Development of Autonomous Mobile Robots and Smart Sensors for Digitalization of Agriculture: Limitations for Oil Palm Plantations

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ADAPTIVE AGROTECH
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1. **Brief intro to the research groups**

2. **Digitalization of Agriculture**

3. **Autonomous Mobile Robots**

4. **Live monitoring and control with IoT**

5. **Limitations for Oil Palm Plantation**

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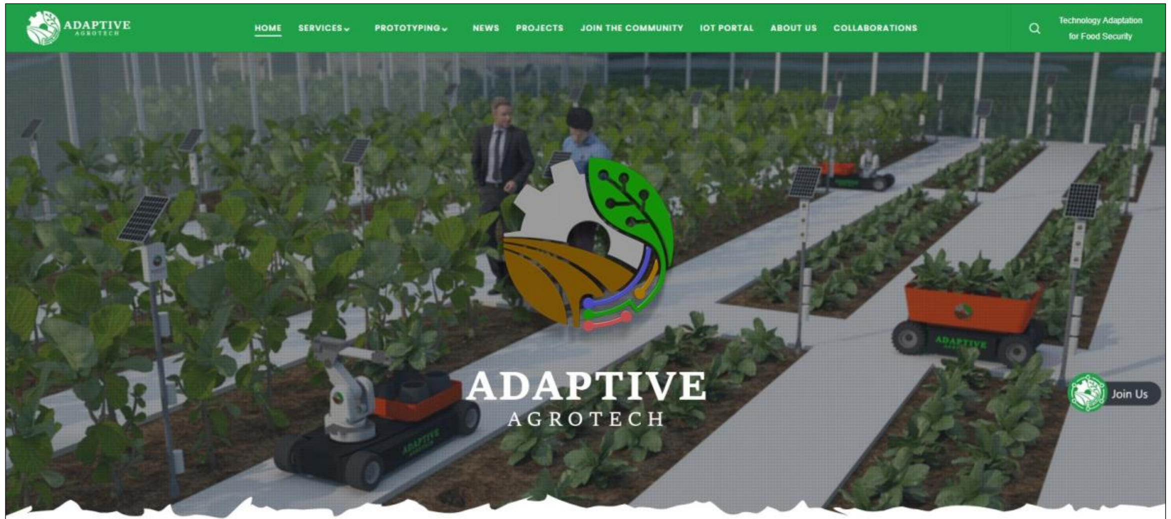

Adaptive AgroTech Consultancy Int, KL, Malaysia

http://adaptiveagrotech.com/

At ATB: Project leaders and research focus

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Department: Engineering for Crop Production

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Online:

Project: SunBot, Emission-free berry production using autonomous e-tractor,
Period: 2018-2023
Funding: Ministry for Rural Development, Environment and Agriculture of the State of Brandenburg

Dr.-Ing. Volker Dworak

Scientist

Department: Engineering for Crop Production

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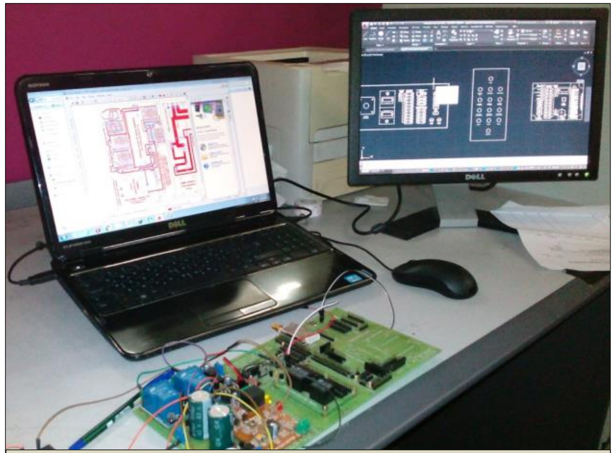
Project: FoodChain: Introduction of 5G in Ag-automation
Period: 2022-2023
Funding: Federal Ministry for Transport, Innovation and Technology

