MAGICIAN

AUTONOMOUS DEFECTS DETECTION AND REPAIR IN MANUFACTURING

MAGICIAN-1st Open Call WEBINAR

Daniele Fontanelli; Margherita Volpe; Ammar Qammaz; Iason Oikonomidis; Antonis Argyros; Luca Muratore; Davide Torielli; Nikolaos Tsagarakis

UNITN; ZAB; FORTH; IIT

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TABLE OF CONTENTS

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I. Introduction to the MAGICIAN Project

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AUTONOMOUS DEFECTS DETECTION AND REPAIR IN MANUFACTURING

Robotic solutions for high quality product aesthetics and a safer working environment in manufacturing

Daniele Fontanelli

UNITN | 24.02.2025

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Challenge

Consumers increasingly expect manufacturing products to be free of defects which sets high standards for the production process.

However, associated working processes are physically and cognitively demanding for workers and executed in a potentially hazardous environment.

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Objectives

MAGICIAN will develop robotic solutions to classify and rework defects from semi-finished products autonomously before the finalization of product aesthetics.

These solutions are designed to be *modular*, applicable to *various manufacturing fields*, *reducing physical strain* and *enhancing safety* for human operators.

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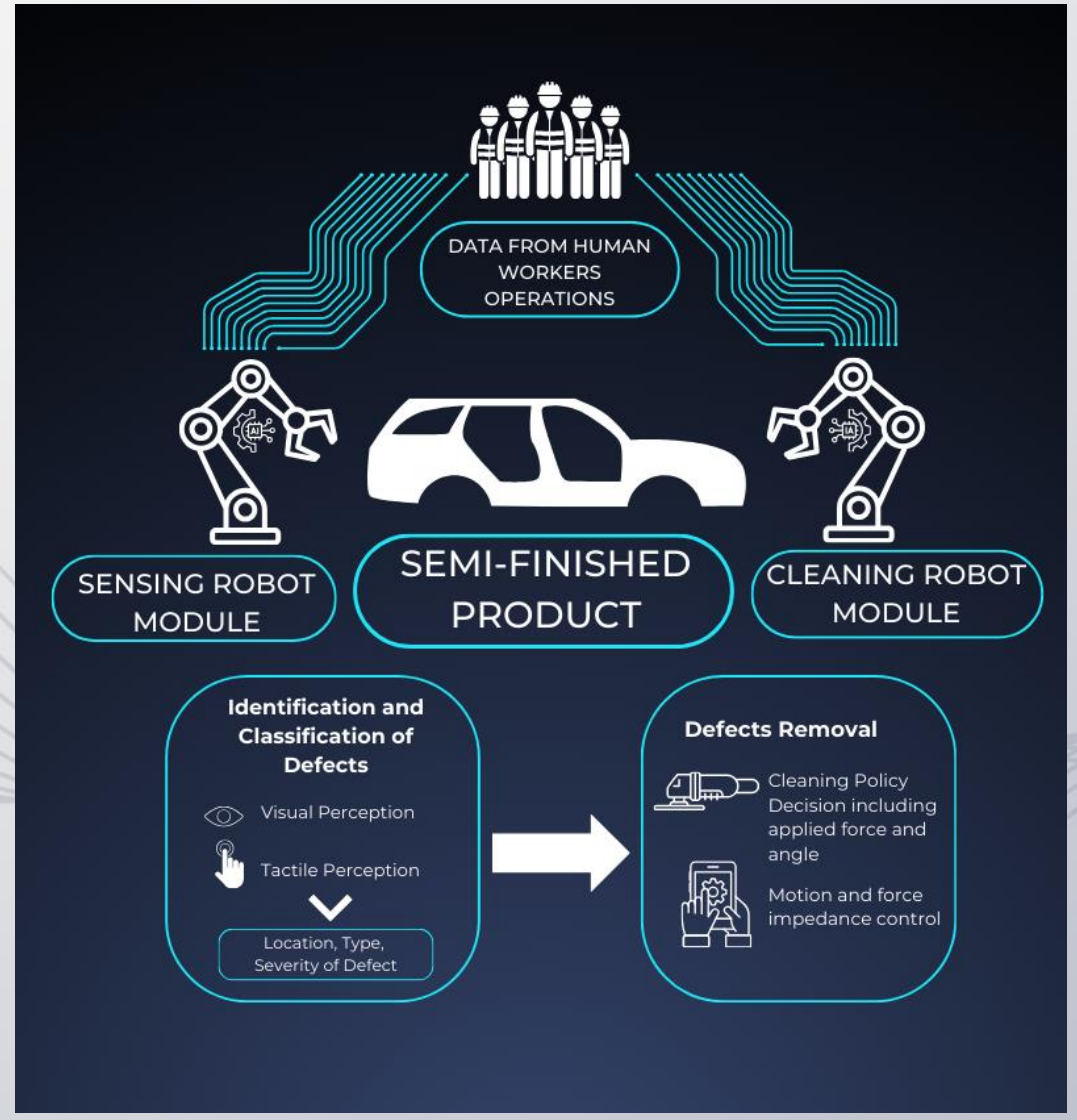
Robotic solutions



Two modular robotic solutions:

- **a sensing robot for defect analysis (SR)**
- **a cleaning robot for reworking defects (CR)**

Both robots will use AI modules to perform associated operations.

Data needed for these AI modules will be gathered by learning from workers operating on semi-finished products.

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Approach

Human-centred approach

MAGICIAN applies a **human-centred design strategy** to shape the progress of automation and human-robot collaboration in manufacturing towards an emphasis on trust, empathy, and ethics.

Use Cases

MAGICIAN solutions will be tested in an **automotive manufacturing use case**. Both robots will be coupled with human operators during the testing to ensure trust-based human-robot collaboration.

Additional use cases will be engaged through **two Open Calls**.

