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ROBOTIZED SERVING OF AUTOMATED WAREHOUSE – MOBILE ROBOT MOTION CONTROL

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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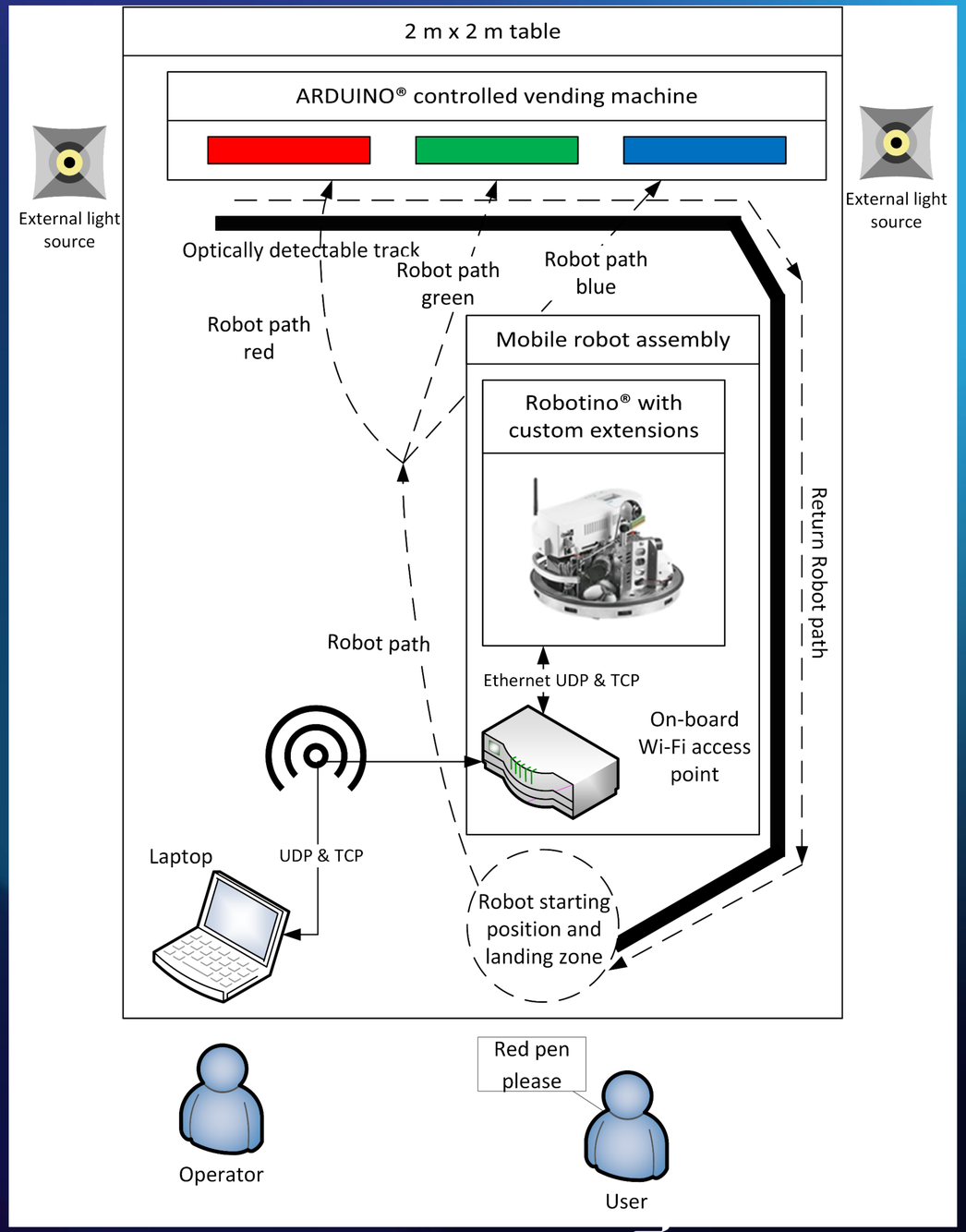
System design

- 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=Z2IuZW4uNTUwLjE3LjE4Ljg1OC40NzUy