At Adaptive AgroTech: Digitalization of Agriculture for food security

Consultancy support

Organizing Workshops

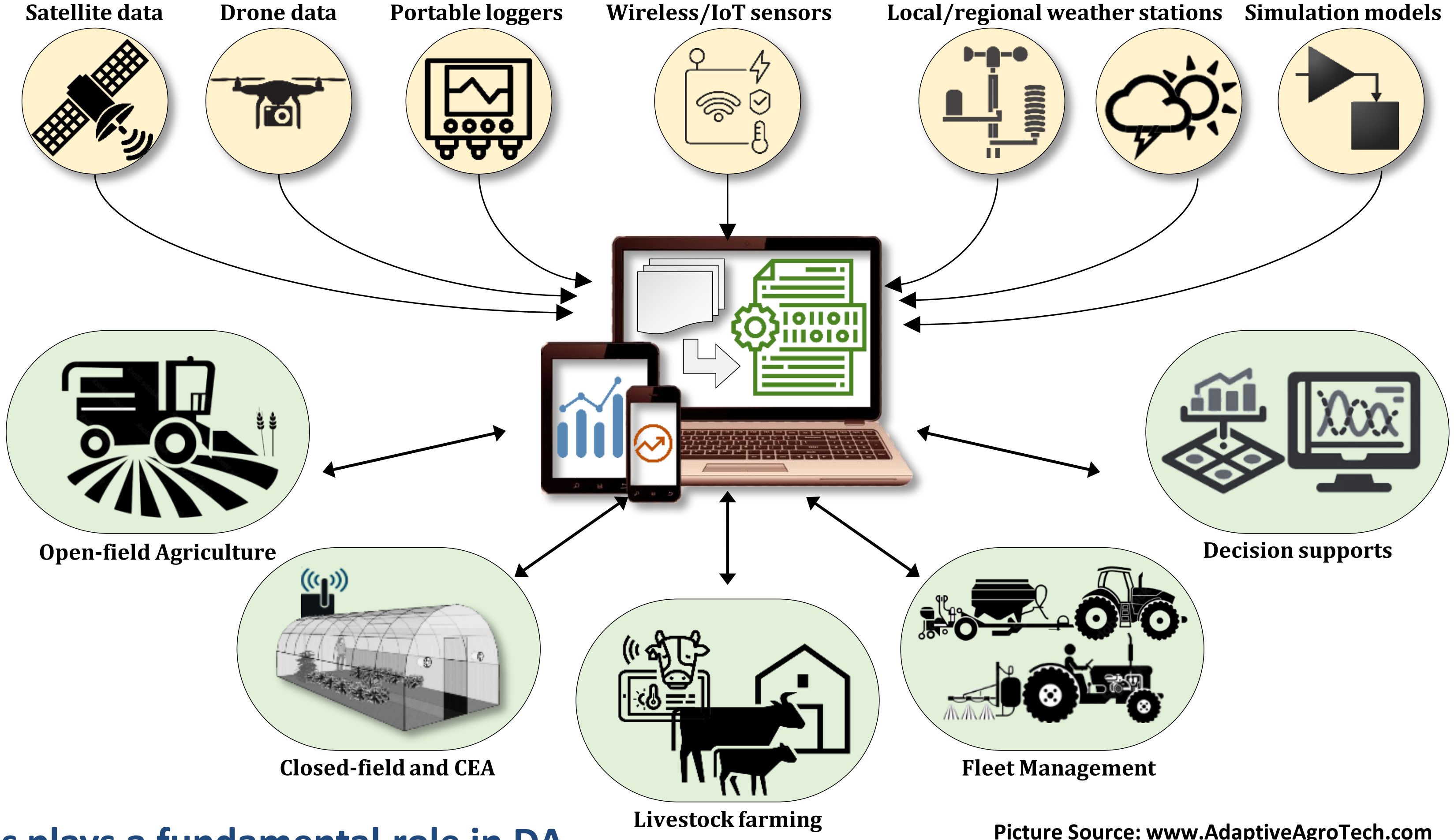
Organizing Study tours


Research and development

Digitalization of Agriculture

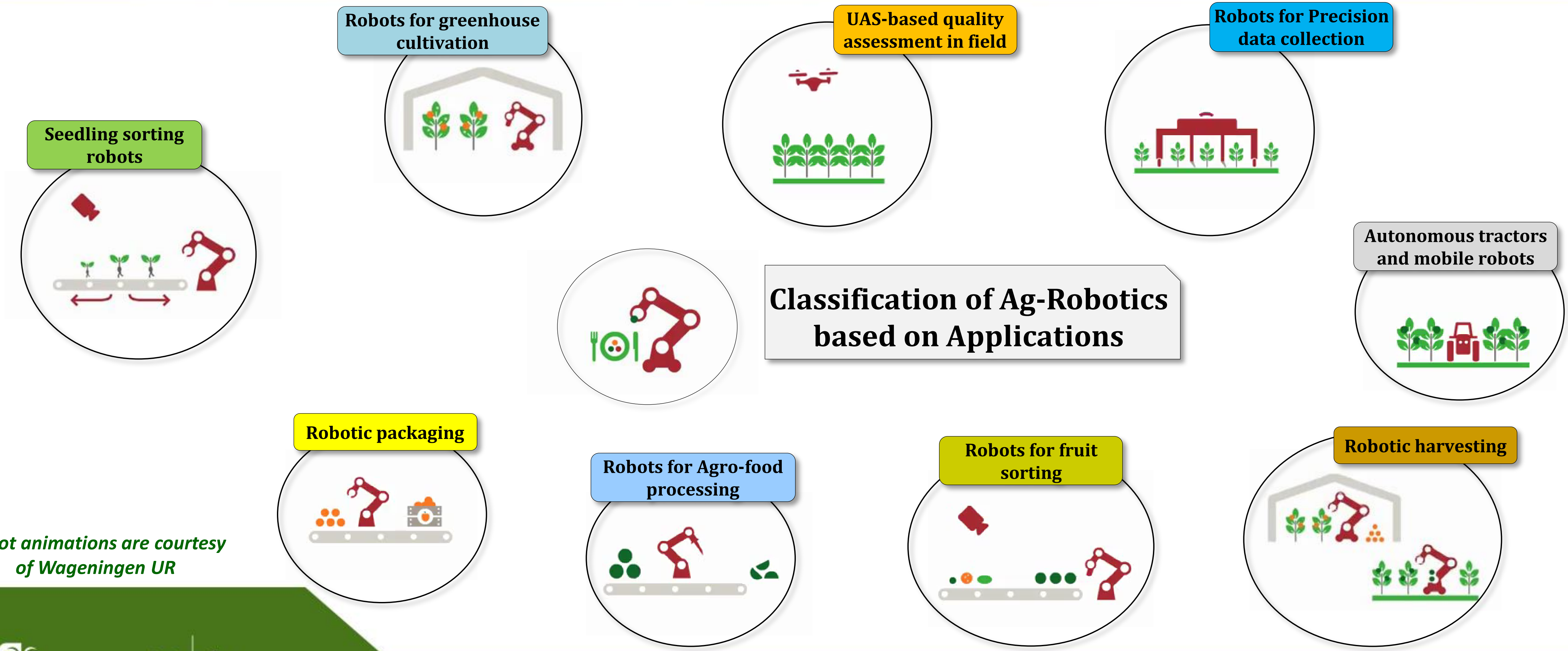
- **Refers** to the practice of modern technologies such as sensors, **robotics**, and data analysis for improving the sustainability and profitability of farms, while at the same time increasing crop yield and quality.

- **Why is it interesting for farmers?**
- Reduce input costs, increase viability
- Automate repetitive tasks
- A solution to labor shortage
- Create more insight about plants, etc



Ag-robotics plays a fundamental role in DA

Picture Source: www.AdaptiveAgroTech.com



Robot animations are courtesy of Wageningen UR

Classification of Ag-Robotics based on Body structure

Mobile (Field robots)

- Field Scouting
- Plant Phenotyping
- Weeding, spraying
- Seeding, Fertilizer
- Transplanting
- Delicate handling
- Multi-purpose

Arm robots

- Automated Harvesting
- Milking robots
- Quality assessment
- Sorting robots
- Phenotyping
- Post-harvesting
- Handling /Packaging
- Pruning
- Pick and place

Aerial Robots (UAV)

- Remote sensing
- Mapping application
- Spraying
- Inventory management
- Yield monitoring
- Disease detection

Multi-robot, Hybrid

Multi-purpose, such as pick-and-place inside fields, or specific applications such as pruning, and Milking

Research and development on mobile robots for agricultural applications

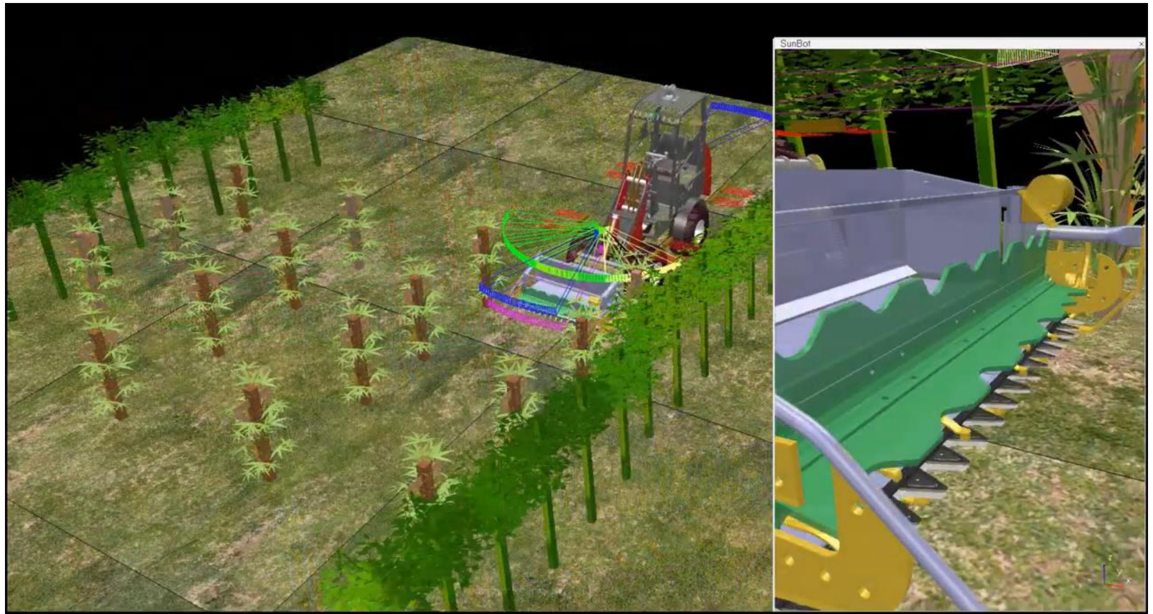
Experimental mobile robot: 4-wheel steering

The electrical tractor for the SunBot project: Articulated steering

Control of Mobile Robots: Autonomous Navigation + Collision Avoidance

Autonomous Navigation

IMU+GPS+Path following algorithms



Scalable Distributed Collision Avoidance System for an articulated steering e-tractor and e-mower

