WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

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UNIVERSIDAD POLITÉCNICA DE MADRID

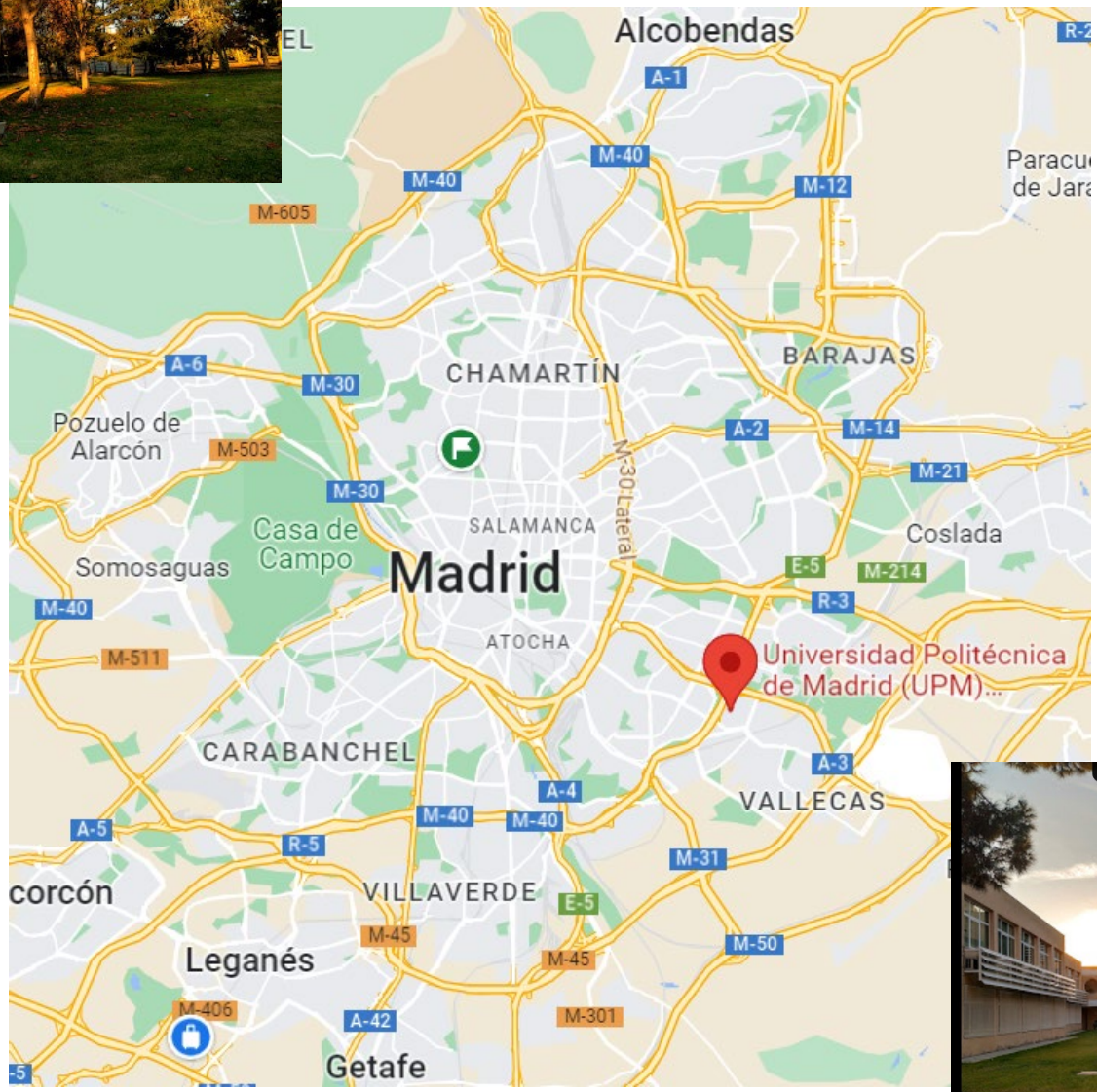
AI+DA

Applied Intelligence & Data Analysis research group


Universidad Politécnica de Madrid (UPM)...
Portugal

Where are we?


