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# ROBOTIZED SERVING OF AUTOMATED WAREHOUSE – ROBOTINO® COMMUNICATION

Training Module Developer version

www.trinityrobotics.eu

The TRINITY project has received funding from the European Union's Horizon 2020 research and innovation programme under the GA 825196

# Introduction

- Fully functional, scaled-down, table-top model of an automated warehouse served by an omnidirectional mobile robot.
- Used as an attraction in exhibitions.
- The goal is to demonstrate the capabilities of mobile robots in intralogistics.

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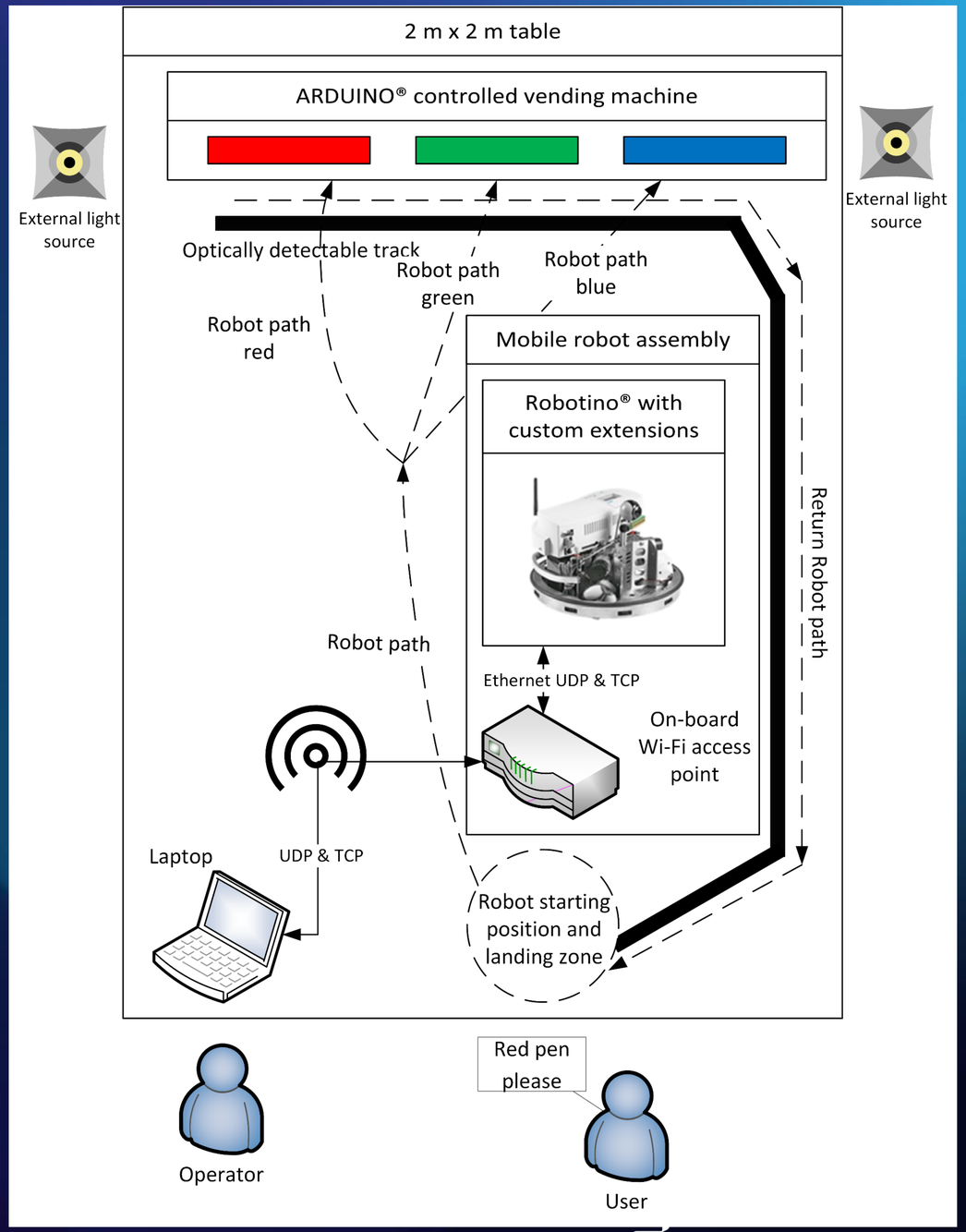
# System design

- Based on an omnidirectional mobile robot equipped with three omni-wheels.
  - Kiwi drivetrain
- The automated warehouse is modeled by a pen vending machine operated by a microcontroller.
- The vending machine has 3 slots for holding 3 differently colored pens
- Serving one pen at a time.