Collision Avoidance

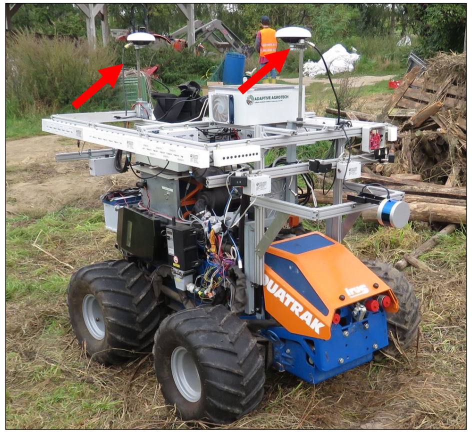
LiDARs, Cameras, Radars

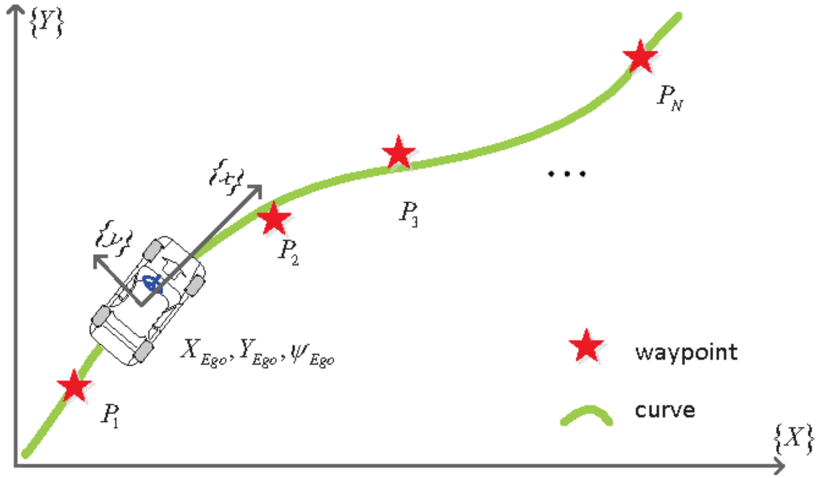
Human collision avoidance with Long-range and short-range distance sensors. (c)SunBot.de, Redmond R. Shamshiri

Main navigation system | RTK GPS, Waypoint tracking algorithm

GPS Navi-box provided the robot with autonomy for path following

- A commercially available GPS-based navigation toolbox was purchased and installed on the mobile robot platform
- **Need for collision avoidance:** The purchased navigation toolboxes did not provide obstacle avoidance features. (The robot could collide with random obstacles while doing autonomous navigation)
- **GPS-denial environments**: Preliminary experiments showed that the performance of the available GPS-navigation toolbox can be interrupted due to GPS receptions, or the issues with IMU calibration.

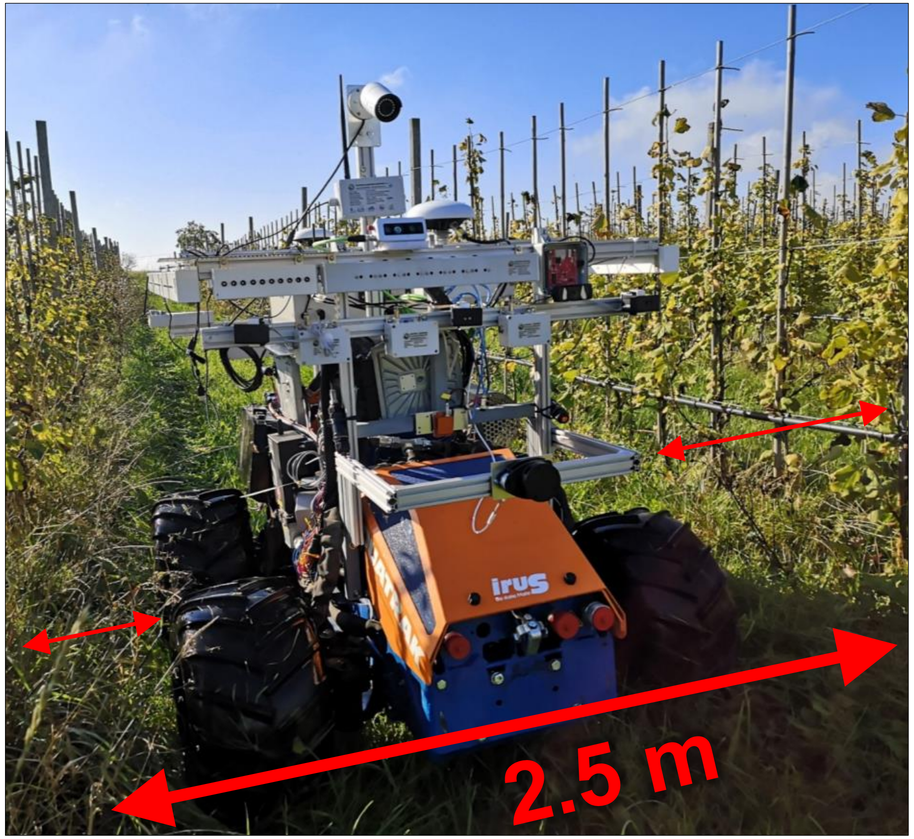


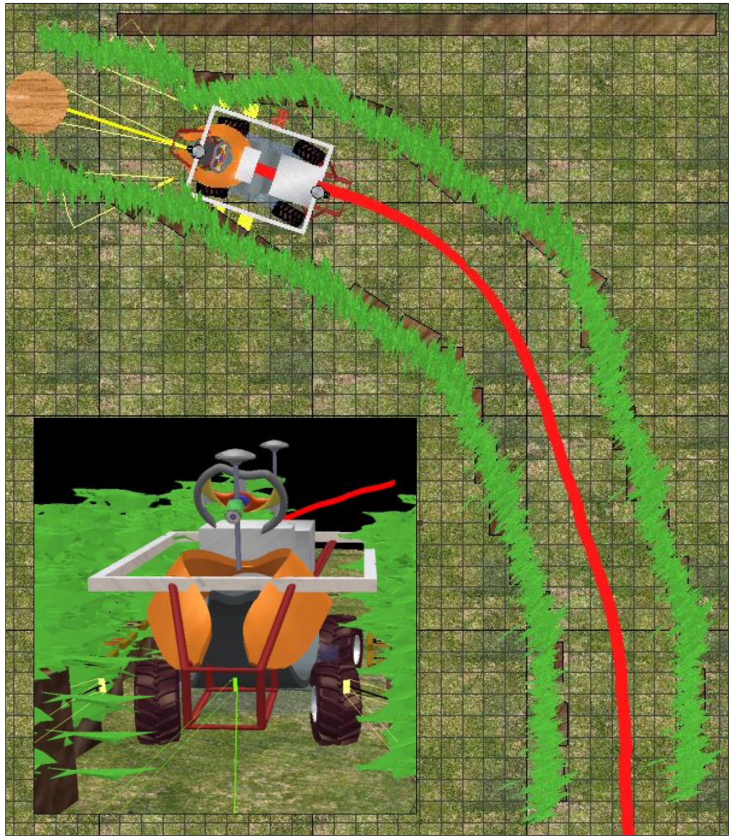


Ref: Jeon, S. J., Kang, C. M., Lee, S. H., & Chung, C. C. (2015, June). GPS waypoint fitting and tracking using model predictive control. In 2015 IEEE Intelligent Vehicles Symposium (IV) (pp. 298-303). IEEE.

Problem to be address by collision avoidance? Maintaining the robot in the center of the row

Collision avoidance is used as an assisted navigation feature in GPS-denial environments.