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Impact Potential

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- Innovative robotic components for mechanical working operations allowing for human-robot collaboration
- Improved productivity in manufacturing and maintenance
- Improved health and safety conditions for human workers and focus on added value operations
- Tested applicability of solutions for various manufacturing application fields
- Strengthened trust in AI and robotic technologies

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Project Details

- MAGICIAN – iMmersive leArninG for ImperfeCtion detectIon and repAir through human-robot interactioN
- 4-year EU project: October 23-September 27
- 11 project partners from 7 countries coordinated by Università di Trento
- 1 Automotive Use Case and extension of Use Cases through 2 Open Calls

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II. Administrative & Operational details of 1st Open call

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- Scope & Definition Open Calls
- Targeted companies
- Single AS & Twin AS Configuration
- Fundings Scheme
- Evaluation, Notification, Sub-grant signature, start-end AS

Margherita Volpe; Francesca Pasqualino

ZAB Brussels | 24.02.2025

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Scope & Definition Open Calls

MAGICIAN project will launch two Open Calls to identify and select promising proposals by SMEs / start-ups for experimentation

1st Open Call

- **General Scope:** Integration of new functionalities within MAGICIAN
- **Open period**: February 3rd- May 2nd 2025
- distribute up to 1 Mill. EUR of total funding to winning proposals for project implementation ≤ 12 months
- select up to 5 projects for 12 months implementation and 200k/EUR budget

2nd Open Call

- **General Scope**: Functionalities application on new use cases
- **Open period**: December 2025-March 2026
- distribute up to 1 Mill. EUR of total funding to winning proposals for project implementation ≤ 12 months
- select up to 5 projects for 12 months implementation and 200k/EUR budget

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Scope & Definition 1st Open Call

The first open call focuses on the integration of new functionalities within MAGICIAN project solutions through close collaboration with MAGICIAN partners.

The aim is to enhance the capabilities of the SR (Sensing Robot) and CR (Cleaning Robot)

Application Solutions must **select a single module** and specify the chosen module at proposal stage (Summary and Excellence) **:**

→**F1. Perception**

→**F2. Human-Robot Collaboration**

Solutions proposed must cover a max of 2 functionalities within the selected module

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Targated Companies

MAGICIAN 1st open Call targets SMEs and Start-ups, as defined by the European Commission **https://ec.europa.eu/growth/smes/business-friendly-environment/sme-definition/**

Company category	Staff headcount	Turnover	Balance sheet total
Medium-sized	< 250	≤ € 50 m	≤ € 43 m
Small	< 50	≤ € 10 m	≤ € 10 m
Micro	< 10	≤ € 2 m	≤ € 2 m

→ Start-ups

N.B. Natural entities (individuals) are NOT allowed to apply

Eligible countries:
EU Member States;
Horizon Europe Associated Countries;

list-3rd-country-participation_horizon-euratom_en.pdf

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Single AS & Twin AS Configuration

MAGICIAN supports SMEs and Start-ups applying according two types of configuration

SINGLE AS

- One Third party (= the applying company)
- Cascade funding partner (ZAB)
- 200 k€ max of cascade funding for the applying company

TWIN AS

- Two Third parties (= the applying company(ies)
- Cascade funding partner (ZAB)
- Each applying consortium receives a max of 200 k€ of cascade funding each
- One of the two legal entities will be designated as **coordinator** and will serve as the **sole** point of contact with the MAGICIAN counterparts

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Funding Scheme

The maximum funding per Application Solution is 200 k€, at a funding rate of **70%** of the budget for **SMEs**, reaching **up to 100%** of the budget in case of **Start-ups**

Pre-financing (50%)
Upon the successful competition KoM Meeting

Final payment (15%)
Following the conclusion of AS and achievement of milestones & deliverables

Intermediate payment (35%)
Following submission and approval of a status report (WP + Risk Ass. + Financial report)

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AS Timeline

END 1ST OC → AS EVALUATION PROCESS

Closing OC: 2nd May, 17:00, CET

EVALUATION CRITERIA
- *Excellence*
- *Impact (Business case-oriented)*
- *Implementation quality*

EVALUATION STEPS
- External experts
- Business case evaluation
- MAGICAN evaluation committee

SCORES
- **1** to **5** for each criteria (equally ranked)
- Minimum total threshold **9** out of **15**
- In case of same score, the ranking depends on best value of **Excellence**

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AS Timeline

AS SELECTION → NOTIFICATION TO APPLICANTS

- ***5 selected proposals*** *will be reported to MAGICIAN project officer for final granting decision*
- *In case of FSTP budget remaining, it will be a* ***potential for an extra solution in 2nd OC***

The first call notifications are planned for **June 30th 2025**
+ In case of **Grant**, it will include outcomes and next steps infos
- In case of **NOT grant**, it will include evaluation report

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AS Timeline

SUB-GRANT SIGNATURE → PROJECT STARTING → PROJECT ENDING

All involved parts will sign **a sub-grant standard agreement** before AS implementation starts

