

AN AUTOMATED GUIDED VEHICLE SIMULATION THROUGH ROBOTINO TO HELP LEARNING COURSE INDUSTRIAL AUTOMATION

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ABSTRACT

This paper presented a simulation of automated guided vehicle works using Robotino®. The vehicle is a battery-powered material handling that uses independently operated, self-propelled vehicles guided along defines pathways. Robotino® is a commercially available mobile robot from Festo Didactic. It is used for both education and research; it features omnidirectional base, bumps sensors or anti-collision sensor, infrared distance sensors and a color VGA camera. Laboratory of Production Manufacturing and Automation is one of the laboratories in Telkom University which skill developing competency to serve the students to be understands all about the automation things in learning course industrial automation.

Key words: automated guided vehicle, Robotino® simulation, industrial automation.

1. INTRODUCTION

The ability of a manufacture to create a production process that is effective and efficient will affect the volume of production, reduce production costs and increase profitability. One of the factors that can influence the effective and the efficient in the production process is the selection of material handling. Material handling is indispensable in the manufacturing process. Material handling is the function of moving the right material to the right place, at the right time, in the right amount, in sequence, and in the right position or condition to minimize production cost (Meyers, 1993).

The selection of material handling is very critical in the process of manufacturing. The selection of unappropriated material handling equipment will disrupt the production process time. Furthermore, the unappropriated of selection the material handling will cause the increasing of the cost. There are four material handling that usually use in the manufacturing, i.e., Industrial trucks, automated guided vehicles, conveyors, and cranes and hoists (Groover, 2001).

An automated guided vehicle (AGV) is a battery-powered material handling that uses independently operated, self-propelled vehicles guided along defines pathways. It

usually used to move palled loads in manufacture or warehouse and moving work-in-process along variable routes in low and medium production. The advantages are battery-powered vehicles, flexible routing, and no obstructive pathways, but it has disadvantage is high cost.

Study about automated guided vehicle in warehousing is quite important in the manufacturing system, because it is expected to face the problem of warehousing in this modern era. Because of that, there should be a study for students, especially industrial engineering, so when they go into world of warehousing they can use their knowledge according to the needs of companies.

Laboratory of Production Manufacturing and Automation is one of the laboratories in Telkom University which skill developing competency to serve the students to be understand all about the automation things in the manufacturers, such as: automation system of material handling; automatic tools machine; feedback control system; computerized system for data collection, planning and decision-making to support manufacturing activity.

To learn the automation system, certainly, need a tool. These skill development centers already have learning tools from Festo-Didactic, PLC OMRON,

PLC Siemens, etc. The learning tools from Festo that already owned are: pneumatic, electro-pneumatic, Robotino®. But these skill development centers still do not have a learning module for learning the automated guided vehicle. Based on the above issues, this paper presented about the simulation of AGV using Robotino® in Inspira Automation Telkom University.

The simulation is conducted as a material for studying about AGV. It programmed similar with how AGV work where designed to carry the product based on its color and put it in a place that have been determined, then it followed the pathway when carrying the product. There are six types of AGVS consist of towing vehicle, load transporter, pallet truck, forklift truck, light-load transporter, and assembly-line vehicle (NCHU, 2014).

Robotino® is a commercially available mobile robot from Festo Didactic. It is used for both education and research, including competitions like RoboCup. It features omnidirectional base, bumps sensors or anti-collision sensor, infrared distance sensors and a color VGA camera. The design of Robotino® is modular, and it can easily be equipped with a variety of accessories, including sensors like laser scanners, gyroscopes, and the Northstar indoor positioning system (KWC, 2014).

Based on the basic element of automation, there are three basic element of Robotino, i.e. battery, Robotino view, and cOntrol unit. Battery is a basic element which used to operate multiple processes in driving and controlling all the components in the Robotino® system. Robotino® uses two rechargeable batteries 12 V as the main power. Robotino® View is an element that is used to program the work process of Robotino®. Control Unit: an element which is the brain of the Robotino® system and serves to regulate the overall work process.

2. ROBOTINO HARDWARE AND SOFTWARE

Robotino® is fully functional, high quality mobile robot system with omnidirectional drive. It has motion to all directions, i.e. forward, backward, and sideways, and it can

be turned on the spot as well. The three omnidirectional drive are mounted at an angle of 120° to each other (Weber & Bellenberg, 2010).

The drive unit consist of five components consist of dc motor, incremental encoder, all-way roller, gear unit with a gear ratio of 16:1, and toothed belt (Weber & Bellenberg, 2010). Rechargeable battery or secondary battery are characterized and have the ability to be recharge by power density, high discharge rate, flat discharge curves, and good low-temperature performance.