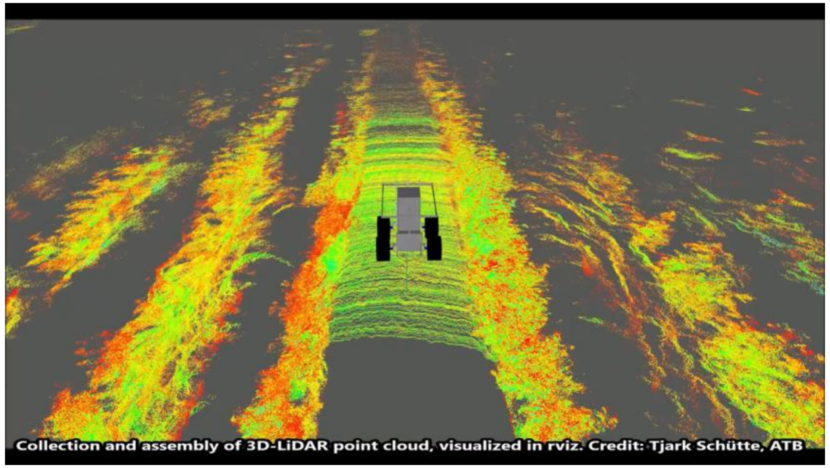




Solutions for collision avoidance

Sensor fusion

High-end LIDARs: widely used for collision avoidance

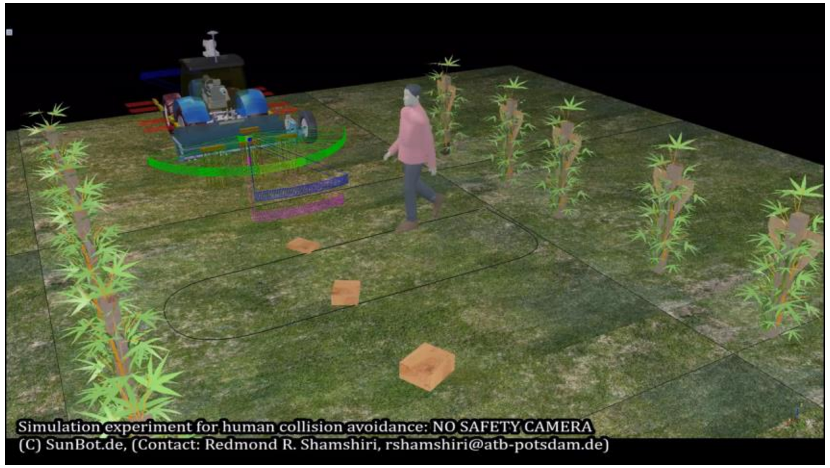


- Add extra cost to the final robot, not affordable by all farmers
- Availability: cannot be easily replaced by farmers upon failure
- Not designed for long-term use in harsh field conditions

Multi channel distance detection (IR, ToF, Ultrasonic)

- Plug-and-sense as an independent ECU
- Affordable, and easily replicable by farmers upon failure
- Custom-build for harsh field conditions
- Open-source programming, Modular hardware
- CANBUS and ROS interface, IoT compatibles

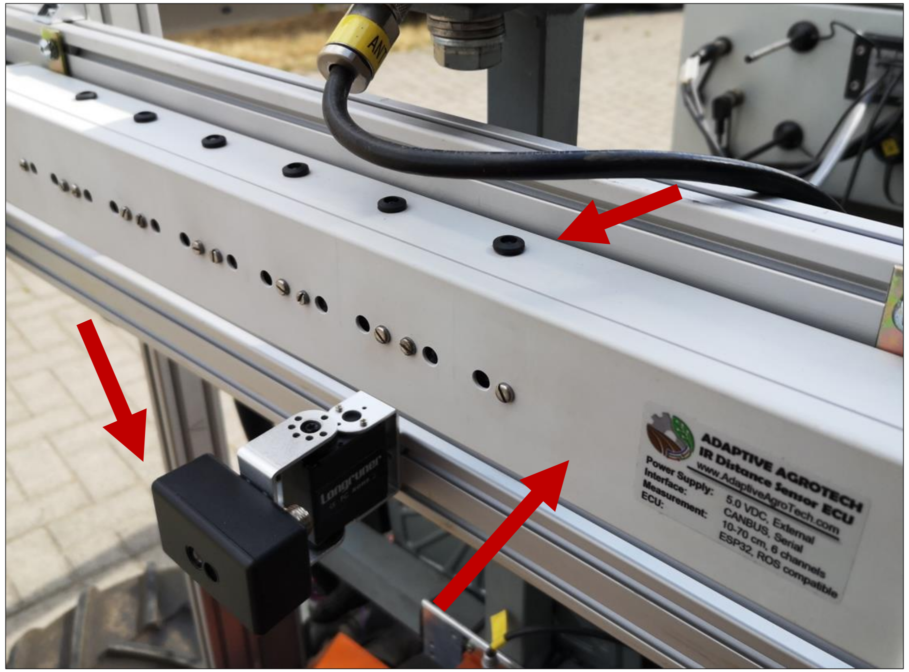
Depth cameras: mainly used for safety (human detection)

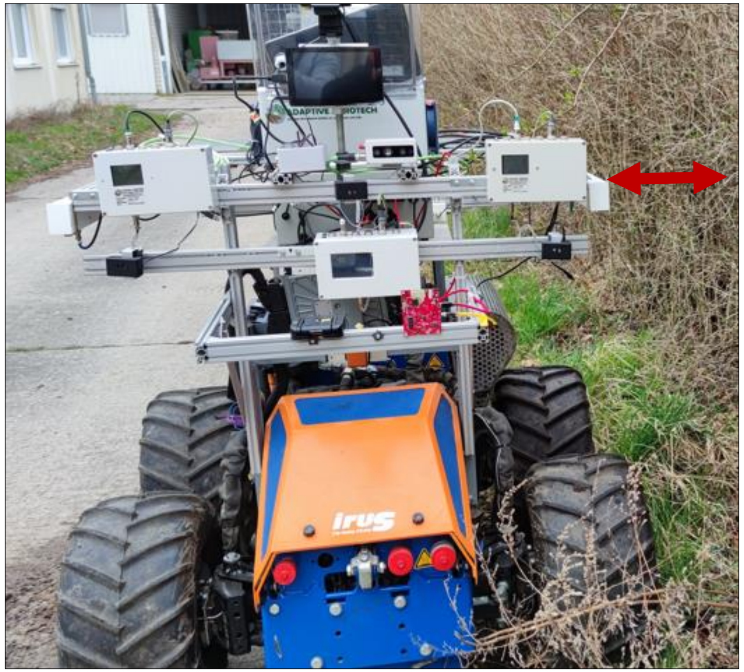


- Human detection, Animal detection, Object recognition
- Easy to implement,
- Available packages: OpenCV, ROS, MATLAB
- Integrated with Artificial Intelligence and Machine learning
- Affordable, and easily replicable by farmers upon failure

Multi channel distance detection (Infrared)

Prototyping, preliminary tests





Multi channel distance detection (Infrared)

