ADVISORS

Dr Alina Patelli is a senior lecturer in Applied Artificial Intelligence at Aston University. An expert in evolutionary and knowledge-centric AI in the context of autonomic systems (PhD awarded by Aston University in 2017) and systems engineering (PhD awarded by the Technical University of Iasi, Romania in 2011), Dr Patelli is currently pursuing the environmental agenda by designing, implementing and deploying cutting-edge traffic prediction algorithms meant to support decision making within public organisations (urban transport authorities in the West Midlands, UK) and industry (via knowledge transfer partnerships with local enterprises that manage vehicle fleets). Dr Patelli is a founding member of the UK Young Academy, an offshoot of the Royal Society that fosters interdisciplinary research and brings it to bear on the world's major challenges.

Anikó Ekárt is professor of Artificial Intelligence at Aston University. Following her PhD at the Eötvös Loránd University, Hungary, she worked at the University of Birmingham as lecturer and at the Institute for Computer Science and Control, Budapest Hungary as senior research fellow. She has started as a lecturer at Aston University in 2006 and has taken various roles since, including Programme Director for MSc programmes in Artificial Intelligence, Associate Dean Postgraduate Taught Programmes and more recently Director of Research Degree Programmes in the College of Engineering and Physical Sciences. She is the director of the recently launched Aston Centre for Artificial Intelligence Research and Application (ACAIRA). Her research interests are centred around artificial intelligence methods and their application, with a focus on evolutionary algorithms and genetic programming. Following genetic programming performance improving methods, she has successfully contributed to applications of AI techniques to health, engineering, transport, and art. She enjoys interdisciplinary collaborations and has a large network of co-authors. In 2022 she was the winner of the Evo* Award for Outstanding Contribution to Evolutionary Computation in Europe.

DESCRIPTION OF RESEARCH GROUP

Dr Patelli and Prof Ekárt are part of the Aston Centre for Artificial Intelligence Research and Application launched in February 2024 under the direction of Prof Ekárt. The centre gathers 27 academic staff members joining forces from various departments within the School of Computer Science and Digital Technologies, and their PhD students, who are typically joined by approximately 200 MSc students working on their dissertations May-to-January every year. The team co-creates AI solutions with stakeholders and uses AI to promote fairness and equity, guided by the 17 UN Sustainable Development Goals. The main aim of ACAIRA is to generate impactful societal benefits through: (1) principled and tailored AI solutions to modern-day social, health and environmental challenges via close collaboration with SMEs, local authorities, and governmental organisations; and (2) educating the next generation of AI leaders.

The research carried out by the team includes:

- Theoretical foundations of AI and ML, their advantages, and limitations.
- Explainability and interpretability of results obtained by AI and ML, especially in critical applications.
- Using AI as a catalyst for a fairer society. The key areas of interest are health, justice, education, transport, and energy.
- Investigating sustainable AI solutions.

COLLABORATIONS

Most of our research is cross-disciplinary. We collaborate with researchers from across Aston University and external organisations alike, e.g., 3. Brain, Agilysis, Arcus, Asos, Blackline, CapGemini, Cognition, Gymshark, SmartApprentices, Thames Laboratories, Google, the Joint Research Centre of the European Commission, Los Alamos National Lab, and universities worldwide, including Aristotle University, Greece, UiT Norway, UF Alfenas, Brazil, Ontario Tech University, Canada, University of Sciences and Technology, Islamabad, Pakistan, Georgia Institute of Technology, USA, University of Texas, Medical Branch, USA, Université Mohammed VI Polytechnique, Morocco, Symbiosis Institute of Technology, Pune, India.