AS will start (KoM) in **July 2025**
AS will last 12 month until **July 2026**

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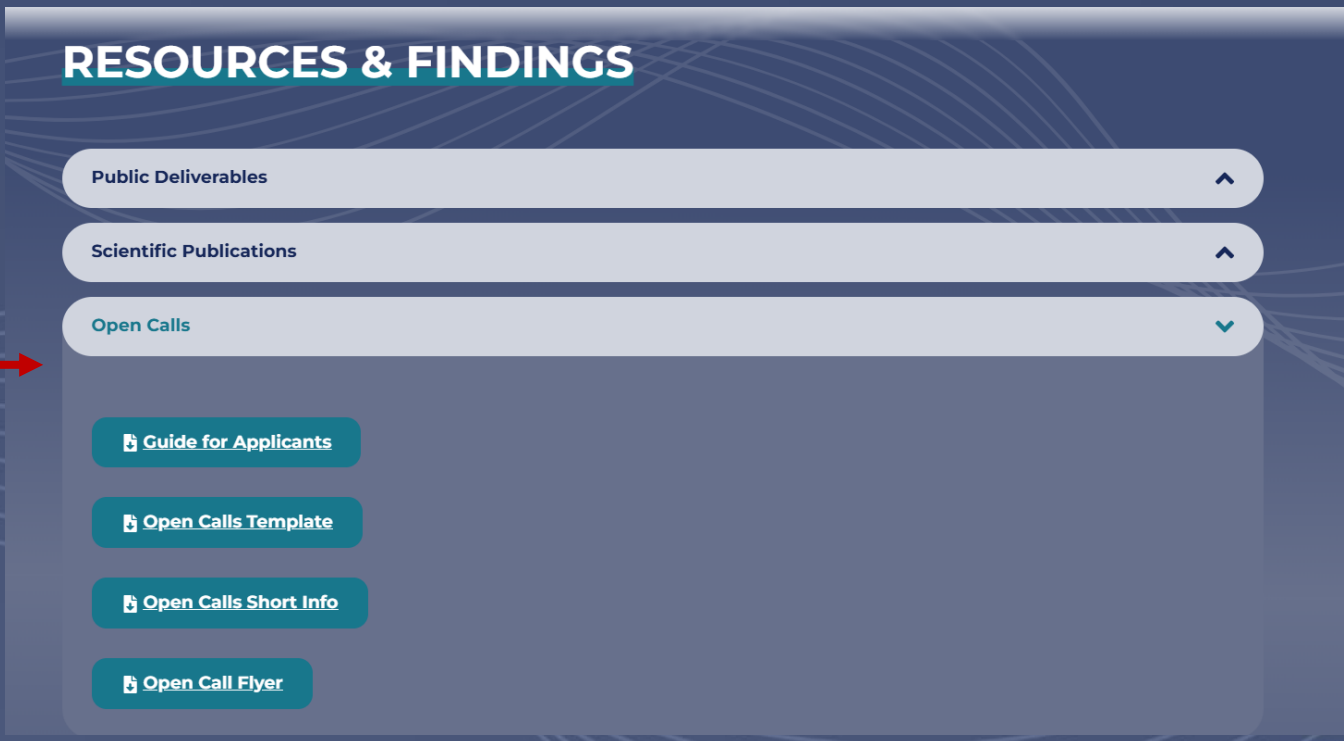
II. Administrative & Operational details of 1st Open call

INFOS REMINDER Open calls | MAGICIAN

Apply now

Get all information here

Join MAGICIAN helpdesk - every Wedn,17-18:00 (CET)



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III. Presentation of key functionalities

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F1. PERCEPTION MODULE
Technical description & Integration expected

Antonis Argyros; Ammar Qammaz; Iason Oikonomidis; Michele Pompilio

FORTH| 24.02.2025

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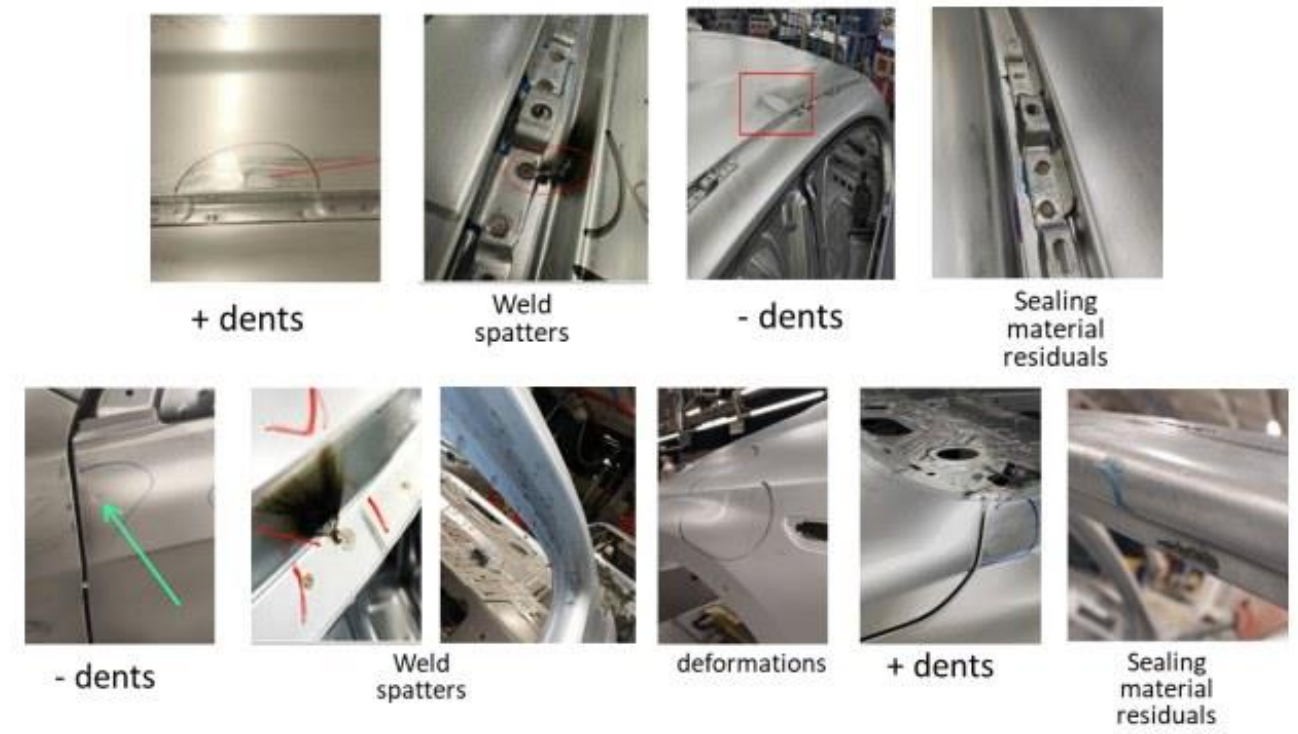
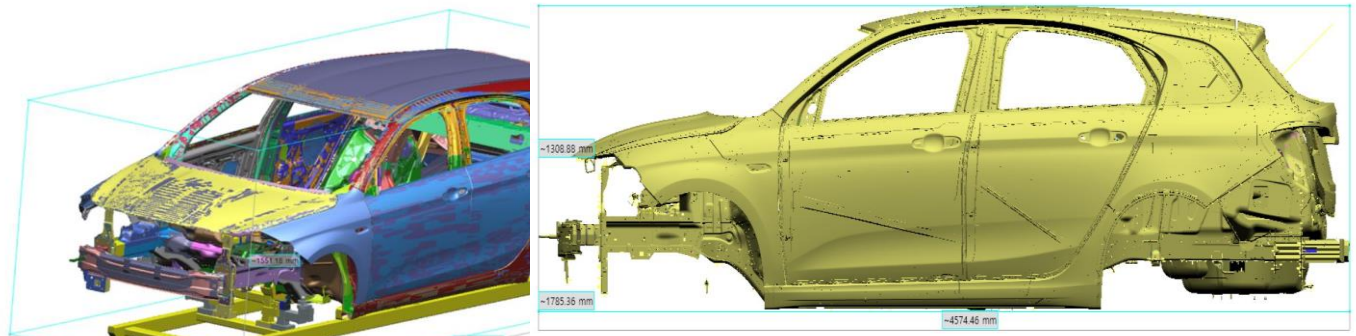
F1. PERCEPTION MODULE

