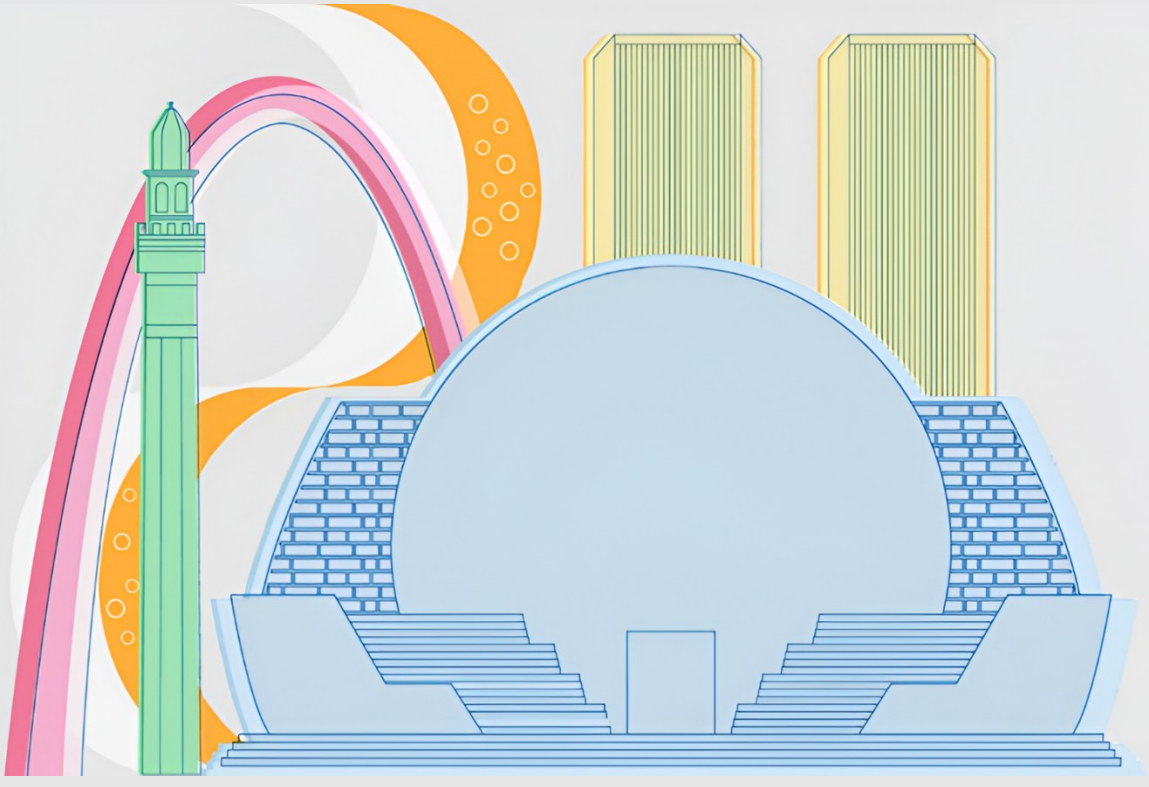
NEO

NUMERICAL AND EVOLUTIONARY OPTIMIZATION

September 23 – 26, 2025

Tijuana, BC, Mexico



With gratitude and respect

In memory of Dr. Gustavo Olague Caballero

It is with deep sorrow that we join the scientific community in mourning the passing of Dr. Gustavo Olague Caballero, researcher at CICESE, who left us on July 26, 2025. Dr. Olague was a close collaborator of the NEO Workshop and a distinguished invited speaker in several of its editions. His pioneering contributions to Computer Vision and Evolutionary Computation have left an enduring impact on both the national and international scientific communities. Beyond his outstanding technical achievements, Dr. Olague was a devoted science communicator, deeply committed to mentoring new generations of researchers and to fostering critical thinking and technological development in Mexico.

On behalf of the NEO organizing committee, we extend our heartfelt condolences to his family, friends, colleagues, and students. His scientific and human legacy will remain a lasting source of inspiration.

Rest in peace.

Contents

Foreword

Welcome

Welcome to NEO 2025, the 12th International Workshop on Numerical and Evolutionary Optimization, taking place from September 23–26, 2025, at the Tecnológico Nacional de México / Instituto Tecnológico de Tijuana and the Sección 2 of the SNTE venue in Tijuana, Baja California.

The goal of the Numerical and Evolutionary Optimization (NEO) workshop series is to bring together researchers and practitioners from all areas of optimization to discuss, compare, and integrate their complementary perspectives. NEO particularly encourages the development of fast and reliable hybrid methods that combine the strengths of different paradigms, reduce their limitations, and extend their applicability to a wide range of problems. In addition, NEO promotes the understanding and treatment of real-world problems, especially those arising in emerging technologies that impact society.

When including the Research Experience Day (RED), this year's edition will feature nearly 70 presentations from participants primarily from across Mexico, as well as international contributions from the USA and France. Over the years, the NEO community has grown not only in size but also in terms of gender diversity. Since 2018, NEO has proudly hosted the Women at NEO (W-NEO) session, an initiative that highlights and gives visibility to the contributions of women in science and engineering.

In addition, NEO 2025 will once again host the RED, offering undergraduate students the chance to attend conferences, tutorials, and discussion panels designed to spark their interest in the wide variety of research career opportunities available to them.

We are delighted to welcome you to NEO 2025 and thank you for being part of this growing community. We hope you enjoy the experience and find it both inspiring and valuable.

Sincerely,
Dr. Daniel E. Hernandez,
Tecnológico Nacional de México/IT de Tijuana,
NEO 2025 General Chair

Acknowledgments

We extend our sincere gratitude to all the researchers, speakers, and participants whose contributions make the NEO 2025 Workshop possible. We also acknowledge the support of academic institutions, sponsoring organizations, and the dedicated members of the organizing and program committees. Their collective efforts ensure the continued success of this event and foster the advancement of scientific exchange and collaboration within our community.

In particular, we would like to thank our Keynote Speakers:
Jian-Qiao Sun; UC Merced, USA
Ryan J. Urbanowicz; Cedars-Sinai Medical Center, USA
Pierrick Legrand; Bordeaux INP and IMS, France
Víctor Díaz Ramírez; Instituto Politécnico Nacional, Mexico

As well as the Speakers and Participants of the Research Experience Day 2025:
Luis Ledezma; Tecnológico Nacional de México/IT de Ciudad Juárez
Guillermo Sánchez; ThermoFisher Scientific
Ricardo Martínez; CETYS Universidad
Ricardo Cárdenas; Tecnológico Nacional de México /IT de Tijuana
Anaid Álvarez; Centro de Investigación y Desarrollo de Tecnología Digital del IPN
Adrián Rodríguez; Universidad Autónoma de Baja California
Noelia Torres; Tecnológico Nacional de México /IT de Tijuana
Rogelio Valdez; Tecnológico Nacional de México /IT de Tijuana

Further, we thank the institutions:
Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI)
Sindicato Nacional de Trabajadores de la Educación Sección 2
CINVESTAV-IPN
Universidad Veracruzana
Tecnológico Nacional de México /IT de Tijuana

And our academic colleagues:
Guadalupe Carmona; Centro de Investigación en Alimentación y Desarrollo
Rolando Menchaca; Centro de Investigación en Computación del IPN

NEO 2025 Organizing Committee

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Mathematical and Computational Applications

IS-LAB

SNTE Sindicato Nacional de Trabajadores de la Educación
"POR LA EDUCACIÓN AL SERVICIO DEL PUEBLO"
2 SECCIÓN

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Schedule

Schedule

Day 1, September 23, 2025 (Research Experience Day)

"(V)" denotes virtual participation

08:00 — 08:30	Registration
08:30 — 9:00	Opening and group photo
09:00 — 10:00	• **Jian-Qiao Sun, UC Merced, USA** What machine learning can do for engineering
10:00 — 11:30	• Panel discussion: Strategic alliance between graduate programs and industry. **Participants: Luis Ledezma (ITJ), Guillermo Sanchez (ThermoFisher Scientific), Leonardo Trujillo (TecNM/ITT)**
11:30 — 11:50	Break
11:50 — 12:50	• **Víctor Díaz Ramírez, CITEDI-IPN, Mexico** Hybrid methods in multichannel vision, image processing, and pattern recognition.
12:50 — 13:50	Finding your graduate program **(ITT, IPN, CETYS)** Dr. Ricardo Martínez Soto, Cetys Universidad, Coordinador de Maestría en Ingeniería e Innovacion. Dr. Ricardo Cardenas, TecNM/ITT, Coordinador de Posgrado en Ciencias de la Ingeniería. M.A.E. Anaid Berenice Álvarez Fuentes, Citedi, Coordinadora de Maestría en Ciencias en Sistemas Digitales.
13:50 — 14:20	Closing
14:20 — 16:00	Break
16:00 — 17:30	• Workshop 01: Opening the Black Box — Neural Networks. **Oliver Cuate, ESFM-IPN** • Workshop 02: Intensive Course — Deploying Large Language Models in Colab. **Adrian Rodriguez Aguiñaga, UABC** • Workshop 03: Interactive Workshop — Data Visualization with Python. **Noelia Torres and Rogelio Valdez, TecNM/ITT**

Day 2, September 24, 2025

08:00 — 09:00 Registration
09:00 — 09:30 Opening
09:30 — 11:00 Session I (GPHS1, 4 talks, Room 1) and Session II (AML1, 4 talks, Main Room)

Session I: Chair: Leonardo Trujillo

- Quantifying the impact of genetic programming feature transformations: an analysis using the optimal transport dataset distance.
  Joel Nation
- Integrating MLIR Infrastructure with MOEAs for FPGA Design Space Exploration.
  Joel Quevedo
- Hardware description language based approach for GSGP design.
  Juan Flores-R
- GSGP-CUDA for Supervised Classification.
  Cesar Lepe García

Session II: Chair: Daniel Hernández

- Embedded System for Vehicle Environment Perception and License Plate Recognition (LPR) Using Computer Vision and Deep Learning.
  Rogelio Leonardo Méndez Macías
- Underwater Computer Vision for Tilapia Aquaculture: YOLACT-Based Trajectory Tracking and Group Behavior Analysis During Feeding.
  Osbaldo Aragón-Banderas
- Optimizing Employee Attrition Prediction Models with TPOT AutoML.
  Daniel E Moreno
- Comparative Analysis of Machine Learning Models for Congestive Heart Failure Detection from QRS Complex.
  Adriel Lozada Romero

11:00 — 11:20 Coffee break
11:20 — 12:20 Keynote I: **Ryan J. Urbanowicz, Cedars-Sinai Medical Center, USA**
Learning to Evolve, Evolving to Learn: Interpretable AI for Unlocking Biomedical Complexity.
12:20 — 12:40 Group Photo
12:40 — 14:00 Poster session
13:00 — 14:00 Lunch Boxes (Lunch boxes will be provided)
14:00 — 15:00 Session III (EMO1, 3 talks, Main Room) and Session IV (OOG1, 3 talks, Room 1)

Session III: Chair: Oliver Schütze

- Multi-objetive Particle Swarm Algorithm for Multi-objective Reinforcement Learning.
  Teresa Becerril (V)
- A Continuation Method for Parameter Dependent Multi-objective Optimization Problems.
  Francisco Vidal
- Course Scheduling Optimization Using Genetic Algorithms: A Case Study in a Mathematics Department.
  Leonardo E. Rivera-Zacarias

Session IV: Chair: Rolando Menchaca-Méndez

- A Comparison of Heuristic Methods for the Identification of Regions of Interest in Wildfires.
  Braulio Leonardo Santa Fe-García (V)
- Socio-Environmental Regionalization Based on Clustering and Geospatial Analysis.
  Erick Estrada Patiño(V)
- Computing Regulatory Control Policies in Facility Location Games Using Reinforcement Learning.
  Rolando Menchaca-Méndez

15:00 — 15:20 Coffee break

15:20 — 17:20 Session V (DO1, 3 talks, Room 1), Session VII (LSEO1, 3 talks, Room 1) and Tutorial (Main Room)

Session V: Chair: Guadalupe Carmona Arroyo

- Optimal Hyperspectral Band Selection Using Metaheuristics for the Detection of Aspergillus flavus in Figs with Convolutional Neural Networks.
  Israel Calderon Aguilar (V)
- A Belief Model for BDI Agents Derived from Roles and Personality Traits.
  Eduardo David Martínez-Hernández (V)
- Knowledge-Based Design Methodology for Human Resources Information Management.
  Sofia Morales Zaleta(V)

Session VII: Chair: Guadalupe Carmona Arroyo

- Study of Performance from Hierarchical Decision Modeling in IVAs within a Greedy Context.
  Francisco Federico Meza Barrón (V)
- Study on the impact of machine learning techniques to support CO2 capture process via Ionic liquids.
  Rodolfo Ortega (V)
- A methodology for Information Retrieval from Industrial Systems based on Artificial Intelligence Methods.
  Jesús Carballo Ruelas (V)

Tutorial:

- Evolutionary Artificial Intelligence: An Industrial Case Study.
  Dr. Octavio Ramos-Figueroa and Marcela Quiroz-Castellanos

Day 3, September 25, 2025

09:00 — 09:30 Registration

09:30 — 11:00 Session VIII (GPHS2, 4 talks, Main Room) and Session IX (EMO2, 4 talks, Room 1)

Session VIII: Chair: Yazmín Maldonado

- Estimation of total body fat using Genetic Programming.
  José Manuel Muñoz Contreras
- Machine Learning Algorithms for Translating Inductive Band Signals into Spirometric Volume Estimates.
  José Rosario Ortega Ramírez
- Implementation of a CNN in FPGA for Pulmonary Volume Estimation.
  Fidel Alejandro Ortega Ramírez
- Exploration of FPGAs as a Platform for the Development of Adaptive Logic Circuit Design Using ANN.
  Teodoro Alvarez-Sanchez

Session IX: Chair: Oliver Cuate

- Scenario Optimization in Fuzzy Cognitive Maps by Means of Multi-objective Evolutionary Algorithms.
  Carlos Ignacio Hernández Castellanos
- RSG, a Method for Pareto Front Approximation and Reference Set Generation.
  Angel Rodriguez-Fernandez
- An Evolutionary Approach for the Computation of ε-Locally Optimal Solutions for Multi-Objective Multimodal Optimization.
  Angel Rodríguez-Fernandez
- Smooth Path Planning for Multi-robot Systems in Warehouses.
  America Morales-Díaz

11:00 — 11:20 Coffee break

11:20 — 12:20 Keynote 2: **Pierrick Legrand, Bordeaux INP and IMS, France**
Artificial Evolution and Illustrative Applications

12:20 — 12:40 Coffee break

12:40 — 13:20 Session X (AML2, 2 talks, Room 1) and Session XI (LSEO2, 2 talks, Main Room)

Session X: Chair: Daniel Hernández

- Analysis of Mexican pandemic COVID-19 mobility data through an NP-hard propagation model.
  José Alejandro Cornejo-Acosta (V)
- Neural Architecture Search with CMA-ES for Facial Emotion Recognition.
  Ricardo Santiago (V)

Session XI: Chair: Marcela Quiroz

- Comparative Analysis of Optimization Techniques Applied to Automotive Assembly Using Big Data.
  Jose Peinado
- Experimental Data-Driven Gaussian Process Regression Model for Thermal Conductivity Prediction in Aluminum Alloys.
  Jaime Guillen

13:20 — 15:00	Lunch (on your own)
15:00 — 15:20	Coffee break
15:20 — 17:20	WNEO Chair: Yazmín Maldonado
19:00 — 23:00	Gala dinner - Food is served at 20:00

Day 4, September 26, 2025

09:00 — 10:00 Session XII (OOG2, 3 talks, Main Room) and Session XIII (EMO3, 3 talks, Room 1)

Session XII: Chair: Rolando Menchaca-Méndez

- Graph-Based Strategies for Grouping Variables in Multiobjective Optimization With Overlap.
  Miguel Angel Hernández Servin
- Fitting and validation of a Monod–logistic model for Stigeoclonium nanum in a thin-layer photobioreactor.
  Jesus Leonel Arce Valdez
- The Moving Firefighter Problem with Heterogeneous Propagation Times.
  Rolando Menchaca-Méndez

Session XIII: Chair: Oliver Cuate

- Bailando++: An Approximation from Computational Creativity.
  Fernando Rodrigo Valenzuela
- The Pareto Tracer for the Numerical Treatment of High-dimensional Multi-objective Optimization Problems.
  Pablo Uriel Benítez Ramírez
- Optimizing Solar Panel Allocation in Smart-City Buildings Using Genetic Algorithms.
  Ponciano Escamilla-Ambrosio

10:00 — 11:00 Session XIV (DO2, 3 talks, Main Room) and Session XV (LSEO3, 3 talks, Room 1)