The energy densities of secondary batteries are generally lower than primary batteries. The charge retention of secondary batteries also is poorer than most of the primary batteries, although the capacity of the secondary batteries that is lost on standing can be restored by recharging (Linden & Reddy, 2002). Robotino® is powered by two rechargeable 12 V batteries with a rating of 4 Ah. Both of those batteries are mounted to the chassis. Robotino® is supplied with 2 additional batteries and a battery charger (Weber & Bellenberg, 2010).

A camera is a device which used to transfer an image onto either a sheet of film or a space on a digital hard drive. It does this by collecting light that is reflected off an object and then creating a copy of an image on whatever storage device the particular camera uses. There a number of different of types of camera, some of which capture still images while others focus on moving images (Orwell, 2014). Robotino® is equipped with a camera system. The height and the inclination of this camera can be adjusted.

The camera make it possible to display live images with the help of Robotino® View. Robotino® View also offers a number of image processing options, which can be used to evaluate camera images of the Robotino® controller. A segment locates surfaces of like color within a given image, and can determine the position and size of any segment. Lines in video images can be detected. Results can be utilized for pinpointing objects, as well as for path and object tracking (Weber & Bellenberg, 2010).

Sensor is a device that detects and responds to some type of input from the physical environment. The specific input

could be light, heat, motion, moisture, pressure, or any one of a great number of other environment phenomena. The output is generally a signal that is converted to human-readable display at the sensor location or transmitted electronically over a network for reading or further processing. (Rouse, 2014).

Robotino® is equipped with nine infrared distance measuring sensors. This sensor is used to determine the distance object from Robotino®. These sensors are mounted on the chassis at an angle 40° to one another. Each sensor can be queried individually via the I/O circuit board. With this sensor, Robotino® can avoid any obstacle around it. Sensor connection is especially simple including just one analogue output signal and supply power. The sensor's evaluating electronics determine distance and read it out as an analogue signal (Weber & Bellenberg, 2010). It can be seen at Figure 1.

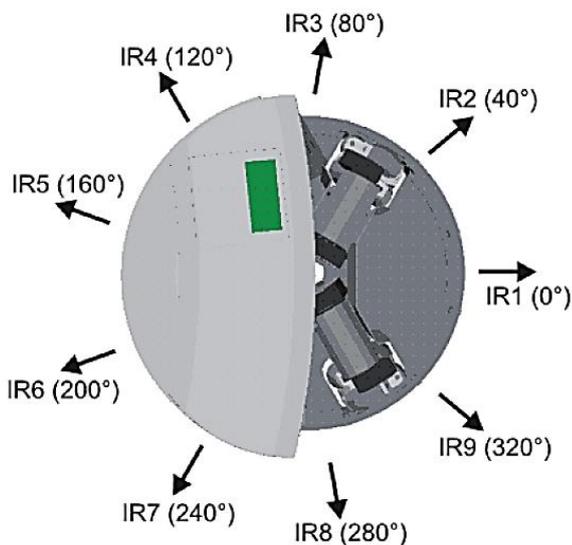


Figure 1. Distance sensors of Robotino®

Incremental encoder is used to measure the actual speed of each motor in RPM (revolutions per minute). With software Robotino® View, the actual motor speed can be adjusted by using PID controller whose parameters are configured in this software. So if the actual motor speed deviates from the set points, it can be configured using Robotino® View (Weber & Bellenberg, 2010).



Figure 2. Three unit sensors of Robotino®: (1) incremental encoder, (2) anti-collision sensor, and (3) distance measuring sensor

Anti-collision sensors are used to keep the Robotino® from collision. The anti-collision sensor is consisting of a switching string. This switching string is secured around the entire circumference of the chassis (Weber & Bellenberg, 2010). It can be seen in Figure 2. The function of control unit is to control all of the equipment. It can also set when is the input device receives the data and process the data. Thus all commands can be performed sequentially without any overlap between one command and the other command.

The controller unit can be set up flexibly through the use of plug-in modules. The Robotino® controller unit consist of three components (Weber & Bellenberg, 2010), i.e. PC 104 processor, compatible with MOPSIcdVE, 300 MHZ, and Linux Operating system with real-time kernel, SDRAM 128 MB, compact flash card with C++ API for controlling Robotino®, and wireless LAN access point. Robotino® View is a software that created by Festo for programming Robotino®.

