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ROBOTIZED SERVING OF AUTOMATED WAREHOUSE – ENVIRONMENT DETECTION

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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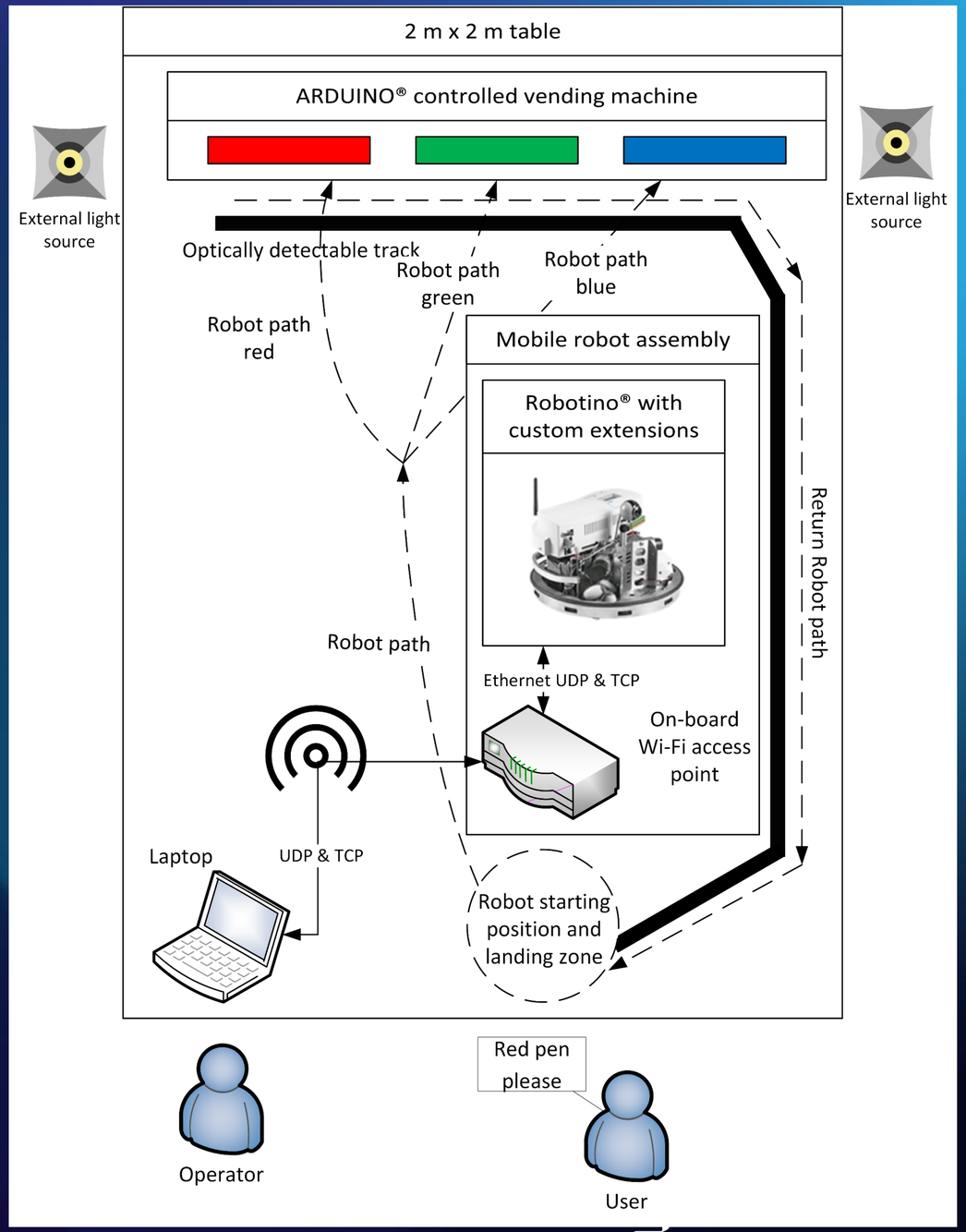
System design

