LIGHTWEIGHT MODELS FOR REAL-TIME APPLICATIONS LM-RTA

Rafał Cupek
Silesian University of Technology
Gliwice, Poland
rcupek@polsl.pl

https://tuai.eu/

AGENDA

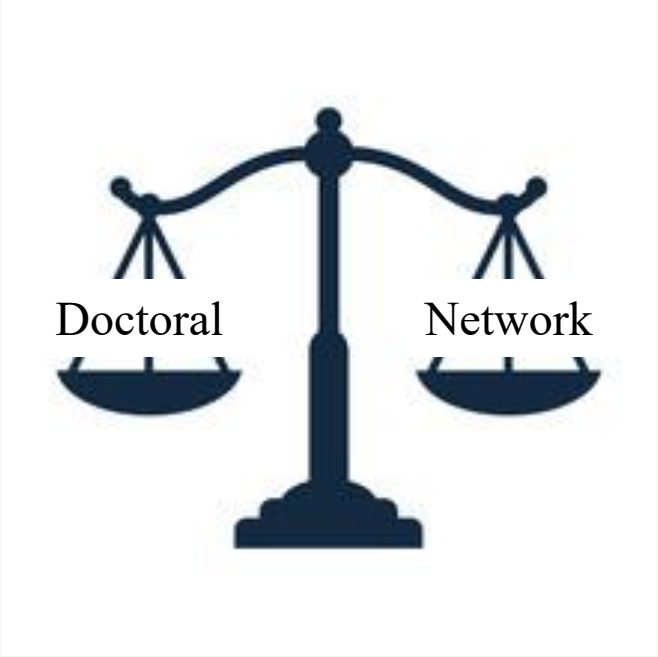
- **HORIZON MSCA Doctoral Network TUAI & Network-Wide Training Events**
- **Problem Based Learning (PBL) approach**
- **Problem statement for LM-RtA**
- **Identify What You Know & What Could Be Supportive**
- **Research Plan**

TOUR DE TABLE

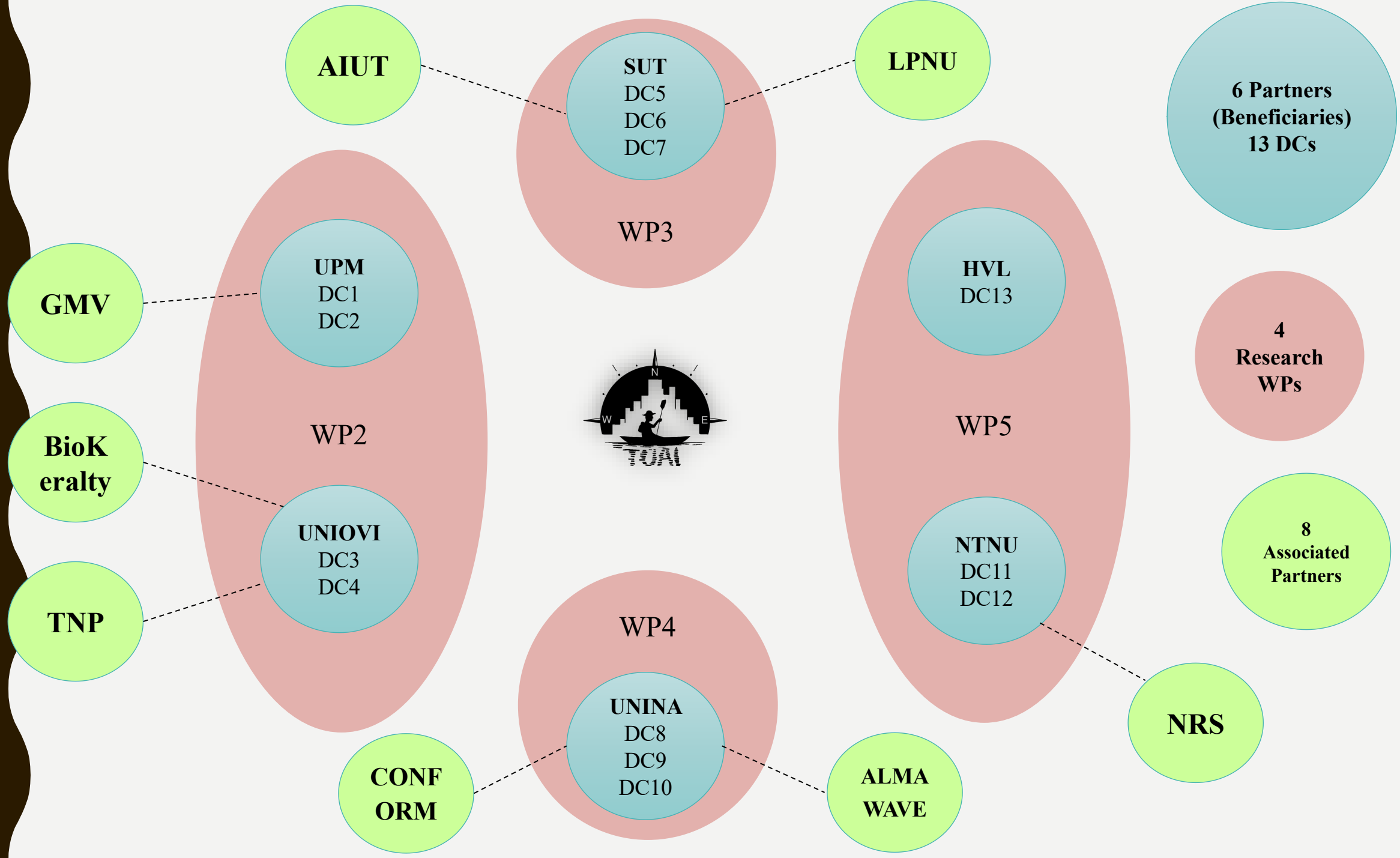
- TUAI Doctoral Candidates:

