**National University of Science and Technology**
**POLITEHNICA Bucharest**

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Habilitation Thesis

in Computer Science, Information Technology and System Engineering

# Vision-Based Methods for Human Motion and Behaviour Understanding

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# Summary

This habilitation thesis presents my scientific and academic contributions developed primarily at the National University of Science and Technology Politehnica Bucharest. My research has evolved at the intersection of computer vision, natural language processing and embedded systems, focusing on developing intelligent methods for human behaviour analysis through visual and sensor data.

My early work, conducted during my PhD at the University of Edinburgh, addressed localisation and behaviour monitoring using GPS-based custom hardware. After completing the PhD, my research evolved towards indoor localisation, where I developed an open research platform integrating datasets, implementations and evaluation tools. This initiative, inspired by similar practices in computer vision, promoted reproducibility and transparent benchmarking within the field.

In recent years, my work has centred on gait analysis and behavioural understanding, aiming to develop models capable of learning robust representations of human movement from limited or unlabelled data. I introduced several key models, including WildGait, one of the first self-supervised frameworks for gait recognition, GaitFormer, a transformer-based model achieving state-of-the-art zero-shot performance without manual annotations, and Gait Pyramid Transformer (GaitPT), which integrates anatomical priors for improved spatial-temporal modelling. I also conducted the first large-scale scaling study for self-supervised gait recognition, demonstrating predictable improvements with increasing data and model capacity.

These methods were supported by the creation of four major datasets, Unconstrained Wild Gait (UWG), DenseGait, UWG-2.7M and PsyMo, which constitute comprehensive resources for advancing research on gait, movement dynamics and psychological trait analysis.

Beyond fundamental research, I have led and contributed to several applied projects in areas such as medical data processing (MATCHMED), automated vehicle damage analysis (InsureAI), human positioning (ATLAS) and behavioural data modelling within the Romanian Hub for Artificial Intelligence (HRIA). These projects reflect a consistent effort to translate theoretical advances into practical, socially relevant technologies.

In parallel, I have developed and coordinated courses including Performance

Evaluation, Startup Engineering and Data Science in Medicine, and currently serve as coordinator of the Master's programme Management in Information Technology. I have also organised summer schools, workshops and industry collaborations through the Fitbit and Google Academic Programmes, promoting applied learning and innovation.

Looking ahead, my research will continue along four main directions: advancing gait analysis through multimodal behavioural modelling; applying computer vision to medical imaging, particularly histopathology; exploring large language model techniques for drug discovery and molecular interaction understanding; and improving the quality and efficiency of text-based telemedicine through intelligent, multi-agent copilots for patients and clinicians. These directions build upon my current expertise and aim to broaden the scientific and societal impact of my work.

Overall, this thesis outlines a coherent academic trajectory integrating research, education and leadership. My work contributes to advancing intelligent methods for human-centred analysis, while strengthening the connection between scientific discovery and real-world applications.