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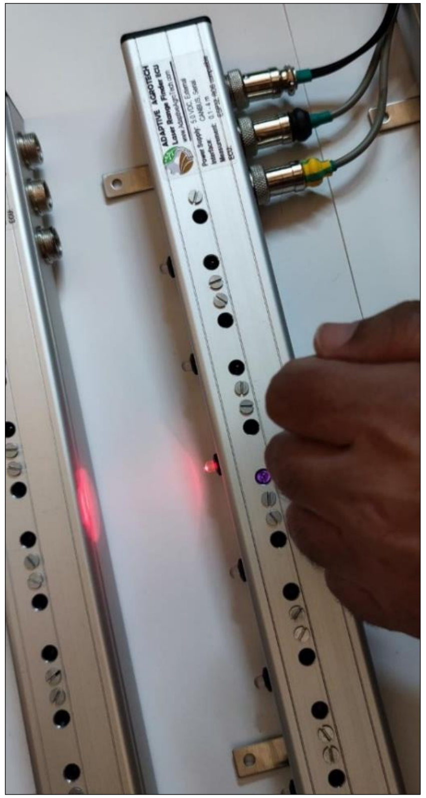
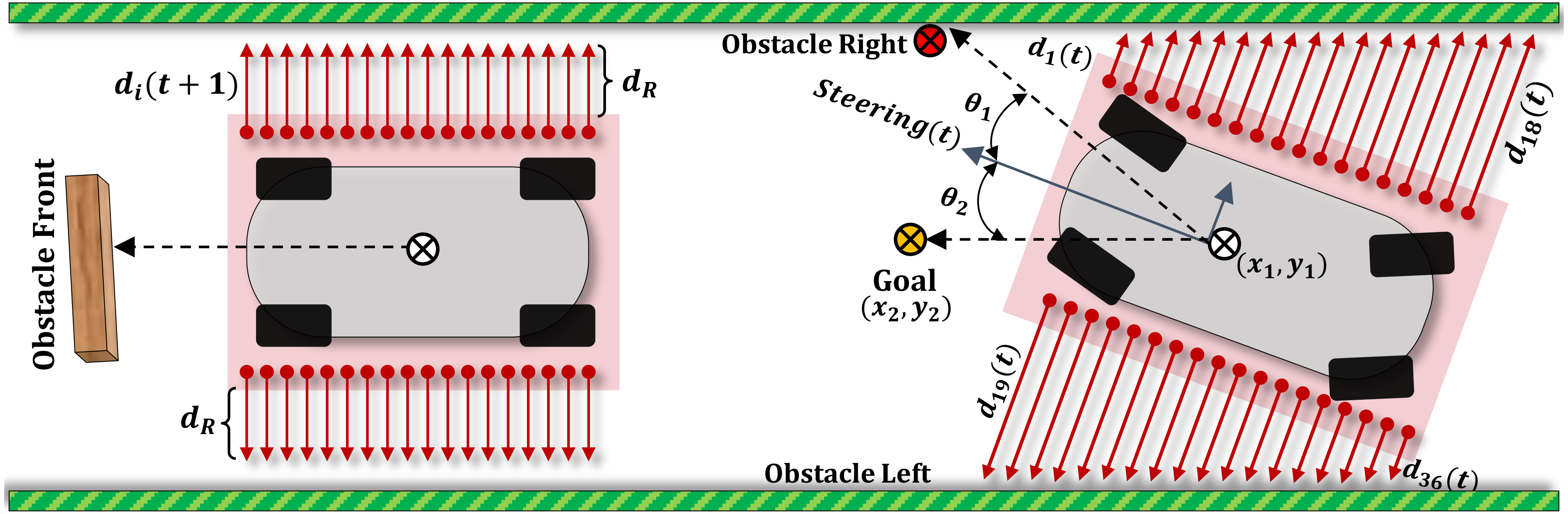


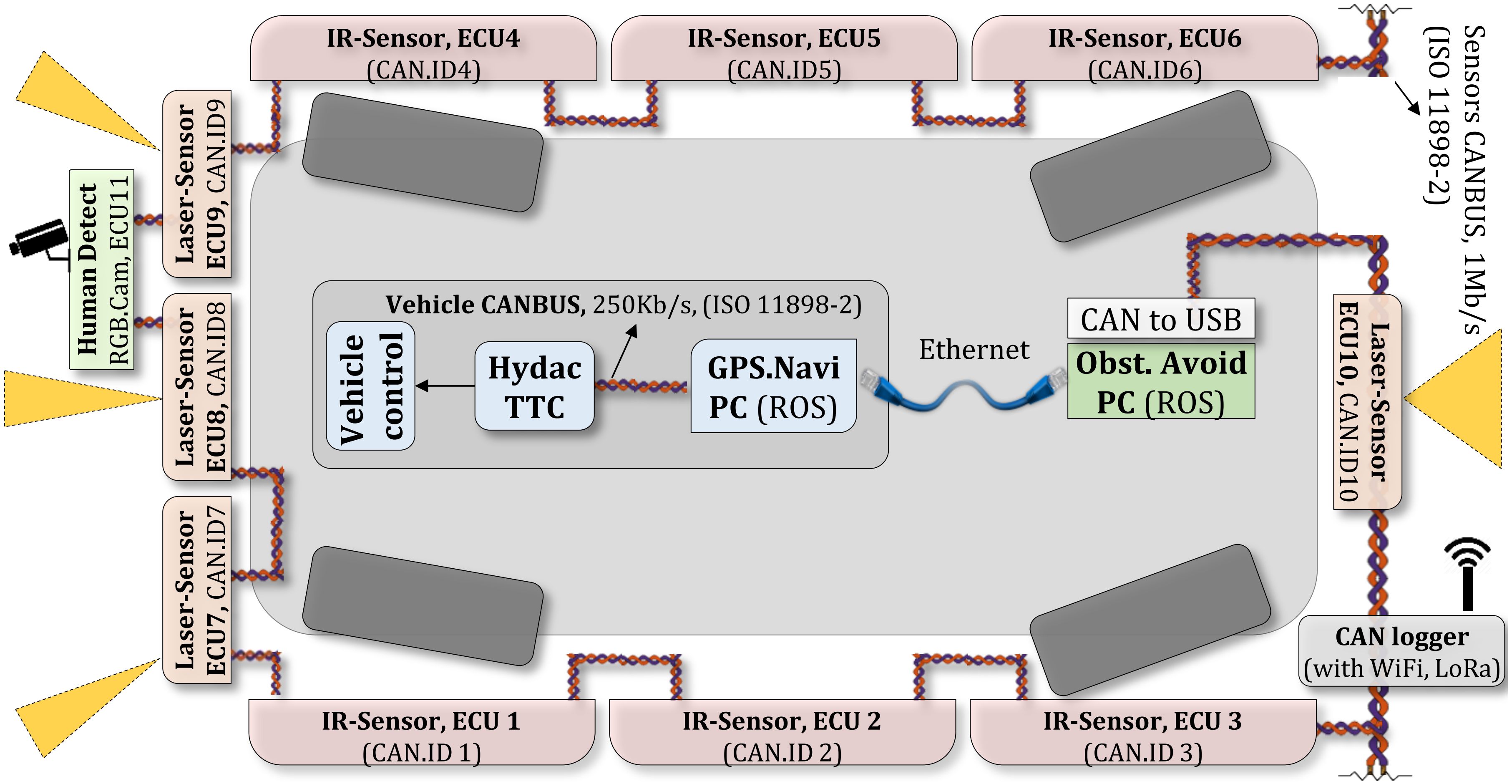
- ✓ Fixed on the left and right of the vehicle
- ✓ Detection range: between 2 and 75 cm
- ✓ Communication: ROS, CANBUS, WiFi