Session XIV: Chair: Marcela Quiroz

- Analysis of Tumor Growth Under Oncological Treatment Using Mathematical Modeling and Artificial Intelligence.
  Uriel Solís Procopio
- Toward a Data Science Pipeline for the Design of Hyper-Heuristic Grouping Genetic Algorithms.
  Octavio Ramos-Figueroa
- Task Scheduling Optimization in Cloud Computing: A Bin Packing and Machine Learning Perspective.
  Jessica Gonzalez San Martin(V)

Session XV: Chair: Guadalupe Carmona Arroyo

- Dynamic Multi-objective Evolutionary Algorithm Based on Decomposition with Adaptive Response Change Environment Method (DMOEA/D-ARCEM).
  Miguel Garcia(V)
- A Hybrid Ensemble Model for Financial Time Series Forecasting Integrating Statistical, Machine Learning and Deep Learning Methods.
  José Olvera (V)
- Efficient Selection of Low Level Heuristics in Hyperheuristics Using Combinatorial Testing for the Master Bay Planning Problem.
  Norberto Castillo-García (V)

11:00 — 11:20 Coffee break

11:20 — 12:40 Session XVI (AML3, 4 talks, Main Room) and Session XVII (DO3, 4 talks, Room 1)

Session XVI: Chair: Paul Valle

- A Machine Learning Approach to Gender Classification via Operating System GUI Interaction Pattern.
  Eduardo Navarro Bautista (V)
- Preprocessing of EEG signals to measure the impact of psychological interventions through Artificial Intelligence.
  David Octavio Roa-Rico
- Evolutionary NAS Models and Pre-Trained CNNs for Tattoo and Face Recognition.
  Benjamin Fajardo Hernandez
- Beyond Hyperscalers: How MLOps Unlocks AI in Latin America.
  Adrian Rodriguez Aguiñaga

Session XVII: Chair: Octavio Ramos-Figueroa

- EV-STSP on Directed Urban Networks: Construction, Energy Enrichment, and Evaluation.
  Juan Hernandez-Marin(V)
- SA and TA algorithms applied to alternative assets in mexican stock exchange.
  José Purata Aldaz(V)
- Ensemble Deep Learning and Metaheuristic Strategies for Stock Forecasting and Investment Portfolio Optimization.
  José Purata Aldaz (V)
- Query Optimization in RAG: Retrieval and Context Construction.
  Fabricio Chia (V)

12:40 — 13:00 Closing

Poster session, September 24, 2025

- Predictive glucose monitoring and telemedicine-enhanced diabetes management.
  Jose Ricardo Cardenas Valdez
- Statistical and Machine-Learning Framework for Climate–Socioeconomic Interactions in Mexico and Developed and Emerging Economies.
  Guadalupe Valdez
- Design and Development of an Optimized Control System for a Solar Tracking System.
  Andres Calvillo-Tellez
- Fuzzy Decision Trees and Genetic Algorithms for the Automated Construction of Fuzzy Predicates.
  Jose Padron Tristan
- Particle Swarm Optimization for Hydro-Thermal Power Scheduling Problem with a Type-1 Fuzzy Controller for Dynamic Parameter Adjustment.
  Norberto Castillo-García

II Invited Speakers

Dr. Jian-Qiao Sun

What machine learning can do for engineering

UC Merced, USA

Talk Abstract

This talk presents discussions on what we can do with machine learning for engineering research. Specifically, we shall discuss the following questions without giving the audience affirmative answers. It is hoped that this talk will motivate more people to learn various methods from the machine learning and artificial intelligence community and apply them to investigate new solutions of engineering research problems.

1. What does machine learning really do?
2. Why do we call the method learning, not solving?
3. How do we define the intelligence?
4. How do we make the ML solution intelligent?
5. Why is it important to study algorithms in the AI age?
6. Why digital twin is a dream of engineers?
7. What have we done in dynamics and control for engineering applications?

Short Biography

Jian-Qiao Sun is Professor Emeritus in the Department of Mechanical and Aerospace Engineering at the University of California, Merced. He earned his Ph.D. and M.S. in 1988 from the University of California, Berkeley, and his B.S. in 1982 from Huazhong University of Science and Technology, Wuhan, China. Professor Sun's research spans vibrations and noise control, sensors and actuators, industrial automation, and biomechanics, including applications in physical rehabilitation. He has also worked on energy-harvesting technologies, smart devices (such as adaptive knee braces for gait evaluation), optimizing systems for sound control, and modeling of human-machine interactions.

Dr. Víctor Díaz Ramírez

Hybrid methods in multiocular vision, image processing, and pattern recognition

CITEDI-IPN, Mexico

Talk Abstract

Multiocular vision and advanced image processing have become fundamental tools for applications in robotics, intelligent systems, and industrial environments. This talk presents hybrid methods that integrate classical digital image processing approaches with modern techniques in machine learning and pattern recognition. The discussion will highlight the advantages of combining information from multiple cameras to improve three-dimensional perception, segmentation, and the analysis of complex scenes.

Experimental results will be shown where the integration of statistical, heuristic, and learning algorithms has enabled the development of more robust and accurate systems for detection and classification tasks. Finally, the talk will address current challenges and research opportunities in this emerging field, with special emphasis on practical applications.

Short Biography

Víctor Díaz Ramírez earned his degrees in Electronics Engineering and Master's in Electronic Engineering from the Mexicali Institute of Technology in 2001 and 2004, respectively. In 2007, he received his Doctor of Science degree in Computer Science from CICESE. Since 2009, he has been a full-time research at the National Polytechnic Institute. He is the author of numerous scientific articles published in journals indexed in the Journal Citation Reports, as well as in national and international conference proceedings. To date, he has supervised eight doctoral theses and more than twenty master's theses. He has served as technical director of various research projects funded by CONAHCYT/SECIHTI and the IPN. He has a granted patent and several works registered under copyright. His research interests include computer vision and image processing, object recognition and tracking, three-dimensional reconstruction, and 3D image processing. He is a member of the National System of Researchers, Level II. He has served as associate editor of the journal Optical Engineering of the International Society for Optics and Photonics, and is currently co-chair of the Optics and Photonics for Information Processing conference at the international conference SPIE Optics + Photonics.

Dr. Ryan J. Urbanowicz

Learning to evolve, evolving to learn: Interpretable AI for unlocking biomedical complexity

Cedars-Sinai Medical Center, USA

Talk Abstract

Biomedical data are inherently complex, heterogeneous, and high-dimensional, posing challenges for both traditional statistical methods and modern machine learning approaches. This keynote will explore how interpretable artificial intelligence can be leveraged to reveal actionable insights in biomedical research, clinical decision support, and precision medicine. Emphasis will be placed on methods that not only achieve high predictive performance but also offer transparency into how models learn, evolve, and adapt to diverse biomedical problems.
Case studies will illustrate how evolutionary computation, rule-based learning, and hybrid interpretable models can uncover hidden patterns in genetic, clinical, and imaging data. By bridging the gap between predictive accuracy and human understanding, these approaches pave the way toward more trustworthy, explainable, and clinically impactful AI systems.

Short Biography

Dr. Ryan J. Urbanowicz is a Research Assistant Professor in the Department of Computational Biomedicine at Cedars-Sinai Medical Center in Los Angeles. His research interests lie at the intersection of genetics, genomics, biostatistics, epidemiology, machine learning, and artificial intelligence. He has adopted a quantitative biomedical research strategy that embraces, rather than ignores, the complexity of the relationship between predictive factors and disease endpoints. Dr. Urbanowicz earned his Ph.D. in Genetics from Dartmouth College's Geisel School of Medicine, a Master of Engineering in Biological Engineering and a Bachelor of Science in Biological and Environmental Engineering, both from Cornell University.

Pierrick Legrand

Artificial evolution and illustrative applications

Bordeaux INP and IMS, France

Talk Abstract

Artificial evolution provides a powerful paradigm for tackling complex optimization and learning problems that defy conventional analytical or numerical approaches. Inspired by natural selection, evolutionary algorithms offer flexibility, robustness, and adaptability, making them particularly effective in dynamic and uncertain environments. This keynote will introduce key principles of artificial evolution and present a variety of illustrative applications across science and engineering.

Examples will include optimization of high-dimensional systems, machine learning model design, and real-world problem solving where traditional methods fail to scale or adapt. Special emphasis will be placed on the interplay between theory and practice, highlighting how evolutionary computation not only delivers competitive solutions but also provides novel insights into the nature of adaptation and learning in artificial systems.

Short Biography

Pierrick Legrand is a Full Professor at Bordeaux INP and IMS, and holder of the IBM France Chair at ENSC. He received his PhD in Applied Mathematics from École Centrale de Nantes and the University of Nantes in 2004. His research interests span multifractal analysis, wavelets, signal processing, and evolutionary computation, with applications ranging from signal processing to biomedical engineering. He is President of the Artificial Evolution Association, Editor of the Artificial Evolution volume series in LNCS (Springer), and a recipient of the French Palmes Académiques.

III

Special Sessions

Women at NEO

Chair: Dr. Yazmin Maldonado

This special session W-NEO is a way to encourage the presence of women in Science, in particular, in numerical optimization and computing. The goal is to gather young and consolidated female researchers and practitioners to share experiences and paths for possible joint work. W-NEO 2025 presents talks about recent research advances reached by women. Additionally, this space will be an opportunity to discuss realities, problems, and possible solutions about the gender gap in our community.
We will also hold space for networking to inspire, engage, and advise students who are currently working—or planning to work—on NEO areas. We will hold some brief talks and a meeting.

Topics of interested include (but are not limited to):

- Optimization.
- Energy.
- Numerical applications.
- Evolutionary computing.
- Artificial Intelligence.

Yazmin Maldonado Robles is a Research Professor at the Instituto Tecnológico de Tijuana. She received her Ph.D. in Computer Science from IT Tijuana, an M.Sc. in Digital Systems from CITEDI-IPN, and a B.Sc. in Electronics Engineering from IT Mazatlán. Her research focuses on fuzzy systems, FPGAs, optimization, and intelligent embedded systems. She is a member of the Mexican National Researchers System (SNII).

Large-scale and expensive optimization

Chair: Dra. Guadalupe Carmona

Many real-world optimization problems in science, engineering, and industry involve large numbers of variables and computationally expensive function evaluations, such as high- fidelity simulations, physical experiments, or complex system designs. These problems pose significant challenges for traditional optimization methods due to their high dimensionality, nonlinearity, and limited evaluation budgets. This special session aims to bring together recent advances in evolutionary computation, numerical optimization, and surrogate-assisted methods to address the scalability and efficiency issues in solving large-scale and expensive optimization problems. We invite contributions that combine theoretical insights, algorithmic innovations, and real-world applications.

Topics of interested include (but are not limited to):

- Decomposition-based methods and variable grouping strategies.
- Dimensionality reduction techniques for high-dimensional optimization.
- Large-scale evolutionary algorithms and coevolutionary approaches.
- Optimization under strict evaluation budgets.
- Surrogate-assisted optimization.
- Multi-objective and constrained optimization for expensive problems.
- Parallel and distributed implementations for scalability.
- Benchmarking and performance metrics for large-scale optimization.
- Techniques for handling dynamic and streaming graphs.
- Transfer learning and meta-model reuse in expensive environments.
- Real-world applications.

Guadalupe Carmona Arroyo studied Mathematics and her Master's and Ph.D. in Artificial Intelligence at the Artificial Intelligence Research Institute, Universidad Veracruzana. In 2023, she received the Sofía Kovalevskaya Award from the Mexican Mathematical Society. Her interests include artificial intelligence, optimization, data science, and their applications.

Evolutionary multiobjective optimization

Chair: Dr. Oliver Schütze

In many applications one is faced with the problem to optimize several objectives concurrently. One important characteristic of such multi-objective optimization problems (MOPs) is that their solution sets – the so-called Pareto sets and fronts – form objects of dimension k-1, where k is the number of objectives involved in the problem. For the treatment of MOPs, specialized evolutionary strategies – multi-objective evolutionary algorithms (MOEAs) – have caught the interest of many researchers and practitioners over the last decades. No continuity or differentiability assumptions are required by EMO algorithms, and problem characteristics such as nonlinearity, multimodality and stochasticity can be handled as well. Furthermore, preference information provided by a decision maker can be used to deliver a finite-size approximation to the optimal solution set in a single optimization run. The Evolutionary Multiobjective Optimization (EMO) session is intended to bring together researchers working in this and related areas to discuss all aspects of EMO development and deployment.

Topics of interested include (but are not limited to):

- Handling of continuous, combinatorial or mixed-integer problems.
- Test problems and performance assessment.
- Benchmarking studies, especially in comparison to non-EMO methods.
- Selection mechanisms.
- Variation mechanisms.
- Hybridization.
- Theoretical foundations and search space analysis that bring new insights to EMO.
- Implementation aspects.
- Preference articulation.
- Interactive optimization.
- Many-objective optimization.
- Large-scale optimization.
- Expensive function evaluations.
- Constraint handling.
- Uncertainty handling.
- Real-world applications.

Oliver Schütze received a Ph.D. in Mathematics from the University of Paderborn, Germany, in 2004. He is currently professor at the CINVESTAV-IPN in Mexico City, Mexico. The research interests of Dr. Schütze focus on numerical and evolutionary optimization where he addresses both numerical and evolutionary techniques. He has co-authored more than 170 publications including 2 mono-graphic books, 5 text books and 16 edited books. Google Scholar reports more than 4,900 citations and a Hirsch index of 36. During his career he received several prices and awards. For instance, he is co-author of two papers that won the IEEE CIS Outstanding Paper Award (for the IEEE TEC papers of 2010 and 2012). He is recipient of the C. S. Hsu Award 2022. He is Editor-in-Chief of the journal Mathematical and Computational Applications, and member of the Editorial Board for IEEE Transactions on Evolutionary Computation, Applied Soft Computing, Computational Optimization and Applications, Engineering Optimization, and Research in Control and Optimization. Dr. Schütze is a member of the Mexican Academy of Sciences (AMC) and the National Network of Researchers (SNII Level III).

Genetic programming

Chair: Dr. Leonardo Trujillo

Genetic Programming is an evolutionary approach to address learning and automatic program induction problems. It has generated strong results in many domains, and continues to develop as a more mature paradigm in machine learning. This special session invites works and talks related to theoretical advances, the development of new algorithms or improvements over existing ones, as well as real-world applications.

Topics of interested include (but are not limited to):

- Theoretical developments in GP and ML.
- GP performance and behavior.
- Algorithms, representations and operators for GP.
- Search-based software engineering.
- Multi-population GP.
- Multi-objective GP.
- Tree-based, Linear, Graph-based, Grammar-based GP.
- Hybrid models.
- Evolutionary machine learning approaches.
- Real-world application.

Leonardo Trujillo is a research professor at the Tecnológico Nacional de México/Instituto Tecnológico de Tijuana (TecNM/ITT), in Tijuana, Mexico working at the Department of Electrical and Electronic Engineering, and the Engineering Sciences graduate program, of which he is co-founder, where he is involved in interdisciplinary research within the fields of evolutionary computation, machine learning, pattern recognition and artificial intelligence. His work focuses on Genetic Programming (GP) and developing new learning and search strategies based on this paradigm. Professor Trujillo received an Electronic Engineering degree (2002) and a Masters in Computer Science (2004) from ITT, as well as a Doctorate in Computer Science from the CICESE research center in Ensenada, Mexico (2008). Professor Trujillo is also an external member of the LASIGE Computer Science and Engineering Research Centre, a research and development (R&D) unit at the Faculty of Sciences of the University of Lisbon (FCUL), in the field of Computer Science and

Engineering. He has published over 90 journal papers, 60 conference papers, 25 book chapters, and has edited seven books, including from the NEO workshop series of which he is series co-chair, and from the Genetic Programming Theory and Practice workshop which he organized on several occasions. He is currently Editor-in-Chief of the Genetic Programming and Evolvable Machines journal published by Springer and an Associate Editor of the European Journal of Artificial Intelligence (Sage) and the Mathematical and Computational Applications journal from MDPI. He is a regular PC member of top conferences, including GECCO, CEC, PPSN, EvoStar, CVPR, ECCV and others, and served as co-chair for the GP track at GECCO in 2021 and 2022. He has been PI or Co-PI for various national and international research grants, and has received over 3,000 citations according to Google Scholar and 2,190 in Scopus with an h-index of 24.

Discrete optimization

Chair: Dr. Marcela Quiroz

Applications of discrete optimization problems arise in engineering, science, economics, and everyday life. It is common to find in many real-world linear, as well as nonlinear programming, that all, or a fraction of variables are restricted to be integer, yielding integer or mixed integer-discrete-continuous problems. Many of these problems are computationally intractable. The approaches that are addressing these problems include: traditional optimization techniques, efficient preprocessing schemes, decomposition techniques, fast heuristics, metaheuristics and hybrid methods. This special session serves as a platform for researchers from all over the world to present and discuss recent advances and perspectives in the mathematical, computational and applied aspects of all areas of integer programming, combinatorial optimization and mixed integer-discrete-continuous optimization.