- 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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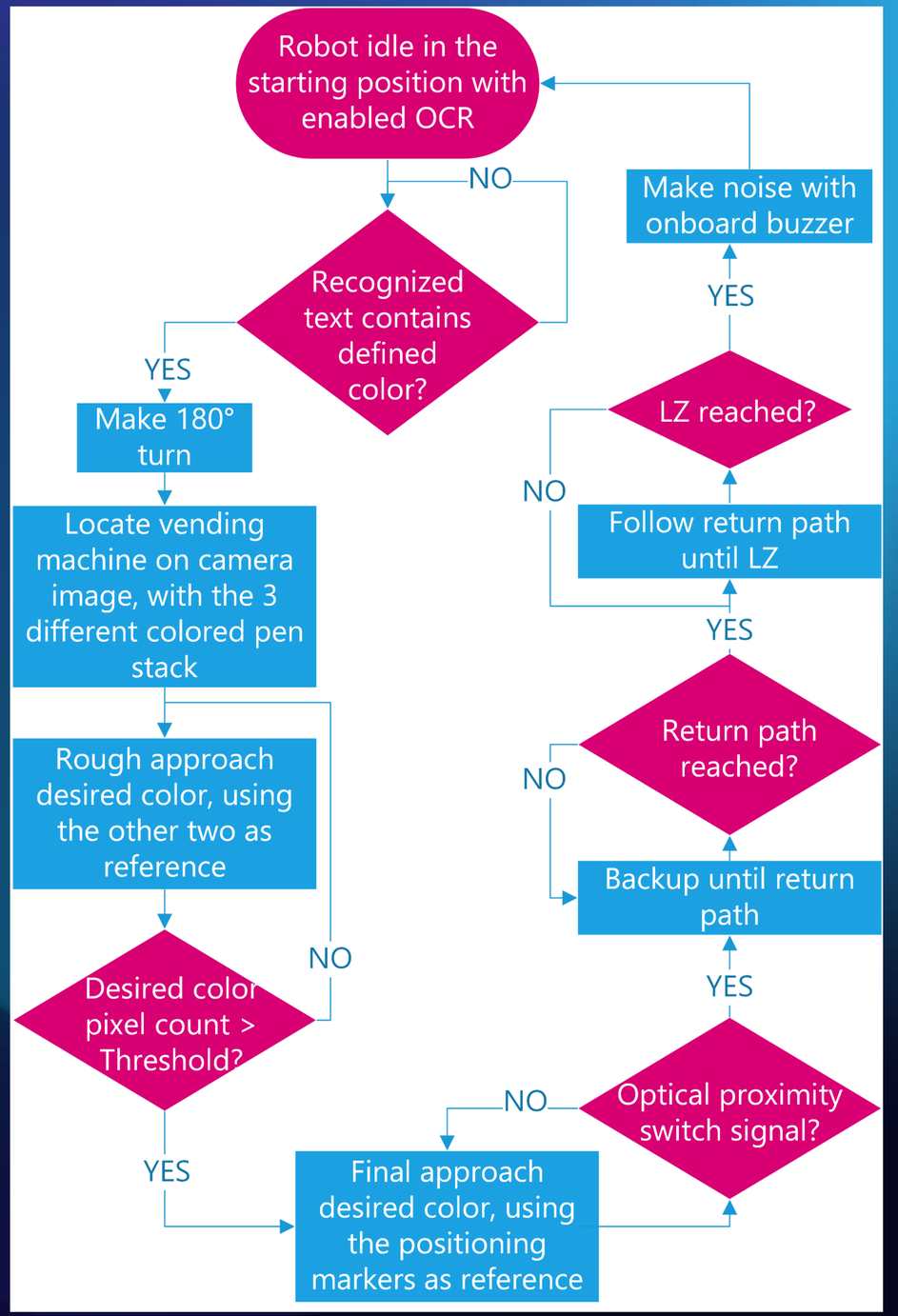
Software infrastructure

