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Contactless control system design for automatic guide vehicle (agv) based on depth camera

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Abstract. In early 2020, Chinese authorities announced news of an outbreak of a disease affecting the respiratory function. The outbreak came to the attention of the world community after in January 2020, health authorities in Wuhan City, Hubei Province, China, said there were patients who died after suffering from pneumonia caused by the virus. The new type of coronavirus that is attacking the world community today, in medical terms is called the 2019 Novel Coronavirus (2019-nCoV). In August 2020, Indonesia became the country with the highest death rate in Asia. However, to maintain economic stability, the government launched the New Normal activity. All activities can be carried out by implementing health protocols, including maintaining distance, washing hands and wearing masks. In the New Normal phase, several technologies are needed to prevent the spread of the virus. One of them is a contactless control technology. In this paper, a contactless control system for an Automatic Guide Vehicle (AGV) is developed. AGV is designed using a tricycle drive system and can be used to carry goods. Using a depth camera, the AGV is programmed to be able to follow human movements without marking or direct contact. The development of the system can be implemented in a broader field, such as supermarkets, airports, government offices, etc.

1. Introduction

In early 2020, Chinese authorities announced that there was an outbreak of a disease that attacks respiratory function. The outbreak came to the attention of the world community after in January 2020, health authorities in Wuhan City, Hubei Province, China, said there were patients who died after suffering pneumonia caused by the virus [1]. The new type of coronavirus currently attacking the world community is known in medical terms as the 2019 Novel Coronavirus (2019-nCoV) [2] [3]. The coronavirus is a type of virus that has been identified as the cause of respiratory disease, which was first detected in Wuhan City, China. The 2019-nCoV virus is known to have first appeared in an animal and seafood market, Wuhan City. It is reported that many patients suffering from respiratory problems are closely related to the animal and seafood market in Wuhan City. The first patient to fall ill with the 2019-nCoV virus was also known to be a trader in the market.

The disease outbreak caused by the 2019-nCoV virus is growing so rapidly that the WHO has categorized this outbreak as a pandemic [4]. In Indonesia, as of 24 March 2020, there were 686 patients who tested positive for the 2019-nCoV virus with 55 cases dying [5]. This made the government extend the disaster period of the Coronavirus outbreak until the end of May 2020 [6]. Various efforts have been made by the Indonesian government, such as: opening emergency hospitals, implementing social

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distancing, and preventing viruses by spraying massive disinfectants. Disinfectant spraying is carried out using the aid of a fire engine or using a spray device [7]. Spraying of disinfectant is carried out on public roads and public spaces.

With the rapid spread of the 2019-nCoV virus through droplets or direct contact, this study developed a contactless control system for wheeled robots. The robot is designed with a 3 wheel drive system[8]. Depth image sensors (depth sensors) are used to detect human positions. With the system created, the robot can be controlled to follow human movements[9]. The top of the robot can be used to carry goods thereby minimizing human contact with objects. The output of this research is expected to contribute to the handling of disease outbreaks caused by the 2019-nCoV virus.

2. Related Work

Research in the field of human-robot interaction includes research on humanlike motion robots [10]. Research in this area discusses how to control a manipulator robot so that it can move to mimic human movements. In 2010, Panagiotis K. and Kostas J.K. control the movement of the robotic arm using EMG signal processing attached to the human arm. In 2011, they perfected the research by using the regime-switching method so that control could be done in real-time. In addition to using EMG, controlling robot arm motion based on human movement can also be done using the stereo-vision method [11]. 2 cameras installed at a certain distance to produce 3-dimensional data from human hands. This data is then processed to move a robotic arm with 6 degrees of freedom. Further developments, after Microsoft released the Kinect RGB-D camera sensor in 2010, several researchers used it for gesture sensing systems [12][13][14]

Based on the use of sensors, motion-sensing systems are divided into 5 types: sensing using electric, optical, acoustic, magnetic, and mechanical sensors. Based on the types of objects that are recognized, motion-sensing systems are divided into 4 types: based on sensor location, illumination, objects and humans, and special needs. The results of the design of the motion itself consist of: dynamic/static motion, heterogeneous/homogeneous, 2D / 3D. With the development of the RGB-D camera sensor, motion sensing with output data in 3D can be done using only 1 sensor. Previously, motion detection based on image data had to use more than 1 camera.