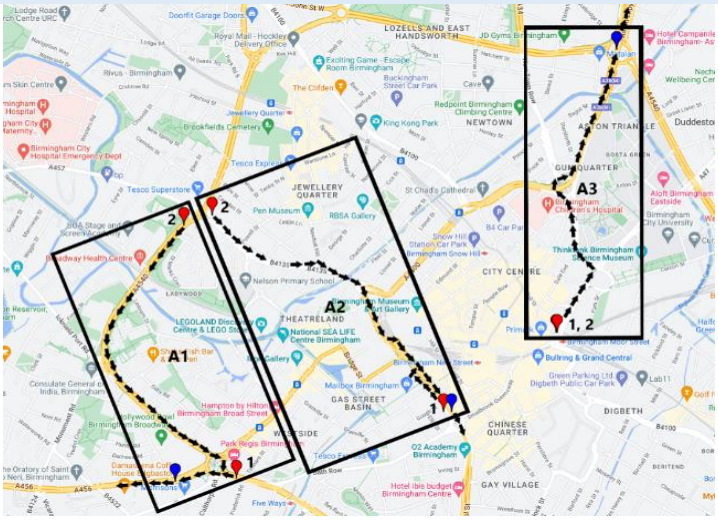
PHYSICAL ENVIRONMENT

Aston University is located on a compact city campus in Central Birmingham in the United Kingdom, easily reachable from anywhere in the world through Birmingham International Airport. Our doctoral students and research associates occupy three shared office areas within the Applied Artificial Intelligence and Robotics and Applied Mathematics departments on the 2nd and 3rd floor of the Main Building. Our facilities include a workshop and a lab with various robots and Virtual Reality headsets for research purposes. PhD students are encouraged to work on campus and use the opportunities to engage with their peers, attend various in-person training, journal clubs and research seminars, including the regular research seminar series within ACAIRA, with a mix of internal and external speakers, currently taking place in hybrid mode.

WORK TO BE CARRIED OUT BY THE STUDENT

BACKGROUND

During the 2022 Commonwealth Games, Birmingham authorities relied on human expertise to streamline city centre traffic (A1, A2 and A3 on the map) via diversion routes and road infrastructure adjustments. We argue that the underlying decision making could have been improved, had additional computational support been available to complement human input.



To that end, we developed a set of intelligent traffic modelling and prediction algorithms that make innovative use of AI techniques to capture the relationship between outflow and inflow traffic, e.g., $\hat{y}(t) = \frac{1}{c}\left(x_0(t) + x_1(t-2)\right), c = const$, where t is time, $\hat{y}$ represents vehicle flow exiting through the blue pushpins on the map and x_0, x_1 stand for traffic measured by a given area's inflow sensors (red pushpins on the map).

WORK CARRIED OUT TO DATE

Our algorithms [1], [2], [3] learn from historical data and use that knowledge to predict future vehicle flow. Our experiments on central Birmingham traffic readings collected before and during the 2022 Commonwealth Games demonstrate that those predictions are of competitive quality when historical data are collected under normal traffic conditions as well as under abnormal ones. Moreover, we have successfully applied our algorithms in heterogeneous scenarios, accurately predicting abnormal traffic (such as it was during the Games) based on readings gathered under typical circumstances and vice-versa. This has been the case even when the area being modelled was not monitored at all (in which situation, learnt patterns were transferred from adjacent (monitored) areas).

IMPACT

Partially automating traffic-related decision making processes by deploying our algorithms will afford human experts with additional insight when planning for disruptive events, designing and investing in infrastructure, drawing optimal clean air zone perimeters, etc. Our algorithms utilise transfer learning that enables the creation of traffic models covering entire cities based solely on data collected from a few key junctions. The technology underpinning our algorithms is explainable, making it easier to clearly show the general public the specific ways in which local government uses AI to improve life in the city.

PROPOSED WORK PLAN

Our algorithms' codebase is built atop the gplearn Python library. The successful candidate will:

1. Identify suitable gplearn alternatives (e.g., DEAP or other symbolic regression packages from the SR benchmark suite). Time permitting, other promising libraries should be explored.
2. Adjust existing Python scripts to efficiently leverage the functionality of the libraries identified in the previous step.
3. Run the experimental analysis on the provided traffic data.
4. Compare the results against the existing ones and recommend the most suitable library to use in the future.

REFERENCES

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[3] J. R. Hamilton, A. Ekárt and A. Patelli, "Predicting Normal and Anomalous Urban Traffic with Vectorial GP and Transfer Learning," In: Correia, J., Smith, S., Qaddoura, R. (eds) Applications of Evolutionary Computation, 2023, LNCS, vol 13989, Springer.

[4] W. La Cava, P. Orzechowski, B. Burlacu, F. O. de França, M. Virgolin, Y. Jin, M. Kommenda, & J. H. Moore (2021). Contemporary Symbolic Regression Methods and their Relative Performance. Neurips Track on Datasets and Benchmarks.