Project proposal

Project Title:

Mobile Multi-Robot Coordination for Logistics Automation

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1. INTRODUCTION

It is common in factory warehouses that products are stored in rows of shelves, each row can contain hundreds of shelves, and human operators are in charge of moving the products to between designated locations, using machines such as forklifts. This process is repeated for every order that arrives to the company, and therefore requires big number of worker, consumes a lot of time and its efficiency is not guaranteed. Fig.1 illustrates the complexities in a typical warehouse.

Figure 1. A Typical Warehouse

One of the main goals of modern factories is to reduce the costs of these logistic tasks using automation technology. In addition, automation, improves reliability and productivity of the factory logistics. The main objectives of any inventory management system are to keep inventories low and deliver products with short response time. It is impossible for big enterprises to do this without a computerized system, but some actions are still carried out by human operators. Therefore, to be really competitive, leading companies are implementing fully automatic systems in which there is no human interaction and all tasks are fulfilled by intelligent robots.

2. PROJECT DESCRIPTION

Industrial automation is a new but very fast growing technology. There is no single solution for an automation problem; there are several options available with different degrees of flexibility,

which enable fast adaption to changes in the process. This project is an attempt to prototype a small warehouse with input and output materials which will be handled by a mobile multi-robot system, considered to be the most versatile automation tool. As showen in fig.2 the mobile robots are part of the FESTO Prolog Factory, a training platform for logistics, communication technology, mechatronics, robotics and industrial engineering. It has three main parts that are: 1) A Production Line 2) a Picking Station and 3) a Logistic Field. The whole system is planned to operate to efficiently process Customer Orders.

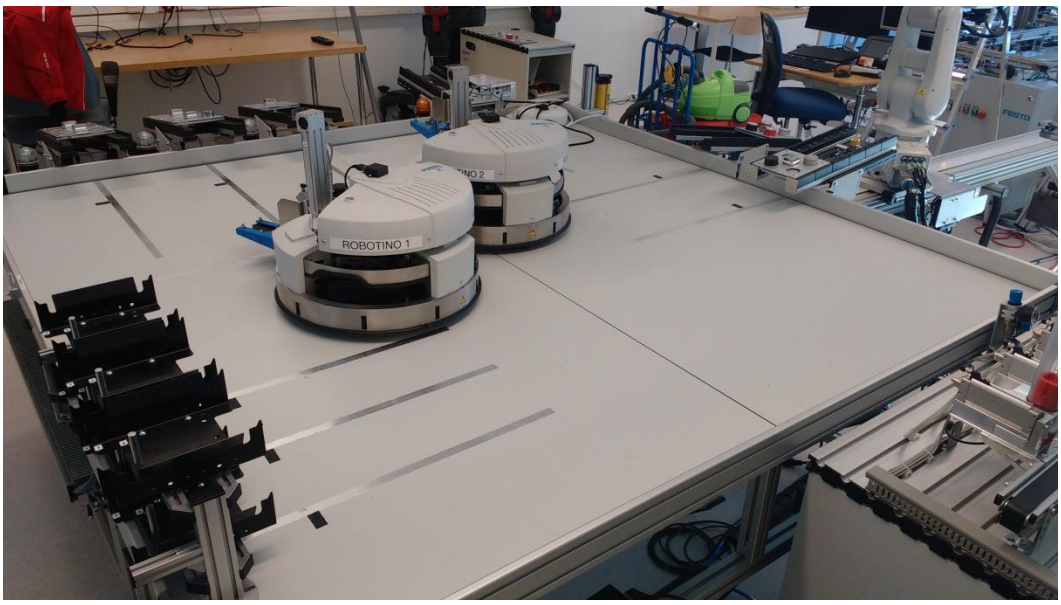


Figure 2. Logistics area of FESTO Prolog Factory

The project will be carried out in the AIC3 lab at the Luleå University of Technology. This lab integrates three different automation domains as: the control flow of production plants, building automation systems, and energy distribution infrastructure. For this project the main domain is the control flow of production plants as a part of factory automation system. The lab includes a model of robotized discrete manufacturing and logistics (FESTO Prolog Factory).

Figure 3. Robotinos

In this project we will only focus in the Logistics area of the FESTO Prolog Factory, where the mobile robots move the pallets coming from the Picking Station, to storage shelves. This work will be fulfilled by the Robotino robots. The Robotino are autonomous mobile robots that have been tested in competitions: they participated in the RoboCup and the WorldSkills where the challenges lie in finding intelligent solutions to problems in logistics automation domain. They are equipped with a telescopic fork and operate like forklift trucks to reach all positions in the warehouse, but other equipment are also available depending on the task they are in charge of performing.

Another important component of the system is the PLC that would be connected to the I/O controllers and the communication modules. The I/O controller will received signals from the sensors in the warehouse, inside the storage shelves and in the places where the pallets enter the logistic area and leave it. It will also activate some lights for human operators to check that the signals are correct and the process has not encountered any problem. There is also a communication module that integrates Profibus DP and WLAN so it can send information wirelessly to the robots. Fig.4 shows the PLC's platform comprising of I/O and communications units.