AGV is a mobile robot that can move automatically without using an operator. In its movement, AGV uses a depth camera as a sensor to read movements and direct it according to the user's wishes. The movement of the AGV is determined from the combination of sensor readings and a software program that will be implemented on an AGV drive which is usually a wheel or leg. In the manufacturing sector, AGV has been widely used in the distribution process. AGV has a function similar to lift-trucks, which functions to deliver goods from a location to a specific location. The AGV used in this final project consists of 3 wheels, 2 front wheels act as driving wheels, and 1 rear wheel as turning wheels.

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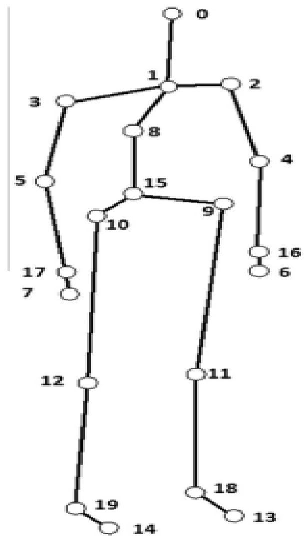

Figure 1 Skeleton data

3. System Design

3.1. Hardware Design

The robot is designed with a tricycle drive system. The front-drive uses 2 PG36 motors. For directional control, a standard servo with a torque of 25 kg is used. The Kinect sensor is installed on the robot's body in a position about 1m above the floor. This position is adjusted to the average human height (about 170cm). A laptop is installed at the bottom of the robot as the main controller. The AGV robot design is shown in Figure 2.

To be able to control the actuator, an ATMega328 microcontroller is connected to the laptop. ATMega328 is an 8-bit microcontroller with a maximum clock of 16MHz. The microcontroller is responsible for translating the instruction data from the laptop to PWM pulses for the PG36 servo and motor. BTS 7960 module is used as a PG36 motor driver. The sensor power supply and the driving motor use a 3S lipo battery respectively. For the microcontroller power supply using a 5v voltage derived from the 2S lipo battery. The microcontroller is connected to the PC using serial communication. The schematic of the circuit used in the AGV is shown in Figure 3.