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



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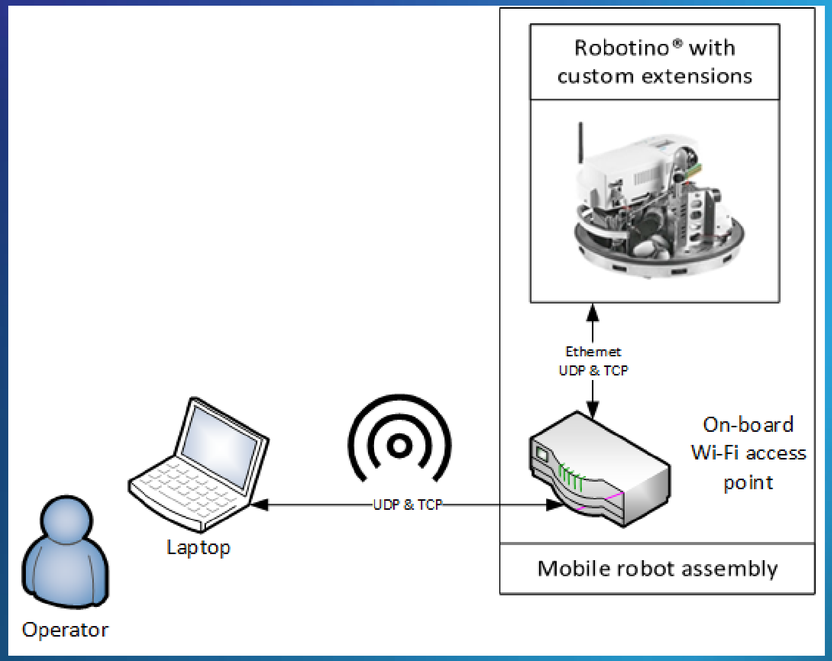
Cyber-security

- 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

- This module consists of three submodules, each performing different sensory tasks.
  - Optical character recognition (OCR)
    - The main functionality of this sub-module is to recognize human-readable characters from images.
  - Object detection by chromatic discrimination
    - The main functionality of this sub-module is to detect objects on an image based on their colour.
  - Optical line following
    - The main functionality of this sub-module is to implement movement algorithms along optically detectable tracks on the ground.

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Optical character recognition (OCR)

- OCR is the process where the machine vision software recognizes text or characters in an image. This sub-module is based on the OCR template created with LabVIEW™ software and modified to recognize only the text appropriate for the task at hand.
- The submodule uses a so-called Character Set File, in which the character templates are stored.
- This submodule uses the HSL colour space and calculates the position (X and Y coordinates) of the centre of mass of the group of pixels represented with the desired colour on a camera image.

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Optical line following

- The Optical line following sub-module requires the FESTO Robotino® v2 mobile robot hardware equipped with 2 optical proximity switches
- The optical proximity switches should be mounted on the base plate of the Robotino®, facing downwards with a relative distance between them matching the width of the track