Topics of interested include (but are not limited to):

- Single and multi-objective optimzation.
- Deterministic approaches.
- Approximation algorithms.
- Randomized algorithms.
- Heuristics.
- Metaheuristics.
- Simulation.
- Stochastic programming.
- Real-world applications.

Marcela Quiroz is a Full-Time Researcher with the Artificial Intelligence Research Institute at the Universidad Veracruzana in Xalapa City, Mexico. Her research interests include: combinatorial optimization, metaheuristics, experimental algorithms, characterization and data mining. She received her Ph.D. in Computer Science from the Instituto Tecnologico de Tijuana, Mexico. She studied engineering in computer systems and received the degree of master in computer science at the Instituto Tecnológico de Ciudad Madero, Mexico. She is a member of the Mexican National Researchers System (SNII), and also a member of the directive committees of the Mexican Computing Academy (AMexComp) and the Mexican Robotics Federation (FMR).

Optimization on graphs: AI and distributed

Chair: Dr. Rolando Menchaca

Optimization problems defined over graphs are ubiquitous in modern science and engineering, serving as the foundation of solutions in areas as diverse as telecommunications, logistics, social network analysis, computational biology, and machine learning. The increasing scale and dynamic nature of real-world graph data present significant challenges and exciting opportunities for novel theoretical and practical advancements. This special session, "Optimization on graphs: AI and Distributed Approaches," aims to bring together researchers and practitioners to explore cutting-edge developments in optimization techniques applied to graph structures. We are particularly interested in original contributions that leverage modern methodologies, including all facets of Artificial Intelligence (AI), to address complex graph optimization challenges. We invite submissions presenting theoretical insights, novel algorithms, and practical applications in graph optimization.

Topics of interested include (but are not limited to):

- AI-Enhanced optimization on graphs: Machine learning for graph optimization (e.g., graph neural networks, reinforcement learning, deep learning approaches).
- Evolutionary computation and swarm intelligence for graph problems.
- Heuristic and metaheuristic algorithms informed by AI for graph optimization.
- Mathematical programming solutions for graph optimization.
- Explainable AI in graph optimization.
- Distributed optimization on graphs: Decentralized algorithms for large-scale graph problems.
- Optimization for very large graphs: Scalable algorithms for massive graph datasets.
- Approximation algorithms for NP-hard graph problems.
- Techniques for handling dynamic and streaming graphs.
- Continual graph learning and optimization: Algorithms for adapting optimization solutions to evolving graph structures.
- Online learning and optimization on graphs.

Applications of graph optimization in:

- Supply chain and logistics.
- Telecommunication networks.
- Bioinformatics and healthcare.

- Transportation and urban planning.
- Smart cities.

We welcome both theoretical contributions presenting rigorous analysis and empirical studies demonstrating the effectiveness of proposed methods on real-world or synthetic datasets. Submissions should highlight the novelty of the proposed approach and its potential impact on graph optimization. This special session is closely related to the Special Issue "Advanced Algorithm Theory and Computation for Complex Networks" in the journal Mathematics.

Rolando Menchaca-Méndez is a Professor of the Network and Data Science Laboratory at the Computer Research Center of the Mexican National Polytechnic Institute. He received his Ph.D. in Computer Engineering from the University of California at Santa Cruz in 2009. His current research interests include combinatorial optimization, reinforcement learning, cloud computing, computer networks, and the IoT.

Applications of machine learning

Chair: Dr. Daniel Hernández

Machine Learning has become an extremely popular approach for solving complex problems in different domains. The ability to process large amounts of data and extract meaningful insight to create predictive models, in order to enhance decision-making and optimize processes, has revolutionized industries such as healthcare, finance, retail, manufacturing, transportation, and more. This session aims to bring together researchers, practitioners, and industry experts to discuss and showcase the latest advancements in the development of new algorithms or improvements over existing ones, and innovative applications of Machine Learning in various fields.

Topics of interested include (but are not limited to):

- Real-world application.
- Social challenges and issues.
- Manufacturing and industry 4.0.
- Energy and sustainability.
- Healthcare and medical diagnosis.
- Finance and economics.
- Retail and e-commerce.
- Transportation and autonomous systems.
- Natural language processing and text mining.
- Computer vision and image processing.
- Social media and web analytics.
- Process optimization.
- Theoretical developments of machine learning algorithms.
- Evolutionary machine learning.
- Optimization of machine learning algorithms.
- Search-based software engineering.
- Hybrid models.
- Ensemble models.
- Reinforcement learning, transfer learning and deep learning.
- Interpretability of machine learning models.
- Leaning with unbalanced or missing data.
- Feature extraction, reduction and selection.

Daniel Hernández is a professor at the Tecnológico Nacional de México/ IT de Tijuana, in Tijuana, BC, Mexico. His research interests include several data science and artificial intelligence topics such as: machine learning, feature engineering, evolutionary computation and computer vision. He received his Ph.D. in Computer Science the from Centro de Investigación Científica y de Educación Superior de Ensenada, B.C., (CICESE), México. He is a member of the National Network of Researchers (SNII Level I).

IV

Contributed Talks

Analysis of Mexican pandemic COVID-19 mobility data through an $\mathcal{NP}$-hard propagation model

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The COVID-19 pandemic had a profound impact on global health systems, with Mexico being particularly affected. In the early stages of the outbreak, preventive measures such as mobility restrictions and social distancing were implemented to contain the spread of the virus. Understanding how the virus spreads became an urgent priority, making it essential to explore techniques for identifying vulnerabilities within a population. Various organizations compiled databases with valuable information that can help to understand the virus and its propagation. One such effort is a dataset proposed by a team of scientists [1], which consists of creating networks that describe people's mobility between municipalities in Mexico. Since some viruses and infections are transmitted by contact between people, analyzing the movement of the population within an area can provide key insights into the decision-making to try to reduce and control the spread of such infections. This research performs an analysis of using network science tools applied to Mexican pandemic COVID-19 mobility data. Furthermore, one of the purposes is to show how scientific proposals can also be used to potentially deal with problems of national interest, specifically in the context of Mexico.

Information spread is a classic topic in network science, which investigates how information, influence, or contagion propagate through networks. In this study, we employed the graph burning problem (GBP), a well-known $\mathcal{NP}$-hard combinatorial optimization problem that represents a simplified deterministic model of how information spreads within networks. Summarizing, the GBP receives as input a simple graph $G = (V, E)$, the goal is to find the shortest sequence of vertices that burns the entire graph by following a predefined burning process. It can be used for contagion vulnerability analysis in networks. In the literature, the GBP has been approached through metaheuristics [2], mathematical optimization [3], and greedy and approximation algorithms [4, 5].

Nevertheless, although the GBP can be used to analyze how vulnerable a network is to contagion, some adaptations were necessary, including pre-processing, data cleaning, and simplification of the networks. Once the pre-processing phase is performed, a mathematical model and an approximation algorithm from the GBP's literature were used [5, 4]. The results suggest a possible important relationship between the GBP and the spread of COVID-19, which indicates that the GBP could be effectively used in supporting health system monitoring for the spread of infections, such as COVID-19. Figure 1 shows a simulation

based on the GBP over a selected network.
Future work involves a deeper analysis, the development of more advanced techniques for network simplification, and the study of GBP variants that consider more realistic spread infection models, which may help in decision-making, monitoring health systems, and analyzing people's infection vulnerability in real-world contexts.

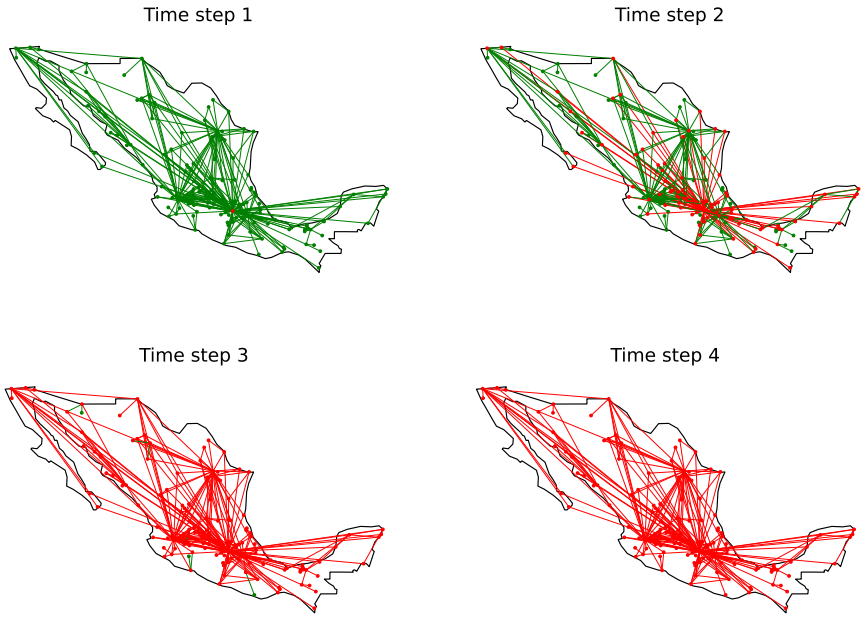

Figure 1: Simulation of COVID-19 spread based on the GBP over a selected network. Geographical INEGI data was used for visualization purposes.

Keywords: graph burning, optimization, COVID-19, health-systems, network-science.

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A Comparison of Heuristic Methods for the Identification of Regions of Interest in Wildfires

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Abstract

Identifying regions of interest (ROI) in remote sensing imagery is highly beneficial for reducing the spatial scale of analysis and minimizing computational costs in wildfire detection tasks. By focusing only on the most relevant areas, it becomes possible to optimize processing time and improve the efficiency of subsequent classification or segmentation methods. In this work, we present a comparison of three heuristic approaches—Genetic Algorithm (GA), Particle Swarm Optimization (PSO), and a hybrid model combining both —for the identification of ROI associated with active wildfires. A false-color composition was applied to enhance visual contrast and mitigate the impact of clouds, smoke, and burned areas. The proposed heuristics are applied to the illumination intensity function of the input image to identify regions exhibiting elevated intensity levels, which are indicative of potential fire activity. Upon detection, a subimage is extracted and centered around the most prominent high-intensity region, as determined by the Density-Based Spatial Clustering of Applications with Noise (DBSCAN) algorithm. The experimental results underscore the respective strengths and limitations of each method, particularly with regard to precision, convergence behavior, and robustness under complex wildfire conditions.

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Optimal Hyperspectral Band Selection Using Metaheuristics for the Detection of Aspergillus flavus in Figs with Convolutional Neural Networks

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Abstract

The contamination of figs by Aspergillus flavus is a critical problem for food safety and the agricultural economy due to the production of carcinogenic aflatoxins. Hyperspectral imaging (HSI) offers a non-invasive solution for detection, but its high dimensionality represents a computational challenge. This work proposes a hybrid approach to optimize detection by selecting the most informative spectral bands. Three metaheuristics—Genetic Algorithms (GA), Particle Swarm Optimization (PSO), and Tabu Search—are used to identify an optimal subset of just three spectral bands. The fitness of each subset is evaluated using the classification accuracy of a pre-trained Convolutional Neural Network (ResNet50). This method is expected to drastically reduce data dimensionality, lowering computational cost without sacrificing accuracy and laying the groundwork for real-time inspection systems.

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Embedded System for Vehicle Environment Perception and License Plate Recognition (LPR) Using Computer Vision and Deep Learning

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The integration of multi-stage vehicle perception pipelines—such as object detection and license plate recognition (LPR)—into low-cost embedded systems poses significant challenges in software optimization and computational efficiency. This paper introduces a modular software framework and an optimized inference strategy designed for an advanced driver assistance system (ADAS), targeting deployment on a Raspberry Pi 5 equipped with a Hailo-8L AI accelerator. A key focus of the methodology is resolving a common MLOps issue: managing conflicting software dependencies. To address this, the system architecture incorporates two isolated virtual environments that interact via an interprocess communication (IPC) bridge. This design enables the coexistence of modules with incompatible requirements and serves as a functional prototype for future migration to a ROS2 distributed framework. The perception pipeline employs a coarse-to-fine optimization approach. A general-purpose detector (Faster R-CNN) first identifies regions of interest—primarily vehicles—narrowing the search space for a specialized high-precision model dedicated to license plate detection. The framework has been successfully validated in a PC-based environment, demonstrating real-time recognition capabilities and achieving performance metrics exceeding 80%, thereby confirming the effectiveness of both the IPC bridge and the cascade detection strategy.

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Quantifying the impact of genetic programming feature transformations: an analysis using the optimal transport dataset distance

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Genetic programming (GP) has gained significant traction in machine learning, particularly for feature space transformation, also known as feature engineering. While numerous GP methods have been developed for this task, they inherently assume GP's capacity to discover novel data representations. However, existing literature has predominantly relied on indirect evaluations, such as the empirical predictive accuracy of subsequent learning methods, without directly quantifying or characterizing the nature of the evolved transformations. The present study addresses this critical gap by employing the Optimal Transport Dataset Distance (OTDD) to directly measure the magnitude of these evolved transformations. Focusing on M3GP as the method under investigation, a comprehensive correlation analysis was conducted to ascertain the relationship between the magnitude of feature space transformations and other performance indicators. This analysis was performed across various levels: the global level (supervised machine learning), the group level (distinguishing between classification and regression tasks), the problem level (individual datasets), and the run level (single algorithm executions). The results indicate that the impact of these evolved transformations varies considerably depending on the chosen level of analysis, with the most pronounced correlations consistently observed at the group level. This highlights the importance of task-specific considerations when evaluating GP-driven feature engineering.

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Integrating MLIR Infrastructure with MOEAs for FPGA Design Space Exploration

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The complexity of hardware design creates a significant bottleneck in algorithm-to-hardware implementation, particularly for reconfigurable platforms like Field-Programmable Gate Arrays (FPGAs). While FPGAs offer substantial performance advantages, their adoption is limited by the steep learning curve associated with Hardware Description Languages (HDLs) such as Verilog and VHDL. High-Level Synthesis (HLS) has addressed this challenge by enabling automatic translation from high-level programming languages (C/C++, SystemC, Python) to synthesizable hardware descriptions, significantly reducing development time, simplifying verification workflows and debugging methods. However, HLS does not ensure implementations as efficient as those created manually [1].

We present a novel approach that combines modern compiler infrastructure with evolutionary computation for hardware optimization. By integrating Multi-Level Intermediate Representation (MLIR) [2] with multi-objective evolutionary algorithms, our framework enables simultaneous optimization of conflicting design objectives such as execution latency, area utilization, and power consumption. The framework operates through an integrated design flow encompassing MLIR-based semantic analysis via Polygeist [3], comprehensive CDFG extraction using custom Python modules, pymoo [4] driven evolutionary optimization for Pareto-optimal solution discovery, presynthesis resource estimation for accelerated design space exploration, and automated generation of synthesizable VHDL implementations. This methodology enables algorithm developers to achieve hardware designs that compete with manual implementations while maintaining the accessibility and rapid prototyping benefits of high-level programming.

Preliminary results from experimental evaluation of programs that solve basic arithmetic problems are presented in Table 1. A critical advantage of our approach is the substantial reduction in generated code length (98 lines) compared to commercial tools like Vitis HLS [5] (700+ lines), which demonstrates significantly higher code complexity that can lead to difficulties during the debugging process. Additionally, while LLMs like ChatGPT and Claude can produce functional hardware designs, they consistently struggle to generate working VHDL code on the first attempt, often requiring multiple debugging iterations and manual interventions to achieve synthesizable results. This contrasts with our systematic approach, which generates optimized, synthesizable code through a controlled evolutionary process.

Table 1: Comparative analysis of synthesis results for basic experiments.

Tool	**Latency** (Clock Cycles)	**Resources** LUT	FF	DSP	BUFG	**Power**	**Synthesizable**	**Lines of Code**
This work	11	123	4	6	4	7.366	✓	98
VHDLbyMOEA	21	217	116	5	1	7.017	✓	86
ChatGPT 3o (Plus)*	8	267	93	4	1	8.277	✓	114
Claude 3.7 Sonnet (Plus)*	5	399	60	1	1	6.224	✓	77
Vitis HLS 2020.1	15	85	111	8	1	8.588	✓	700+

* Synthezisable code was achieved following an expert debugging process. Logic errors were founded in code.

The framework demonstrates the potential of combining evolutionary optimization with advanced compiler technologies to achieve competitive results against established methodologies. Future work will focus on supporting more complex algorithmic structures, expanding the optimization objectives, and completing the web-based tool deployment for broader accessibility to the hardware design community.

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A Continuation Method for Parameter Dependent Multi-objective Optimization Problems

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In many applications one is faced with the problem that several objectives have to be optimized concurrently. Further, it may happen that the objectives are subject to certain external parameters. Problems of that kind are termed parameter dependent multi-objective optimization problems (PMOPs). One important characteristic of continuous PMOPs is that one can expect that the solution set forms –at least locally and under certain mild conditions on the model– an object of dimension $l + k - 1$. Hereby, l is the dimension of the external parameter vector λ, and k is the number of objectives. In this work, we present our first results obtained by classical predictor-corrector methods taylored to PMOPs for the numerical treatment of such problems.