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# Hardware infrastructure

- FESTO Robotino®
- Uniquely designed parts
  - Workpiece tray,
    - Bent sheet metal part accommodating the workpiece during the wending process.
  - ARDUINO® controlled vending machine,
  - Proximity switch holder,
    - Bent sheet metal part holding in place a factory standard optical proximity switch accessory to detect the proximity of the wending machine during the final approach.
  - Optically detectable path
    - Painted or glued tape.
- Commercially available parts
  - 4 $m^2$ wooden flooring,
  - Two standard light sources on a tripod,
  - Laptop with Microsoft Windows® operating system.

Image Source: https://www.festo-didactic.co.uk/gb-en/learning-systems/education-and-research-robots-robotino/the-highlights.htm?fbid=Z2luZW4uNTUwLjE3LjE4Ljg1OC40NzUy

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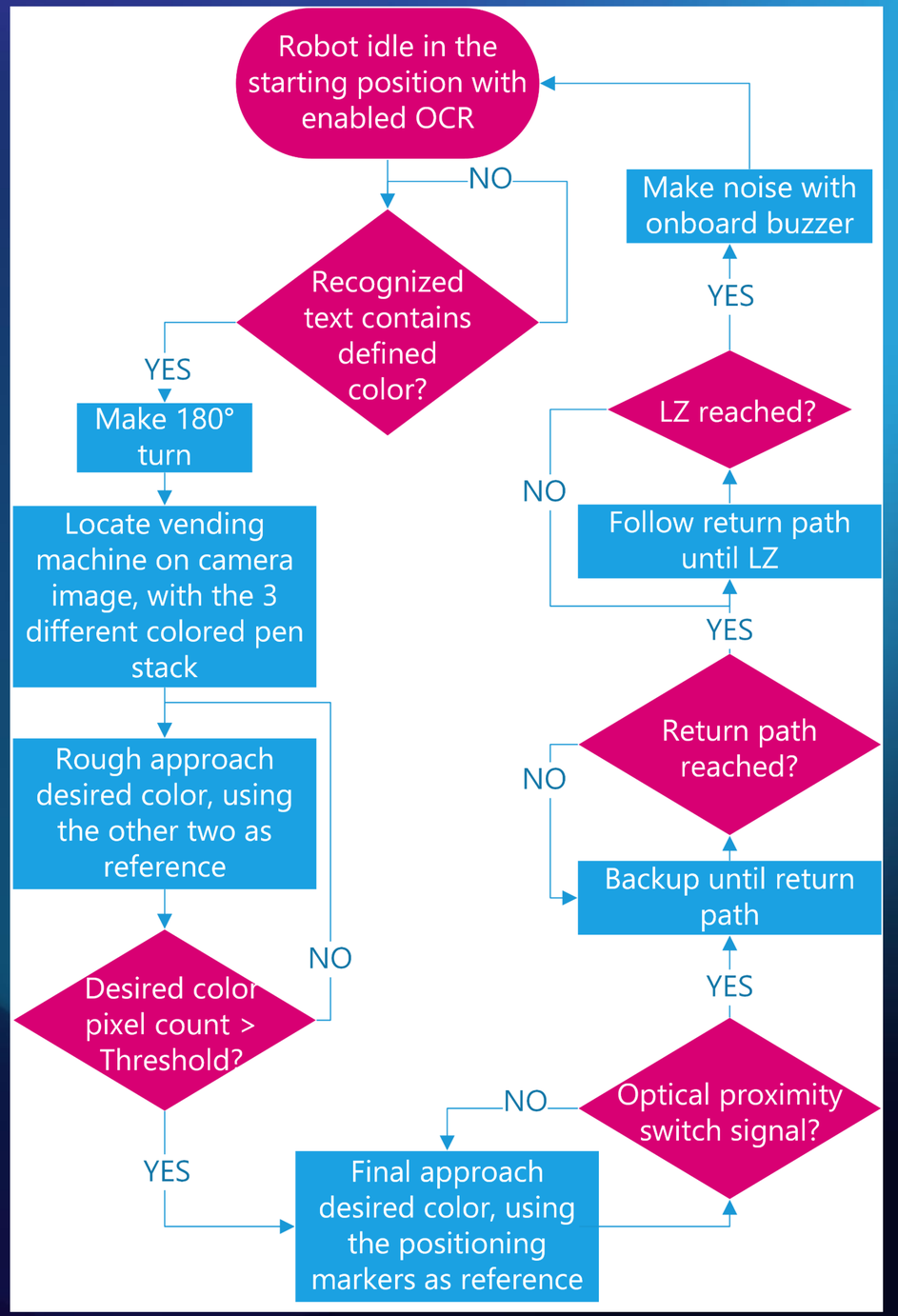
# Software infrastructure

- The complete robot control software is made with National Instruments LabVIEW™ graphical programming language