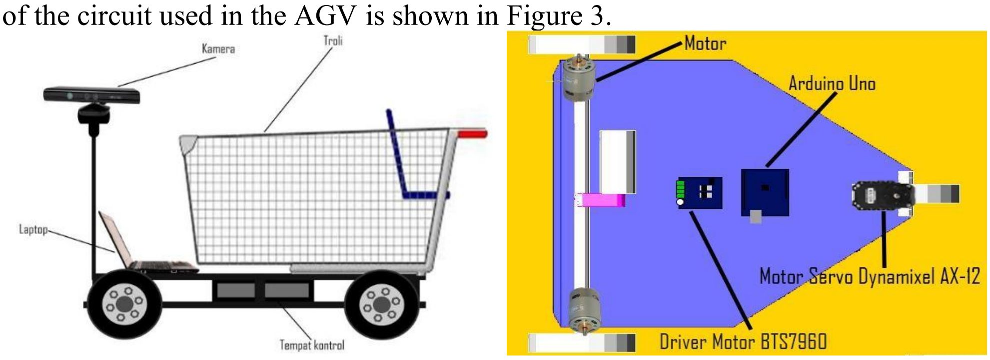

Figure 2. Robot design

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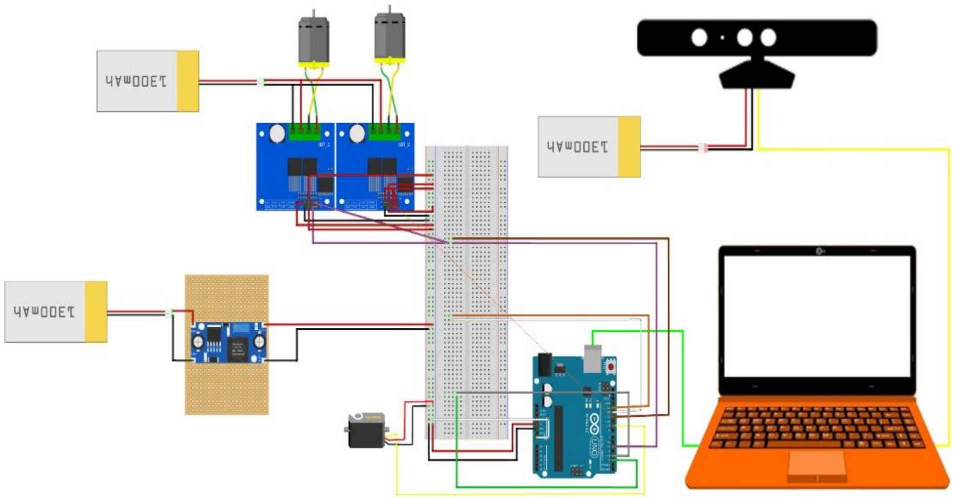

Figure 3. Diagram Block System

3.2. Software Design

There are 2 programming languages used in software design. The first is the use of Visual Basic for Kinect data processing. The Kinect sensor provides 3-dimensional coordinate data on each joint of the body. The coordinate data is in pixels (x, y) and centimeters (Z). In this study, the shoulder center joint point was used as the setpoint value. The data is then processed into the servo working angle and motor speed. The mockup design for the application is shown in Figure 3.

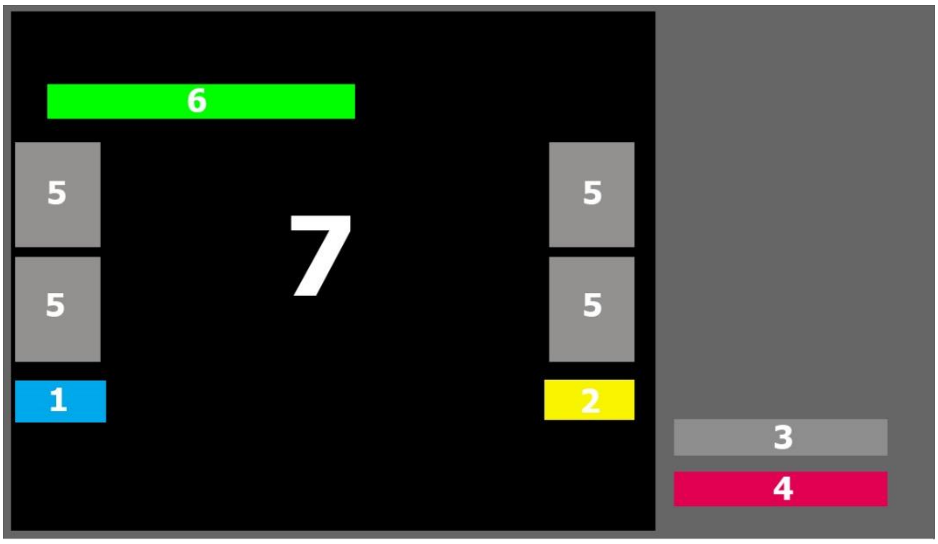

Figure 4 Mock-up GUI

The second is programming the Arduino IDE for microcontrollers. The microcontroller converts the data sent by the PC into PWM data for the servo and motor drivers. The data protocol sent by the PC is shown in Figure 5. The data is a combination of data on the direction of rotation and speed of the PG36 motor and the working angle of the servo. Furthermore, the data is broken down into 5 variable values by the microcontroller. The programming flowchart for the microcontroller and PC is shown in Figure 6.