Course Scheduling Optimization Using Genetic Algorithms: A Case Study in a Mathematics Department

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The present work, entitled *Course Scheduling Optimization Using Genetic Algorithms: A Case Study in a Mathematics Department*, falls within the field of numerical and evolutionary optimization. The main objective is to apply genetic algorithms to address the problem of assigning courses to professors in a mathematics department, considering a set of specific constraints defined by the head of the department.

The combinatorial and highly restrictive nature of the scheduling problem makes it a representative case of the challenges typically encountered in this field. In this sense, the use of genetic algorithms provides an efficient way to explore the solution space, offering both flexibility and adaptability to different institutional scenarios.

As a theoretical background and motivation, the reference work [Michael, 1995], was considered, as it provides a solid conceptual framework on the fundamentals of scheduling and its practical applications. This case study contributes to the literature on evolutionary optimization by demonstrating how a methodology inspired by genetic algorithms can be adapted to a real academic context, aligned with the needs of the department as in [Cuate et al., 2025].

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Analysis of Tumor Growth Under Oncological Treatment Using Mathematical Modeling and Artificial Intelligence

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This work proposes a hybrid approach to analyze tumor growth, combining a mathematical model based on differential equations with artificial intelligence techniques. The relationship between tumor volume and nutrient availability is studied using experimental data from murine models with human breast cancer tumors, treated with different drugs (Cisplatin, Cyclophosphamide, Docetaxel, and Doxorubicin). The model is solved through the Runge-Kutta numerical method and fitted to experimental data using genetic algorithms, with the aim of obtaining global and biologically interpretable parameter estimates. In parallel, a neural network is trained to classify tumor responses according to the treatment applied. Overall, this approach combines mathematics and artificial intelligence to provide a clearer view of tumor growth.

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Hardware description language based approach for GSGP design

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Genetic programming (GP) is a branch of artificial intelligence (AI) that utilizes principles from natural selection and genetics to solve computational problems [1]. This method involves the creation of a population of individuals, each representing a potential solution. These individuals are evaluated based on their performance on a specific dataset. Through processes such as mutation and crossover, new individuals are generated in an iterative process aimed at identifying the optimal solution.

In 2012, a new set of operators, known as Geometric Semantics (GSGP) [2], was introduced in the field of genetic programming. Traditionally, the search space was explored in the syntax domain, directly manipulating the individuals themselves. However, with semantic operators, the search shifts to the semantic space. Here, mutations and crossovers are based on the output values produced by the individuals, which creates a unimodal fitness landscape. As a result, each new individual generated through mutation and crossover is closer to the expected target.

In 2024, the work [3] based on the VHDL descriptive language for FPGA (Field Programmable Gate Array) electronic device was presented. This design is divided into two main modules: the first works with training data, while the second handles test data. GSGP-Hardware represents the first full implementation of GSGP on a chip. The results show that GSGP-Hardware achieved speedups of nearly four orders of magnitude compared to the most efficient GSGP implementation in CUDA [4]. The block diagram of the GSGP-Hardware design is presented in the Figure 1. One of GSGP-Hardware's limitations is that it requires two FPGAs, making it less efficient in terms of latency for inter-module communication and higher hardware resource consumption. In this paper, we present the new version of GSGP-Hardware, called GSGP on Chip System (GSGPoC-System).

The GSGPoC-System features two key improvements. First, it integrates the evaluation and training stages into a single main module. Second, the geometric semantic mutation module has been optimized. While the original GSGP-Hardware generated this module for each individual in every mutation generation, the GSGPoC-System now generates

it just once per individual and reuses it in a loop across all generations. In the Figure 2 is the block diagram of the GSGPoC System design.

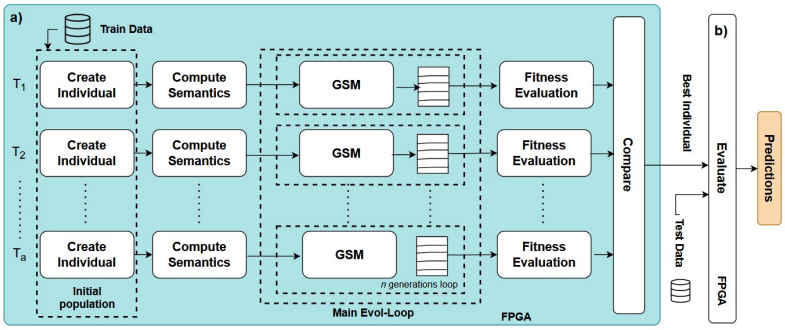

Figure 1: GSGP-Hardware design. GSGP-Hardware has six modules: The initial population is created in the first stage; next, the semantics of each individual are obtained; a geometric semantic mutation is then performed on each individual for a set number of generations; the fitness of each individual's most recent semantic is then evaluated; followed by a comparison of all fitness values to find the best-performing individual; finally, in the sixth stage, the best individual's generated values are used to make a prediction on a separate test dataset.

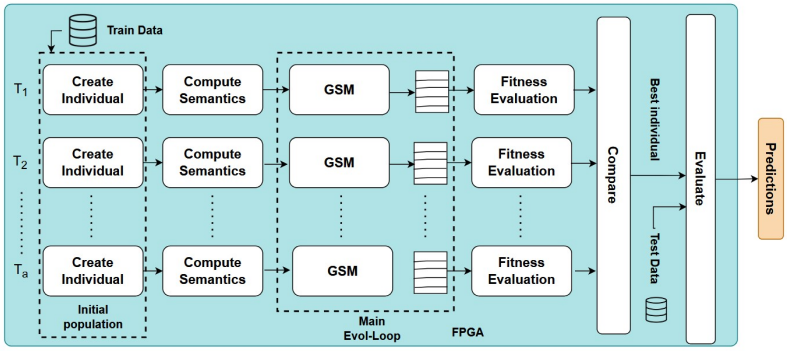

Figure 2: GSGPoC-System design.

The Table 1 presents the hyperparameters used for the benchmark between the GSP-Hardware and GSGPoC System. Being the main ones, a total of 128 individuals, 20 generations, and a fixed representation of 12 total bits, with a fractional part of 4 bits. The hyperparameters utilized for the benchmark between the GSGP-Hardware and the GSGPoC-System are presented in Table 2. The primary parameters were a population of 128 individuals, 20 generations, and a fixed-point representation consisting of a total

Table 1: Hyperparameter configuration used for benchmarking.

Hyperparamter	**Value**
Generations	20
Terminals	Problem Features Random integers in $[0, 15]$
Functions	$+, -, \times, pd$
Number of individuals	128
Number representation	Fixed point
Amount of bits	fix12_4

of 12 bits, 4 of which were for the fractional part.

Table 2: Total resource usage on the FPGA between the GSGP-Hardware and GSGPoC-System.

Resources / GSGP Version	Area				Latency	Power
	LUT	FF	DSP	BUFG	clock cycles	
Training for GSGP-Hardware	3,364,793	1,133,445	0	12	786	1,413 W
Evaluator for GSGP-Hardware	46,190	19,471	114	12	122	42 W
GSGPoC system	1,354,582	471,151	38	4	916	612 W

The updated GSGPoC-System performs significantly better than the original GSGP-Hardware, primarily in terms of resource usage. It requires almost a third of the resources while maintaining similar latency. Because the new system is a single main module, it eliminates the need to manage the interconnections between the separate train and test modules of the GSGP-Hardware.

Some of the improvements we plan to make are the implementation of random trees for the mutation stage, and the adjustment to the arithmetic unit, to use a different representation for the cases when the value overflows or underflows.

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Course Scheduling Optimization Using Genetic Algorithms: A Case Study in a Mathematics Department

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The present work, entitled *Course Scheduling Optimization Using Genetic Algorithms: A Case Study in a Mathematics Department*, falls within the field of numerical and evolutionary optimization. The main objective is to apply genetic algorithms to address the problem of assigning courses to professors in a mathematics department, considering a set of specific constraints defined by the head of the department.

The combinatorial and highly restrictive nature of the scheduling problem makes it a representative case of the challenges typically encountered in this field. In this sense, the use of genetic algorithms provides an efficient way to explore the solution space, offering both flexibility and adaptability to different institutional scenarios.

As a theoretical background and motivation, the reference work [Michael, 1995], was considered, as it provides a solid conceptual framework on the fundamentals of scheduling and its practical applications. This case study contributes to the literature on evolutionary optimization by demonstrating how a methodology inspired by genetic algorithms can be adapted to a real academic context, aligned with the needs of the department as in [Cuate et al., 2025].

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Multi-objetive Particle Swarm Algorithm for Multi-objective Reinforcement Learning

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Multi-objective reinforcement learning provides a framework for solving problems involving sequential decision-making with multiple reward functions, modeling them as multi-objective Markov decision processes [2]. Among the approaches to solving these problems, multi-objective bio-inspired methods have demonstrated great potential for generating diverse sets of policies that approximate the Pareto front [4]. A promising candidate is multi-objective particle swarm optimization, which uses Pareto dominance-based leader selection with an external archive to preserve non-dominated solutions [1]. Its simplicity, fast convergence, and population-based nature make it a promising alternative to more expensive strategies.
In this work, we propose adapting the optimized multi-objective particle swarm optimization algorithm [3] for multi-objective reinforcement learning problems, where each particle represents a policy parameterized by the weights of a neural network. This variant incorporates an ε-archive for non-ε-dominated solutions, a crowding distance metric for diversity, and a Pareto-dominance-based leader selection strategy. These mechanisms guide exploration and maintain a well-distributed set of policies, offering a practical alternative to gradient-based and more expensive evolutionary algorithms.
We evaluate the proposed method on MuJoCo problems from the MO-Gymnasium suite, comparing it against four multi-objective evolutionary algorithms. We measure performance using hypervolume, inverted generational distance plus, and generational distance plus. Preliminary results show that our approach achieves competitive performance, in some cases surpassing existing methods. These findings highlight the potential of swarm-based algorithms in multi-objective reinforcement learning and suggest they provide efficient alternatives for solving continuous multi-objective problems.

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Beyond Hyperscalers: How MLOps Unlocks AI in Latin America

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This paper presents a comprehensive analysis of the current state and future trajectory of **Machine Learning Operations (MLOps)** in Mexico and Latin America, arguing that MLOps—when integrated with cloud computing, edge artificial intelligence (edge AI), and open-source toolchains—serves as the primary catalyst for democratizing AI across the region. A core contribution is demonstrating how this paradigm enables Latin American economies to circumvent structural barriers, particularly the absence of domestically owned hyperscale data centers [1], thereby expanding access to advanced AI capabilities for startups, SMEs, and large enterprises alike.

Findings reveal accelerating adoption as organizations transition from exploratory AI initiatives to production deployment, driven by the operational complexity of scaling AI systems (requiring automation, governance, and scalability). Leading sectors include fintech, retail, and telecommunications, where MLOps-driven efficiency gains are most pronounced. However, the sustainability of this emerging ecosystem hinges on addressing two critical challenges: (1) acute talent shortages and brain drain in AI engineering [3], and (2) fragmented, uncertain regulatory frameworks across most countries [2].

Strategic recommendations are proposed for stakeholders: - **Business leaders**: Institutionalize MLOps as a core organizational capability and prioritize talent retention through competitive compensation and upskilling. - **Policymakers**: Provide regulatory clarity and foster regional collaboration to build a cohesive, competitive AI market. - **Investors**: Target opportunities in MLOps enablement and startups leveraging distributed architectures (e.g., edge AI, TinyML) to solve region-specific problems.

The paper concludes that MLOps is not merely a technological framework but a transformative force for inclusive AI development in Latin America—if talent and regulatory barriers are addressed, the region can leverage its unique strengths to emerge as a global leader in accessible, impact-driven AI.

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Scenario Optimization in Fuzzy Cognitive Maps by Means of Multi-objective Evolutionary Algorithms

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Fuzzy Cognitive Maps allow modeling complex systems through the interaction between concepts and have been widely used to simulate scenarios and analyze the impact of decisions on key concepts [1]. These types of simulations can lead to conflicts between concepts or discrepancies within the decision-making group. This can be modeled as a multi-objective optimization problem. In this work, we propose using multi-objective evolutionary algorithms to find a set of interventions that optimize a set of concepts.
In particular, we propose using NSGA-II with an external archive (ArchiveUpdateTight2 [2]), which ensures the approximation of the solution set at the limit. Subsequently, we apply reference point methods, where an ideal point is defined, and the closest scenarios within the approximation of the found Pareto front are identified. Finally, to demonstrate the effectiveness of the proposed workflow, we analyze a case study in the city of Mérida, Yucatán, focused on mobility and sustainability, which was validated with decision-makers. In this case, we found that the proposed workflow allowed us to identify effective interventions in key concepts such as well-being and access to transportation.

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A Belief Model for BDI Agents Derived from Roles and Personality Traits

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Advances in AI have enabled the development of autonomous agents capable of interacting in complex and dynamic environments [1]. Among these are deliberative agents, which are notable for using cognitive architectures such as BDI (Belief-Desire-Intention) to represent reasoning processes inspired by human cognition, such as planning and decision-making [2, 3].
However, the initial definition of the beliefs that form an agent's cognitive profile remains an open challenge. The assignment of these beliefs not only conditions the system's internal coherence but also its ability to scale to different contexts and maintain behavioral consistency over time. In many cases, this process is addressed through manual and ad hoc approaches [4], which limits systematicity and hinders the theoretical validation of the models.
This work introduces the Personality-Role-Belief Model (P-R-B) for BDI agents, a novel architecture for the generation of cognitive profiles, applicable in domains such as social simulation, intelligent tutoring systems, and non-player characters (NPCs) in video games. The model translates scores from the FFM into a set of social roles (e.g., 'leader', 'mediator'), assigning base beliefs to each role. The main contribution of this work is a weighting mechanism that resolves conflicts among beliefs when multiple roles coexist. This weighting mechanism, inspired by Cohen's effect size conventions [5], establishes a hierarchy of influence that allows the agent to exhibit coherent and multifaceted behavior.

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Study of Performance from Hierarchical Decision Modeling in IVAs within a Greedy Context

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This study examines decision-making in intelligent virtual agents (IVAs), and formalizes the distinction between tactical decisions (individual actions) and strategic decisions (composed of sequences of tactical actions) through a mathematical model based on set theory and the Bellman equation. Although the equation itself is not modified, the analysis reveals that the discount factor (γ) influences the type of decision: low values favor tactical decisions, while high values favor strategic ones. The model was implemented and validated in a proof-of-concept simulated environment (Snake/SCCP), showing significant differences between agents with different decision profiles. These findings suggest that adjusting γ can serve as a useful mechanism to regulate both tactical and strategic decision-making processes in IVAs, thus facilitating the design of more intelligent and adaptive agents in video games, robotics, and artificial intelligence.

Study on the impact of machine learning techniques to support CO2 capture process via Ionic liquids.

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The growing concern about climate change has driven the search for smart alternatives for CO_2 capture. CO_2 is a greenhouse gas and contributor to global warming. Human activities, such as the use of fossil fuels and deforestation, have increased CO_2 concentrations, contributing to the rise in the global mean temperature. In this context, ionic liquids (ILs) have emerged as a promising alternative to conventional solvents, such as amines, due to their low volatility, higher thermos-chemical stability, and potential for reutilization. However, the success of ILs largely depends on the relationship between their molecular structure and specific operating conditions. The vast diversity of ILs makes it impractical to study all possible combinations empirically, creating the need to guide their design prior to synthesis. Recently, this challenge has been addressed using machine learning (ML) techniques and process simulators, which facilitate the prediction of physicochemical properties, CO_2 solubility, and the optimization of operating conditions in capture processes. This work theoretically analyzes how ML techniques can complement and optimize CO_2 capture using ILs. One dimension of the study identifies the role that ML plays on process simulators, particularly when integrating it with IL properties and features stored on large experimental datasets. An alternative dimension of analysis involved prediction models developed by different authors using diverse ML techniques and thermodynamic models. As a result, the research carried out identified a high degree of accuracy using ML to estimate CO_2 solubility in various ILs, mainly observed R^2 above 0.98 in some cases, having a MAE averaging 0.048. Additionally, the most studied ILs across different operating conditions and contributions to energy optimization were identified. Finally, this analysis highlights why combining ML with ILs represents a smart strategy to support global objectives for reducing CO_2 emissions.

