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Development of Design and Control Manipulator Arm on Hexapod Robot with Smart Vision Sensor

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ABSTRACT

In 2021, the Indonesian Search and Rescue Robot Competition underwent significant changes, transitioning from its original name of "Firefighting Robot Contest" to "Search and Rescue Robot Contest." With existing regulations and new races, this robot used in the Indonesian Search and Rescue Robot Contest is an essential addition manipulator robot arm to finish mission victim rescue. With existing study about Design Development and Control Manipulator Arm on this Hexapod Robot with Smart Vision Sensor expected can help the development of the AL-JAZARI team's hexapod robot in mission victim rescue. Research, This does development design and control from a manipulator robot arm that can save victims in the rules of the Indonesian Search and Rescue Robot Contest. This uses input from the Pixy Camera, and its output is from the movement of the manipulator arm of the MG90S servo, which can save the orange victim. A Pixy Camera detects the victim and is picked up by a robotic arm. The manipulator's arm uses the MG90S servo as the actuator. In contrast, the buffer from the servo uses a 3D print designed to adapt to robotic bodies and efficiently, at times, save victims. Result study This robot can run on the victim rescue track by pushing the start button, then the robot will move autonomously with level success casualty rescue by 85% at good lighting and level lighting success dim by 80%.

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1. INTRODUCTION

The Kontes Robot Indonesia (KRI) is an event competition designed to get up as well as manipulation in field robotics [1],[2]. The National Achievement Center organizes KRI, Ministry of Education and Culture, Republic Indonesia. The Indonesian Search and Rescue Robot Contest is a competition division of the Indonesian Robot Contest. These robots can rescue trapped victims [3], at the time of the COVID-19 pandemic for the Search and Rescue Robot Contest organized by the Ministry of Education and Culture in the form of an online competition (in network) [4]. In 2021 this robot contest experienced a significant change starting from the Fire Fighting Robot Contest name. In 2021 it was changed to a Search and Rescue Robot Contest. Not only change in name, on side rules, matches, and calculations scores are also different from the previous. At the Search and Rescue Robot Contest, a significant mission is to turn off candles and victim rescue because the second mission has a very high point value, and if it does not succeed, it will impose a big penalty. Regulation competition in Kontes Robot Search and Rescue, all robots used in the competition are entirely autonomous, or no interaction can exist in real time between robots and the participant race. If there are participants who did interaction with robots, then the team will be disqualified.

Research this uses a six-legged hexapod robot [5]-[7]. The AL-JAZARI robot can down the room and off fire in the room First in time, 37 seconds. Also, for robot leg movement already movement robot category fast, but at the moment mission rescues victims, the AL-JAZARI hexapod robot yet can save the victim because the AL-JAZARI robot has not can find the object as well movement from the AL-JAZARI robotic arm does not can take casualties on missions rescue victim. With existing study This expected can help the development of the hexapod robot team AL-JAZARI in mission victim rescue use detection of victim objects using Pixy Camera Arduino and communication serial with the leg program on the hexapod robot, as well with existing design and control a manipulator robot arm with control robotic arm using more algorithms well, as well design (form) more robotic arm short and light and well-positioned pedestal the robotic arm is placed on the part lower robot body for rescue more fast, efficient and right on time do mission victim rescue.

2. METHODS

Based on the Introduction to the research, This development design and control from a manipulator robot arm that can save victims in the Indonesian Search and Rescue Robot Contest rules. Study This uses input from the Pixy camera. Its output is from the movement of the manipulator arm of the MG90S servo, which can save the victim in orange, on camera there is processing the image from the picture be data that the microcontroller can process [8]-[10], the Pixy Camera got detect object based on shape and color [11],[12], the Pixy Camera can see a thing so that user can get data from Pixy Camera that can be utilized For give order to actuators [13],[14], in research, This used Pixy Camera for detect location victim's position so that it can be rescued and taken by the arm robot arm [15], a manipulator robot arm is robotic arm used For move goods or object certain [16]-[18]. The manipulator's arm uses the MG90S servo as the actuator. In contrast, the buffer from the servo uses a 3D print that has been designed such as to get adept with a robotic body and efficiently [19] at the time save the victim. System robotic mechanics is designed in type articulated joints and is a robot that can take the object a particular [20]-[22], which consists of an arm and clamp simple (gripper) [23],[24]. This research uses an Arduino Due microcontroller to control a hexapod robot. The microcontroller is a brain that controls a robot which enters Language programming into it as desired designer [25],[26].