INFORMÁTICA


Alcobendas
A-1
M-40
M-12
M-605
A-6
M-30
CHAMARTÍN
BARAJAS
Pozuelo de Alarcón
M-503
A-2
M-14
M-21
Casa de Campo
SALAMANCA
Madrid
Coslada
Somosaguas
E-5
M-214
R-3
M-40
ATOCHA
M-511
Universidad Politécnica de Madrid (UPM)...
CARABANCHEL
A-3
A-4
VALLECAS
A-5
R-5
M-31
VILLAVERDE
E-5
M-45
M-50
Leganés
M-406
A-42
M-301
Getafe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UNIVERSIDAD
POLITÉCNICA
DE MADRID
Where are we?
• Technical University of Madrid (UPM)
• South Campus
• Computer Systems Engineering Technical School
• Computer Systems Engineering Department
AI+DA
Applied Intelligence and Data
Analysis research group
AI+DA

Who are we?

- Specialized group on **A**rtificial **I**ntelligence **(Machine Learning & Data Mining) and D**ata **A**nalysis
- Background on: Computer Science (AI/ML),Telecommunications, Mathematics, Physics, Psychology, Sociology
- **Multidisciplinary** research group
- **400+** publications
- **60+** research and industrial projects

AIDA research areas

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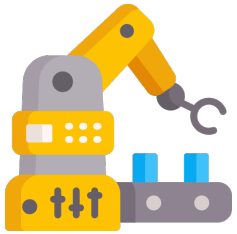
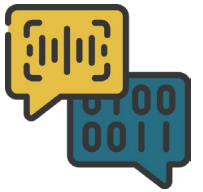
Artificial Intelligence & Machine Learning

Industry solutions



AIDA in a nutshell

Natural Language Processing



Social Network Analysis

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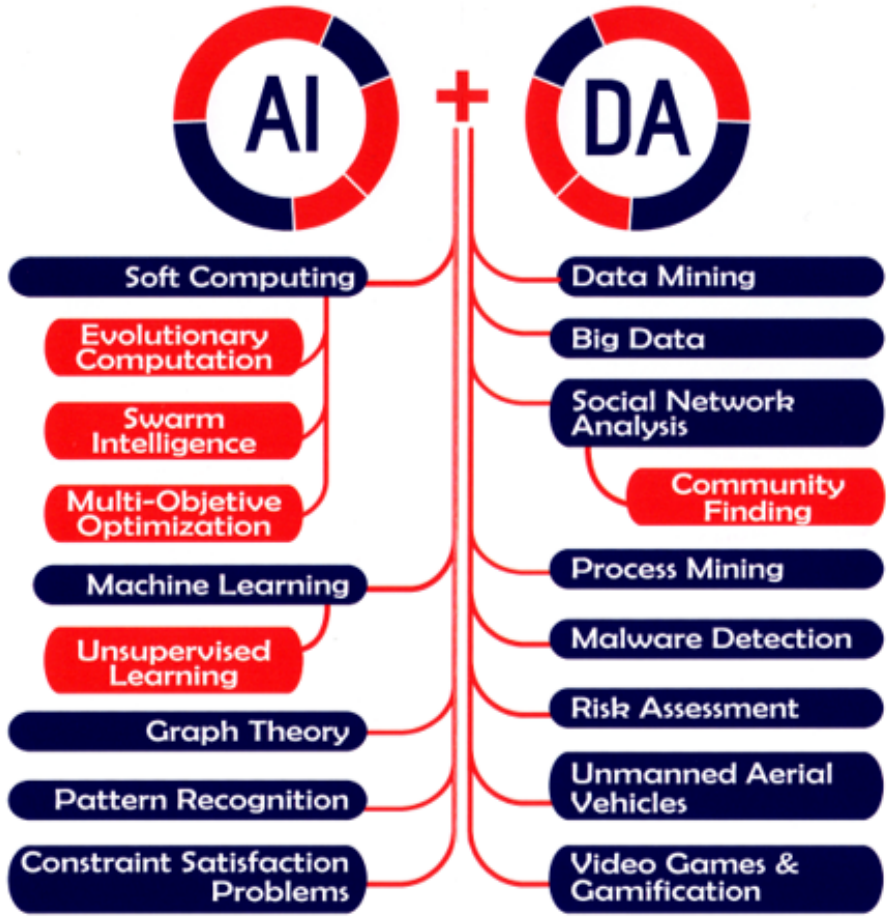
Research areas & expertise