Model	R^2	MAE	ILs N°	Data N°	References
ANN-GC	0.9836	0.0202	124	10,116	Song et al., 2020 [4]
SVM-GC	0.9783	0.0240	124	10,116	Song et al., 2020 [4]
ANN (DNN)	0.9860	0.0172	124	10,116	Ali et al., 2024 [2]
LSTM	0.9850	0.0175	124	10,116	Ali et al., 2024 [2]
RF	0.9200	0.0400	185	10,848	Venkatraman & Alsberg, 2017 [12]
CTREE	0.8200	0.1000	185	10,848	Venkatraman & Alsberg, 2017 [12]
COSMO-RS	0.7100	0.1200	185	10,848	Venkatraman & Alsberg, 2017 [12]

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Toward a Data Science Pipeline for the Design of Hyper-Heuristic Grouping Genetic Algorithms

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Grouping problems are a key subclass of combinatorial optimization where a finite set of elements must be partitioned into mutually exclusive and exhaustive subsets, often under domain-specific constraints. They appear in many applications, including job assignment in manufacturing, vehicle routing and bin packing in logistics, course scheduling in education, patient allocation in healthcare, and frequency assignment in telecommunications. Efficient solutions are critical for improving performance, resource use, and service quality [1]. However, their NP-hard nature makes them computationally difficult as instance size and complexity increase [2], and traditional algorithms often fail. Metaheuristics, particularly Genetic Algorithms (GAs), are therefore widely used. Grouping Genetic Algorithms (GGAs) incorporate tailored representations and operators to exploit problem structure, and many variants have been proposed with different reproduction mechanisms and variation operators [3]. Yet, a fundamental question remains: what instance-specific factors drive algorithm behavior? [4]. Understanding this could clarify the strengths and weaknesses of different methods and guide their effective use [5, 6]. This work proposes a data-driven approach to Hyper-heuristic GGAs (HGGAs), integrating data science to automate the configuration of operators, selection mechanisms, and neighborhood structures. By extracting meta-features from problem instances and combining them with performance data, HGGAs can dynamically adapt to context. Our methodology includes instance selection, feature extraction, algorithm evaluation, and supervised learning to predict effective configurations for new cases. To demonstrate, we apply it using the state-of-the-art GGA with Intelligent Heuristic Strategies (GGA-IHS) on the Unrelated Parallel Machine Scheduling Problem with Makespan Minimization. The Hyper-heuristic GGA-IHS employs decision rules learned from experiments to select crossover operators based on instance properties automatically. Preliminary results are promising: the hyper-heuristic version outperforms the original by adjusting only one genetic component. This contributes to the development of general-purpose heuristic frameworks for solving complex grouping problems across domains.

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Comparative Analysis of Optimization Techniques Applied to Automotive Assembly Using Big Data

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This study presents a comparative analysis of optimization methods applied to the assignment of parts to workstations in automotive assembly, with the primary objective of minimizing total assembly time. Efficient scheduling of assembly tasks is critical in modern automotive manufacturing, where production lines involve multiple interdependent stations and a large number of possible configurations. To resolve this issue, four optimization strategies were evaluated: simulated annealing, tabu search, exhaustive search, and a simple greedy heuristic. All methods were combined with Big Data tools to efficiently manage and process large volumes of information, reflecting the computational demands of real-world industrial applications.

The experiments were conducted considering seven main assembly stations—chassis, engine, transmission, wheels, electrical parts, interiors, and doors. Each method was executed with 25, 50, 75, and 100 repetitions to evaluate stability, convergence behavior, and consistency of results. Performance was analyzed using analysis of variance (ANOVA) at a 95% confidence level, which highlighted statistically significant differences among the approaches. Simulated annealing consistently achieved the lowest average assembly time (0.2172 seconds), outperforming tabu search (0.2540 seconds), exhaustive search (0.2312 seconds), and the greedy heuristic (0.3008 seconds).

These results demonstrate that simulated annealing, when integrated with Big Data techniques, provides an effective balance between solution quality and computational efficiency. In conclusion, simulated annealing is a robust, scalable, and practical alternative for solving complex combinatorial optimization problems in automotive manufacturing, with potential applicability in other production and logistics systems.

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Neural Architecture Search with CMA-ES for Facial Emotion Recognition

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Facial Emotion Recognition (FER) is an important task because emotions are central to human communication and decision-making. Much of what humans express and understand in social interactions is nonverbal, and facial expressions are one of the most universal, immediate, and relevant signals of how someone reacts to a stimulus. This study explores the use of Neural Architecture Search (NAS) with Covariance Matrix Adaptation Evolution Strategy (CMA-ES) to optimize neural networks for FER. Manual architecture design is often suboptimal and time-consuming, while CMA-ES offers an efficient evolutionary approach for exploring the architecture search space. Using the CK+ dataset, the task is formulated at three levels of complexity: binary classification (Negative: Anger, Contempt, Disgust, Fear, Sadness; Positive: Happy, Surprise), a three-class grouping (anger, happy and sadness), and the full seven-class problem (anger, contempt, disgust, fear, happy, sadness, and surprise). The proposed NAS framework automatically discovers lightweight and accurate architectures tailored to FER without relying on handcrafted design. Experimental results show that CMA-ES–driven NAS produces models with strong accuracy and adaptability across all settings, achieving competitive performance while maintaining efficiency. These findings highlight the potential of evolutionary NAS approaches in advancing FER applications, offering scalable and robust solutions for real-world deployment.

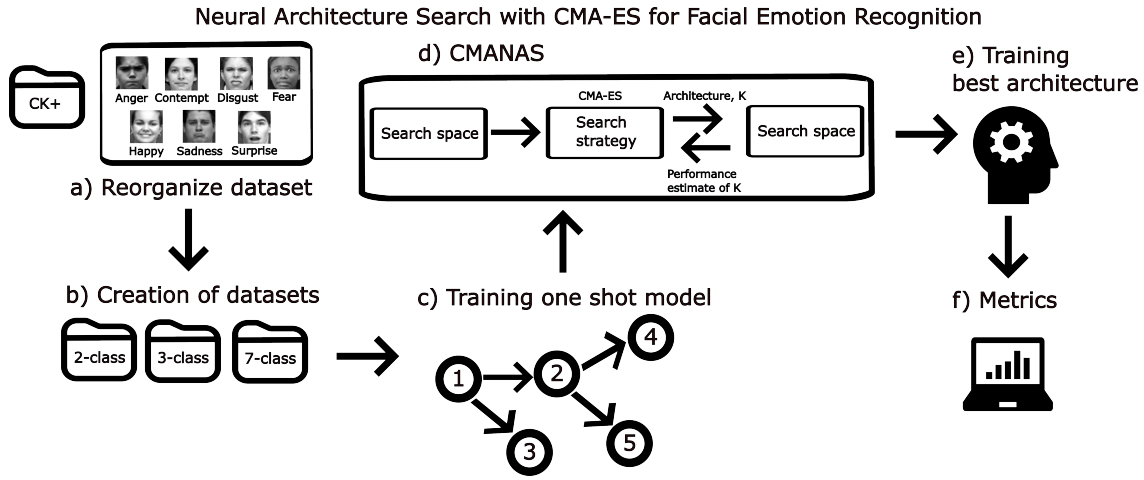

Figure 1: Visual Abstract

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Underwater Computer Vision for Tilapia Aquaculture: YOLACT-Based Trajectory Tracking and Group Behavior Analysis During Feeding

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The global increase in food demand highlights the urgent need to optimize aquaculture production while ensuring sustainability and animal welfare [1][2]. In the case of gray tilapia farming, traditional monitoring techniques remain predominantly manual and inefficient, resulting in poor feed management and increased risks to fish health [3][4]. This study addresses these limitations by introducing an innovative, non-invasive computer vision approach for underwater monitoring of tilapia behavior in semi-closed aquaponic systems under realistic rearing conditions [5][6].

First, an original dataset was developed from images and videos obtained in commercial rearing ponds, filling a gap in the absence of available datasets in comparable environments [7]. With this resource, a YOLACT-based instance segmentation model was trained, enhanced with specific data augmentation techniques, including Gaussian and field blurring to address turbidity and environmental variations [8][9]. The YOLACT model demonstrated high accuracy, achieving an IoU of 0.98 for a threshold of 0.75 and 0.83 for a threshold of 0.90 in the detection of bounding boxes [10]. To translate these detections into behavioral information, Argos Animal Tracking software was implemented, generating individual trajectories that were subsequently analyzed as a group to identify feeding dynamics.

The results showed consistent and quantifiable patterns, with clear variations in spatial density and swimming speed throughout the pre-feeding, feeding, and post-feeding phases [11]. As an illustrative example, speed peaks of 20–25 pixels/second were recorded during feeding, compared to 5–10

pixels/second under normal conditions, demonstrating the system's ability to detect behavioral changes even in high-density and low-visibility scenarios. The main contribution of this work lies in establishing a non-invasive methodology that combines advanced vision segmentation with behavioral analysis in real-life aquaponic conditions. Beyond its immediate application in tilapia farming, the system is highly transferable to other aquaculture farms with similar conditions, offering a scalable solution to optimize feeding, reduce resource waste, and promote sustainable practices in intensive production systems.

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GSGP-CUDA for Supervised Classification

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Geometric Semantic Genetic Programming (GSGP) is a state-of-the-art machine learning method based on evolutionary computation that has demonstrated high effectiveness in addressing symbolic regression tasks [1] and, more recently, binary classification problems through the incorporation of an activation function inspired by perceptron neural networks, while retaining the properties of geometric semantic operators [3, 4]. In this study, we propose a parallel variant of GSGP implemented on a GPU [2] using CUDA for binary classification. The proposed approach evaluates the influence of the Optimal Mutation Step (OMS) and a sigmoidal activation function on both classification accuracy and model generalization. Experimental results indicate that OMS substantially accelerates convergence within a reduced number of generations, confirm the critical role of the sigmoidal function during training and prediction, and demonstrate that GPU-based parallelization considerably decreases training time.

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RSG, a Method for Pareto Front Approximation and Reference Set Generation

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In this study, we address the problem of obtaining bias-free and complete finite size approximations of the solution sets (Pareto fronts) of multi-objective optimization problems (MOPs). Such approximations are, in particular, required for the fair usage of distance-based performance indicators, which are frequently used in evolutionary multi-objective optimization (EMO). If the Pareto front approximations are biased or incomplete, the use of these performance indicators can lead to misleading or false information. To address this issue, we propose the Reference Set Generator (RSG), which can, in principle, be applied to Pareto fronts of any shape and dimension. We finally demonstrate the strength of the novel approach on several benchmark problems.

An Evolutionary Approach for the Computation of ϵ-Locally Optimal Solutions for Multi-Objective Multimodal Optimization

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In this work, we address the problem of efficiently computing finite-size approximations of the set of ϵ-locally optimal solutions of a given multi-objective optimization problem (MOP). Such sets are in particular interesting in the context of multi-objective multimodal optimization (MMO). To this end, we first propose a bounded archiver, $ArchiveUpdateL_{Q,\epsilon}B$, that is, a modification of a previously proposed unbounded archiver. These archivers can be used as external archivers to in principle any multi-objective evolutionary algorithm (MOEA). In order to reduce the computational cost compared to such archive equipped MOEAs, we propose, in a next step $L_{Q,\epsilon}$MOEA. This evolutionary algorithm directly uses $ArchiveUpdateL_{Q,\epsilon}B$ for the selection process and hence does not need an external archive for the computation of ϵ-locally optimal solutions. We further propose a hybrid of $L_{Q,\epsilon}$MOEA with a multi-objective continuation method, which significantly improves the accuracy of the obtained solutions in case the gradient information is at hand. Finally, we show some numerical results that demonstrate the benefit of both the bounded archiver and the new MOEAs.

Experimental Data-Driven Gaussian Process Regression Model for Thermal Conductivity Prediction in Aluminum Alloys

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1 Introduction

This proposal describes the implementation of a supervised machine learning model for the prediction of thermal conductivity in aluminum alloys. An Exponential Gaussian Process Regression-based model ($EGPR$) was considered to estimate the thermal conductivity, having the chemical composition of the material, the operating temperature, and fabrication method as regressor variables. The results show that the model is highly precise as it achieves a Coefficient of Determination (R^2) of 0.92, with a Root Mean Square Error ($RMSE$) of 0.15228. The model was trained using a dataset consisting of a set of experimental aluminum alloys records that have different chemical compositions, methods of fabrication, and operating temperatures. The phases described here account for: database construction, model training, and performance evaluation. This methodology highlights the capacity of the regression algorithm to quantify with great accuracy the thermal conductivity for aluminum alloys, which is a property of great relevance in both engineering and science fields.

2 Gaussian Process Regression for predicting thermal conductivity

Currently, the use of Machine Learning (ML) techniques in materials engineering has increased considerably, making significant contributions to the design of materials with exceptional properties [1]. Unlike statistical models, which are often limited to linear relationships, ML algorithms are capable of handling complex and nonlinear relationships governing the physical and chemical properties of materials. Furthermore, by utilizing large volumes of multidimensional data, ML models enable the detection of patterns in complex systems where a wide range of parameters interact, as is the case with thermal conductivity, where chemical composition and material processing techniques play a fundamental role in its final value.

Gaussian Processes (GP) is a nonparametric supervised learning method used to solve regression and probabilistic classification problems. Gaussian Process Regression (GPR) implements GP for regression purposes. GPR works on the basis of using prior knowledge functions, also known as kernels, to make predictions over new data [2]. The mean function used in the process of regression is obtained from a probability distribution of a set of possible functions that could explain the outcomes for a given input data.

GPR is proven to be effective in assessing complex non-linear problems with multivariate data [3]. For the case of thermal conductivity in aluminum alloys, this model is promising, as it is able to handle the complex relationships among the chemical composition, process of fabrication, and operating temperature of the material. For the present work, we implemented a GPR-based ML regression model using the software MATLAB, as it integrates a built-in ML and Deep Learning application module.

Previous works have proven the ability of ML models in assessing tasks regarding the prediction of thermal conductivity in different materials. Bhandari et al. [4] applied an Extreme Gradient Boosting model on a database consisting of pure additively manufactured alloys, described by their chemical composition and processing conditions, whose range of operating temperature went from 300 to 1273 K. They ended up with a Coefficient of Determination (R^2) of 0.99. On another instance, Lu et al. [5] applied the same type of algorithm for the prediction of thermal conductivity on a database consisting of 227 as-cast aluminum alloys, which were also described by their chemical composition, as well as parameters related to the processing of the as-cast material. They achieved a R^2 of 0.93.

For this work, the thermal conductivity for multiple aluminum alloys was recorded and integrated into a single database. This resulted in 864 entries, having for each one three types of descriptors:

1. The chemical composition of the alloy, given by the weight percentage of every chemical element present.
2. The operation temperature for which the thermal conductivity was obtained.
3. A proposed system of classification for the processing technique of the material. For every aluminum alloy registered, it could be labeled as one of the next three types of processing techniques: a) As fabricated; b) Annealed; and c) Other (given to aluminum alloys that were obtained by special processing techniques, such as various types of heat treatments).

The constructed database could be used to test the GPR model's capability to handle complex non-linear relationships and predict the thermal conductivity of aluminum alloys—obtained through different processing techniques—at various operating temperatures.

3 Methodology

The methodology proposed in this work consists of five stages, starting from the database integration and ending with the model evaluation for obtaining performance metrics. These stages are briefly described in the next subsections.

3.1 Database integration.

The research conducted by Touloukian et al. [6] has been chosen as the primary source of information to integrate the database, as it contains significant data related to thermal conductivity of aluminum alloys. The data was structured within a spreadsheet, in which each entry (row) of data is formed by two main

parts: a) Descriptors. They take into account each chemical element present in the alloy; the processing technique for the material; and the operating temperature; and b) target variable, corresponding to the thermal conductivity of a specific aluminum alloy.

There are a total of 864 entries in the spreadsheet. Regarding the regressors, each entry (corresponding to a specific aluminum alloy) is described by its chemical composition in terms of the elements present and their respective weight percentage. A total of 23 chemical elements are present among all the aluminum alloys. Furthermore, three variables were considered to describe the type of processing technique used in obtaining the material. In this sense, an aluminum alloy has one of the three variables set as a "1", while the others remain as "0". This classification was developed considering the information given by the source, as:

- *As fabricated.* Corresponds to an aluminum alloy that has been obtained by means of as-cast or forge processes, and has not been subjected to any other treatment.
- *Annealed.* For any aluminum alloy that was finally obtained by means of an annealing process.
- *Other.* Corresponds to any other aluminum alloy for which the processing technique is more complex, and couldn't be labeled as the first two. Usually corresponding to heat treated aluminum alloys.

Additionally, for each entry, the operating temperature of the material is given. Each alloy has its specific thermal conductivity and is considered as the result of the combinations of the previously mentioned attributes.

3.2 Data Standardization

Within the configuration of the GPR models, there is the possibility to perform data standardization to each regressor variable. This process is recommended when the scales of the values in the regressors are considerably different. For the purposes of this work, we considered standard data scaling given that the database integrates variables that account for different chemical and physical attributes of aluminum alloys over different value ranges.

Data standardization enhances the predictive capacity of models, taking all the regressor variables to a similar scale. For each data entry (x_s), its standardized value is calculated as [7]:

$$x_s = \frac{x - \mu}{\sigma} \tag{1}$$

Where:

- x corresponds to the original value of the entry, for a specific regressor.
- μ refers to the mean of the values of the specific regressor.
- σ corresponds to the standard deviation for the data of the specific regressor.