F1.1 Sensors for accurate defect detection and classification

Our pilot use case targets a variety of minor production defects in car manufacturing

- Detect very small surface irregularities (down to ~0.3 mm)
- Maintain high throughput with rapid data/image acquisition
- Ensure robust, reliable detection across diverse material surfaces and defect types
- < 1 min scan time for a car-sized surface to support factory production throughput





4.5m x 1.3m x 1.7m

F1. PERCEPTION MODULE

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What MAGICIAN seeks as integrated functionality

- Alternative non-invasive sensing modalities: laser scanners, structured light, Time-of-Flight, thermographic, eddy current, ultrasound
- Real-time or near real-time defect classification on commodity hardware
- Scalable prototypes that enhance detection accuracy and speed
- Seamless integration with the existing perception modules, vision-based, tactile, and lighting setup
- Complementarity with existing modules

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F1. PERCEPTION MODULE

F1.2 Polarised Camera system

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We considered:

- - Monochrome/Color cameras
- - Hyperspectral camera
- - Infrared camera
- - Time Of Flight Sensors
- - Laser scattering
- - Polarized camera ←
- - 3D Scanner

General requirements:

- - High Resolution
- - Fast Acquisition throughput
- - Low exposure time
- - Global Shutter
- - Clear images
- - Cover large are fast with detail

What MAGICIAN seeks as integrated functionality

- Alternate sensing technologies
- Able to handle a large volume of data in R/T
- Full software & hardware integration with ROS2/Magician Robot
- Produce clear data suitable for use by the autonomous NN equipped robot.
- Comply to strict KPIs w.r.t. performance and accuracy

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F1. PERCEPTION MODULE

F1.3 Increase defect removal and rework abilities

We have:

- Robot platform with specific end-effector and control algorithms
- Suitably interfaced commercial Grinding Tool
- A solution to rework excess material (spatters, positive dents)

We would like:

- Hammer-like end effector for small dents repair
- Other/Versatile end-effectors for other defects
- Solutions co-developed, designed and integrated with the Magician end-effector and control algorithms
- Extend support defect removal and rework abilities

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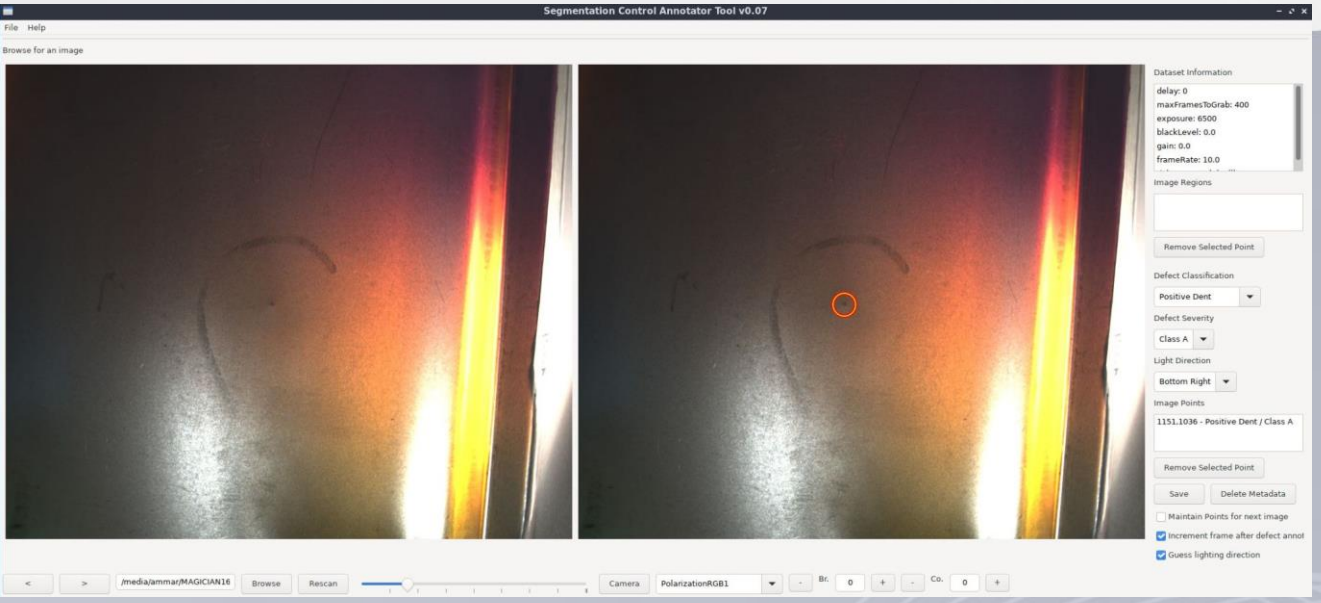
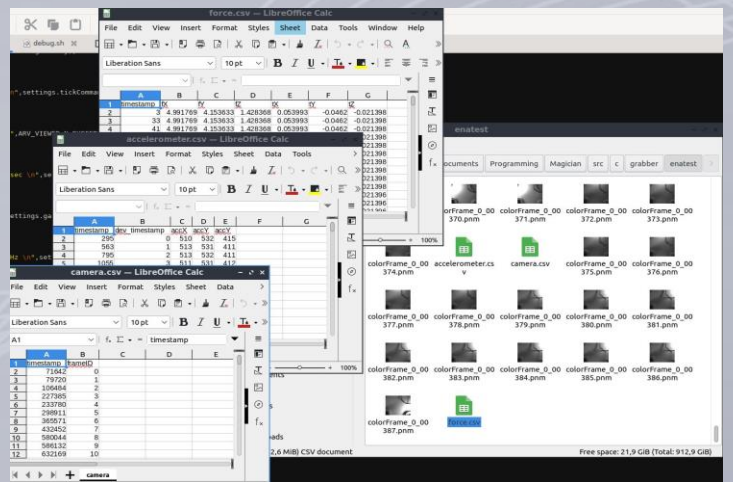
F1. PERCEPTION MODULE