- **Machine Learning:**
  - **Deep Learning, Ensembles**
  - Clustering, HMM, LDA
- **Bio-inspired Computation:**
  - Evolutionary Computation (GA, MOGA, GP)
  - Swarm Intelligence (ACO, PSO, ABC)
- **Natural Language Processing**
- **Video and Image Processing (Computer Vision, Vision Transformers)**
- **Social Networks Analysis**
- **Others: Industry 4.0, Disinformation, Video games, UAVs, Cyber intelligence, Malware, ...**



WP2

Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

The main objective of this WP will be to develop a comprehensive **framework** for advanced **time series analysis** that leverages **transfer learning**, **pre-trained models** and **self-supervised learning**, while also integrating the neural network techniques with visual analytics to improve **pattern discovery**, **representation learning** and **anomaly detection** in time series data.

WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

Objectives

- **O1:** To study the **limitations** of the current **time series analysis techniques** when faced with complex industrial problems
- **O2:** To create **novel time series models** by incorporating methods such as transfer learning, pre-trained models and self-supervised learning
- **O3:** To **harness** the capabilities of **visual analytics techniques** for creating innovative explanation methods that are applicable to time series analysis and outlier detection challenges

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TASKS:

- **T2.1:** Fusing Neural Networks and Visual Analytics for Explainable Time Series Analysis
- **T2.3:** Advancing Time Series Analysis via Transfer Learning, Pre-trained Models, and Self-Supervised Learning
- **T2.3:** Deployment and Evaluation of Developed Models and Tools in Real-world Scenarios

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TASK 2.1

- The task aims to **develop an integrated approach combining eXplainable Artificial Intelligence (XAI)** and **advanced visualization techniques** for **time series data**.
- The goal is to **merge neural networks' feature extraction** and **learning** abilities with the **interpretability** offered by visual analytics.
- The project will create **XAI models** that enhance the understanding and explanation of deep learning results, while **advanced visualizations** will help identify patterns, anomalies, and outliers in the data.
- This approach will be tested across different **industries**, such as space and industry, to demonstrate its real-world applicability.

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TASK 2.2

- This task aims to address the **challenges of traditional time series analysis**, particularly the **large** and **varied nature of temporal data**, by leveraging advanced deep learning techniques.
- Key approaches include **transfer learning**, where **pre-trained models** are fine-tuned for related tasks, and **self-supervised learning**, which enables models to generate labels from the data, useful in scenarios with limited labeled data.
- The objective is to improve the **accuracy**, **interpretability**, and **adaptability** of time series analysis using these innovative deep learning methods.

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TASK 2.3

- This task focuses on the **practical deployment** and **evaluation** of the models developed in previous phases (T3.1 and T3.2) within **real industrial settings**.
- It aims to implement and validate these methodologies in authentic **industry contexts**, assessing their feasibility and establishing collaborations with relevant industrial stakeholders.
- The goal is to demonstrate the **real-world applicability** of the models and showcase the tangible benefits of these innovations through **industry-academia partnerships**.