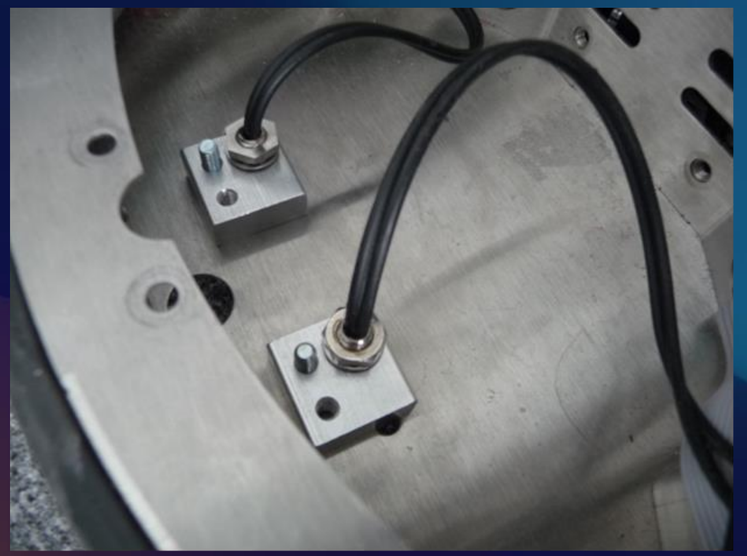

Image source: https://wiki.openrobotino.org

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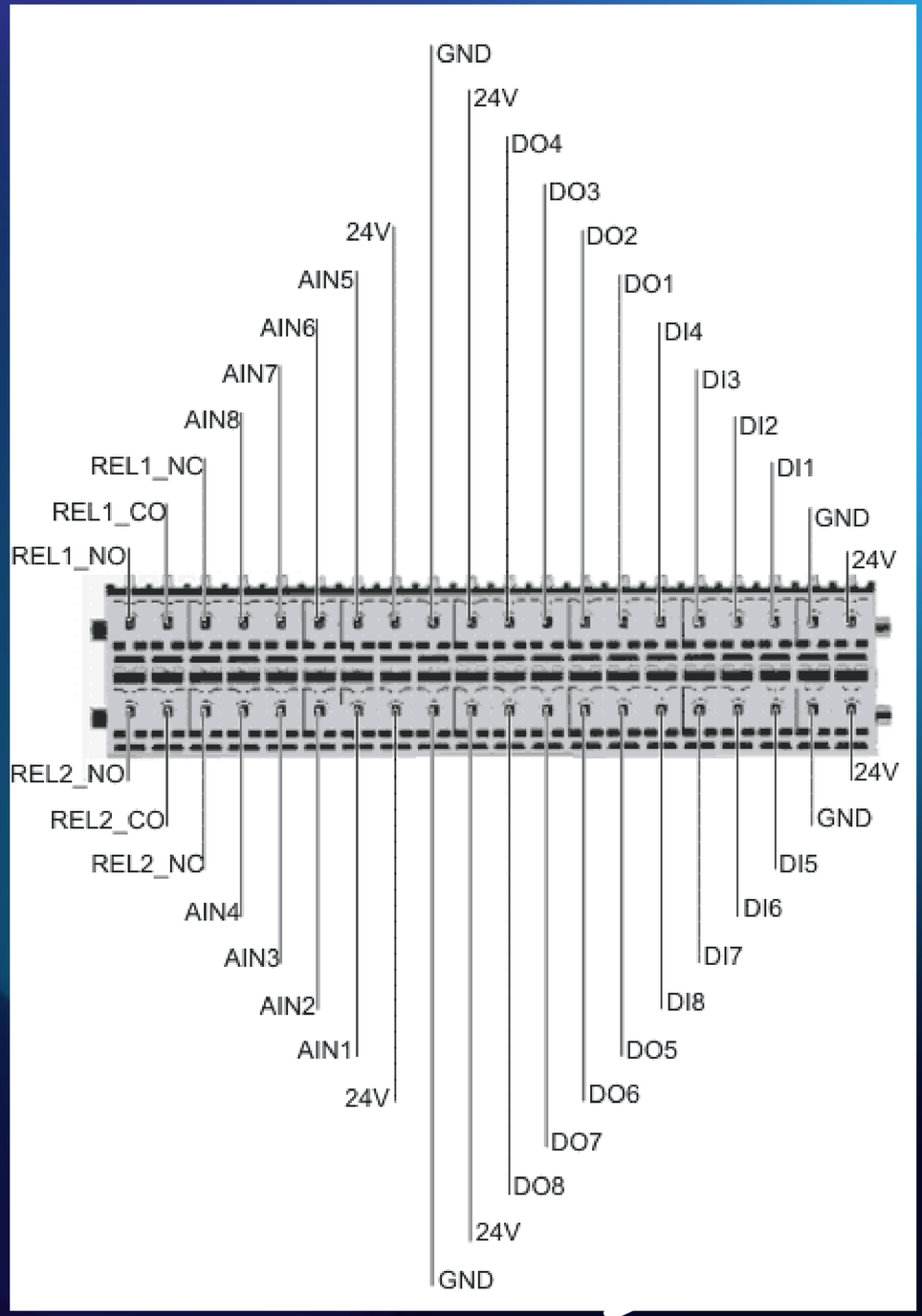
Optical line following

- The sensors should be connected to the DI0 and DI1 inputs of the input and output port of the Robotino®. The submodule can operate on a bright floor with a dark track or on a dark floor with a bright track



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Inputs and outputs of the submodules

- OCR
  - Inputs: grayscale image in JPEG format, Character Set File, text to be recognized.
  - Outputs: Recognized text in ASCII string format.
- Object detection by chromatic discrimination
  - Inputs: image, HSL parameters of the desired color, the minimum number of pixels.
  - Outputs: the desired color is found, the position of the center of mass, segmented image highlighting the group of pixels represented with the desired color.
- Optical line following
  - Inputs: State of the optical proximity switches.
  - Output: movement speeds for the Robotino®.

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Thank you!

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