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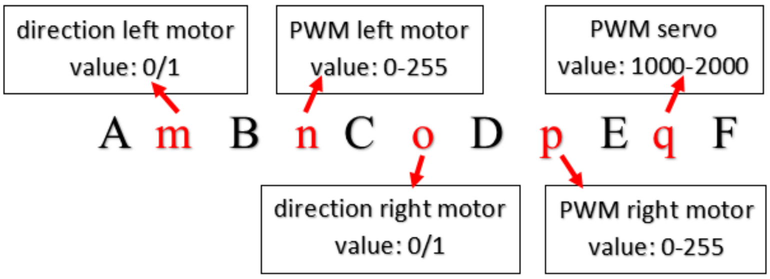

Figure 5. Serial data protocol

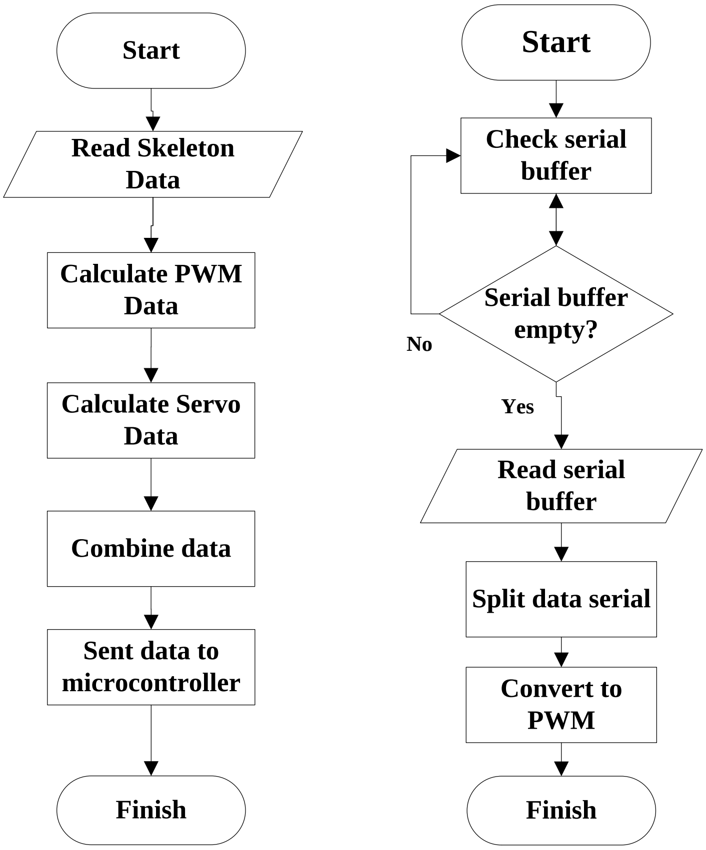

Figure 6 Flowchart system

4. Result and Discussion

4.1. System Realization

The front wheels of the robot use rubber wheels with a diameter of 15cm. While the rear uses 11cm diameter rubber wheels. The front wheels are coupled to the motor directly using an 8-inch hub. This is so that the robot can maneuver on uneven floor areas. Figure 7 is a display of the realization of the robot body.

The rear wheel is connected to the servo steering via a circular slider. The difference in the servo working angle will affect the direction of the motion of the robot. The servo working angle is influenced by the X coordinate value at the shoulder center. Convert the X coordinate value to the PWM servo value using equation 1. According to Figure 8, if the object's position is in area A, the servo will move

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clockwise. This will make the robot turn to the left proportional to the value of X. Conversely, if the object's position is in area B, the servo will move counterclockwise so that the robot turns right.

Meanwhile, the motor rotational speed is influenced by the Z coordinate value of the shoulder center. The Z coordinate represents the distance between the human object and the robot. The greater the Z value, the higher the motor rotational speed is proportional. This is so that the robot response can adjust according to the distance of the object being followed. Convert the Z value into the motor PWM value using equation 2.

$$\text{pwmServo} = \begin{cases} \frac{500}{320} * x + 1000, & x < 300; x > 340 \\ 1500, & 300 \le x \le 340 \end{cases} \quad \text{......... 1)}$$

$$\text{pwmMotor} = \begin{cases} \frac{255}{150} * (z - 100), & 100 \le z \le 250 \\ 0, & z \le 100 \end{cases} \quad \text{.........2)}$$