Robotino® View is the interactive, graphic programming environment for Robotino®. With Robotino® View, control program can be created and executed (Festo, 2014). Figure 3 demonstrated a Robotino® view. There are eight functionality of Robotino® View:

1. Sequencing programs are displayed as GRAFCETs.
2. Simultaneous control of more than one Robotino®.

3. Representing of hardware components as function blocks, such as: Motor, I/Os, sensors, camera, odometry, gripper, manipulator, power output, shaft encoder input.
4. Function blocks for navigation: position navigator, distance navigator, obstacle avoidance.
5. Function blocks for data exchange: UDP, TCP/IP client/server, OPC.
6. Download and start Robotino® View programs directly at Robotino®.
7. Creation and integration of individualized function block in C++.
8. User interface and user help in German, English, Spanish, and French.

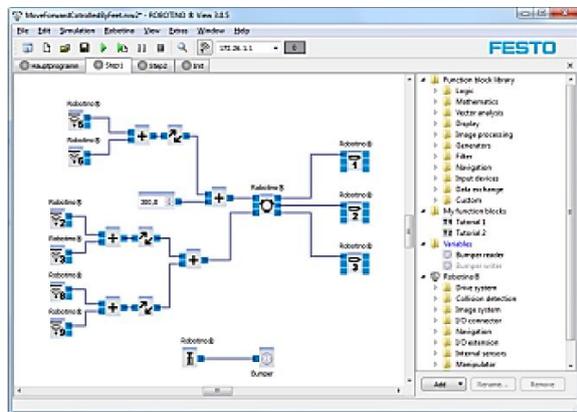


Figure 3. Robotino® view

3. RESEARCH METHOD

The role of Robotino® as a material handling is to moving the material into the right place. The material will be moved from the sorting workstation to the designated place. To move from one workstation to another workstation, Robotino® will move using an inductive line as a guidance. Scenario process is the flows of the process that will be perform by the AGV. This scenario process depends on the type of AGV application that will be made and the ability of the processes conducted by the AGV, and will affect the design of the program that will be made.

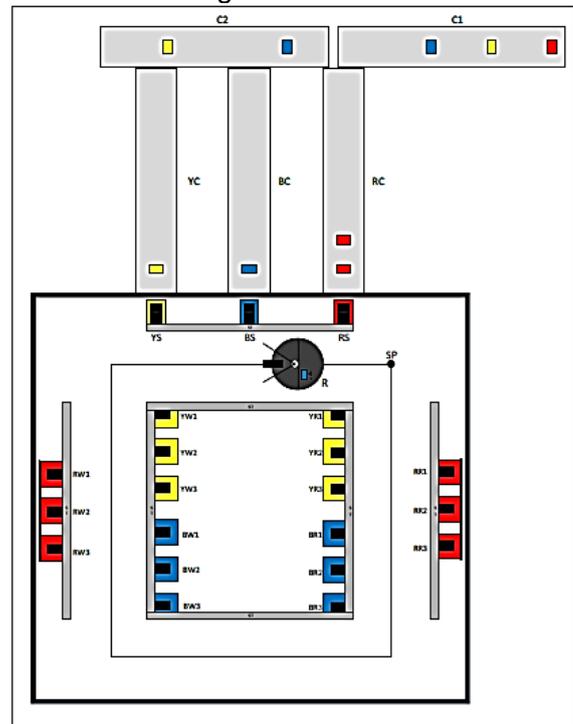
The example of the scenario process can be seen in Table 1. Arena is necessary to run the scenario that has been made. Arena will be designed to be able to meet the criteria of scenario that have been made.

Figure 4 is explained about the desire arena that will be building.

Table 1. Scenario process

Scenario	Pick Up Material From	Put Down Material To
1	Red Slider	Red Workstation 1
2	Red Slider	Red Workstation 1
3	Red Slider	Red Workstation 1
4	Blue Slider	Blue Workstation 1
5	Blue Slider	Blue Workstation 1
6	Blue Slider	Blue Workstation 1
7	Yellow Slider	Yellow Workstation 1
8	Yellow Slider	Yellow Workstation 1
9	Yellow Slider	Yellow Workstation 1

Figure 4. Arena



There are 29 components that will be placed; it can be shown in Table 2. Based on Figure 4, there are nine scenario processes can be breakdown become nine figures for each workstation. Scenario

process picks up red material from red slider and put down the material to red workstation 1. It can be seen that from start point Robotino® will move forward to red slider to pick up red material. After that it will transport it through inductive line and will put down red material to red workstation 1. The distance is 280 cm, and so on.

Table 2. Components of the arena

Code	Means
SP	Start Point
R	Robotino®
C1	Conveyor 1
C2	Conveyor 1
RC	Red Conveyor
BC	Blue Conveyor
YC	Yellow Conveyor
RS	Red Slider
BS	Blue Slider
YS	Yellow Slider
ST	Sensor Trigger
RW1/2/3	Red Workstation 1/2/3
BW1/2/3	Blue Workstation 1/2/3
YW1/2/3	Yellow Workstation 1/2/3
RR1/2/3	Red Rack 1/2/3
BR1/2/3	Blue Rack 1/2/3
YR1/2/3	Yellow Rack 1/2/3

4. RESULT AND DISCUSSION

After running the simulation, Robotino® can finding the inductive line and it can move to the slider to pick up the material. After pick up the material, Robotino® move to the workstation to put down the material. Picking and putting the material is based on the color of material. To determine which color that will be taken, can be seen in Figure 5.