2.1. Design System

After doing some data and studying What only will be needed in originating research from relevant references, component datasheets, and book guides, the next step is planning system research. On planning systems, there are designing hardware and software systems in research. The block diagram of a hexapod robot whole can be seen in Figure 1.

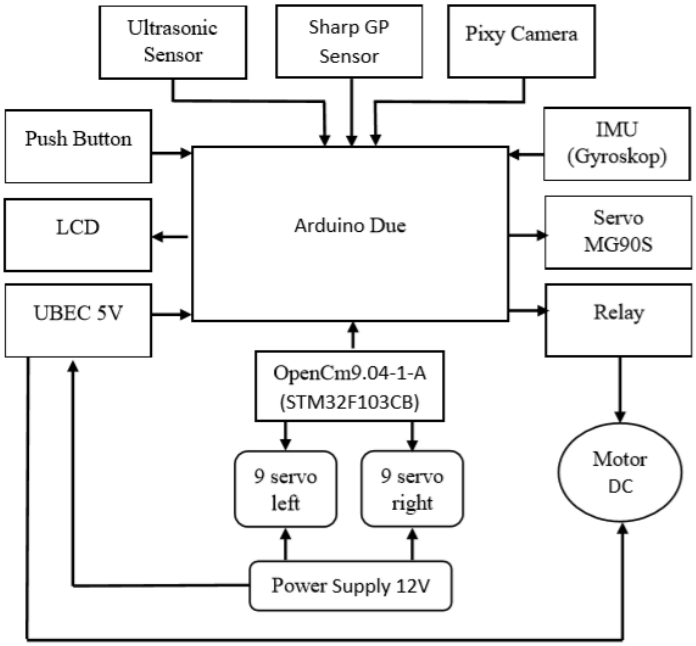


Figure 1. Block Diagram Design Hexapod Robotic System

The block diagram in Figure 1. is a separate block diagram on a hexapod robot. The block diagram in Figure 2. will be explained in more detail into two parts: software and hardware design.

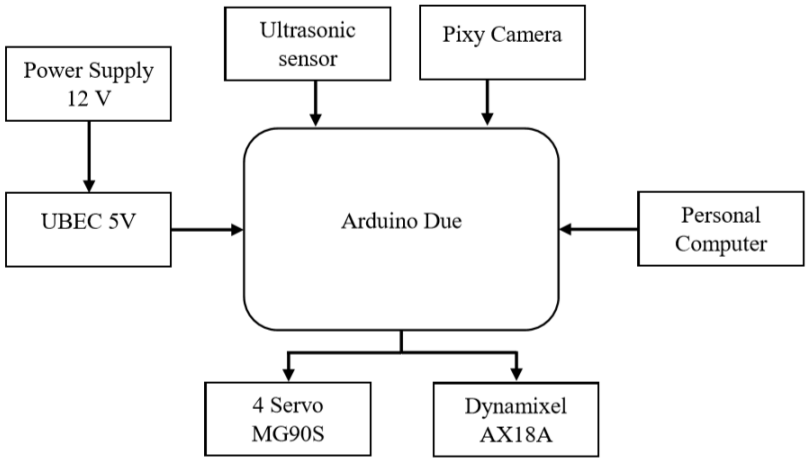


Figure 2. Research Block Diagram

Figure 2. shows the block diagram of research to be used and developed in a study. The diagram explains the researcher's need to study Design Development and Control Manipulator Robot Arm on a Hexapod Robot. In research, This uses the input from a Pixy Camera and ultrasonic sensor, Pixy Camera is used to detect victim objects, and the ultrasonic sensor is used to measure objects [27]- [29]. In research, it's an ultrasonic sensor used to detect victim distance and distance wall around the victim. Input from the system on research This is in the form of AX-18 A servo and MG90S servo. Sevo AX-18 A for moving the robot's legs, while the MG90S servo is used For moving the robot's arm. The flowchart in research This can be seen in Figure 3.