For the present study, two cases will be studied: 1)Without data standardization; and 2) with the data being standardized.

3.3 Hyperparameter tunning

Depending on the GPR implementation, the model will have a specific set of hyperparameters that would define the ability of the model for fitting to the training data. These, in turn, will have a direct impact on the behavior and performance of the predictions. Among the main hyperparameters for GPR models are the basis function, the kernel mode, and the prior mean, which need to be carefully selected according to the dynamics of the data.

For this study, the following configuration was determined to perform optimally given the input data for the prediction of the thermal conductivity:

- Basis function: Constant.
- Kernel function: Exponential.
- Isotropic kernel: Yes.
- Kernel mode: Auto.
- Kernel scale: 7.571 (defined by the model).
- Signal standard deviation value: 0.3915 (defined by the model).
- Sigma mode: Auto.
- Sigma value: 0.3915 (defined by the model).
- Standardize data: Yes and no (to make a distinction on the performance when having selected this property).
- Optimize numeric parameters: Yes.

3.4 Cross Validation

Cross validation of the model was conducted following a k-fold strategy. Cross validation technique is critical to evaluate the performance and generalization of the predictive model by splitting a dataset into multiple training and validation subsets, training the model on the training portions, and testing it on the corresponding validation portions [8]. A total of 10 folds were considered for evaluating the model; therefore a 90-10 training-test subset was considered.

3.5 Evaluation

In this work, two metrics were used to evaluate the GPR model on the thermal conductivity database: Root Mean Square Error ($RMSE$) and Coefficient of Determination (R^2).

The RMSE measures the magnitude of the error in the regression model, and is expressed in terms of the target variable [9]. Therefore, it's desired to have its value closer to zero, as it means that the model is making accurate predictions with minimum deviations from the true values.

The R^2 represents the variance of the target variable which is explained by the descriptors. A value of 1 for this metric reflects that a model is capable of understanding the inherent patterns of the system under study, making accurate predictions of the target variable [10].

4 Results

By using the GPR model to study and predict the thermal conductivity of aluminum alloys, a Coefficient of Determination (R^2) of 0.92 was achieved. Also, a Root Mean Square Error ($RMSE$) value of 0.15228 was obtained. These values correspond to the analysis conducted with standardized data, as seen in Table 1. It is also evident that the metrics for the non-standardized data analysis were significantly lower than those for the standardized data. It highlights the importance of doing this type of adjustment to the data in order to have better prediction values.

Table 1: Metrics of performance for Exponential GPR model.

Metric	**Non-standardized data**	**Standardized data**
RMSE	0.24705	0.15228
R^2	0.80	0.92

Figure 1 shows the predicted vs. true response for the analysis performed on the standardized data. Here, the data show an adequate fit, as the points are clustered along the diagonal line, which represents an adequate model accuracy.

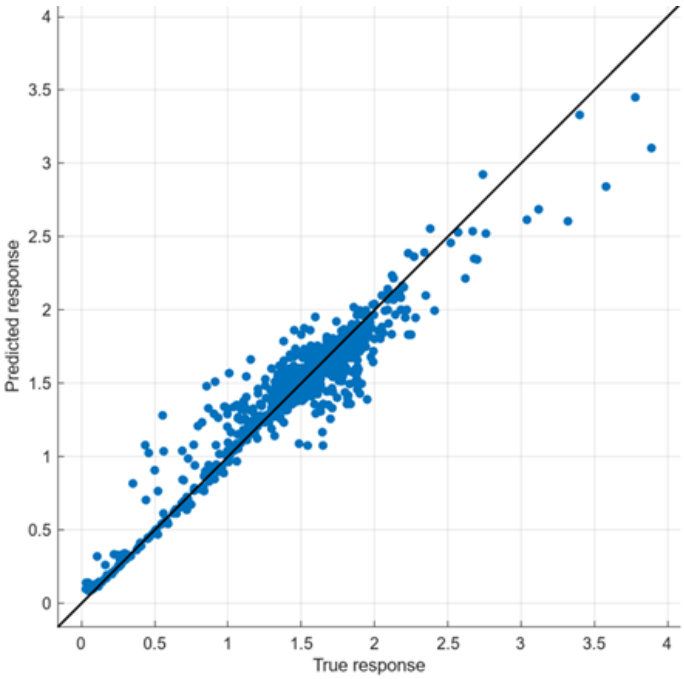

Figure 1: True against predicted values for thermal conductivity of aluminum alloys, using the Exponential GPR model.

5 Conclusions

Based on the progress demonstrated in this study, the following conclusions are derived:

1. A database designed to be used in ML regression models for predicting the thermal conductivity of aluminum alloys was constructed.

2. The database contains descriptions of multiple aluminum alloys, characterized by their chemical composition, material processing technique, and operating temperature. These are defined as descriptors that confer a specific thermal conductivity to each alloy.

3. An analysis that used an Exponential Gaussian Process Regression model for the database showed its capabilities to predict accurately the values for the thermal conductivity in aluminum alloys. A Coefficient of Determination (R^2) of 0.92 was reached, while a Root Mean Square Error ($RMSE$) 0.15228 was obtained.

Future work will move towards determining the incidence that each variable (regressor) has on the determination of the thermal conductivity. This process will serve as a model optimization, on which a feature selection takes place to improve the model performance in terms of explainability and prediction error.

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A methodology for Information Retrieval from Industrial Systems based on Artificial Intelligence Methods

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Abstract

Information Retrieval (IR) has been essential for the development of various industrial, commercial, academic, and governmental applications. Recently, IR has gained significant relevance due to the rapid increase in security problems stemming from issues arising with the advent of new systems, such as those of the Black Net. The proposed methodology contemplates aspects such as a) Needs Analysis; b) Resource Typology; c) Main Components; and d) User Profiles. The methodology is supported by the principal classical IR methodologies, such as the Boolean Models, the Probabilistic Model or Bayesian methods, and Salton's Vectorial method. This research work presents the main IR tools, and a qualitative evaluation is carried out; in the same way, an assessment of the principal IR methodologies is analyzed. Finally, the general conclusions of this work are presented.

Keywords: Information Recovery, Security Systems, Bayesian Methods, Vectorial Method

Smooth Path Planning for Multi-robot Systems in Warehouses

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The present work proposes a method to find simplified and collision-free paths between whichever two points inside a maze, along with a set of continuous Bézier curves for a multi-robot system (MRS) to follow. The final trajectory considers speed variations to facilitate the path following task in complicated curves. Additionally, we provide a path following controller with coordinated repulsion capabilities to avoid collisions against other robots in the maze while following the desired path. The provided experimental results – video footage and data – with differential drive robots (DDRs) show the effectiveness of the path planning method and the controller with single and multiple robots. The implementation of the proposed path planning algorithm and controller exhibit a runtime in order of milliseconds, which accounts for multi-platform versatility.

Estimation of total body fat using Genetic Programming

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Body fat percentage has become established as a more accurate alternative to body mass index (BMI) for assessing overweight and obesity, as it more accurately reflects body composition. This paper explores three variants of GP: Genetic Programming, Grammatical Evolution (GE) [2], Context-Free Grammatical Genetic Programming (CFG-GP) [3], and Dynamic Structured Grammatical Evolution (DSGE) [4], with the aim of obtaining interpretable and precise mathematical expressions for estimating body fat percentage. The central objective is to achieve a balance between predictive accuracy and explainability, so that the resulting models are useful in clinical and healthcare contexts. To this end, the performance of these variants is evaluated on a public anthropometric dataset and the results are compared with those obtained using the QLattice framework [1], representative of the state of the art in symbolic regression. The experimental results show that grammatical evolution techniques can generate competitive models in both accuracy and interpretability, highlighting their potential as complementary tools in the assessment of obesity and overweight.

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Knowledge-Based Design Methodology for Human Resources Information Management

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Human resource management is a strategic axis for organizations, especially in contexts where artificial intelligence (AI) tools, such as natural language processing and large language models (LLMs), play a fundamental role. In this scenario, developing methodologies for designing knowledge bases is essential to efficiently manage information related to human capital. Two main application scenarios can be identified: a) internal employees who are potential candidates for promotion, and b) external candidates seeking to join the organization. This research focuses on the latter, specifically the selection of external applicants according to predefined requirements for a vacant position. The proposed methodology involves collecting applicant documents, structuring and indexing the data within a knowledge base, applying AI-supported retrieval techniques, and ranking candidates based on role-specific criteria. It is designed to build a knowledge base comprising official documents and records related to applicants' professional trajectories. It incorporates techniques for storage, organization, access, and information retrieval, aiming to optimize the identification and selection of suitable candidates. Additionally, the study presents a state-of-the-art review of existing knowledge base design methodologies, analyzing their advantages and limitations. The proposed approach offers improvements in efficiency, accuracy, and usability compared to current practices, providing organizations with a systematic tool to enhance their recruitment processes. This methodology provides a structured, AI-supported framework for human resource management, enabling better-informed decision-making and promoting the strategic alignment of talent acquisition with organizational objectives.

Keywords: Human resource management, Artificial intelligence, large language models, Knowledge base, Candidate selection.

Fitting and validation of a Monod–logistic model for *Stigeoclonium nanum* in a thin-layer photobioreactor

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Microalgae are used in nutrient treatment and bioenergy applications, multiple mechanistic models describe their dynamics in photobioreactors. However, for *Stigeoclonium nanum*, the modeled evidence is limited, and there is no framework calibrated with experimental data in thin-layer systems [1, 2]. We present the fitting and validation of an ODE model that combines Monod-type uptake with a logistic growth term [3], applied to *S. nanum* cultivated in a thin-layer flat photobioreactor.

The dataset consists of three independent 16-day runs with daily sampling. Preprocessing used a Savitzky–Golay filter, and numerical integration employed a fixed time step after a step-size convergence test to ensure integration stability.

Parameter identification was performed with bounded nonlinear least squares (`lsqcurvefit`); model evaluation used 3-fold cross-validation [4]. Goodness of fit was quantified using RMSE and the coefficient of determination [5, 6]. With filtered data, the model reproduced the sigmoidal biomass growth and the sustained decrease of N–NO_3 and P–PO_4, with the following ranges: (i) biomass RMSE = 9.43–13.30 mg/L and $R^2 = 0.990$–0.994; (ii) N–NO_3 RMSE = 0.97–2.11 mg/L and $R^2 = 0.994$–0.998; (iii) P–PO_4 RMSE = 0.045–0.148 mg/L and $R^2 = 0.991$–0.999. These ranges were consistent across the three folds (two runs for training and one for testing, with the folds rotated). To contextualize magnitudes, the estimated carrying capacity was $\sigma = 268.97$ mg/L, so biomass errors correspond to RMSE/$\sigma = 3.51$–4.94%. The mean parameter estimates (across the three folds) were: $\rho_1 = 9.90 \times 10^{-2}$ d^{-1}, $\rho_2 = 3.74 \times 10^{-1}$ d^{-1}, $\rho_3 = 5.66 \times 10^{-2}$ d^{-1}, $\rho_4 = 2.60 \times 10^{-1}$ d^{-1}, $\varphi_1 = 98$ mg/L, $\varphi_2 = 63.37$ mg/L, $\varphi_3 = 8.13$ mg/L, $\alpha_1 = 5.7 \times 10^{-2}$ d^{-1}, $\alpha_2 = 3.03 \times 10^{-2}$ d^{-1}, $\alpha_3 = 6.3 \times 10^{-3}$ d^{-1}, and $\sigma = 268.97$ mg/L.

Reported simulations included: (a) time trajectories of biomass, N–NO_3, and P–PO_4 versus the validation data; (b) an error breakdown by fold and by variable; and (c) numerical sensitivity to initial conditions in the first octant and to $\pm 10\%$ perturbations in parameters and initial conditions, all evaluated with the same fitting metrics. Overall, the study documents a reproducible fitting-and-validation workflow for a Monod–logistic model calibrated with experimental data for *S. nanum* in a thin-layer system.

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Task Scheduling Optimization in Cloud Computing: A Bin Packing and Machine Learning Perspective

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Task scheduling in cloud computing is a key optimization problem that directly impacts several important performance metrics in these environments, such as system throughput, energy consumption, and operating costs. In recent years, machine learning (ML) techniques have gained relevance in addressing this problem thanks to their ability to adapt to dynamic workloads and learn efficient scheduling strategies. This paper presents a review of ML-based approaches to task scheduling in the cloud, including different strategies such as supervised, unsupervised, reinforcement learning, deep reinforcement learning, and others. The optimized objectives, test sets used, and cloud simulation environments are discussed.

In addition, we present a practical case in which ML is integrated with a genetic algorithm for task scheduling, modeled as a Bin Packing Problem. The approach incorporates Q-Learning to dynamically select among multiple heuristics during the generation of initial solutions. The reward function is based on the number of correctly assigned tasks, allowing the learning agent to improve its selection policy over time. Experimental results in simulated cloud environments show improved task assignment efficiency compared to using static heuristics. This study highlights the potential of reinforcement learning to enhance traditional optimization algorithms in cloud systems.

Machine Learning Algorithms for Translating Inductive Band Signals into Spirometric Volume Estimates

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The assessment of pulmonary function is an essential component in the diagnosis and monitoring of respiratory diseases, with spirometry serving as the reference procedure in clinical practice [1, 2]. However, its routine application in non-hospital settings is limited by the need for specialized equipment, frequent calibration, and the patient's active cooperation [3]. In this context, inductive bands have emerged as a portable, low-cost alternative that enables prolonged recording of thoracic expansion and relaxation [3]. Nevertheless, the main challenge lies in converting these signals into reliable estimates of respiratory volume, comparable to those obtained via spirometry [1].
In this study, a methodology was developed that combines signal processing techniques [4, 5] with machine learning models [6, 7] to transform the inductive band signal into an accurate representation of respiratory volume. A total of 1,180 recordings were collected from 112 healthy volunteers under four distinct respiratory protocols, which included both resting conditions and post-exercise states. The acquired signals were subjected to filtering, differentiation, integration, and temporal alignment to improve correspondence with spirometric curves [4]. Subsequently, a diverse set of machine learning algorithms was trained and evaluated using a cross-validation scheme, including neural networks, ensemble models, and distance-based methods [8].
The results showed that a convolutional neural network (CNN) achieved the best performance, demonstrating a strong relationship between the estimated volume and spirometry measurements. Additionally, the machine learning models provided adjustments that reduced residual error between inductive band signals and spirometry. These findings support the feasibility of this approach as a tool for prolonged respiratory monitoring [7, 9].

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Comparative Analysis of Machine Learning Models for Congestive Heart Failure Detection from QRS Complex

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Early detection of congestive heart failure (CHF) from the Electrocardiogram (ECG), particularly subtle anomalies in the QRS complex, is crucial to reduce mortality, especially in resource-limited healthcare settings. Manual ECG interpretation, however, is time-consuming and subject to inter-physician variability, potentially delaying accurate diagnosis [1]. Automated methods based on machine learning offer objective support, improving diagnostic consistency and aiding clinical decision-making [2]. This study evaluates and compares the performance of five supervised classifiers —Random Forest, XGBoost, Gradient Boosting, 1D CNN, and MiniRocket —for CHF detection centered on the QRS complex. A total of 44,987 heartbeats from the BIDM-CHF Database [3] were preprocessed through filtering, normalization and segmentation, followed by feature extraction across temporal, spectral, morphological, and complexity domains. Class imbalance is a critical challenge in medical datasets, as it often leads models to be biased toward the majority class, reducing their ability to correctly detect clinically relevant minority classes [4]. To mitigate this, class imbalance was addressed using moderate under-sampling and BorderlineSMOTE [5]. Among the tested models, XGBoost achieved the best performance (97.14% accuracy, 97.78% F1-score, 98.60% precision, and 97.14% recall) and demonstrated consistent cross-validation results (99.53% +/- 0.16%). These findings highlight XGBoost as a robust and interpretable approach for ECG-based CHF detection, with strong potential for integration into clinical decision support and portable detection tools [6].

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Socio-Environmental Regionalization Based on Clustering and Geospatial Analysis

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Regionalization is a key tool in territorial planning and sustainable resource management, allowing for the identification of spatial units with homogeneous characteristics. Traditionally, these delimitations have been based on administrative criteria, which limit the integration of socio-environmental and economic dimensions. In this work, we propose a socio-environmental regionalization methodology based on clustering techniques and geospatial analysis, aiming to generate a regional classification, specifically the most representative of the territorial reality. The approach used in this methodology integrates the following groups of variables: a) air quality, specifically, vegetation cover, water availability, and temperature; b) social variables, such as population density, educational level, access to basic services, and health indicators; c) economic variables, including industrial activity, employment, and gross domestic product per capita. Before the analysis, the variables were standardized and subjected to dimensionality reduction using principal component analysis (PCA), which optimized the quality of the clusters. Clustering algorithms, such as k-means, DBSCAN, and hierarchical clustering, were subsequently applied to evaluate their performance. The results show that the regionalization derived from clustering can reveal territorial patterns that transcend political and administrative boundaries, highlighting the emergence of homogeneous regions around environmental issues and socioeconomic inequalities. Furthermore, the use of geospatial analysis enabled the cartographic representation of the clusters, facilitating the interpretation of the results and their potential application in differentiated public policies. Finally, we concluded that the combination of multivariate clustering and geospatial analysis constitutes a robust strategy for socio-environmental regionalization, capable of providing scientific evidence for decision-making related to territorial management, reducing inequalities, and fostering the transition toward sustainable development.