Robust data communication via CANBUS

Makes possible adding and removing ECU

Open-source programming



Experiments with 4WD vehicle

Conceptualization, Prototyping

Simulation study

Lab experiments

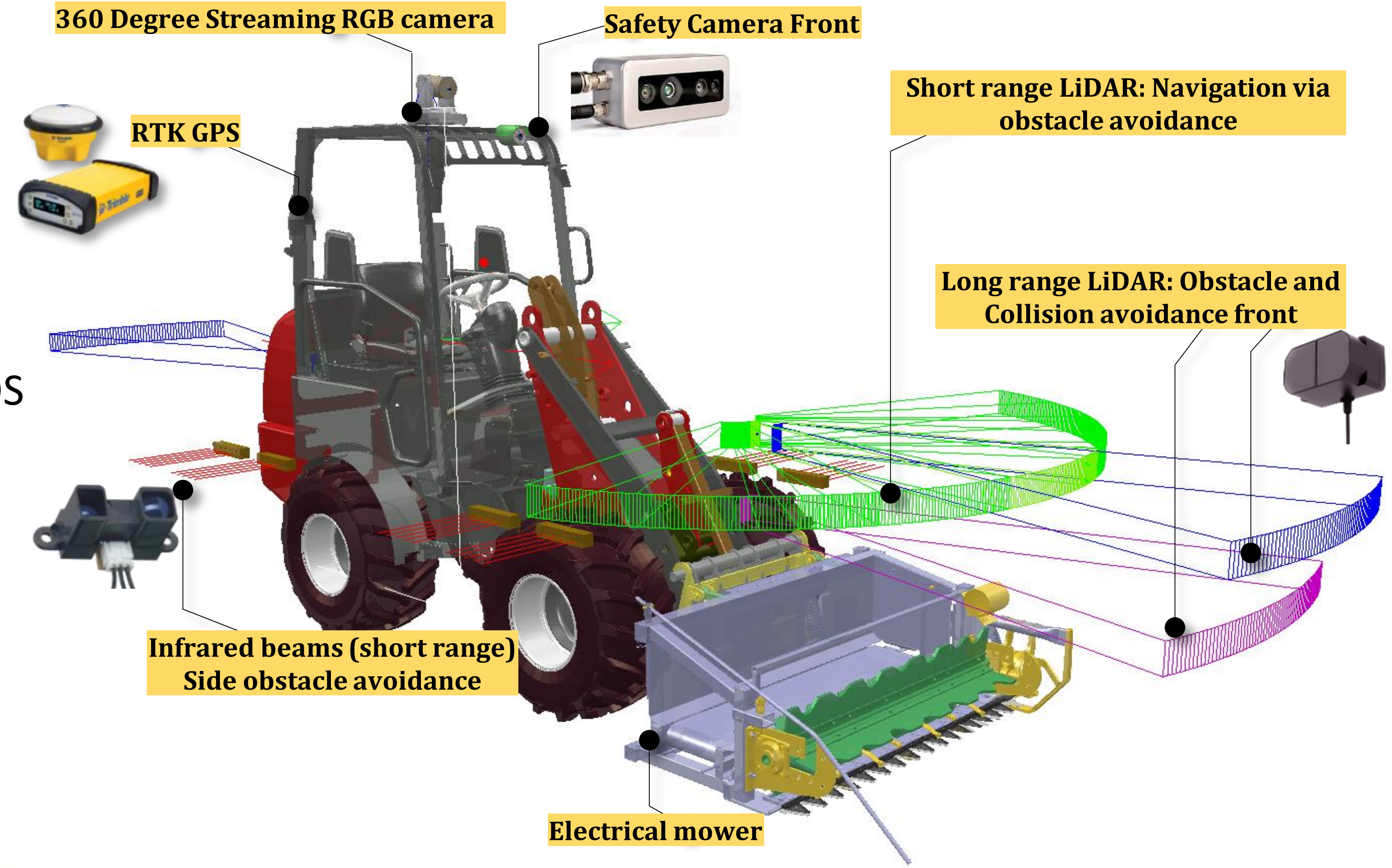
Field experiments

Onboard computers for testing

Overview of the final collision avoidance

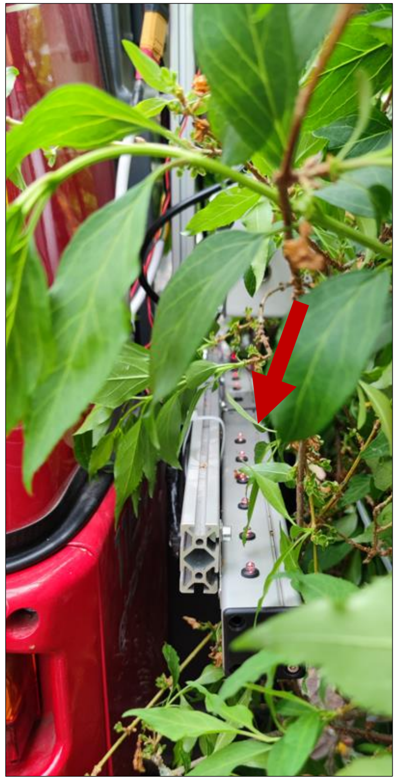
- ✓ Distributed Control System
- ✓ Modular hardware and ECUs
- ✓ Withstand harsh field conditions
- ✓ Robust communication between ECUS: CANBUS, ROS
- ✓ Logging of CANBUS line and control messages
- ✓ IoT supervising, Over the air programming
- ✓ **Assisted navigation in GPS-Denial Environments**