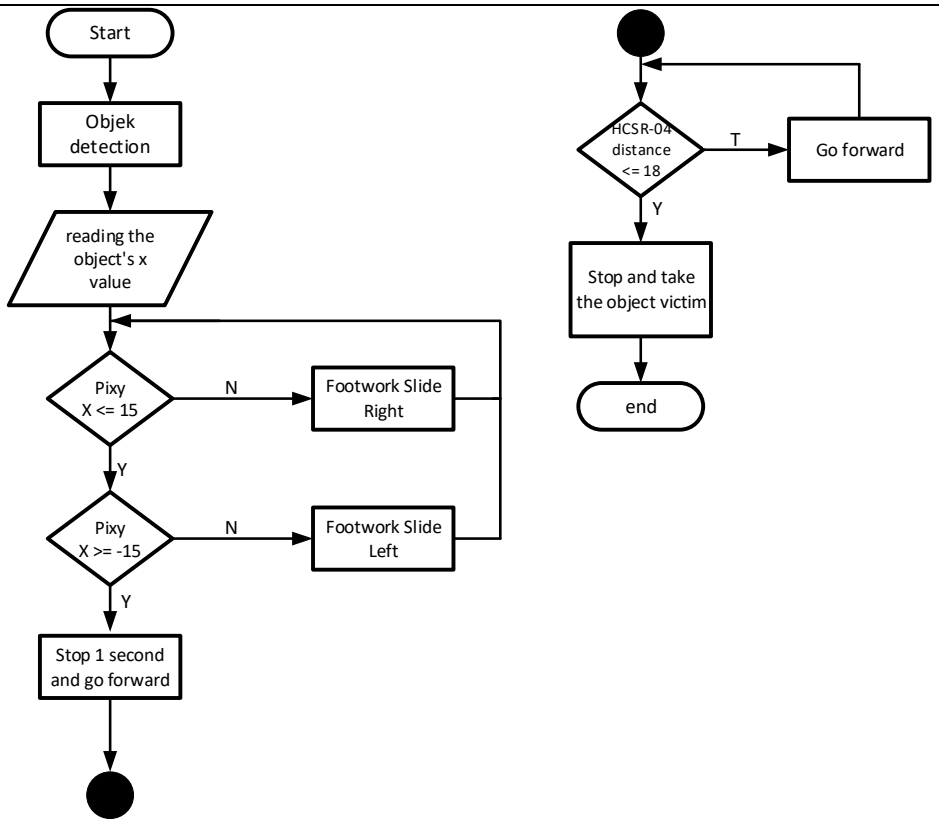


Figure 3. Research Flowchart

Figure 3. is a system flowchart on the Hexapod robot on a mission. Victim rescue begins with system start, then the Pixy Camera detects an object, and after the thing detected, so system on the Pixy Camera can read the mark position of the victim (x value) on the Pixy Camera if mark detected object is (X > 15) then the robot will shift right until the position of the robot is in the middle front victim object (-15 < X < 15), if where the victim is next to robot left or value (X > 15) then the robot will slide left right until the position of the robot is in the middle front victim object (-15 < X < 15), if the robot has been in place in front of the victim with value (-15 < X < 15) then the robot will stop for 1 second and move forward to direction front approach the victim and will stop if the sensor HCSR-04 part front of the robot has been detecting robot distance with wall with sensor value <= 18 after the robot stops such position pincers ready lifting the victim, then the victim is taken.

The victim rescue video link can be accessed at the following URL.