Keywords: Regionalization, Clustering, Geospatial Analysis, Sustainability, Socio-environmental Variables, Territorial Planning.

Dynamic Multi-objective Evolutionary Algorithm Based on Decomposition with Adaptive Response Change Environment Method (DMOEA/D-ARCEM)

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Currently, dynamic multi-objective optimization has become highly relevant due to the emergence of new dynamic multi-objective optimization problems. A dynamic multi-objective problem is one in which its objective function and/or constraints change over time. Due to its dynamic nature, the fronts of a dynamic problem change as the problem itself changes. Therefore, a decision must be made as to whether the new environment will be solved as a new problem from scratch or whether the information from the previous environment will be used to converge quickly. There are various strategies for reacting to changes in the problem. This paper proposes a mechanism for responding to change based on a reinforced learning agent. The agent can select three possible actions in response to a change: the first action replaces the entire population and generates new solutions using the Latin Hypercube technique; the second action replaces 30% of the population with solutions generated using the SBX crossover method; and the third action applies a 30% mutation to the population solutions using polynomial mutation. The mechanism has been added to the dynamic version of the MOEA/D algorithm, and eight dynamic multi-objective benchmark

problems have been solved. Wilcoxon and Friedman tests were applied with 95% reliability.

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EV-STSP on Directed Urban Networks: Construction, Energy Enrichment, and Evaluation

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This article presents a methodology to generate synthetic instances of the Steiner Traveling Salesman Problem for Electric Vehicles (EV-STSP) in its directed variant, emulating one and two-way streets in urban networks. Starting from a real road graph, we map nodes onto a regular grid at four scales: Small (8×8), Medium (12×15), Large (20×25), and Extra-Large (35×50), in order to modulate instance size while preserving Manhattan adjacency (4 neighbors) and geographic coherence. For distances between adjacent nodes, we fit a Gaussian kernel density estimator (KDE) to 94,264 Madrid road segments (Silverman's rule, $h \approx 16.70$ m) and sample lengths with truncation to [6.73, 499.46] m (p2 to p98). Slopes are drawn from empirical distributions, and we reconstruct elevations via least squares to ensure cycle-level consistency. Maximum speed per edge follows the empirical distribution within plausible bounds (see Methods) and a neural network trained on real data estimates per-edge energy consumption (Wh), yielding enriched instances that integrate network structure, terrain, and energy demand. Within the Steiner setting, required nodes (terminals) are explicitly defined for mandatory visitation, while optional Steiner nodes correspond to charging stations and other non-required nodes that can be leveraged to ensure connectivity and energy feasibility. We validate coherence using distributional similarity tests (KS and JSD) on lengths, slopes, and energy, together with topological metrics such as degree, average path length, clustering, and betweenness, and we report detailed results in the manuscript. As a limitation, the model does not yet incorporate dynamic traffic, signaling, or environmental conditions, which are left for future work.

Bailando++: An Approximation from Computational Creativity

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Despite advances in AI for music and visual arts, dance remains relatively underexplored as a computational creativity problem. Dance combines embodiment, rhythm, and improvisation, making it both technically challenging for AI and valuable for the creative domain.
In this work, we address this challenge by enhancing Bailando++ [2, 3], a dance sequence generator, with a creative module. Bailando++ utilizes reinforcement learning and GPT models to generate fluent and plausible dance sequences. However, it lacks explicit mechanisms for evaluating and promoting creativity. Such mechanisms can be modeled as additional objectives, resulting in a multi-objective optimization problem. Namely, we incorporated creative quality indicators, including fluency, diversity, and novelty of the sequence of dancing moves. It is important to note that these objectives often conflict with each other. For instance, generating different moves and sequences can compromise executability.
Further, we applied NSGA-III [1] on the latent space of the GPT model to optimize the proposed objectives. Finally, we compare NSGA-III to the classical Bailando++ as well as a weighted sum approach. Our preliminary results show competitive hypervolume performance and promising improvements in generating fluent, diverse, and novel dance sequences. This work illustrates how multi-objective optimization can foster creativity in generative AI for the performing arts.

Keywords: Artificial Intelligence, Dance Generation, Multi-Objective Optimization, NSGA-III, Computational Creativity, Reinforcement Learning.

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SA and TA algorithms applied to alternative assets in mexican stock exchange

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Exchange-Traded Funds (ETFs) and Infrastructure and Real Estate Trusts (FIBRAs) on the Mexican Stock Exchange have been shown to combine strong performance, diversification, and liquidity, posing challenges for constrained asset allocation. The present study integrates heuristic optimization and hybrid forecasting with a view to enhancing portfolio construction. In the subsequent optimization phase, a mean-variance framework is solved using simulated annealing (SA) to navigate the non-convex search space under practical constraints. In order to facilitate the process of forecasting, the following methodologies are applied: ARIMA, seasonal decomposition, feed-forward neural networks, and recurrent neural networks (RNN). The purpose of this is to predict weekly price movements of 28 ETFs and FIBRAs over 335 observations. An ensemble strategy is employed to aggregate these forecasts, with weights that have been optimized via the Threshold Accepting (TA) algorithm to minimize symmetric mean absolute percentage error (sMAPE). Empirical evidence has demonstrated that the SA-optimized portfolio achieves a return of 0.1918, a risk of 0.00626, and a Sharpe ratio of 1.0614. Furthermore, the TA-weighted ensemble demonstrates superior performance in comparison to both individual models and equally weighted ensembles, yielding the lowest sMAPE. The proposed approach emphasises the efficacy of metaheuristics in both portfolio optimization and forecast ensembling, offering high-quality solutions within a reasonable computational timeframe. The findings of the present study have practical implications for investment strategies in emerging markets.

Keywords: Portfolio, Simulated Annealing, Threshold Accepting, Forecast

Forecasting and Optimization of Stock Market Assets Using Metaheuristics and Deep Learning

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ABSTRACT

An investment portfolio is a collection of financial assets, including stocks, fixed-income securities, mutual funds, and real estate, strategically held by investors to achieve diversification and optimize returns. The utilization of appropriate tools in the forecasting of assets enables investors to anticipate events and obtain valuable information for decision-making purposes. In works by other authors on this subject, models have been proposed that seek to meet these two key needs for the formation of investment portfolios. However, the focus has been on using metaheuristics and traditional methods to forecast and optimize assets. This work proposes a methodology that utilizes algorithms to perform two important tasks: forecasting and optimizing an investment portfolio. The data set employed in this study is drawn from the S&P 500 Stock Exchange. The S&P 500 index is regarded as the most representative of the US stock market. Our proposal aims to leverage the capabilities of heuristic methods and deep learning to improve forecast accuracy and investment portfolio optimization. To improve forecast accuracy, we assemble five forecasting methods: ARIMA, ETS, FFORMA, JAGANATHAN, and CNN. The combination of forecasting methods enhances the accuracy and reliability of forecasts. Investment portfolio optimization is essential; this allows capital to be distributed among different asset classes and economic sectors to obtain the best balance between return and risk. To achieve this task, the proposed methodology uses the TAIPO algorithm, which is a metaheuristic technique based on the threshold acceptance algorithm for asset selection and portfolio optimization. The results show the potential for developing high-performance portfolios that outperform traditional forecasting methods.

Keywords: Portfolios, Forecasting, Metaheuristics, Finance, Deep- learning.

A Hybrid Ensemble Model for Financial Time Series Forecasting Integrating Statistical, Machine Learning and Deep Learning Methods

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Abstract

Time series forecasting is a highly relevant tool across multiple domains, including finance, climatology, healthcare, and energy, as it enables the anticipation of future behaviors based on historical data analysis. However, the increasing complexity, the presence of nonlinearities, and the seasonality patterns observed in many modern series have revealed the limitations of traditional approaches, thereby underscoring the need for more robust and adaptive methods. The present work is structured as a hybrid ensemble model aimed at integrating statistical techniques, machine learning techniques, and deep learning architectures. The central objective is to enhance the accuracy, adaptability, and generalization capacity of the forecasts produced. The proposal considers the use of models such as ARIMA, Exponential Smoothing, Support Vector Regression, and LSTM neural networks. These models are combined in this work using the Stacking ensemble strategy to leverage their individual strengths while mitigating their limitations. In addition, to reinforce the proposed architecture, a Genetic Algorithm is incorporated for hyperparameter optimization. Finally, the performance of the model will be validated on multiple financial time series datasets and assessed using widely adopted evaluation metrics in the literature, such as Mean Absolute Error, Root Mean Squared Error, and Symmetric Mean Absolute Percentage Error.

The Moving Firefighter Problem with Heterogeneous Propagation Times

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The classical Firefighter Problem (FP), initially formulated as a discrete-time diffusion model on graphs by Hartnell in 1995 [1], assumes uniform propagation and firefighter movement at constant discrete-time intervals. The Moving Firefighter Problem (MFP), introduced in [2], generalizes FP by incorporating a variable movement time function $\tau : (V \cup \{a\}) \times V \to \mathbb{R}_{\geq 0}$ for firefighters, where $G = (V, E)$ is the underlying graph and a is the firefighter's depot. This extension aims to better model realistic scenarios such as wildfire containment. For the single-firefighter case (1-MFP), we previously developed the first Mixed-Integer Quadratically Constrained Programming (MIQCP) formulation. In this work, we introduce the *Moving Firefighter Problem with Heterogeneous Propagation Times (MFP-HPT)*, a novel extension of the MFP. Unlike the standard MFP where fire propagates uniformly in constant time slots T_S, the MFP-HPT considers a *varying* fire propagation time $\delta(u, v) > 0$ for each edge $(u, v) \in E$. This refined formulation captures heterogeneous spreading dynamics more accurately, making it applicable to various phenomena beyond firefighting, such as disease transmission or information diffusion across networks. We demonstrate that any finite instance of the MFP-HPT can be ε-approximated, in polynomial time, by an instance of the standard MFP. This reduction allows for the direct application of existing solution methodologies, including the aforementioned MIQCP formulation for the 1-MFP. Our preliminary computational experiments with random graph instances highlight the intrinsic computational complexity inherited from the original MIQCP formulation used for the 1-MFP. Despite these complexity challenges, explicitly accounting for edge-specific propagation dynamics significantly enhances the realism, versatility, and applicability of the Moving Firefighter Problem across various domains within operational research and computational optimization.

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Implementation of a CNN in FPGA for Pulmonary Volume Estimation

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Pulmonary function testing is a cornerstone in the diagnosis and monitoring of respiratory diseases. However, reference techniques such as spirometry and whole-body plethysmography face limitations in terms of portability, consumable costs, and the need for patient cooperation [1, 2]. Inductive respiratory bands emerge as a portable, non-invasive alternative, though the main challenge lies in transforming their signals into reliable volume estimations [3].

In this work, an optimized convolutional neural network (CNN) was developed to translate inductive band signals into pulmonary volume estimates. The model was first trained in Python and then quantized to fixed-point arithmetic to reduce computational complexity while preserving inference quality. Subsequently, the architecture was translated into hardware description language (VHDL) and deployed on an Artix-7 FPGA. The design was structured into modular hardware blocks—including sliding window buffering, convolutional filtering, ReLU activation, max pooling, and dense layer computation—interconnected through lightweight control and synchronization protocols. This modular approach leverages the inherent parallelism of FPGAs, enabling real-time inference with low power consumption and reduced latency compared to GPU or CPU implementations [4, 5].

The implementation demonstrates the feasibility of embedding CNNs into reconfigurable hardware for biomedical applications. This approach represents a step forward in the development of wearable instruments capable of estimating pulmonary volumes outside hospital environments, with potential applications in telemedicine and home-based monitoring.

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Computing Regulatory Control Policies in Facility Location Games Using Reinforcement Learning

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This paper introduces a novel application of reinforcement learning to address the computational challenges of finding Nash Equilibrium states in Facility Location Games (FLG). These games are a class of multi-agent systems with broad relevance in logistics, urban planning, and traffic management [1]. While traditional methods, such as Best Response Dynamics (BRD), are commonly used, they often suffer from slow convergence. Furthermore, achieving the Social Optimum is known to be computationally intractable. Our proposed approach uses a Q-Learning [2] agent to dynamically manage the BRD process, significantly accelerating the convergence to a Nash Equilibrium.

The core of our method is a regulatory agent, or regulator, that intervenes in the sequential player updates of BRD. Instead of relying on a random or fixed update schedule, the regulator dynamically selects which player makes the next move. This turns the player-update schedule into a control variable. The regulator's decision is based on a compact state representation that includes game information, such as the current configuration of open and taken facilities, served demand, and players' utility functions. The agent's action space is simply the set of player indices.

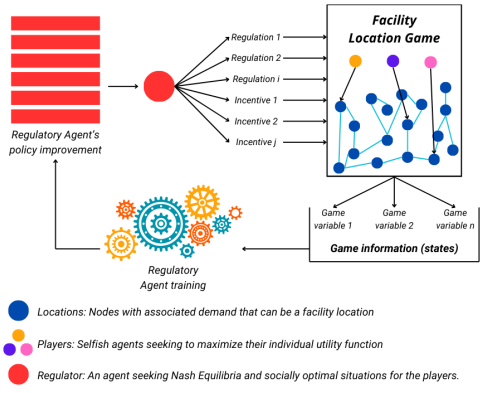

Figure 1: Proposed architecture

We evaluate this method using FLG simulations on tree topologies. In our model, each node represents a demand point, and edge weights represent the cost of serving that demand. These costs and demands are generated from a normal distribution. Each player establishes a single facility at a time, without any opening costs. Demand nodes are assigned to the closest facility (the one with the minimum serving cost), with ties broken randomly. The proposed architecture is illustrated in Figure 1.

Our preliminary results demonstrate the effectiveness of this approach. We measure performance by evaluating the mean number of BRD steps required for convergence and the total social welfare achieved. Our findings show a reduction in convergence time, with up to a 25% decrease compared to un-regulated BRD. These performance gains are robust across various demand distributions.

This work presents a promising new direction at the intersection of algorithmic game theory and reinforcement learning for enhancing efficiency in multi-agent systems. Future research will explore more sophisticated regulatory actions and the use of function approximation to improve scalability and further enhance social welfare. This research has potential broader implications for fields such as economics, robotics, and engineering.

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A Machine Learning Approach to Gender Classification via Operating System GUI Interaction Patterns

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Abstract

A Graphical User Interface (GUI) enables Human-Computer interaction through symbolic representations and pointing devices. This study addresses the classification of GUI images in personal operating systems through local texture analysis and discretization of visual elements. Emotional perceptions of users are incorporated from the perspective of Human-Computer Interaction (HCI), integrating a gender approach. This concept, understood as a dynamic sociocultural construction, influences female representation in Information and Communication Technologies (ICT), where, despite exceeding 60% in higher education, only 23% are incorporated into these disciplines. The methodology used incorporates visual considerations of participants segmented by age. Preliminary results show a 100% recognition rate when using two classifiers, which allows us to quantify the gender associated with GUIs. This research contributes to linking technology, emotions and gender, promoting an inclusive approach to computational analysis.

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Preprocessing of EEG signals to measure the impact of psychological interventions through Artificial Intelligence

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This work in progress is presented to analyze brain activity using EEG signals and measure the impact of eight psychological interventions on university students experiencing stress and anxiety. This pre-processing stage is key to ensuring the validity of subsequent analyses. A psychology team previously evaluated these students to confirm the presence of stress and anxiety. Once assessed, electroencephalographic recordings were obtained under resting conditions with eyes closed using the Epoc X Brain-Computer Interface. The preprocessing of the data received includes the detection and replacement of outliers, smoothing using a moving average to reduce high-frequency noise, and global normalization, which facilitates comparison between sessions and subjects. For data cleaning, the Clean Data tool of MATLAB 2024b was used, allowing the elimination of physiological artifacts (blinking, muscle movements).

From these signals, spectral features and statistics were extracted. In the frequency domain, the average powers were calculated in the Alpha, Beta, and Gamma bands. In the temporal domain, metrics such as mean, variance, and kurtosis were also included. These characteristics form the basis for the next stage of the project: the training of artificial intelligence models, whose objective will be to identify patterns associated with the changes produced by different psychological interventions in university students.

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The Pareto Tracer for the Numerical Treatment of High-dimensional Multi-objective Optimization Problems

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In many applications the problem arises that several objectives have to be optimized concurrently. One important characteristic of such multi-objective optimization problems (MOPs) is that their solution sets typically form objects of a certain dimension. Multi-objective continuation methods make use of this observation. In this presentation, we will present the changes to efficiently treat high-dimensional MOPs with the continuation method Pareto Tracer [1, 2]. The key will be to retrieve the data obtained by the Jacobian of the objective map. The resulting predictor-corrector methods is Hessian-free and applicable to problems with higher dimensional decision variable space. We will present numerical results with up to 2 million decision variables.