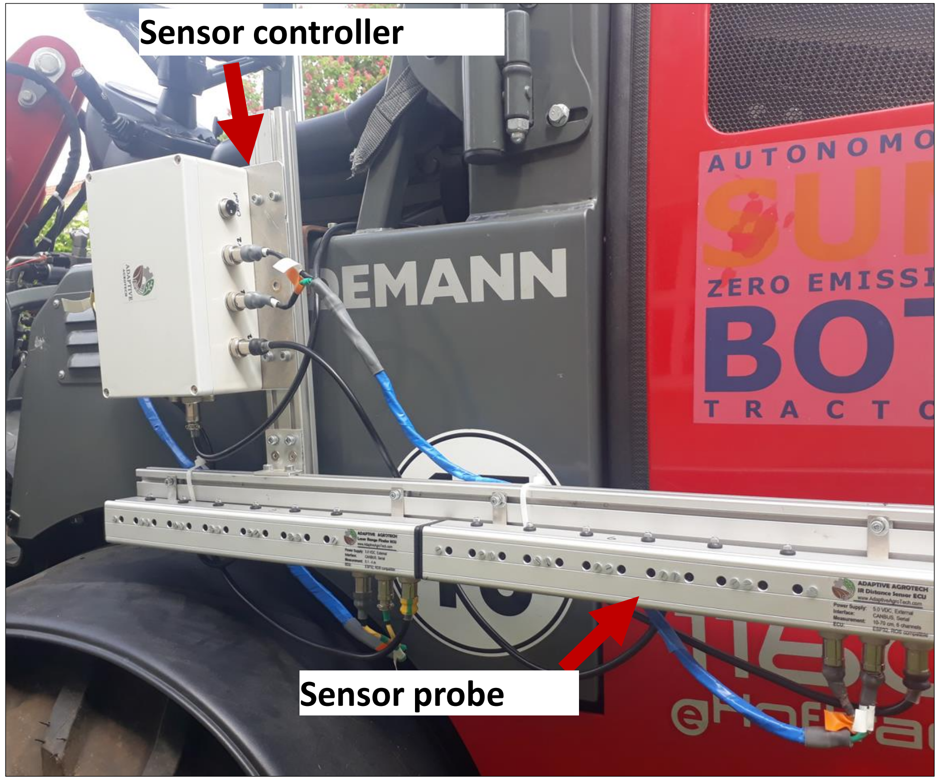
Sensor fusion

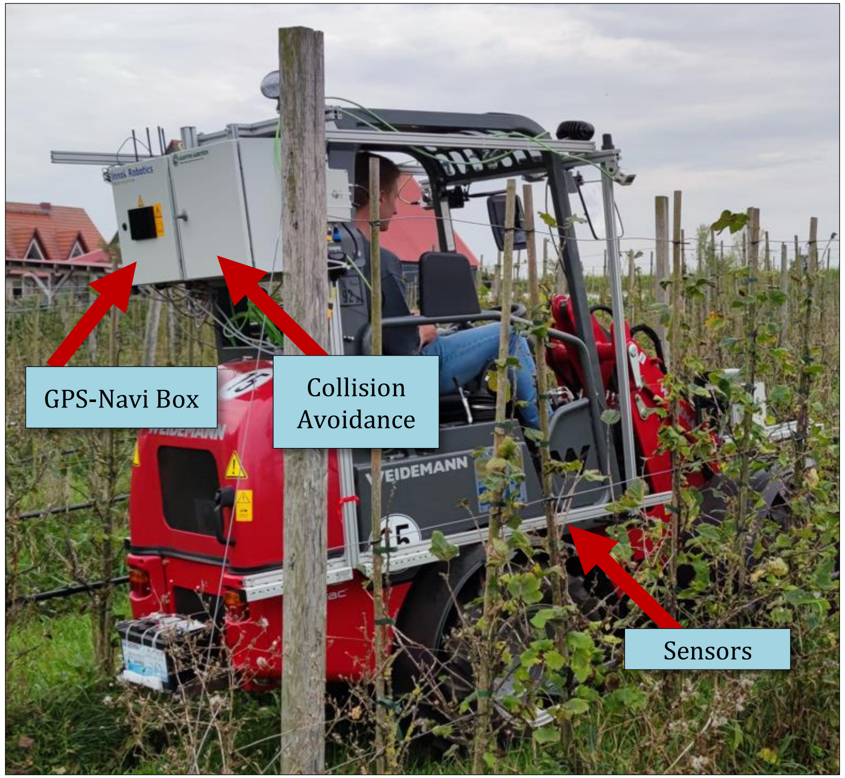


Overview of the final collision avoidance

Sensor fusion







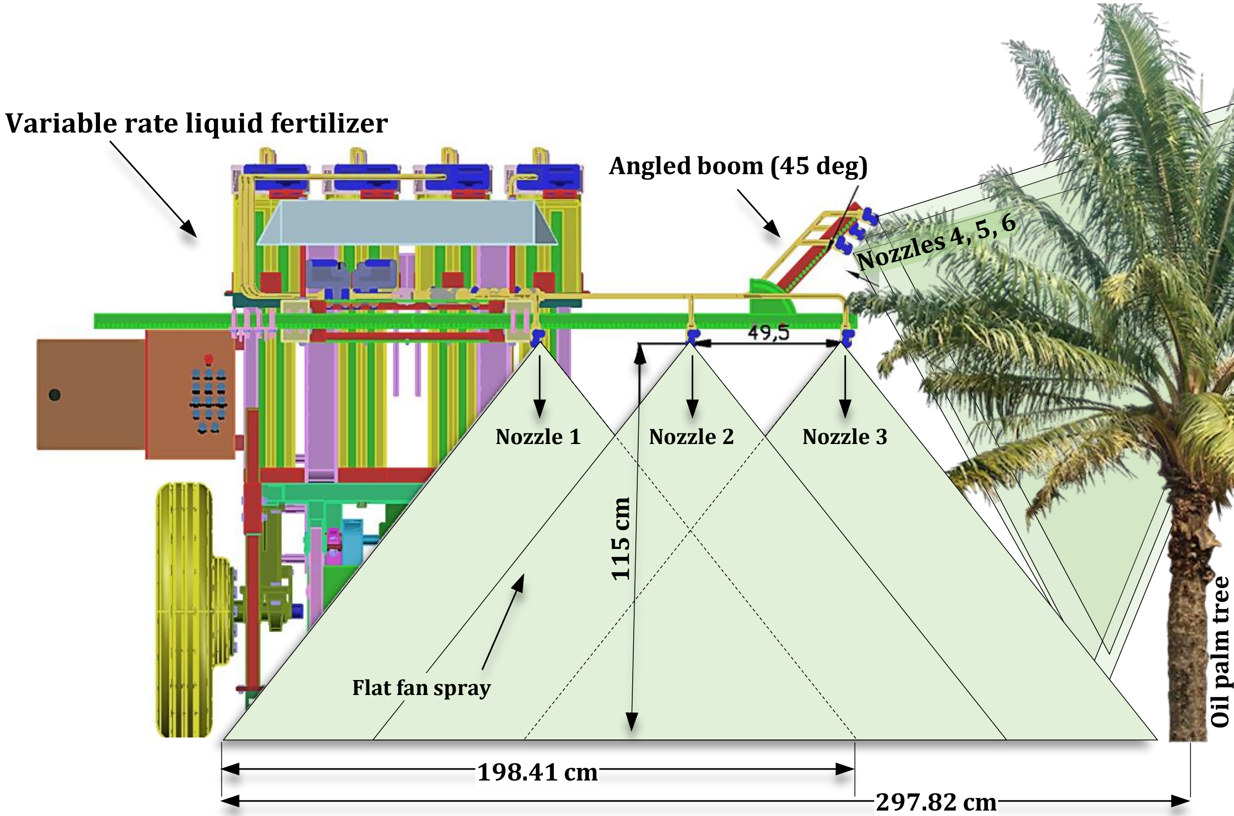
Experiments

In field and simulation

Simulation study

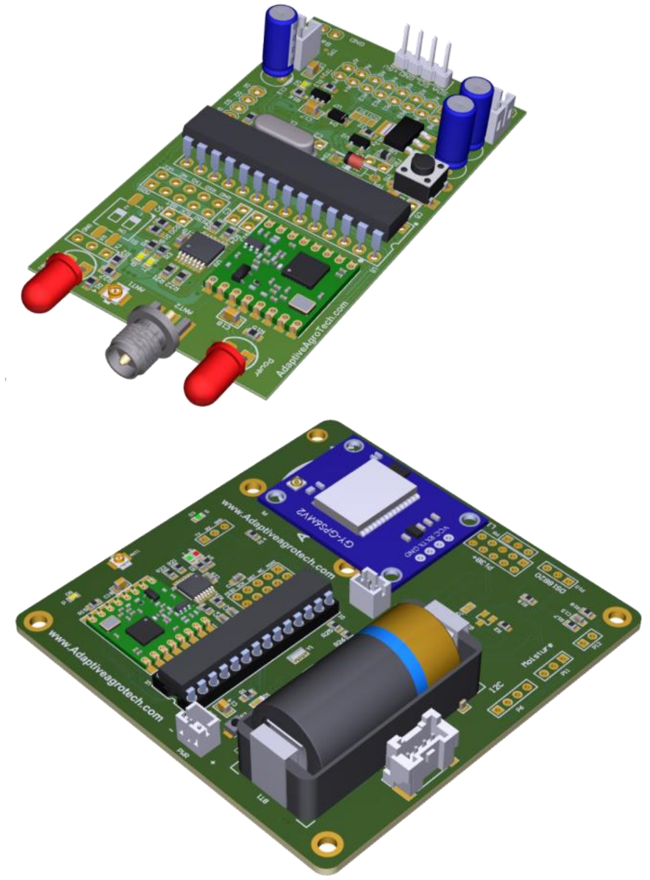
Field experiments

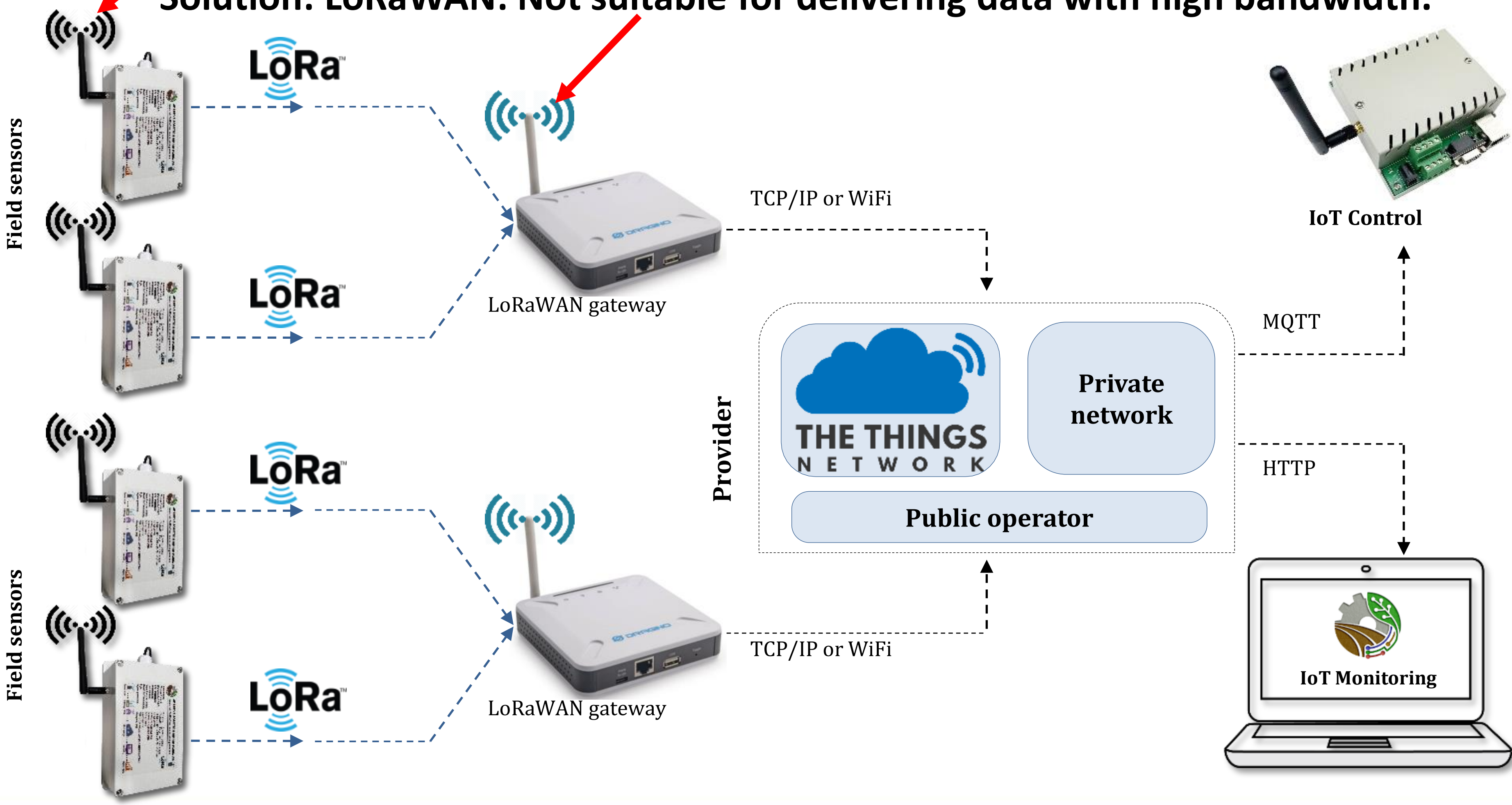
Application for Oil Palm: Autonomous navigation with collision avoidance for a Variable rate liquid fertilizer



For commercialization: Must have IoT supervision

