precisely, we present a solution for LPWAN sensors emissions scheduling to ensure overall regular sensor data emissions over time (at a rate chosen by the user) while limiting management costs incurred by sensors' arrivals and departure. Our objectives include monitoring quality that we evaluate through a "diversity" metric encompassing that information value depletes with time, plus management cost quantified by the number of orders sent to sensors. Modeling arrivals and departures as random processes, we compute those performance metrics as functions of the overall data reception period selected and evaluate them against alternative scheduling methods. We show that our solution is better suited for Massive IoT contexts.

- **G. Maudet**, M. Batton-Hubert, P. Maille, and L. Toutain, "Emission Scheduling Strategies for Massive-IoT: Implementation and Performance Optimization," en, in *IEEE/IFIP Network Operations and Management Symposium*, Apr. 2022.
  Abstract: In today's monitoring solutions, each application involves custom deployment and requires significant configuration efforts to accommodate sensor changes. In contrast, in this paper, we consider a massive deployment of battery-powered sensors to propose a more versatile monitoring solution that is not tied to the physical deployment of devices. First, we define a framework for the definition of a monitoring strategy, for which we propose a generic monitoring accuracy metric, which, weighted to the lifetime of the monitoring network, allows the characterization of a multi-objective problem. We then introduce a specific two-parameter instantiation for the period update function, that ensures strictly periodic emissions from sensors even when new sensors join the system over time. We show through simulations how the two parameters– target emission period and number of jointly used sensors–can be chosen according to the objectives for the monitoring, by highlighting the Pareto front for accuracy and energy-efficiency.

National Conferences

- **G. Maudet**, M. Batton-Hubert, P. Maille, and L. Toutain, "Grouper les Capteurs Similaires Grace à leurs Données dans le Contexte de Massive IoT," in *26èmes Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications*, May 2024.
  Abstract: L'expansion de l'Internet des objets, conjointement à la réduction du coût des appareils connectés, a permis le déploiement massif de capteurs. Puisque les capteurs sont présents en grande quantité, ils fournissent souvent des données similaires en raison de leur proximité. Dans cet article, nous cherchons à identifier de telles similitudes entre les capteurs en fonction de leurs données renvoyées, en constituant des groupes de capteurs similaires. Nous considérons un scénario générique où les capteurs sont déployés à différents moments et existent dans l'environnement pour une durée limitée, transmettant des données bruitées et irrégulières au fil du temps, sans synchronisation entre eux. Pour résoudre ce problème, nous introduisons une métrique de distance basée sur des interpolations et une solution de regroupement hiérarchique. À travers des simulations, nous démontrons la supériorité de notre méthode par rapport aux propositions de la littérature.

Research Writings (continued)

- **G. Maudet**, M. Batton-Hubert, P. Maille, and L. Toutain, "Réduction de la Redondance de Messages des Capteurs dans un Contexte Massive IoT," in *25èmes Rencontres Francophones sur les Aspects Algorithmiques des Télécommunications*, May 2023.
  Abstract: Dans les solutions actuelles de surveillance basées sur des capteurs, chaque application nécessite un déploiement spécifique et des efforts de configuration importants pour s'adapter aux changements dans le champ de capteurs. Dans cet article, nous proposons une solution générique qui repose sur un déploiement massif de capteurs alimentés par batterie. Plus précisément, nous présentons une solution de planification des émissions de capteurs pour garantir des émissions régulières de données de capteur dans le temps (à un taux choisi par l'utilisateur) tout en limitant les coûts de gestion engendrés par les arrivées et départs de capteurs. Nos objectifs comprennent la qualité de surveillance que nous évaluons à travers une métrique de "diversité" qui englobe le fait que la valeur de l'information s'épuise avec le temps, plus les coûts de gestion quantifiés par le nombre d'ordres envoyés aux capteurs. Nous comparons notre méthode à des méthodes d'autres solutions, et montrons que notre solution est davantage performante.

On Going Work

- **G. Maudet**, M. Batton-Hubert, P. Maille, and L. Toutain, "A Survey On Data Collection Based on Sensors Similarity," en, In progress, 2023.
  Abstract: The Internet of Things (IoT) is commonly employed for monitoring various physical quantities. In the innovative approach of Massive IoT (MIoT), a massive deployment of highly constrained sensors is considered to reduce deployment and maintenance costs. To align with this scenario, the objective is to develop mechanisms to reduce sensor energy consumption. This survey delves into energy-efficient solutions derived from existing literature, which harness the concept of similarity evaluated between sensors to efficiently distribute the observation workload. Through a comprehensive investigation of papers in the literature that tackle this scenario, we demonstrate that a solution can be deconstructed into three core components, namely the similarity metric, the covering subset algorithm and the activation allocation method. The *similarity metric* serves as a real-valued measure that quantifies the proximity among sensors based on known sensor information. Leveraging this similarity metric, the *covering subset algorithm* constructs one or more subsets of sensors, with each subset ensuring the fulfillment of the physical quantity monitoring requirements. Finally, relying on the coverage subsets, the *activation allocation method* determines how to distribute the load of observation sent by the sensors. For each of these components, we present the contributions found in the existing literature while identifying their inherent limitations. We analyze them from different perspectives crucial to a MIoT deployment, thereby shedding light on the limitations of existing works.