We kindly invite each candidate to present their scientific profile and research progress on the website https://tuai.eu/

TUAI - HORIZON MSCA Doctoral Network



- research excellence: (i) training program, (ii) secondments, (iii) network wide training activities
- collaboration with commercial companies to face the real challenges
- mentoring by primary and auxiliary supervisors and support from industrial advisers


AIUT
SUT
DC5
DC6
DC7
LPNU
6 Partners
(Beneficiaries)
13 DCs
WP3
GMV
UPM
DC1
DC2
HVL
DC13
4
Research
WPs
WP2
WP5
BioK
eralty
UNIOVI
DC3
DC4
NTNU
DC11
DC12
8
Associated
Partners
TNP
WP4
NRS
CONF
ORM
UNINA
DC8
DC9
DC10
ALMA
WAVE

NETWORK-WIDE TRAINING EVENTS

	Research workshops	ECTS	Lead Institution
1	on lightweight models for real-time applications (WP3)	3	SUT
2	on deep visual analytics (WP2)	3	UPM
3	on graph neural networks (WP4)	3	UNINA
4	on of cyber-physical systems (WP5)	3	NTNU

- implemented within one semester time-frame
- bi-weekly meetings mainly in hybrid mode,
- implemented in accordance with the principle of problem-based learning

NETWORK-WIDE TRAINING EVENTS

	Summer/winer schools	ECTS	Lead Institution
1	Winter school on time series analysis - Spain	3	UPM
2	Summer school on sensor fusion – Poland	3	SUT/LPNU
3	Winter school on federated learning - Italy	3	UNINA
4	Summer school on sustainability and trustworthiness of AI solutions - Norway	3	NTNU/NRS

- on side, one-week long activities
- lectures
- practical trainings
- seminars
- transferable skills

NETWORK-WIDE TRAINING EVENTS

	Industrial workshops	ECTS	Lead Institution
1	on space industry (GMV) - Spain	-	UPM
2	on smart healthcare (BioKeralty) - Spain	-	UNIOVI
3	on AI for e-learing (CONFORM) – Italy	-	UNINA
4	on smart manufacturing (AIUT) - Poland	-	SUT
5	on natural language processing (ALMAWAVE) - Italy	-	UNINA

- on side activities
- hosted by a university with activities that are prepared by the associated partner

HORIZON MSCA - Maria Skłodowska-Curie Action

- She was born in Warsaw 1867- the part of the Russian Empire
- Women were not allowed to attend universities in the Russian Empire, especially in the sciences.
- Polish intellectuals and nationalists were persecuted. Maria's family, who were well-educated and patriotic, suffered under these policies—her father lost his job, and her sister joined the underground resistance.
- In 1891, aged 24, she followed her elder sister Bronisława to study in Paris.
- France, especially Paris and the Sorbonne, offered far greater academic freedom and educational opportunities for women.
- In 1895, she married the French physicist Pierre Curie
- She is the first woman to win a Nobel Prize, the first person to win a Nobel Prize twice, and the only person to win a Nobel Prize in two scientific fields: 1903 in Physics, 1911 in Chemistry

TOWARDS AN UNDERSTANDING OF ARTIFICIAL INTELLIGENCE

https://tuai.eu/

PROBLEM BASED LEARNING (PBL) APPROACH

Problem-Based Learning (PBL)