URL: https://drive.google.com/file/d/1yGx1_DTdo0kNM9GNsENUQExLKqgcZHUY/view?usp=share_link

2.2. Testing System

The testing system carried out in the research is that the hexapod robot will be equipped with a manipulator's arm for taking casualties on rescue missions. Testing process control manipulator arm with record mark percentage from success manipulator arm at the moment take a toll, with level success victim taking >75% with do testing as much as ten times. As well as The hexapod robot will also be equipped with a Pixy Camera to detect the victim's position to be saved, and the rate success robot arm can move by the position that the Pixy Camera has processed.

3. RESULT AND DISCUSSION

On Research, this obtained results detection and percentage from successful victim rescue Research This detection victim object uses Arduino Pixy Camera, then controlled by Arduino Due, meanwhile, control robot leg movements using OpenCM.

3.1. Pixy and Arduino Due Camera Communication

Intermediate series Pixy Camera and Arduino are Due to connect communication between Arduino Due with Pixy Camera so that the victim's object can be processed on Arduino Due to do order next. On camera, possible image change picture processing can be the data to become commands on the microcontroller [30]-

[32]. For calculating the victim's position using the formula detection program Pixy Camera with calculation mark x and y angles at the moment detection victim object. The object detection value can be seen in Figure 4. Serial communication between Pixy and Arduino Due is shown in Figure 5.
Formula program victim position :

```
Victim_x = (int32_ t) pixy .frameWidth / 2 - (int32_t) pixy.ccc.blocks [0]. m_x ;
Victim_y = (int32_ t) pixy.ccc .blocks [0]. m_y - (int32_t) pixy. frame height / 2;
```

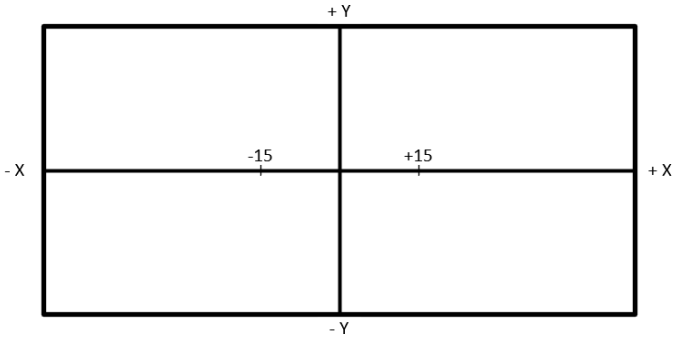
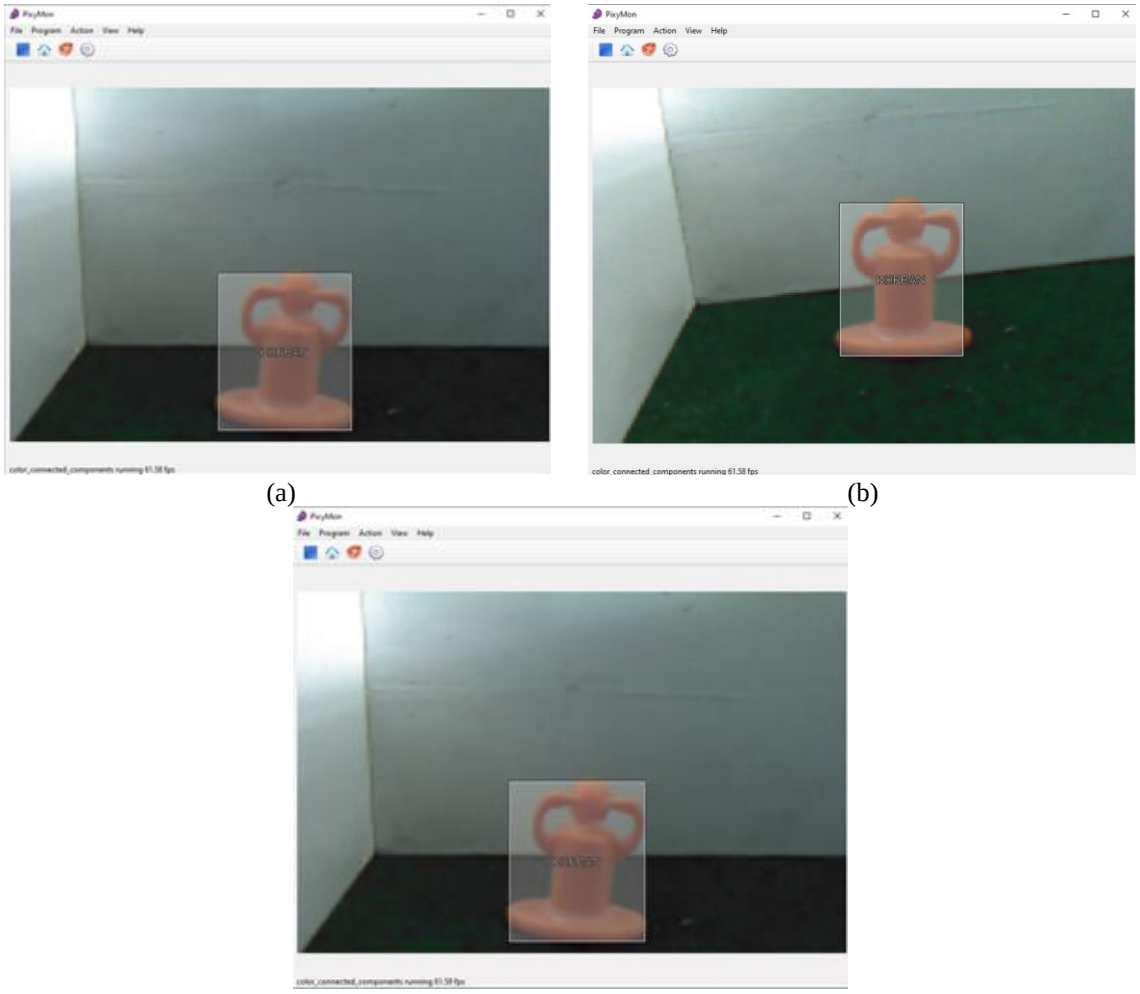