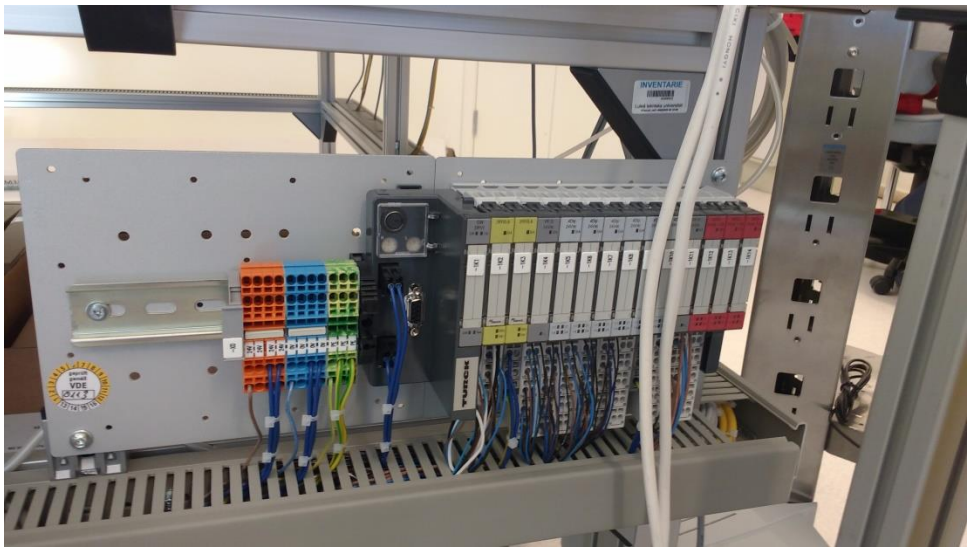


Figure 4. PLC spot with I/O and communication controller

As shown in fig.5, at the input/output units of the storage system, appropriate sensors are installed that give information about the current state of the pallets. In the input the system has to check if the pallet is ready to move forward, as it will be displaced to the position where the robot can lift it by the inclination of the trail. Similarly the Output rails have installed the same kind of sensor with the addition of a warning light and a different inclination of the rails.

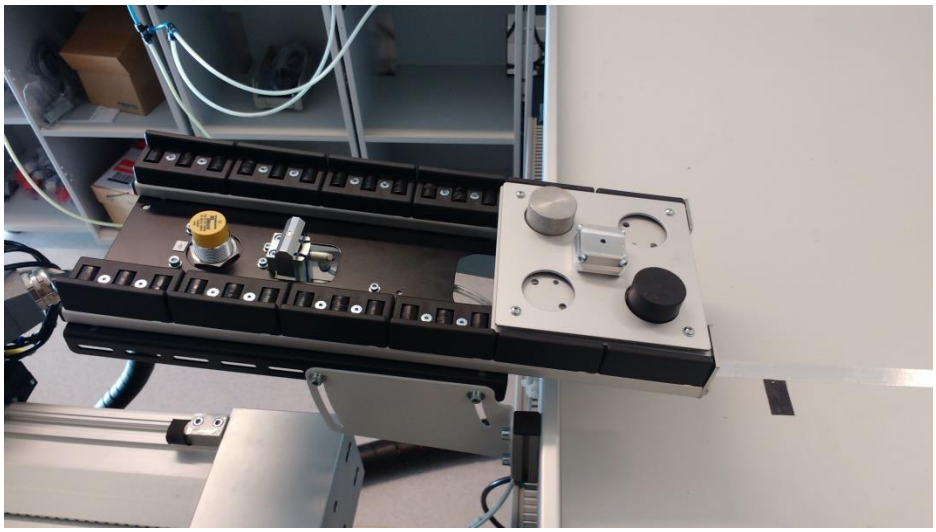


Figure 5. Output of the Picking station, input to the system

As shown in Fig.6, in the storage shelves, there is one sensor installed for sensing each cell, but in a real automated warehouse there could be other type of information about the state of the material saved, as weight, temperature or humidity.