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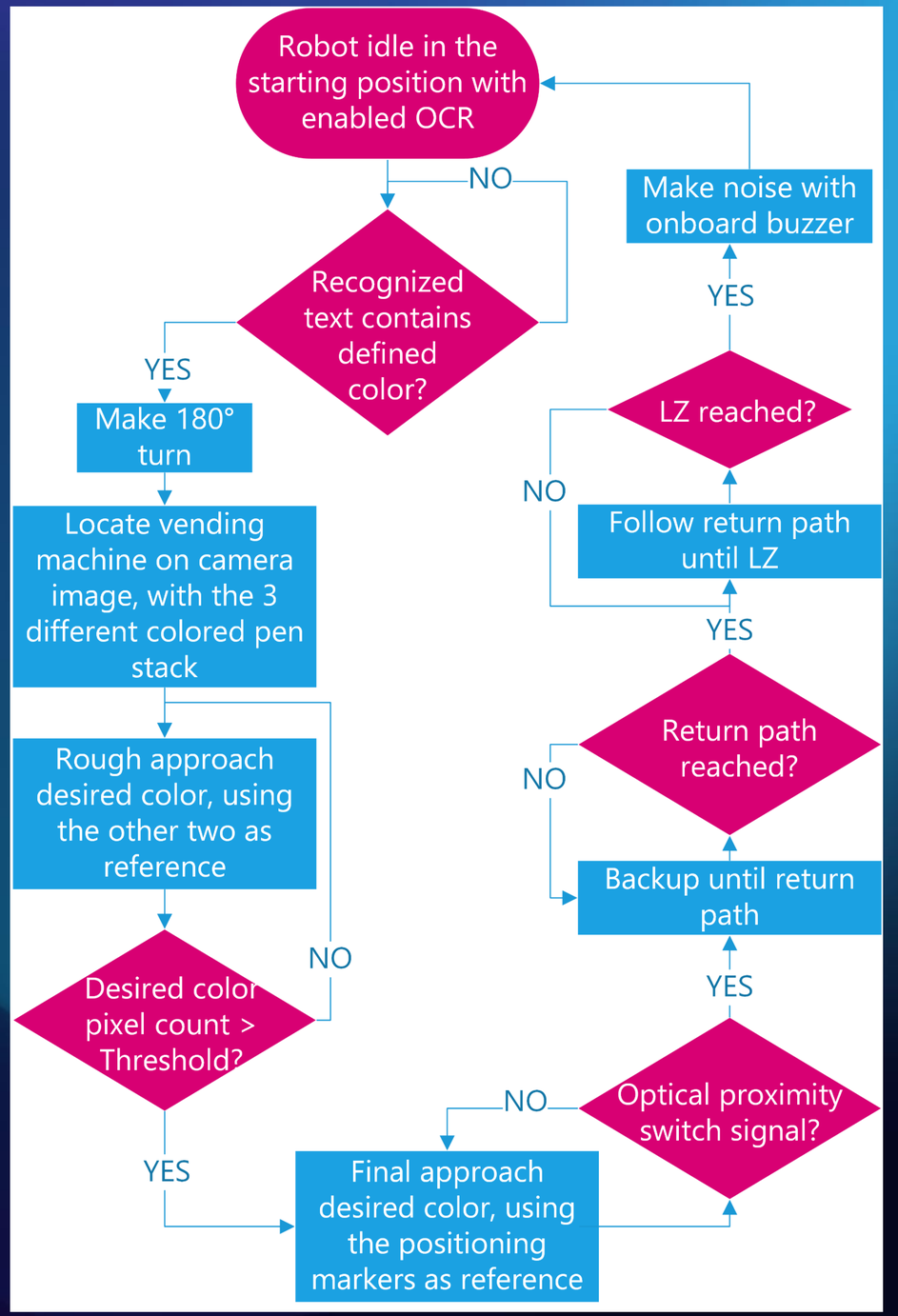
Software infrastructure

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



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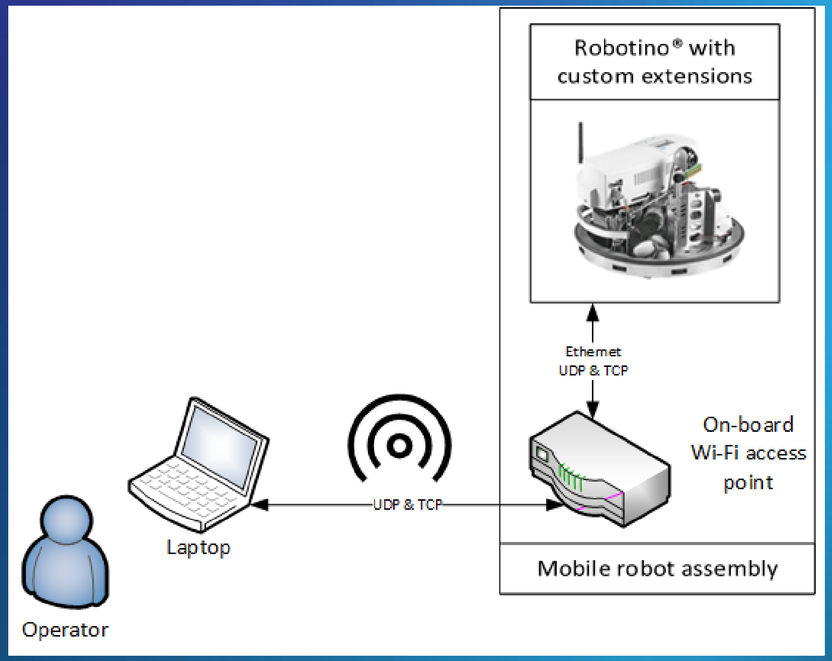
Cyber-security

- 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 two submodules, each performing different motion control tasks.
- The main functionality of the Open-loop motion control submodule is to perform different pre-programmed or time-controlled movement patterns.
- The main functionality of the Machine vision-based closed-loop motion control sub-module is to implement closed-loop motion control algorithms based on machine vision calculations executed on images.

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Requirements

- The Open-loop motion control submodule does not require any hardware.
- The Machine vision-based closed-loop motion control submodule requires the FESTO Robotino® v2 equipped with 3 optical proximity switches.
  - Two of them are the same optical proximity switches as in the Optical line following submodule.
  - One additional optical proximity switch is required to be mounted on the front of the Robotino® and connected to the DI2 input of the Robotino®.
  - The Machine vision-based closed-loop motion control submodule requires the Object detection by chromatic discrimination submodule.

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Inputs and outputs of the submodules

- Open-loop motion control
  - Inputs: rotational and linear speeds, the amount of time while the module is executing.
  - Outputs: movement speeds for the Robotino®.
- Machine vision-based closed-loop motion control
  - Inputs: image, HSL parameters of all objects to be detected, HSL parameters of the targeting markers, the minimum number of pixels, DI0:3 inputs from the Robotino®
  - Output: movement speeds for the Robotino®.

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Thank you!

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