F1.4 Annotation Tools for Multi-Modal Data





We have developed a Graphical User Interface for Annotation

- Lossless image compression (PNM/PNG)
- ~5 sec per image annotation
- CSV timestamped sensor metadata
- Easy to use to support data acquisition for the project

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F1. PERCEPTION MODULE

F1.4 Annotation Tools for Multi-Modal Data

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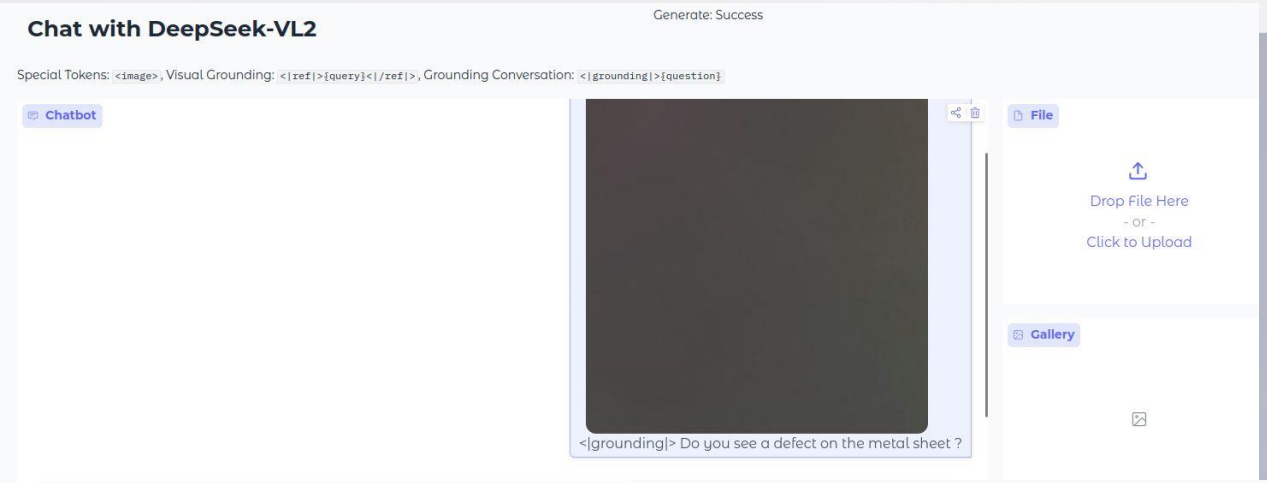

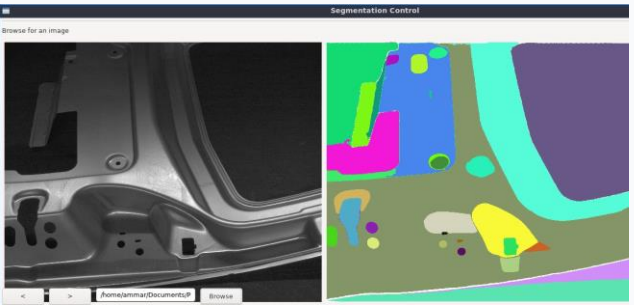

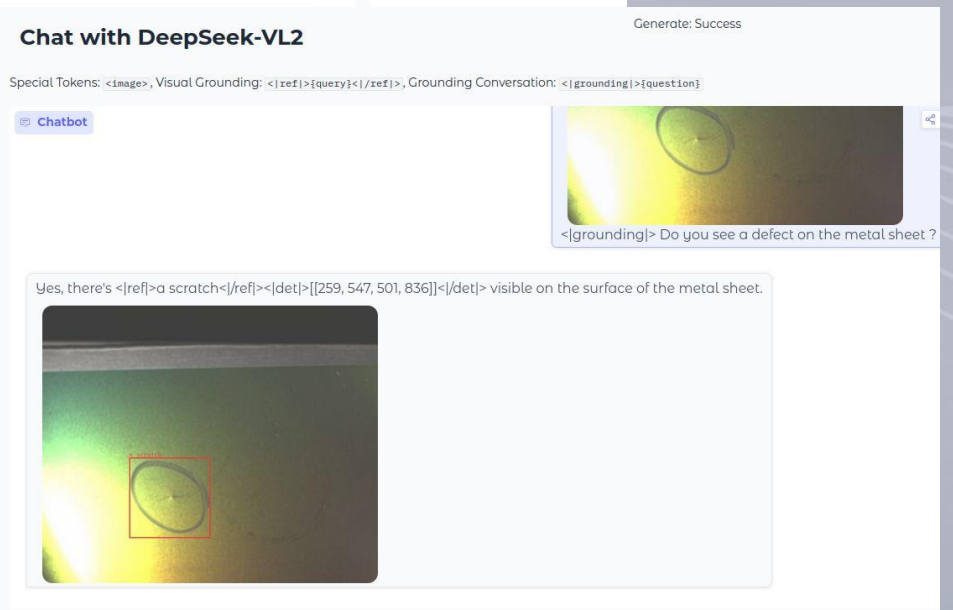

We actively experiment on semi-automating data annotation by feeding classifications from our currently developed NN as well as and state of the art Foundation Models like:

