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ROBOTIZED SERVING OF AUTOMATED WAREHOUSE

Budapest University of Technology and Economics (BME) Department of Mechatronics, Optics and Mechanical Engineering Informatics



TRINITY Use Case demonstration by BME

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Agenda

 Introduction System design Hardware infrastructure Software infrastructure Cyber-security Offered Modules



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.



System design

- Based on an omnidirectional mobile robot equipped with three omniwheels.
 - 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.



Hardware infrastructure

- FESTO Robotino[®]
- Uniquely designed parts
 - Workpiece tray,
 - ARDUINO[®] controlled vending machine,
 - Proximity switch holder,
 - proximity of the wending machine during the final approach.
 - Optically detectable path
 - Painted or glued tape.
- Commercially available parts
 - 4 m² 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/thehighlights.htm?fbid=Z2IuZW4uNTUwLjE3LjE4Ljg1OC40NzUy



Bent sheet metal part accommodating the workpiece during the wending process.

Bent sheet metal part holding in place a factory standard optical proximity switch accessory to detect the







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

	() () () () () () () () () ()
Control laptop security: if the laptop is online for any reason	Com
Wireless encryption	
Wireless router security key issue	MAC a
Interference caused to wireless communication	
DHCP service	Disabli
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	

Mitigation

npletely prevent control laptop internet access

Already has WEP, will be changed to WPA

ddress filtering on the wireless network. AP only accepts allowed MAC addresses

ng the DHCP server, only fix IP addresses will be allowed

Offered Modules

- architecture
- Robotino[®] communication
- Environment detection
- Mobile robot motion control

Queued Message Handler (QMH) software

Availability of Modules

- desktop application.
- Licensing
 - During TRINITY
 - GNU GPL v3 excluding LabVIEW
 - AfterTRINITY
 - For Open-Source projects
 - GNU GPL v3 excluding LabVIEW
 - For commercial applications

The Modules are available both in source code and as a standalone

Availability and usage are based on a commercial license agreement with BME.

Queued Message Handler (QMH) software architecture

 Organize the whole software in separate tasks and execute them in parallel at different execution rates Multilingual user interface

Queued Message Handler Template documentation available at http://www.ni.com/tutorial/53391/en/ Image Source: http://www.ni.com/tutorial/53391/en/

Robotino[®] communication module

qDSA protocol description available at https://wiki.openrobotino.org/index.php?title=Downloads#API.2C_Plugins_.26_Packages Legal disclaimer: Robotino® is a trademark of FESTO AG & Co. KG. This publication is independent of FESTO, which is not affiliated with the publisher or the author, and does not authorize, sponsor, endorse or otherwise approve this publication.

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

Environment detection module

 Optical character recognition (OCR) Recognize human readable characters from images

Environment detection module

• Object detection by chromatic discrimination

 Detect objects on an image based on their color

Environment detection module

Optical line following
Implement movement alg tracks on the ground

Implement movement algorithms along optically detectable

Mobile robot motion control module

 Open-loop motion control Perform different pre-programed or time-controlled movement patterns

trinity engage with AGILE MANUFACTURING

Mobile robot motion control module

 Machine vision-based closed-loop motion control vison calculations executed on images

Implement closed-loop motion control algorithms based on machine

Video

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Thank you!

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