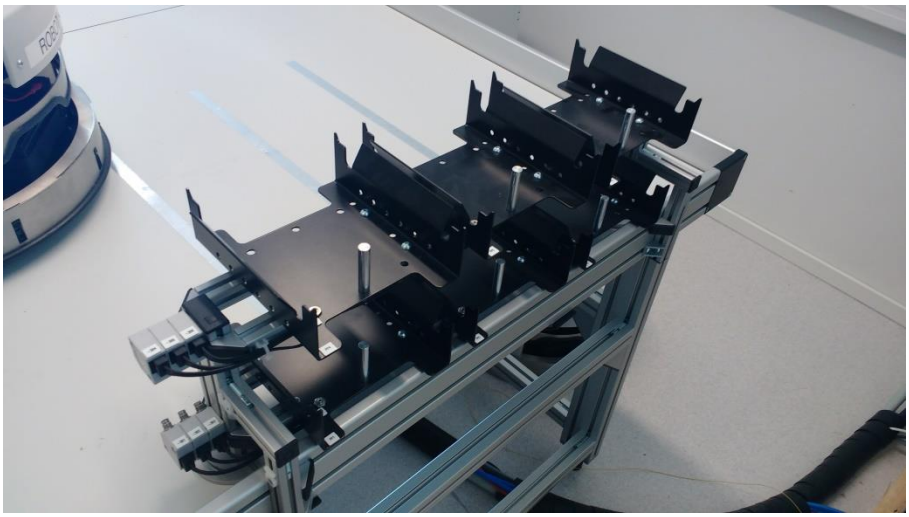


Figure 6. Storage containers

3. MAIN GOAL

The main goal of the project is to prototype an automated warehouse, utilizing coordinated mobile multi-robot system. There will be two robots in the system, one in charge of taking inputs and storing them in the warehouse, and the other for picking the material from the storage and carrying them to the output rails. In coordinating their tasks, the robots must communicate with the inventory management system which is in charge of the orders, as it can read the information from all sensors in the warehouse. The robots will start from initial position and go to the input station indicated by the system. Using appropriate coordination and communication models, the inventory management system will schedule tasks to prevent collisions between the robots. All this work will be carried out in a protective environment, a table designed for education with stripes indicating the rout to the different stations for the robots, AGV, to achieve destination precisely.

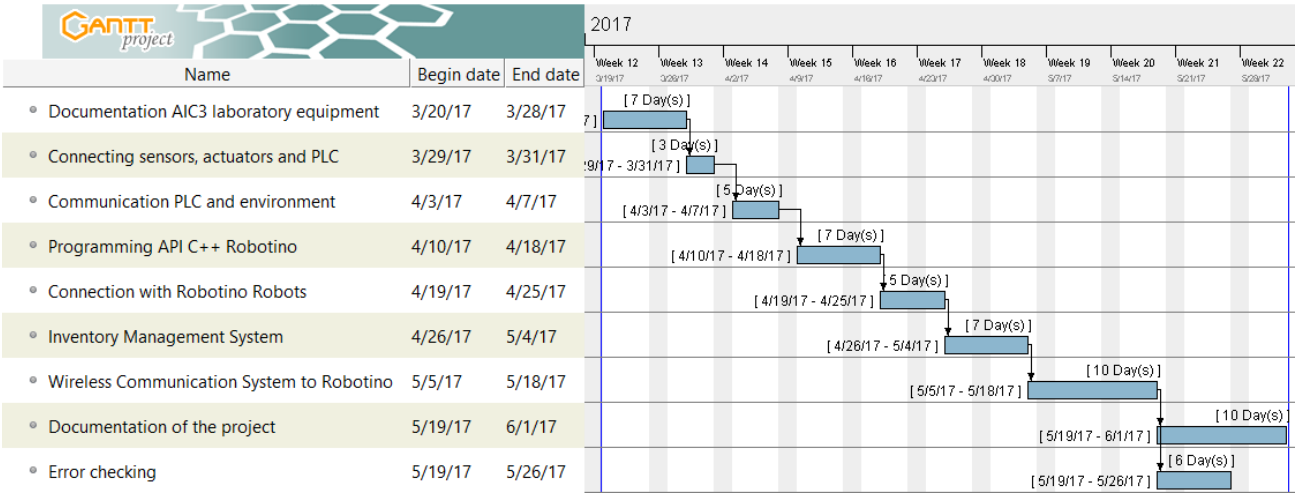
4. OBJECTIVES

- To develop environment monitoring system: the inventory management system needs to read the information from the sensors in the prototype warehouse.
- To develop control programs for Robotino robots; enabling them to move in the right directions, follow the paths and pick and place materials precisely.

- To develop communication model: between Robots, Warehouse, Input/output units etc.
- To develop appropriate coordination and planning model to coordinate the tasks such as storing, task allocation, collision avoidance etc..

5. SCHEDULE AND TIME LINE

The work is planned for one student in 10 week, starting in March 2017 and ends in May 2017. To schedules the work a Gantt chart has been created with the main tasks.



The first weeks will be to set up the Logistic Field of the FESTO Prolog Factory, for which all the documentation should be read in advance to make the actual connections. Once all sensor and actuators are connected to the system and the PLC is available, we will start by reading the data and doing the proper checks with pallet loads.

The last component missing would be the Robotino, for which a C++ API is available at the Robotino Wiki: http://wiki.openrobotino.org/index.php?title=Main_Page. With this library we should be able to command the Robotino some simple task, and those same commands will be later send by wireless communication.

Now the Inventory Management system should be set up, so it can acknowledge incoming materials, store them in a logic way, and tag them for retrieving them later by the orders of the costumers. Finally we can try to join and coordinate all the tasks together for obtaining the final

system. Afterwards we can finish the documentation of the project and some minor mistakes that can be improved.

6. EVALUATION OF THE PROJECT

The outcome of the project will be evaluated based on the objectives of the project. An automation scenario has to be developed and implemented for this purpose. The multi-robot coordination will be tested against the conditions and the requirements of the scenario. The results will be evaluated based on factors such as accuracy, task completion time and collision avoidance.