- **DeepSeek VL2**
- **Segment Anything**

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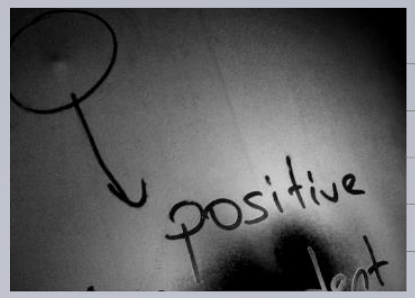
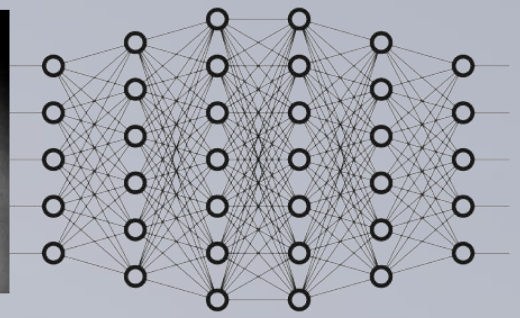
F1. PERCEPTION MODULE

F1.5 Innovative approaches and architectures for improved defect detection and classification





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We seek a M/L solution that:

- Works with the selected sensor solutions, (ideally multimodal)
- Can be combined with an annotation tool
- Can be trained with very few defect samples (~50)
- Ignores annotation marks without overfitting on them
- Evaluates data in R/T
- Has high precision/recall
- Classifies both defect type & severity
- Is extendable to other use-cases
- Is closely integrated with the rest of the software stack of the magician robot sharing GPU compute resources with other Neural Networks that execute e.g. Pose estimation

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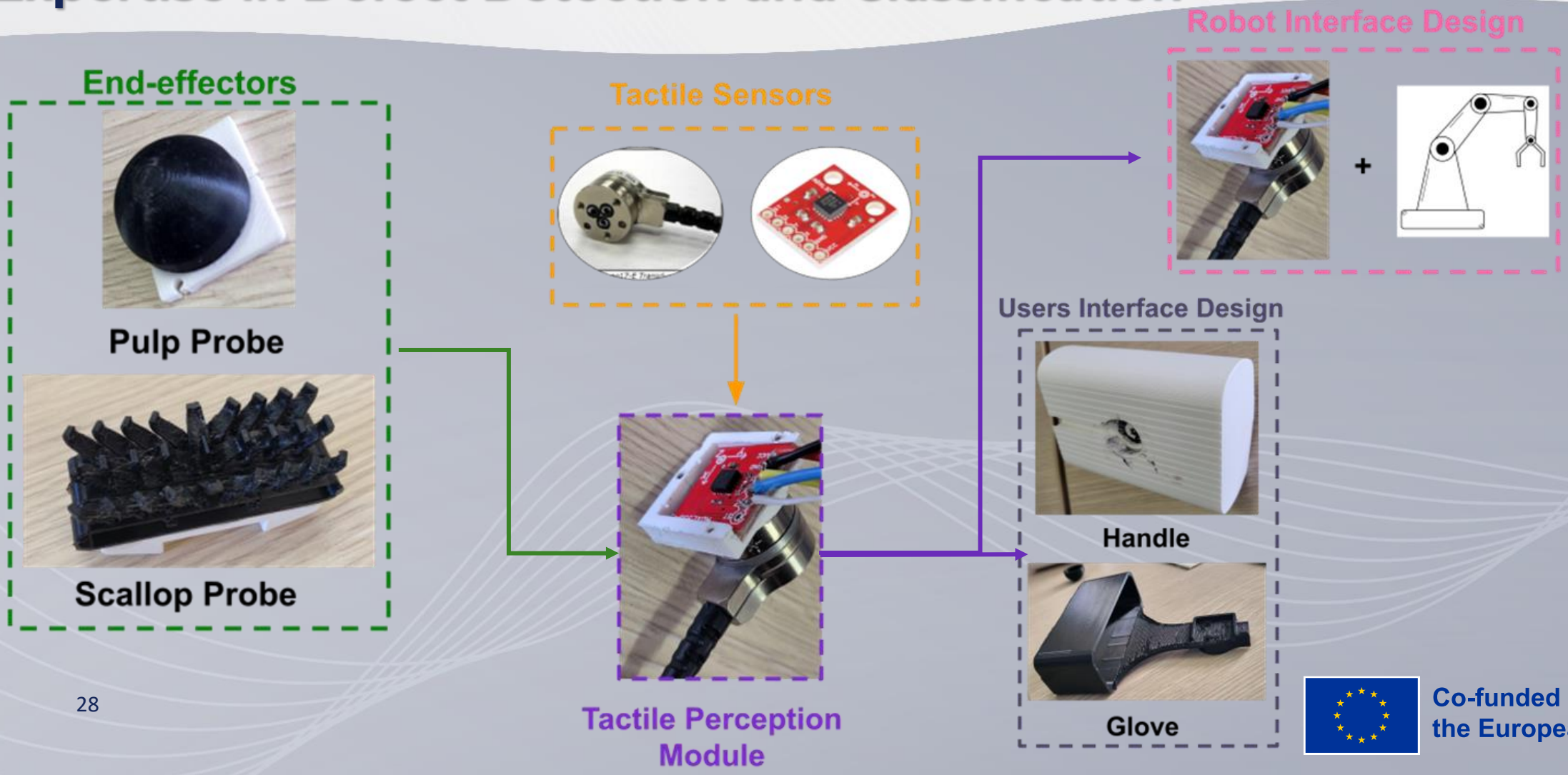
F1. PERCEPTION MODULE

F1.6 Wearable Tactile Systems for Capturing Operator Expertise in Defect Detection and Classification