- Encouraging active learning through real-world challenges
- Promoting collaboration and interdisciplinary thinking
- Focusing on problem-solving and critical thinking skill
- Instead of passively receiving information through lectures, students actively explore, research, and collaborate to find solutions

Key Focus Areas

- collaboration and communication skills
- developing as independent learners
- connecting learning to real-world situations

PROBLEM BASED LEARNING (PBL) APPROACH

Role of Supervisors

- supervisors take on the role of facilitators or guides, rather than traditional lecturers
- help students stay on track
- ask guiding questions
- support group work
- encourage reflection and deeper thinking

PROBLEM STATEMENT

Collision Avoidance in Crowded Environments

- AGV (Automated Guided Vehicle) must operate safely in a factory where forklifts, workers, and other robots are constantly moving

https://aformic.com/

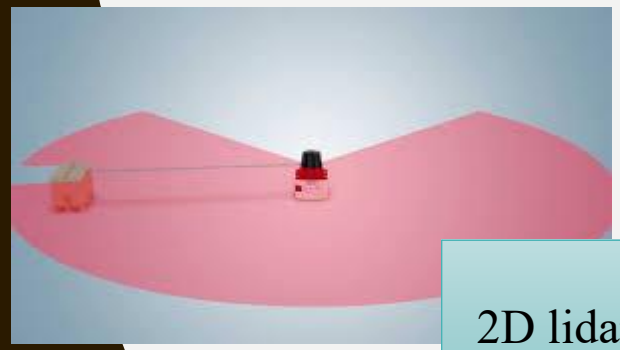
Learning Applications

- Sensor Fusion: Combine LiDAR, ultrasonic sensors, and cameras to detect and predict movement
- Lightweight Models: Design real-time object detection and path prediction models that can avoid collisions on the fly

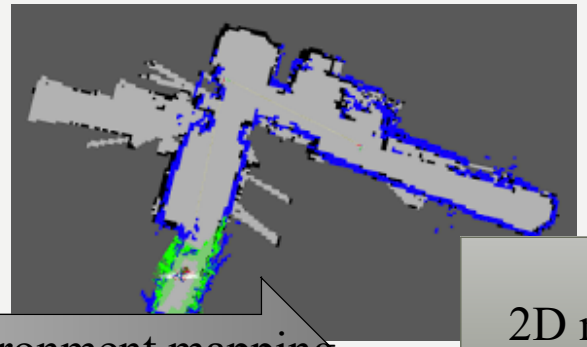
AGV NAVIGATION POSSIBILITIES

- Line following:
  - Magnetic (Hall effect, reed switch, magneto-resistive)
  - Color (optical)
  - Metal (inductive)
- Beacon/anchor localization:
  - Mirrors and rotating laser,
  - Passive or active RFID tags,
  - DMX (readers) or symbols (computer vision)
  - BLE or UWB tags
  - GPS
- Natural navigation
  - Signal strength (Wi-Fi)
  - Environment mapping (2D/3D scanners, lidars, radars, 3D or stereo cameras)