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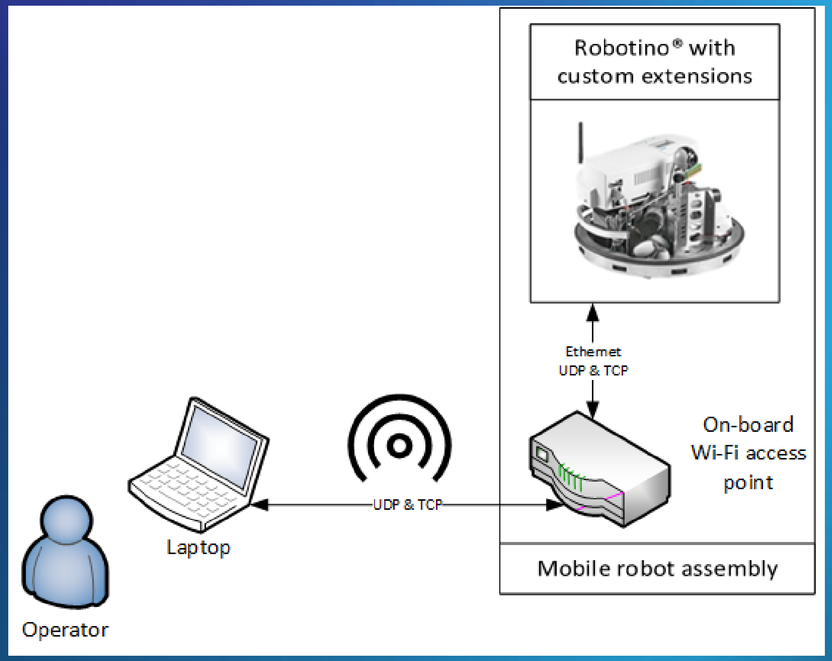
# Cyber-security

- Closed system with no need for access to the internet.




| Vulnerabilities | Mitigation |
|---|---|
| Control laptop security: if the laptop is online for any reason | Completely prevent control laptop internet access |
| Wireless encryption | Already has WEP, will be changed to WPA |
| Wireless router security key issue | MAC address filtering on the wireless network. AP only accepts allowed MAC addresses |
| Interference caused to wireless communication | |
| DHCP service | Disabling the DHCP server, only fix IP addresses will be allowed |
| The qDSA protocol is open source and publicly available | |
| No encryption implemented in the qDSA protocol | |
| The mobile robot enables a secondary connection in spectator mode and sends the camera image and feedback messages to the spectator | |

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# Module description

- The main functionality of the module is to communicate with the Robotino®
- Robotino® is a mobile robot platform for research and education developed by Robotics Equipment Corporation GmbH

Product homepage: https://www.festo-didactic.co.uk/gb-en/learning-systems/education-and-research-robots-robotino/?fbid=Z2IuZW4uNTUwLjE3LjIwLjg1OA&page=1&offset=0&showitems=32
Company homepage: http://www.servicerobotik.eu/

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# Module description

- This module is an adaptation of the qDSA protocol of the API1 for Robotino® v2
- Made in native Vis for use with LabVIEW™ software without the need to call external code

Description available at https://wiki.openrobotino.org/index.php?title=Downloads#API.2C_Plugins_.26_Packages

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# Module description

- The module consists of two continuously running parallel loops (tasks).
  - First task is dedicated to the keep-alive type communication of the Robotino®, where the Robotino® continuously sends data to the host computer and expects data in response.
  - The second task is the receiver of the camera images, continuously transmitted by the Robotino® if the camera is enabled.

Description available at https://wiki.openrobotino.org/index.php?title=Downloads#API.2C_Plugins_.26_Packages

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# Keep-alive communication Host side

- The inputs and outputs for the module are separated into two sections: the "Keep-alive" communication from the PC (Host) side and the Camera control from the PC (Host) side

| | Inputs | Outputs |
|---|---|---|
| qDSA protocol | State of 8 digital outputs | State of 8 digital inputs |
| | State of 2 relay outputs | State of the collision detection switch |
| | Motor speed set-points in RPM for each motor | State of the power button |
| | Reset Position for each motor | Sequence number of the communication |
| | Break for each motor | Readings of 8 analog voltage inputs |
| | On-board PID controller parameters for each motor | Current readings of each motor |
| | Odometry (Position of the robot) | Actual position of each motor |
| | Set Odometry switch | Actual speed of each motor |
| | Camera enable switch | Actual Odometry (Position of the robot) |
| | Shutdown switch | Readings of 9 IR distance sensors |
| | | Reading of the battery voltage |
| | IP address of the Robotino® | Is the Robotino® connected switch |
| | Constructional parameters of the Robotino® | Kinematics and inverse kinematics matrices of the Robotino® |

# Camera control Host side

- The inputs and outputs for the module are separated into two sections: the "Keep-alive" communication from the PC (Host) side and the Camera control from the PC (Host) side

| Inputs | Outputs |
|---|---|
| IP address of the Robotino® | Is the Robotino® connected switch |
| UDP Port Parameters | Image |
| Image parameters | Framerate of the image |

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# Thank you!

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