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Predictive glucose monitoring and telemedicine-enhanced diabetes management

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This work outlines the development of a Python-based graphical interface for simulating the Bergman Minimal Model (BMM), which addresses the dynamics of glucose and insulin in patients with Type 1 Diabetes Mellitus (T1DM). A Graphic User Interface (GUI) is developed to simplify the analysis of the influence of various parameters on these dynamics, which is confirmed by comparing it to previous research. A machine learning-based prediction model, an insulin control algorithm, a continuous glucose monitor (CGM), and radio-frequency (RF) technology for remote monitoring are integrated into a proposed system. A set of 12 measurements obtained every 5 minutes, the prediction model forecasts critical events (hyperglycemia and hypoglycemia) within minute windows. This model notifies patients of potential critical events, and remote health specialists transmit real-time glucose levels wirelessly to conduct subsequent diagnostic analyses. The system aims to improve glycemic control and reduce complications, particularly in areas with limited internet access. Furthermore, a correlation study is performed to guarantee that the information transmitted is the expected at the receiver stage.

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Statistical and Machine-Learning Framework for Climate–Socioeconomic Interactions in Mexico and Developed and Emerging Economies

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Abstract

The study of climate change requires quantitative approaches that integrate climate, demographic, and industrial information to identify trends and relationships among variables critical to sustainable development. This paper presents a descriptive and inferential analysis of climate change in Mexico and in some G20 countries, as well as in other countries with emerging economies, aiming to characterize and contrast metrics of climate risk, greenhouse gas (GHG) emissions, population density, and industrial growth. The methodology collects historical data from official international sources, processes them using multivariate statistical techniques, and generates predictions with machine-learning time-series models to project the future evolution of these variables. Descriptive statistics summarize the distribution and variability of key indicators, while inferential procedures evaluate significant associations between industrial development, GHG emissions, and population density across diverse regional contexts. The forecasting component extends the time frame of observed trends, providing a forward-looking perspective that complements descriptive findings over the study horizon and across national datasets. The framework enables the explanation of interactions between climatic and socioeconomic factors in countries with developed and emerging economic structures through forecasting techniques, contributing to understanding climate-change phenomena and their interactions with anthropogenic sociodemographic variables that shape GHG emissions and societies' vulnerability to impacts.

Keywords: Machine learning, Statistical Methods, Climate Change.

Query Optimization in RAG: Retrieval and Context Construction

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When a question is asked of an artificial intelligence assistant, the quality of the query has a decisive impact on the quality of the answer. In RAG (Retrieval Augmented Generation), the first stage is user interaction, where Conversational Query Reformulation (CQR) is applied to obtain a canonical or autonomous query that no longer depends on prior dialogue context. In a second stage, called the retrieval and re-ranking stage (RRS), ideally automatic and without user interaction, the canonical query is transformed before retrieving evidence. Contemporary techniques seek to maximize evidence coverage and minimize hallucinations, cost, and latency.

The current development presents an RRS preliminary architecture and a basic comparison with a commercial LLM (ChatGPT). In this version, retrieval orchestration and context construction are based on manually designed prompt templates: unintended responses are identified through error analysis, and the templates are adjusted to guide retrieval and generation in similar queries. Automatic query optimization or automatic template generation/structuring is not currently performed.

As future work, we propose to automate the generation and structuring of prompt templates using Automatic Prompt Optimization (APO) methods and to frame query improvement as an optimization problem. Some APO techniques include automatic query expansion and reformulation; decomposition into subqueries for complex questions; and routing queries to experts or sources.

Keywords: Query, Context construction, Large language models, Retrieval Augmented Generation, prompt templates.

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Design and Development of an Optimized Control System for a Solar Tracking System

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Abstract

In response to the growing energy, environmental, and food security challenges of the 21st century, this work presents the design and development of an optimized solar tracking system (SS) based on mechatronic principles and intelligent control techniques. The proposed system aims to reduce energy consumption without compromising production efficiency, integrating mechanical, electrical, and processing components under criteria of sustainability, precision, and cost-effectiveness—particularly relevant for energy-intensive agricultural applications such as greenhouse cultivation.

The proposed methodology for the development of an optimized solar tracking system (SS) is structured into three core stages. First, the system is characterized by defining operational requirements based on the photovoltaic configuration and control architecture. Second, a heuristic optimization process is applied to minimize a cost function that integrates tracking error and energy consumption, enabling the selection of the optimal combination of mechanical, electrical, and control components. Finally, the selected configuration is implemented and experimentally validated, with performance assessed through real-world testing to confirm the system's efficiency, precision, and sustainability.

Numerical validation of the solar tracking system (SS) was conducted using a multibody simulation environment in Matlab-Simulink®, with offline-generated solar trajectories and MPC-assisted control. The results demonstrated high tracking accuracy, maintaining angular errors below ±2° in both elevation and

azimuth axes. Control efforts remained within an efficient operating range (0–3 Nm), representing only 12% of the motor's rated capacity, which confirms effective energy optimization. The total energy consumption was calculated at 15.58 Wh, validating the robustness of the system design and the effectiveness of the proposed control strategy.

In conclusion, the optimized SS demonstrates strong potential for sustainable agricultural applications by significantly reducing energy consumption while maintaining high precision and reliability. Its modular and scalable design supports broader adoption in resource-constrained environments, contributing to the transition toward intelligent and energy-efficient farming systems

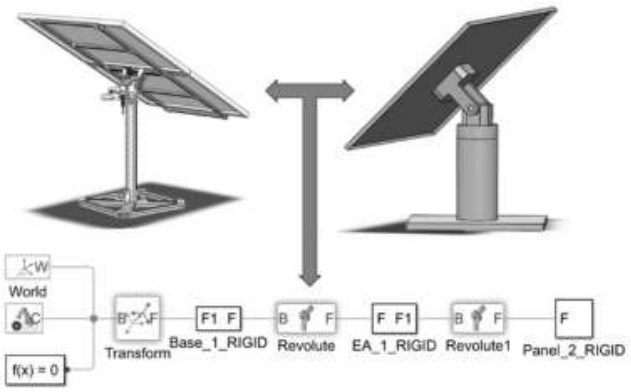

Fig. 1. Equivalence of solar tracker in SolidWorks® and Matlab-Simulink® environment.

Results

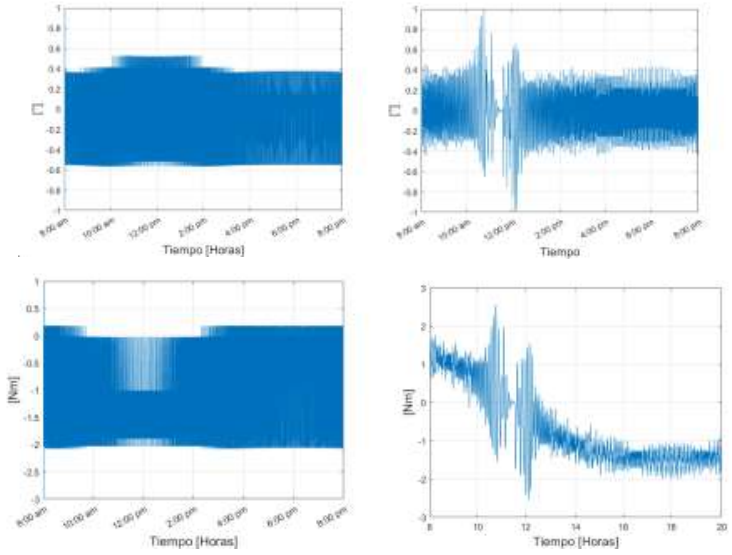

Fig. 2. Graphical results of tracking error. In (a) elevation axis and in (b) azimuthal axis. And of force in (c) elevation axis and in (d) azimuthal axis.

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Evolutionary NAS Models and Pre-Trained CNNs for Tattoo and Face Recognition

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This work presents an advanced computer vision approach for forensic identification, integrating evolutionary Neural Architecture Search (NAS) with pre-trained Convolutional Neural Networks (CNNs) for tattoo and face recognition. The project focuses on two main objectives: (1) the development of a web-based system for facial verification of cadavers in the Forensic Medical Service of Baja California, and (2) the design of unsupervised machine learning models for tattoo verification in forensic contexts. The tattoo dataset comprises approximately 4,500 images, which pose unique challenges due to variations in shape, color, texture, and skin deformations over time. To address these challenges, NAS techniques were explored, leveraging search spaces of possible architectures, evolutionary-based search strategies, and performance evaluation metrics. Tools such as AutoKeras, Microsoft NNI, and AutoCNN were evaluated, with AutoKeras selected due to time and computational constraints. Experiments with pre-trained models, including ResNet50, EfficientNet-B0, MobileNetV3, and MnasNet, demonstrated that pre-trained networks outperform models trained from scratch on limited data. However, challenges such as overfitting and high computational costs persist. Preliminary results highlight the promise of combining evolutionary NAS with transfer learning to optimize architecture selection while reducing human bias. This research contributes to forensic science by providing scalable, efficient, and adaptable models for biometric verification through tattoos and facial features.

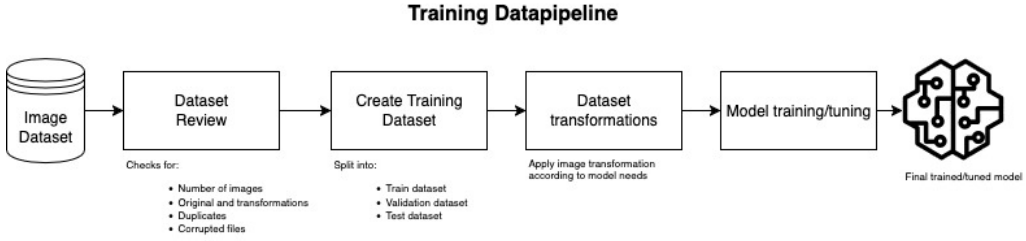

Figure 1: Proposed data pipeline for tattoo and face recognition using NAS and pre-trained CNN models.

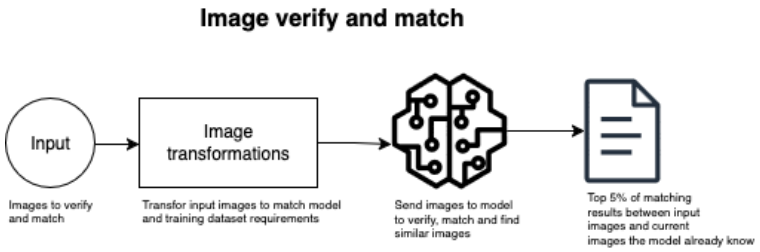

Figure 2: Proposed use case for users to input images and start the verification and matching.

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Optimizing Solar Panel Allocation in Smart-City Buildings Using Genetic Algorithms

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Climate change is already driving widespread and intensifying impacts across natural and human systems, and limiting future risks requires deep, rapid and sustained greenhouse-gas emission reductions this decade [1]. Among mitigation options, solar photovoltaics (PV) stands out for scalability and rapid cost declines; in the IEA's 2023 *Tracking Clean Energy Progress* assessment, PV was one of only three technologies rated "on track" with the Net Zero by 2050 pathway, reflecting record growth in recent years [2] and substantial avoided CO_2 and air-pollution damages documented in empirical studies [3].

Motivated by this context, we consider a city-scale scenario with very high rooftop PV penetration in which buildings host interoperable PV modules and can share energy through community or peer-to-peer (P2P) arrangements. Prior work on energy communities/P2P markets shows that design choices (who shares with whom and under what coordination rules) materially affect self-sufficiency, costs and grid impacts, highlighting the importance of system-level allocation decisions [4], [5].

Within this setting, we pose the panel-allocation problem: how should rooftop PV capacity be distributed across buildings to minimize electricity purchased from the grid. We cast it as a combinatorial optimization. To solve it we employ genetic algorithms (GAs), well-established metaheuristics for siting and sizing distributed generation with discrete decisions, non-convex objectives and network constraints to search over allocations; previous studies demonstrate GA/NSGA-II effectiveness for Distributed Generation placement and multi-objective trade-offs [6]. This approach provides insights into efficient energy allocation for future smart-city scenarios.

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Fuzzy Decision Trees and Genetic Algorithms for the Automated Construction of Fuzzy Predicates

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This work presents novel learning methods for fuzzy inference systems that aim to balance interpretability with high classification accuracy. The proposed approach integrates fuzzy decision trees and genetic algorithms (GAs) to automate the construction of fuzzy predicates. In the fuzzy decision tree framework, each node corresponds to a linguistic state represented by a membership function, enabling adaptive classification and dataset segmentation. A tree was implemented inspired in the ID3 algorithm, and its performance was evaluated through experiments on the Iris and Pima Indian datasets. Alternatively, the GA-based method focuses on the automatic optimization of membership functions and the generation of fuzzy predicates. The algorithm leverages statistical data for population initialization and employs advanced selection mechanisms, such as taboo and weighted roulette, together with logical operators (implication, equivalence), deductive structures, and logical quantifiers (universal, existential) to ensure consistent and precise fuzzy predicates.. This method was also validated through experiments on the Iris and Pima Indian datasets. The experimental results confirm that fuzzy decision trees and GAs represent two distinct yet effective methodologies for constructing fuzzy models. The proposed approaches demonstrate strong potential for application to a wide variety of real-world classification and decision-making problems.

Particle Swarm Optimization for Hydro-Thermal Power Scheduling Problem with a Type-1 Fuzzy Controller for Dynamic Parameter Adjustment

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The Hydro-Thermal Power Scheduling Problem (HTPSP) is a complex combinatorial optimization task that involves determining the optimal generation schedule for a set of hydroelectric and thermal units while satisfying operational and demand constraints. A multiobjective Particle Swarm Optimization (PSO) approach for this problem was previously proposed by Castillo-García et al. (2024) in [1], providing a framework for exploring the solution space using collective agent dynamics. In this work, we propose an enhancement to the conventional PSO by integrating a Type-1 fuzzy controller to dynamically adjust the algorithm diversification and intensification parameters during execution. The fuzzy controller monitors the current state of the search process and adaptively modulates the influence of exploration and exploitation mechanisms, enabling a more flexible and responsive search behavior. The proposed framework is evaluated using the same case study reported in the original PSO implementation. This integration introduces a methodological novelty that allows for adaptive parameter tuning without altering the underlying algorithmic structure, offering a platform for further experimental analysis in future studies.

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Efficient Selection of Low Level Heuristics in Hyperheuristics Using Combinatorial Testing for the Master Bay Planning Problem

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This study focuses on the Containership Stowage Problem. It is an NP-hard combinatorial optimization problem whose goal is finding the best plan to load a set of containers into a set of available locations in the containership, subject to several structural and operational constraints. This problem is difficult to solve and very important due to practical decision-making in the context of maritime port logistics. We present a combinatorial testing approach to select the low level heuristics of the hyperheuristic for solving this NP-hard problem. Choosing appropriate low level heuristics is essential in the development of hyperheuristic algorithms. Selecting inappropriate heuristics can lead to poor results or wasted time in experimentation. We use the well-known covering array method to reduce the number of tests of combinations of the low level heuristics of the hyperheuristic. According to the experimental results, the simultaneous use of all low level heuristics does not constitute a necessary condition for achieving high-quality solutions; in fact, restricting the algorithm to a reduced subset of heuristics may result in improved computational efficiency and solution quality.

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Optimizing Employee Attrition Prediction Models with TPOT AutoML

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High turnover of software engineers has become a critical issue in the technology industry, generating high costs in recruitment, training, and project continuity. Predicting attrition is complex, as no single variable (e.g., salary) is decisive; instead, patterns emerge from the interaction of multiple factors such as tenure, age, performance, and job satisfaction. In this study, we first implemented and evaluated traditional machine learning pipelines manually, testing models including XGBoost, SVM, logistic regression, and random forests on the IBM HR Analytics Attrition dataset. These models achieved promising results but required significant manual effort in feature selection, hyperparameter tuning, and pipeline design. To reduce this effort and further optimize performance, we applied Automated Machine Learning (AutoML) using the Tree-based Pipeline Optimization Tool (TPOT), which employs genetic programming as to automatically explore preprocessing, model selection, and hyperparameter optimization. Results show that the TPOT-optimized XGBoost pipeline achieved Precision of 0.88, F1-Score of 0.92, and ROC of 0.80, compared to the manually tuned XGBoost model (Precision 0.87, F1-Score 0.60, ROC 0.82). While ROC values were similar, the large improvement in F1-Score demonstrates that TPOT produced a model with a much better balance between catching true attrition cases and avoiding false alarms, all while reducing development time. This research highlights the value of combining manual modeling with AutoML, showing that TPOT can streamline the construction of robust predictive pipelines for attrition analysis and other classification problems.

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