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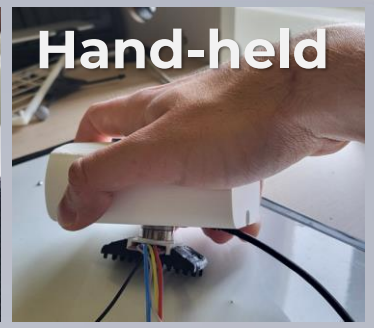
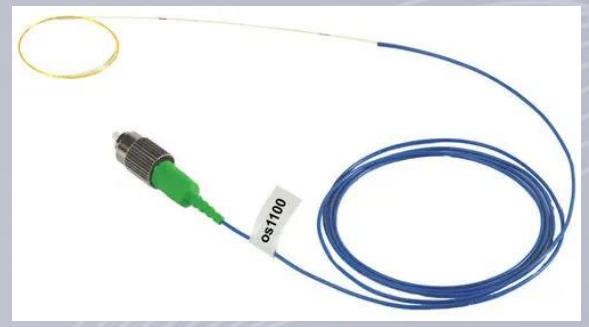
F1. PERCEPTION MODULE

F1.6 Wearable Tactile Systems for Capturing Operator Expertise in Defect Detection and Classification





What MAGICIAN seeks as integration

- Design of a fully wearable solution
- Exploring alternative sensors such as microphones, Bragg fiber sensors or others
- To acquire a larger dataset to enable a comprehensive testing of various tactile sensors

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III. Presentation of key functionalities

F2. HUMAN-ROBOT COLLABORATION MODULE
Technical description & Integration Expected

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Nikolaos Tsagarakis, Luca Muratore; Davide Torielli

IIT| 24.02.2025

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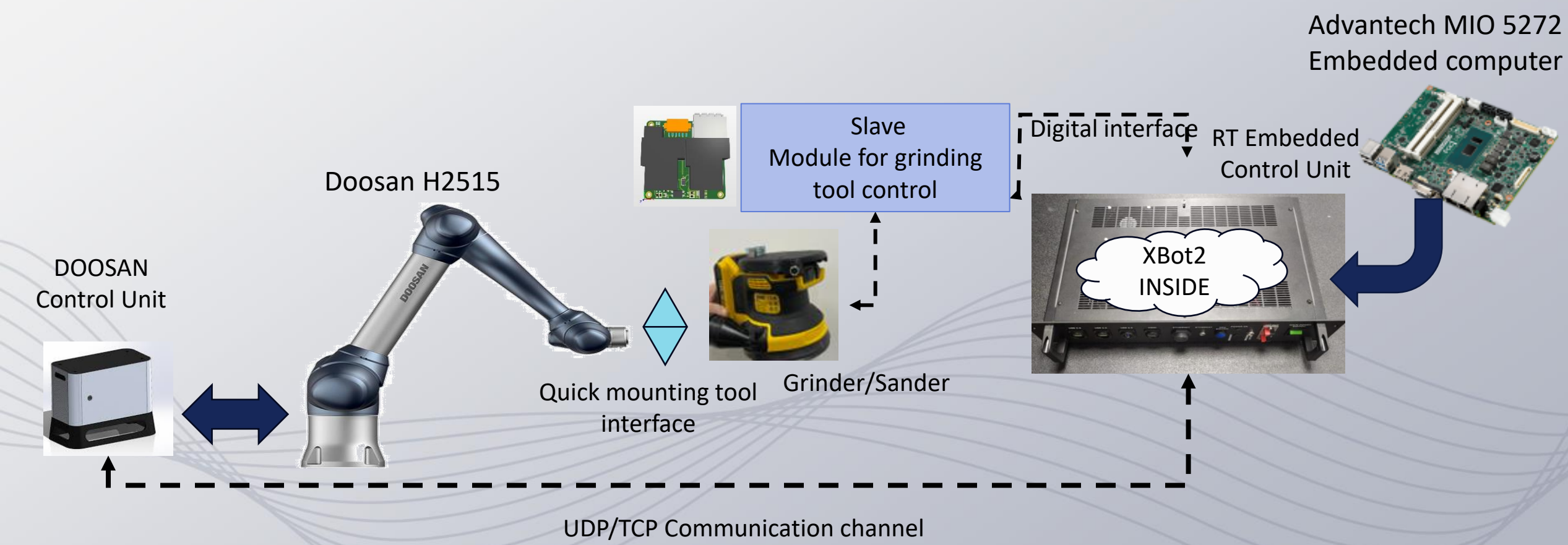
Overview of the MAGICAN Robotic System Hardware/Control architecture



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F2. HUMAN-ROBOT COLLABORATION MODULE

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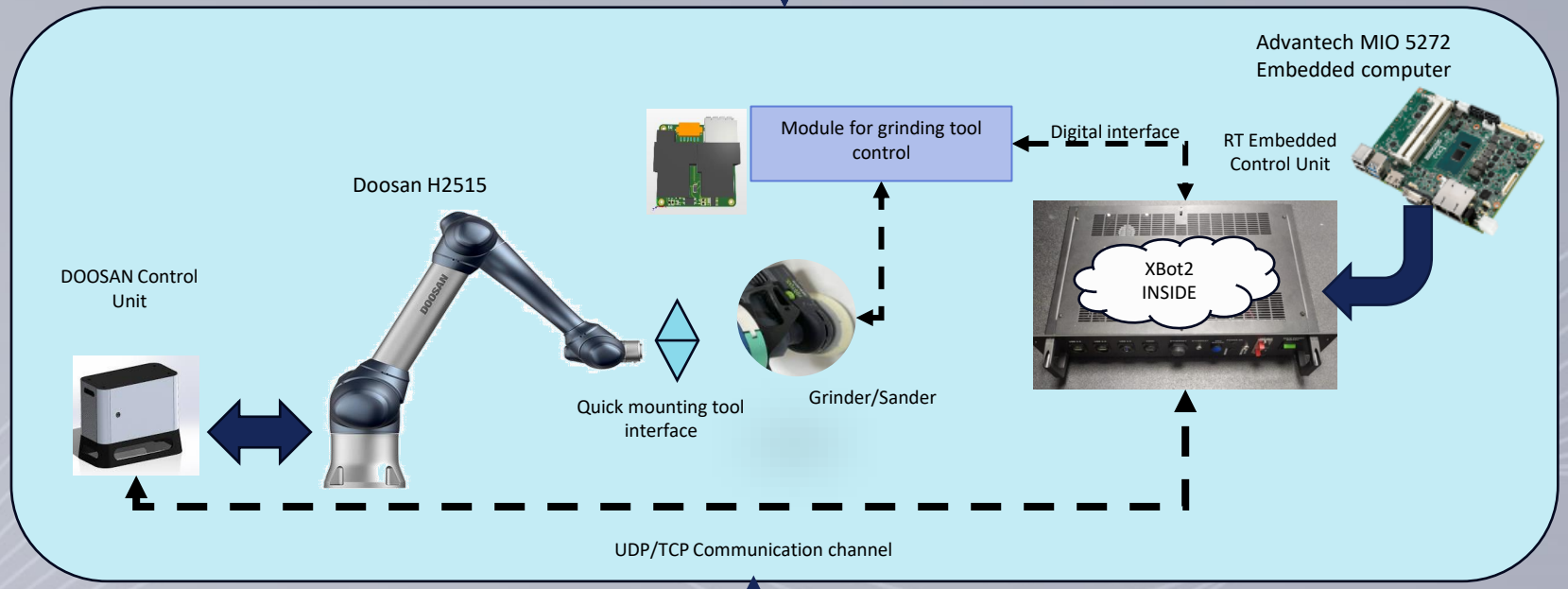
F2.1 Human Observation