Figure 7. Robot Hardware

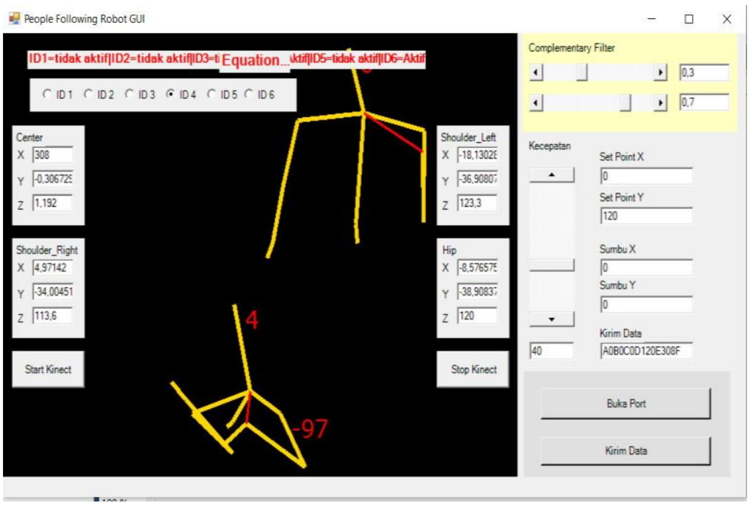

Figure 8. Depth Image Processing

4.2. Testing result

Testing is done by tracking objects on a certain path. The path used for testing is shown in Figure 9. The test results show that the system can follow the movement of human objects according to the trajectory passed. According to the sensor capability, the robot can track objects with a maximum distance of 3 meters. Table 1 and Table 2 are the results of robot testing according to the test path. Sensor recognition response speed based on the distance of the robot to the object. The shorter the distance of the robot to the object, the faster the initial recognition time. The tracking system can keep up with the speed of movement of human objects under normal running conditions. Normal walking speed is about 1.6 m/s.

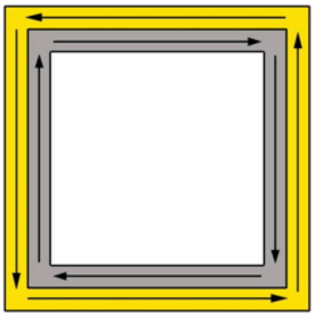

Figure 9. Testing Route

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Table 1. Tracking Test

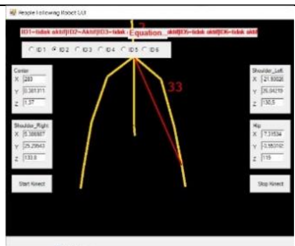
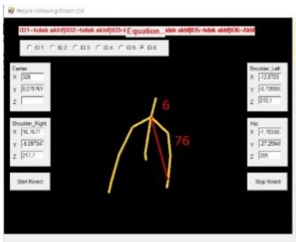
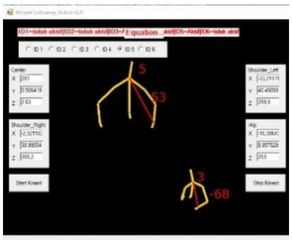
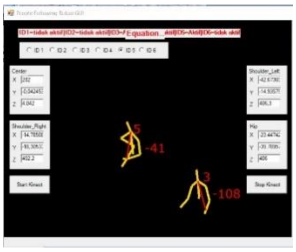
Testing number	Position Object	Image Procession Result	Delay Response	Information
1			6,27 second	Success
2			3,42 second	Success
3			5,44 second	Success
4			2,11 second	Success
5			5,23 second	Success

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Table 2. Response test

Testing Number	Distance for moving objects	Object Following Accuracy	Time moving	Information
1	10 Meter	Move accurately	15 second	Success
2	11 meter	Move accurately	17 second	Success
3	12 meter	Move accurately	20 second	Success
4	13 meter	Move accurately	21 second	Success
5	14 meter	Move accurately	23 second	Success

5. Conclusion

Contactless control system design for automatic guide vehicle (agv) based on depth camera are already presented on this paper. Based on testing, the system can work properly for tracking human objects. It's just that the performance response needs to be improved. In addition, the Kinect sensor has a low level of recognition when working outdoors with direct sun exposure. Therefore, this system is suitable for use in rooms with adequate lighting systems. Subsequent research is focused on adding robotic features to recognize obstacles in the environment while tracking.

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