Research Writings (continued)

- **G. Maudet**, M. Batton-Hubert, P. Maillé, and L. Toutain, "Grouping Sensors Based on Observations in a Massive IoT Deployment," en, In progress, 2023.
  Abstract: In the context of deploying a large number of sensors in an environment to monitor a physical quantity, proximity between sensors often leads to closely correlated observations. Assessing this similarity among sensors offers a valuable opportunity to reduce redundant observations and conserve sensor energy resources through optimized data transmission strategies. In this paper, we tackle the challenge of sensor grouping based on the similarity of observations they provide. These sensors are deployed in the environment for a limited duration and transmit observations with irregular temporal spacing, lacking synchronization. Our contributions include the introduction of a distance metric utilizing the Kriging interpolation method to assess discrepancies in average magnitude between interpolations from pairs of sensors. Additionally, we propose a hierarchical clustering approach for grouping similar sensors, incorporating a linkage method that assigns greater weight to distances calculated over extended time intervals. Through simulations, we demonstrate that our distance metric effectively distinguishes sensors following the same phenomenon from those following different ones, outperforming the Jaccard index, which is our comparative metric due to its suitability for our assumptions. Furthermore, we adapt an existing solution from the literature, aiming to limit the maximum discrepancy between all interpolations within the same cluster. We establish the superiority of our approach in terms of the quality of sensor grouping.

Supervision

PhD

2023–Present
- **Alisa Vorokhta**, PhD student. Research on the application of machine learning methods to enhance the efficiency of MILP solvers, especially by reducing the impact of the lower bound computation.

Interns

2025
- **Baka Junior Cedric Ble**, Master's student (5months). Worked on clustering methods for MILP instances, aiming to develop a portfolio-based approach where specific MLMILP models are applied to homogeneous groups of instances. (5 months)

- **Mathis Da Cunha**, Master's student(5months). Research on the use of genetic programming to define cutting plan selection strategies within branch-and-bound frameworks. (5 months)

2022
- **Issam Belhorma**, Master's student(4 months). Applied kriging-based techniques to estimate sensor positions using returned sensor data and references from known-position nodes. (4 months)

2021
- **Carlos Delgado**, Master's student (3months). Worked on sensor deployment in vertical green walls for monitoring and regulating soil humidity levels. (2 months)

Teaching

2024-2025

- Project Lead for student groups at *University of Luxembourg, Esch-sur-Alzette, Luxembourg*. Supervised a team of three master's students in Information and Computer Science, working on a research project for four hours per week over three months. The first project (2024) focused on analyzing the performance of two lower-bound strategies in branch-and-bound algorithms applied to the Permutation Flowshop Scheduling Problem. The second project (2025) addressed cutting plan selection in branch-and-bound frameworks. The aim was to investigate the trade-off involved in choosing an appropriate cutting strategy and to develop methods based on genetic programming for automatically generating effective cutting plan selection strategies.

2024

- Lecturer at *University of Luxembourg, Esch-sur-Alzette, Luxembourg*. Taught the first semester of the first-year master's program in Information and Computer Sciences to approximately 58 students in an amphitheater. Delivered 4 of the 12 sessions, each lasting 1.5 hours, covering the following topics:

    * Introduction to Integer Linear Programming: Explained the components of branch-and-bound with an interactive example for students to follow.

    * Development of Population-Based Metaheuristic Algorithms: Focused on evolutionary algorithms (e.g., genetic algorithms, genetic programming) and swarm intelligence methods (e.g., ant colony optimization, particle swarm optimization), discussing design choices and applications.

    * Application of Optimization Methods to the Traveling Salesman Problem: Designed a hands-on session using a self-contained Jupyter Notebook to tackle the problem with brute force, heuristics, and metaheuristics. Students implemented and analyzed results from algorithms such as genetic algorithms and ant colony optimization.

    * Presentation of Recent Research: Demonstrated the integration of branch-and-bound and genetic programming to automate the construction of a key branch-and-bound component (search strategy), showcasing the practical application of these tools to current optimization challenges.