DC1

WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

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Fellow *(e.g. researcher1)*	Host institution	PhD enrolment*	Start date *(e.g. Month 6)*	Duration *(e.g. 36 months)*	Deliverables *(refer to numbers in table 3.1b)*
DC1	**UPM**	**UPM**	**9**	**36**	
Project: ***Explainable Time Series Analysis: Integrating a Neural Network and Visual Analytics for Pattern Discovery, Representation Learning, and Anomaly Detection*** /WP 1/ **PhD Supervisor:** David Camacho (ER1/UPM); **Auxiliary supervisors:** Francesco Piccialli (ER8/UNINA), Dariusz Mrozek (ER6/SUT), Volker Stolz (ER13/HVL); **R&D cooperation:** Felipe Jiménez González (GMV)					
Objectives: The aim of this project will attempt to develop an integrated platform based on XAI and Visualisation techniques that combines the power of neural networks for feature extraction and representation learning with visual analytics for intuitive and interpretable insights into time series data. The end goal is to provide a comprehensive tool for domain experts be able to understand, interpret and potentially predict patterns and anomalies within time series data.					
Expected Results: The main result of this project will be to develop a "Deep Visual Analytics" platform that leverages XAI techniques and deep learning models in order to detect anomalies and patterns in a series, which will be applied to various industrial domains, e.g., space or industry to demonstrate the feasibility of the implemented models and techniques. It will also be applied to various industrial domains, e.g., space or industry) to demonstrate the feasibility of the implemented models. **Applied research:** The primary outcome of DC1 will be the innovation of XAI techniques and deep learning models, to effectively identify anomalies and patterns within time series data, which will be applied to diverse industrial domains, such as space and industry including applied research with GMV , and will serve to showcase the developed models and techniques.					
Planned secondment(s): UNINA (4 months); SUT(4 months); HVL(4 months)			**Enrolment in Doctoral degree(s):** UPM		

DC2

WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

Fellow *(e.g. researcher1)*	Host institution	PhD enrolment*	Start date *(e.g. Month 6)*	Duration *(e.g. 36 months)*	Deliverables *(refer to numbers in table 3.1b)*
DC2	**UPM**	**UPM**	**9**	**36**	
Project: ***Enhancing time series analysis through transfer learning, pre-trained models and self-supervised learning*** /WP 1/ **PhD Supervisor:** prof. David Camacho -Fernandez (ER2/UPM); **Auxiliary supervisors:** Salvatore Cuomo (ER9/UNINA), Dariusz Mrozek (ER7/SUT), Jia-Chun Lin (ER12/NTNU); **R&D cooperation:** Felipe Jiménez González (GMV)					
Objectives: The adoption of deep learning has been slower for time series than for computer vision and natural language processing. The emergence of techniques that are based on deep learning such as generative AI, transfer learning (which involves taking a pre-trained model from one task and fine-tuning it on a different but related task), the use of pre-trained models (ML models that are trained on a diverse range of time series data and can be used as feature extractors or for transfer learning), self-supervised learning (a technique where the model generates its own labels from the data, thereby making it particularly useful when labelled data is scarce or expensive to obtain), provide a new environment that would enable exploring and discovering innovative methods for time series analysis and prediction at large scales.					
Expected Results: The main result of this project will be the development and implementation of state-of-the-art deep learning pipelines for time series data, which will scale up the vast amount of time series data that is available in a wide range of domains. The project will be used in various industrial domains, e.g., space or industry in order to demonstrate the feasibility of the implemented models. **Applied research:** The primary objective of DC2 is to design and implement new and deep learning-based time series data techniques, the project will be applied to industrial sectors (e.g. space under the collaboration with GMV), to validate the practicality and feasibility of the new time series models.					
Planned secondment(s): UNINA (4 months); SUT(4 months);NTNU(4 months)				**Enrolment in Doctoral degree(s):** UPM	

DC3

Universidad de Oviedo

WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

Fellow *(e.g. researcher1)*	Host institution	PhD enrolment*	Start date *(e.g. Month 6)*	Duration *(e.g. 36 months)*	Deliverables *(refer to numbers in table 3.1b)*
DC3	**UNIOVI**	**UNIOVI**	**9**	**36**	

Project: ***Reliable and Explainable AI solutions for chronic diseases*** /WP2/ **PhD Supervisor:** prof. Vicente García Díaz (ER3/UNIOVI) **Auxiliary supervisors:** David Camacho (ER1/UPM), Jerry C.-W. Lin (ER5/SUT), Shen Yin (ER11/NTNU); **R&D cooperation:** Andrés Arbona (BioKeralty), Diego Díaz Fidalgo (TNP)

Objectives: Interpretable and explainable AI methods, algorithms and services are key factors for trustworthy applications in Health Informatics. The project will focus on accuracy of the machine learning models to associate a cause to an effect and the ability of the parameters to justify results. The first and necessary condition is dimensionality reduction to minimise model complexity and overfitting and automatic support for feature selection and extraction for explainable AI models. In particular, the work will focus on predicting and handling the onset and progression of chronic diseases such as diabetes, heart disease and Alzheimer, focusing on early intervention strategies.