F2.2 Human Interface and Interaction

F2.3 Human worker speaking system

Topics & technology functionalities

- Human observation tools
- Interfaces for human-robot interaction
- Natural language interface
- Technologies for improving the system mobility and motion flexibility



F2.4 Motion improvements

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F2. HUMAN-ROBOT COLLABORATION MODULE

F2.1 Human Observation

What MAGICIAN seeks to integrate

Advance motion learning techniques to improve robotic precision, adaptability, and efficiency. The goal is to develop methods that better capture complex motion dependencies, enable rapid adaptation to new tasks, and ensure scalable, computationally efficient, and robust performance.

Desired features and spefications

- **Advanced Motion Learning Techniques**: Provide innovative approaches to refine human skill modeling, improving accuracy and adaptability in robotic motion execution.
- **Zero-Shot Learning & Generalization**: The developed methods shall enable MAGICIAN robots to adapt with minimal training, enhancing flexibility in MAGICIAN's task scenarios.
- **Improved Motion Dependency Modeling**: The developed techniques should be able to capture complex motion relationships for greater precision and robustness.
- **Scalability & Computational Efficiency**: Real-time execution without excessive computational overhead is required
- **Seamless Integration**: The developed modules should provide the necessary software interfaces permitting the integration and execution within the MAGICIAN's Xbot2 robotic framework.

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F2. HUMAN-ROBOT COLLABORATION MODULE

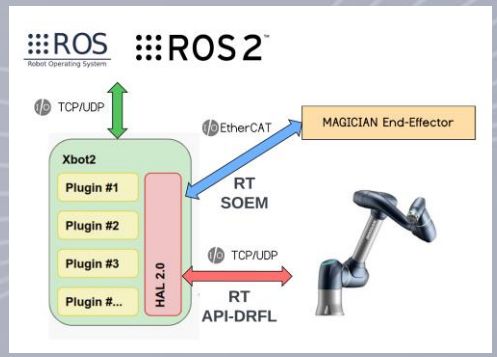
F2.2 Human Interface and Interaction

What MAGICIAN seeks to integrate

A flexible interface, preferably also offering AR features through augmented reality devices, that enhances user interaction while operating the MAGICAN robotic systems. The interface shall allow for the flexible and intuitive interaction facilitating both the supervision and correction of robotic tasks by the human worker.

Desired features and spefications

- An intuitive User Interface (UI) combined with an Augmented Reality (AR) device/system
- It should provide **two-way communication** between the human operator enabling both information flow and command control.
- The UI/AR systems must integrate with the MAGICIAN platform's perception and robot control systems to **visualize real-time data and convey feedback** to the human operator.
- The interface must **integrate with the MAGICIAN robot's existing task control** systems to send commands for adjustments (e.g., fine-tuning detection or rework tasks).
- The interface shall **interact with the platform's Xbot2 software architecture**, through appropriate APIs, supporting also standards in communication, such as ROS.



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F2. HUMAN-ROBOT COLLABORATION MODULE

F2.3 Human worker speaking system

What MAGICIAN seeks to integrate

An intuitive natural language interface that enables workers to verbally communicate with and control the MAGICIAN robots during defect detection and rework operations. The system should allow workers to issue commands, provide feedback, and adjust robotic actions in real time using voice inputs.

Desired features and spefications

- **Voice Command and Contro**l: A reliable voice recognition system that enables task guidance, correction, and workflow management through verbal inputs.
- **Voice Feedback**: The system should also provide audible feedback to confirm actions taken or to request further clarification if needed
- **Microphone & Sensor Integration**: Ergonomic and noise-resistant microphone systems are necessary to ensure clear voice capture in industrial environments.
- **Speaking system Integration**: APIs should be provided enabling the smooth integration of the speaking interface and its communication with the Xbot2 framework and the control system of the MAGICIAN robot.

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F2. HUMAN-ROBOT COLLABORATION MODULE

F2.4 Motion improvements

What MAGICIAN seeks to integrate

A mobility system to enhance the flexibility of MAGICIAN robotics arms enabling to transition from the current fixed or mechanical-slider-mounted robot to a mobile robot arm system.

DOOSAN Control Unit

Doosan Cobot H2515

+

Desired features and spefications

- **Mobile base**: A mobile robotic platform that can integrate (mechanically and electrically) and host robotic arms such as the Doosan Cobot H2515 and its control system.
- **Whole-Body Motion Coordination**: Integrated control of both robotic arm and mobile base to generate coordinated and optimized motion plans.
- **Perception / Navigation**: The mobile base should provide safe and dynamic navigation of the mobile system in shared workspaces.
- **Interoperability**: Interfaces and APIs shall permit seamless integration with MAGICIAN's existing robotic infrastructure, and intuitive operator interfaces for enhanced usability

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Q&A

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MAGICIAN Partners

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