Figure 4. Position of the Victim Detection Frame



(a) (b)

(c)

Figure 5. (a) Victim Detection Results on the Left, (b) Victim Detection Results on the Right, (c) Victim Detection Results in the Middle

In Formula Program, Victim Position is the calculation victim's position to be obtained the x and y values of the victim object. The x and y values will be processed and used for the condition position object, with existing x and y values then will give order to the microcontroller [15], para actuate the servo accordingly with the robot movement mode that has been there. Figure 4. Obtained frame chart on the Pixy Camera from Formula Program Victim, with these frames getting x and y values that can be used for giving orders to Arduino Due and OpenCM. Figure 5. (a), (b) and (c) is the position of the victim object. If the victim object is to the robot's right (x> 15), then the robot will move right. If the victim is to the left of the robot (x<- 15), then the robot will shift left, and if the victim object is already in the middle of the robot (-15<X<15), then the robot will stop and get ready to take the victim object.

This detection object uses a Pixy Camera in this research because, if used webcam camera or the like needs a microprocessor like a mini PC [33]-[35]. The detection mini PC object needs training data for the detection object [36],[37], as well as using the Python programming language [38] and others. Meanwhile, Pixy Camera does not need training data for the detection object. It only does serial data call from Pixy Camera that Pixy Camera has processed.

3.2. Manipulator Arm

Control the manipulator robot arm using a program with an algorithm already designed [39],[40]. The driver from the manipulator robot arm uses the existing Arduino Due on the robot, with the actuator using 4 MG90S servos used for lifting and pinching the victim accordingly to the position of the victim and the hexapod robot. The robot and its arms are shown in Figure 6. The arm movement mode table is shown in Table 1.