Figure 5, is the result of taking the desired color of red material. After capture the image of the material, the value will come out automatically. This program will automatically find the material with range of hue from 20 until 3480, range of saturation is from 47% until 78% and value from 36% until 52%. If the Robotino® cannot detect the color of material within that range, so it will try to find the red material within those ranges for 2499.99ms.

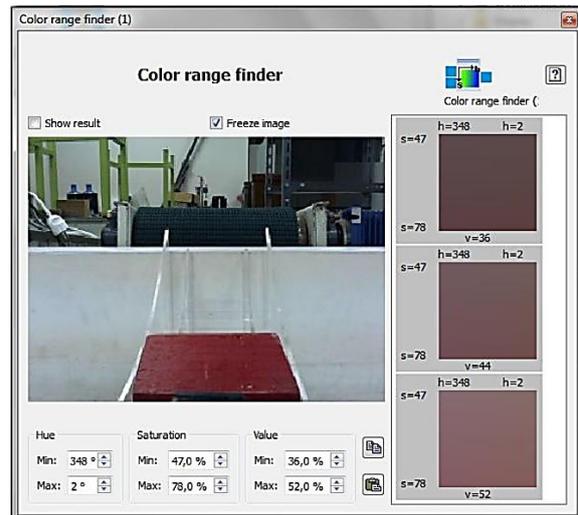


Figure 5. Detect red material

Table 2. Transport time

Scenario Process	Distance (cm)	Time (s)
Pick Up Red Material from Red Slider to Red Workstation 1	280	30.00
Pick Up Red Material from Red Slider to Red Workstation 2	297	30.85
Pick Up Red Material from Red Slider to Red Workstation 3	314	31.70
Pick Up Blue Material from Blue Slider to Blue Workstation 1	176	24.80
Pick Up Blue Material from Blue Slider to Blue Workstation 2	193	25.65
Pick Up Blue Material from Blue Slider to Blue Workstation 3	210	26.50
Pick Up Yellow Material from Yellow Slider to Yellow Workstation 1	70	19.50
Pick Up Yellow Material from Yellow Slider to Yellow Workstation 2	87	20.35
Pick Up Yellow Material from Yellow Slider to Yellow Workstation 3	104	21.20

To know the optimum time for each process, assume that all of the processes run correctly. It can be seen in Table 2. It can be seen that process pick up yellow material from yellow slider to yellow

workstation 1 is the fastest among the others. It is because of the distance itself. That process has the shortest distance among the others. It is different with process pick up red material from red slider to red workstation 3. This process has the longest distance and has the longest time.

5. CONCLUSION

The navigation system for Robotino® is using inductive line as a guidance. The use of inductive line is to ensure that Robotino® can transport the material in accordance with the predetermined line. Robotino® can successfully move from one workstation to another workstation using inductive line as a guidance.

To pick up the material by its color, Robotino® will move to the slider to detect the material on the slider using webcam. When it can detect the material on the slider based on its color, and then it will activate the gripper. After that the material will be gripped by the gripper.

To put down the material, sensor Distance 1, 3, and 8 of Robotino® will detect the distance of the wall to make sure Robotino® can stop right in front of the workstation for each material. After Robotino® stop in front of the workstation, then it will rotate facing the workstation. After that Robotino® will move forward approaching the workstation.

When Robotino® is has reached the specified distance, and then it will stop and activated the gripper to open. And then the gripper will release the material. To be able to move on the inductive line, Robotino® can use speed below than 300mm/s. Because within that speed, Robotino® still can be controlled so it will not move out of the inductive line.

Sensor Distance #2 and sensor Distance #9 are used as a safety for Robotino® to remain on the inductive line. Sensor Distance #2 will make the Robotino® rotate to the right when it can detect an object within a specified distance, while sensor Distance #9 will make the Robotino® rotate to the left when it can detect an object within a specified distance.

So it will make the Robotino® remain on the inductive line. The priority picking is used because with using Robotino® View, Robotino® cannot figure out which is material that first arrived. Because of that, Robotino® will check in every slider whether there is a material or not. If during the process of detecting material Robotino® can detect the material, so it will move forward to pick up the material. And if during the process of detecting material Robotino® cannot detect the material, so it will move to the another slider. The process of detecting material is based on its color.

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