Expected Results: The DC3 will be expected to experiment with different sets of data applied to health informatics and understanding the best way to treat them and next to experimenting with different technologies to interpret and explain models applied to chronic diseases such as diabetes, heart disease or Alzheimer.

Applied research: The research results on models and services to improve the current state of the art in predicting and handling different chronic diseases. They will be verified by BioKeralty in its healthcare applications. Newly developed models and services can potentially extend the portfolio of technology used by BioKeralty in its health centers and hospitals. The TNP will support DC3 with DNA laboratories.

Planned secondment(s): UPM (4 months); NTNU(4 months); SUT (4 months) **Enrolment in Doctoral degree(s):** UNIOVI

DC4

Universidad de Oviedo

WP2: Advanced Time Series Analysis through Explainable AI, Transfer Learning and Visual Analytics

Fellow *(e.g. researcher1)*	Host institution	PhD enrolment*	Start date *(e.g. Month 6)*	Duration *(e.g. 36 months)*	Deliverables *(refer to numbers in table 3.1b)*
DC4	**UNIOVI**	**UNIOVI**	**9**	**36**	
Project: ***Personalized Health Recommendation Systems Powered by Large Language Models*** / WP2/ **PhD Supervisor:** prof. Edward Rolando Núñez Valdez (ER4/UNIOVI); **Auxiliary supervisors** Victor Rodriguez-Fernandez (ER2/UPM), Jia-Chun Lin (ER12/NTNU), Rafał Cupek (ER7/SUT); **R&D cooperation:** Andrés Arbona (BioKeralty) , Diego Díaz Fidalgo (TNP)					
Objectives: The primary goal of this project is to thoroughly investigate the key techniques, algorithms, and tools required to develop and implement a highly personalised health recommendation system. This system will use Large Language Models (LLMs) and machine learning techniques to interpret medical literature, patient records, and current health trends. The fundamental purpose of this project is to provide personalised health advice and early warning signals. Furthermore, we aim to employ advanced LLMs and explainable artificial intelligence to analyse large volumes of medical research and patient data. To achieve this, innovative algorithms will be applied to ensure transparency and accuracy in the recommendations generated by the system. As an integral part of this objective, comprehensive research will be conducted to develop methods that enable the quantification and visualisation of the reasoning process of the LLM. This approach will significantly contribute to the understanding and continuous improvement of the personalised health recommendation system.					
Expected Results: The main expected outcome is to conduct a series of experiments to develop a tool tailored for healthcare providers and patients. This tool aims to support informed decision-making by leveraging a comprehensive understanding of individual health contexts and the latest medical knowledge. The potential tool seeks to enhance medical decision-making and will be fundamentally supported by a recommendation system that is accurate, transparent, scalable, and ensures user privacy and security. **Applied research:** The creation of a tool based on these technologies aims to significantly enhance medical decision-making, resulting in tangible benefits for the well-being of patients and healthcare personnel in healthcare institutions. The integration of advanced Large Language Models (LLMs) and explainable artificial intelligence into the tool will provide transparency and accuracy in decision support, fostering the enhancement and comprehension of the personalised health recommendation system. The developed components will be verified by BioKeralty in their healthcare applications. These systems have the potential to expand and improve the technological portfolio used by BioKeralty in their health centres and hospitals. The TNP will support DC3 with laboratory infrastructure.					
Planned secondment(s): UPM (4 months); NTNU(4 months); SUT (4 months)			**Enrolment in Doctoral degree(s):** UNIOVI		

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