NATURAL NAVIGATION



2D lidars



Environment mapping

2D map

Odometry

Reference points

Encoders

Odometry

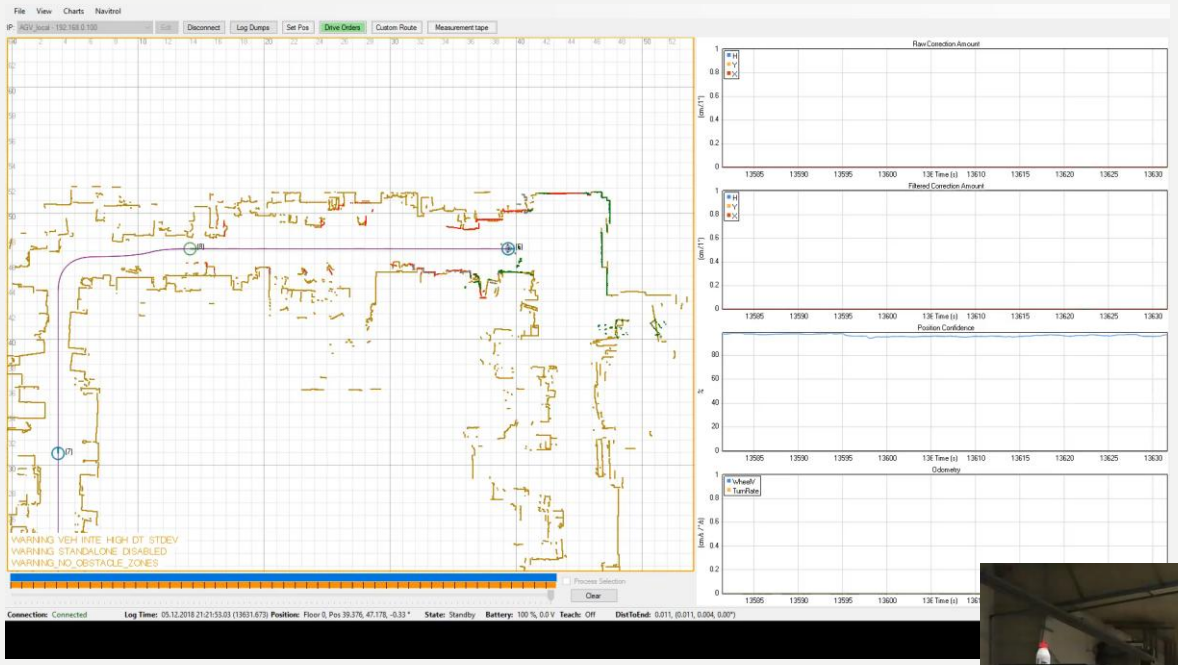
Localistaion

Possibilities to enhance the localization:

1. Using inertial measurement units (IMU): gyroscope and accelerometer
2. Using received signal strength (RSSI) for reflectivity indication and using objects as positioning mirrors (anchors)
3. Reinitialization of position through automatic coordinate refreshing (global points used as position reference)
4. Using Simultaneous Localization and Mapping approach (SLAM) for dynamic environments

NATURAL NAVIGATION COMMISSIONING

- Gathering of measurement data in teaching mode
- Construction of a reference map using dedicated software
- Determination of trajectories and navigation points
- Initialisation of robot's position
- Calculation of position and using odometry for determination of shifting within map coordinate system
- Navigation through following of virtual lines



SAFETY OF MOBILE ROBOTS

- Compliance with machine directives
- Compliance with safety regulations, e.g. PN-ISO 3691
- Integrated safety components:
  - Programmable safety controller
  - Safe speed measurement (Sin-Cos/SSI encoders + technological module)
  - Safe stop buttons
  - Emergency bumpers
  - Laser 2D devices (LIDAR 2D) with switchable protective fields
  - Light indication (LED + Bluespot)
  - Mechanical design preventive incidents, e.g. crushing
- Auxiliary systems:
  - Weight measurement and payload distribution system (strain gauges)
  - 3D depth analysis system for collision detection with payload,
  - Ultrasonic detection system for detection of transparent objects
- Additional environmental elements: signs, trainings, continuous increasing of awareness

Agropomoc.pl, b2b-partner.pl, Eaton.com, sick.com

IDENTIFY WHAT YOU KNOW & WHAT COULD BE SUPPORTIVE

Tour de table

LIGHTWEIGHT MODELS FOR REAL-TIME APPLICATIONS (LM-RTA)

23.10.25 (Thursday), 10:00 - 13:00 – Zoom

- PBL Approach
- Problem statement
- Identify What You Know
- Research Plan

07.11.25 (Friday) , 10:00 - 13:00 – Zoom

- Identify What You Need to Learn
- Research & Inquiry
- Data Management Plan

21.11.25 (Friday), 10:00 - 13:00 – Zoom

- Concept Solutions
- Obtaining Data

04.12.25 (Thursday), 10:00 - 15:00 – on-site event - Gliwice, Poland

LIGHTWEIGHT MODELS FOR REAL-TIME APPLICATIONS (LM-RTA)

09.01.26 (Friday) , 10:00 - 13:00 – Zoom

- Mid-Term Presentations
- Milestone Decisions

23.01.26 (Friday), 10:00 - 13:00 – Zoom

- Final Presentations
- Industrial (Aiut) Feedback
- Results Analysis

06.02.26 (Friday), 10:00 - 13:00 – Zoom

- Reflect & Get Feedback
- Dissemination Plan
- Final Discussion

PREPARE FOR THE NEXT MEETING

07.11.25 (Friday) , 10:00 - 13:00 – Zoom

Collaborate & Discuss

For Each Group:

- Share What You've Learned
- Identify What You Need to Learn
- Debate different ideas

Data Management Plan

For Each Group Propose a Basic Data Management Plan:

- Specification of the required data
- Verification of data availability and feasibility of collection
- Adapting project ideas to infrastructure or resource constraints

THANK YOU FOR YOUR ACTIVE PARTICIPATION