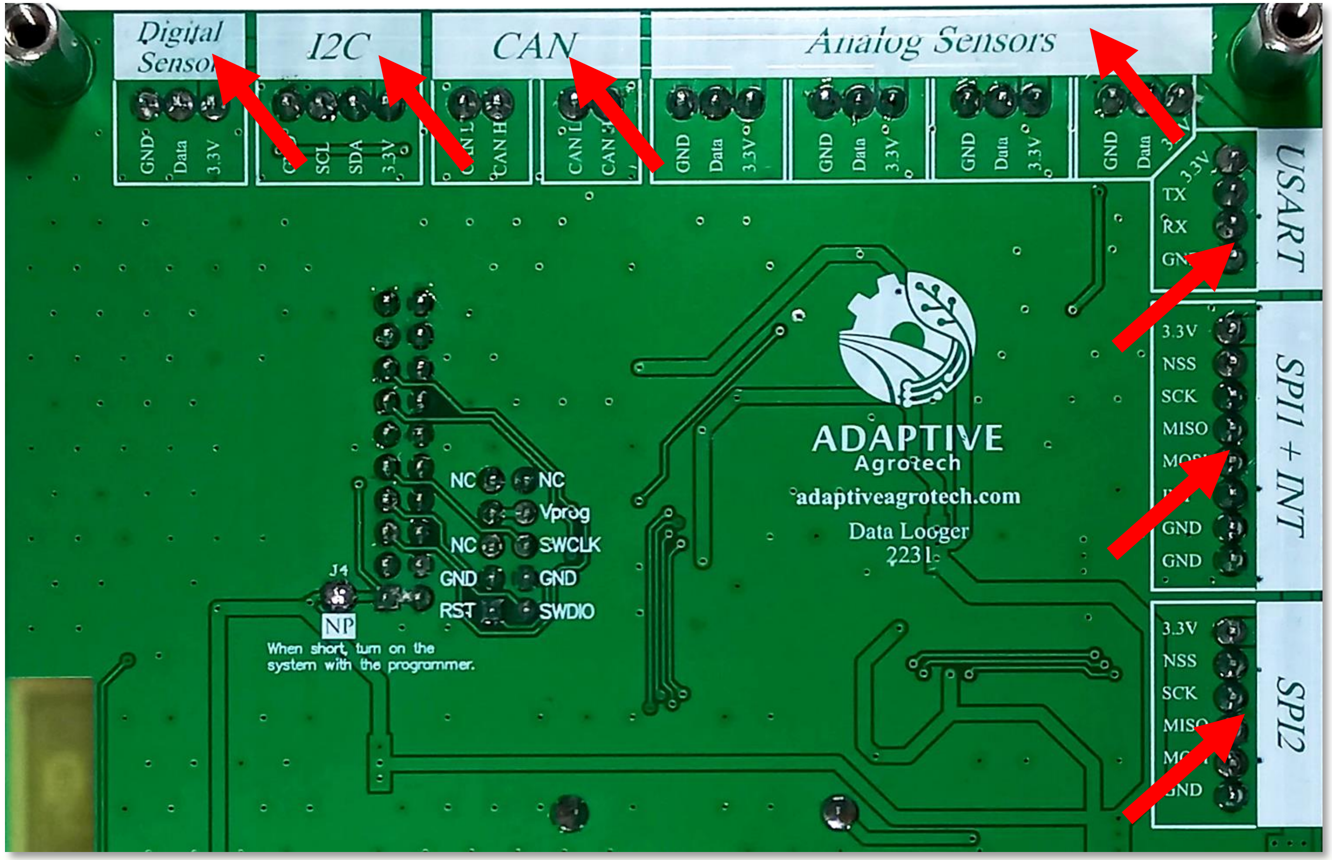
Solution: LoRaWAN: Not suitable for delivering data with high bandwidth.





Adaptive AgroTech Universal Motherboard for Digital Agriculture

STM32+ESP32+RTC+SD+CAN



Conclusion: Limitations for IoT implementation in large scale oil palm plantations

- **Main issues:** Remote area (no WiFi/LAN), Line of sight, signal blockings by trees and leaves

Solution: 5G, Under research (Foodchain project)

XX OIL PALM
International Conference

THE TRANSFORMATIVE
POWER OF OIL PALM

Thanks