Teaching (continued)

2022 - 2023

- Practice teacher at *IMT Atlantique, Rennes, France*. Supported the first semester of a two-year international master's program in IT, focusing on mathematics and programming foundations. Courses were conducted remotely, with instructors based in Brest. Worked with 12 students in 2022 and 24 in 2023. All courses were delivered in English.
    * Matlab - 6h (2022) + 6h (2023): Introduction to Matlab programming, applying it to mathematical concepts such as complex numbers, matrix calculations, sequences, and signal processing.
    * Algebra - 6h (2022) + 6h (2023): Covered linear spaces, eigenvectors, eigenvalues, and matrix transformations.
    * Introduction to Python - 9h (2022) + 9h (2023): Introduced Python programming, focusing on objects, functions, and libraries such as *RegEx*, *Numpy*, and *Pandas*.
    * Python for Data Science - 16h (2022) + 16h (2023): Explored data science concepts from visualization to machine learning. Students completed projects such as analyzing forest fire data (2022) or researching and applying novel machine learning concepts (2023).
    * Operational Research - 7h30 (2022): Provided an overview of linear programming, integer linear programming, and heuristics. Students tackled optimization problems in heating, telecommunications, and hub location networks.
    * Probability and Statistics - 4h (2022): Assisted with statistical tasks, including generating random variables from cumulative distribution functions.
    * Signal Processing - 2h30 (2023): Supported signal analysis tasks in Matlab, including identifying harmonics and object positioning through trilateration.

2012 - 2019

- Private tutor in *Brittany, France*. Provided personalized teaching to primary and secondary school students, averaging two students per week.

Presentations

2025

- **Search Strategy Generation for Branch and Bound Using Genetic Programming**, at *AAAI, Philadelphia, USA*. Oral presentation and poster. The oral presentation was one of approximately 600 selected from over 3,000 accepted papers at the conference.

2024

- **Grouper les capteurs similaires grâce à leurs données dans le contexte de Massive IoT**, at *ALGOTEL, Saint-Briac-sur-Mer, France*.

2023

- **Energy Efficient Message Scheduling with Redundancy Control for Massive IoT Monitoring**, at *IEEE WCNC, Glasgow, Scotland*.
- **Réduction de la Redondance de Messages des Capteurs dans un Contexte Massive IoT**, at *ALGOTEL, Cargese, France*.

2022

- **New Monitoring Strategies using Massive IoT** , at *Plate-forme Intelligence Artificelle, Saint-Étienne, France*.

Presentations (continued)

- **Emission Scheduling Strategies for Massive-IoT: Implementation and Performance Optimization**, at *IEEE NOMS, Budapest, Hungary*.

2021

- **Poster: Dynamic management of a field of sensors to extend the monitoring time**, at *Symposium IMT: internet du futur, Villeneuve d'Ascq, France*.
- **Strategies for transmitting LoRa wireless sensors to optimize supervision**, at *Journées LPWAN, Clermont-Ferrand, France*.

2019

- Master of ceremonies, at *IMT Atlantique students' graduation ceremony, Nantes, France*.

Review Committee

PC chair

2025

- Shadow PC Chair for the *Algotel-Cores* Conference. Led the organization of the shadow reviewing process, including the call for shadow reviewers, introductory sessions on peer-review methodology, bidding setup, and paper discussions. The shadow review program allows early-career researchers to participate in a full peer-review process without impacting the official paper selection.

Reviewing

2024-2025

- Two times reviewed two seven pages double column papers for the *PDCO* Workshop of the international conference *IPDPS*.

2024

- Reviewed one twelve pages double column paper for the international journal *IEEE TNSM*.
- Reviewed one fourteen pages double column paper for the international journal *IEEE Sensors Journal*.

2023

- Shadow reviewed four four-page single-column conference papers for the French national conference "*Cores et Algotel*".

Miscellaneous Experience

Position in Associations and Institutions

2022 - 2023

- **President of the association of PhD students and young researchers** in *IMT Atlantique Rennes*.

2023

- **Representative of the PhD students** for the *doctoral school "SPIN"*.

Sports

- Indoor and outdoor climber (lead and bouldering, level 7a).
- Trail and road runner (half-marathon in 1h50).
- Judoka (black belt).

Skills

Languages	• Strong reading, writing and speaking competencies for English (C1), basic comprehension and expression skills in Spanish (A2) and italian (A2).
Coding	• Python (ML & DS packages), R (statistics and Kriging), DBeaver, MongoDB, LaTeX, …
Misc.	• Academic research, teaching, training, internship supervision, LaTeX typesetting and publishing.

References

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