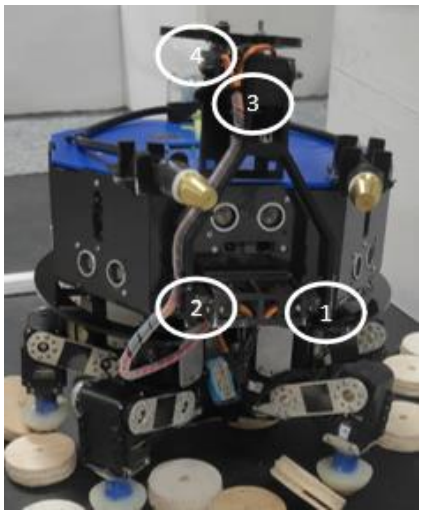


Figure 6. Servo Position

Table 1. Manipulator Arm Servo Control

Mode/Step	Corner			
	Servos 1	Servos 2	Servos 3	Servos 4
Stand By	0	180	160	120
Bottom Gripper	180	0	150	30
Lift Grippers	0	180	100	5
Get Target	-	-	-	30

Table 1 shows each servo's angle at the time the mode or step has been made. Currently, the rescue victim mode or step has a sequence of stages. Stand By is the position beginning from the manipulator's arm when the robot is turned on. The standby position is not bothered position reading from the sensors on the robot. The bottom Gripper positions the manipulator arm when Robot and Survivor are inside parallel states, and then the manipulator arm will down approach the victim's position. Grippers lift is a position manipulator arm for lifting a few casualties and pinch victims. Get targets is a movement to change the gripper position easily if you want to change the open mode to close the Gripper.

3.3. Victim Rescue

Experiments on Lightning are good, and Dim was carried out with deep robot trials, victim rescue, and robot runs, then saving victims. Robot trials are carried out on the race track with the put position of the victim

in the circle already white. There are conditions for Indonesian Search and Rescue Robot Contest competition, trial results in victim rescue observed in Table 2. and Table 3.

Table 2. Experiments on Lighting Good

Test	Success	Detection time (seconds)	Total time (seconds)	Victim Position
1	Succeed	2	7	Right
2	Fail	2	7	Left
3	Fail	9	13	Left
4	Succeed	3	9	Right
5	Fail	1	5	left
6	Succeed	4	9	Left
7	Succeed	2	7	Right
8	Succeed	2	7	Right
9	Succeed	3	7	Left
10	Succeed	5	10	Right
11	Succeed	5	11	Left
12	Succeed	1	6	right
13	Succeed	4	8	right
14	Succeed	10	15	left
15	Succeed	3	7	right
16	Succeed	6	11	left
17	Succeed	4	10	right
18	Succeed	4	9	right
19	Succeed	5	9	left
20	Succeed	4	10	right

Table 3. Experiments on Lighting Dim

Test	Success	Detection time (seconds)	Total time (seconds)	Victim Position
1	Succeed	7	12	Left
2	Succeed	4	7	Right
3	Fail	3	8	Right
4	Succeed	4	9	Left
5	Succeed	5	8	Right
6	Succeed	4	9	Left
7	Succeed	18	21	Right
8	Succeed	6	12	Left
9	Succeed	4	8	Right
10	Succeed	6	10	Left
11	Succeed	3	7	Right
12	Succeed	4	8	Left
13	Fail	4	8	Right
14	Succeed	4	8	Left
15	Succeed	9	12	Left
16	Succeed	3	8	Right
17	Succeed	2	6	Left
18	Succeed	3	8	Right
19	Fail	4	8	Left
20	Fail	2	6	Right

The test results in Table 2. can count the percentage success of victim rescue as follows:

$$\text{Percentage success} = (\text{count successful} / \text{amount of data}) \times 100\%$$

$$\text{Percentage success} = \frac{17}{20} \; x\,100\,\%$$

$$= 85\,\%$$

test results in Table 3. can count the percentage success of victim rescue as follows:

$$\text{Percentage success} = (\text{count successful} / \text{Amount of data}) \times 100\%$$

$$\text{Percentage success} = \frac{16}{20} \; x\,100\,\%$$

$$= 80\,\%$$

From the percentage success of victim rescue at the time of testing Still, there is a failure in victim rescue, yes several things cause failure. This Arduino Pixy Camera needs calibration because it is very influential with light if it has done setting signatures and parameters. Level failure from victim detection and rescue will be reduced. On the AL-JAZARI hexapod robot, it is necessarily done checking the HC-SR04 sensor automatically periodically because the AL-JAZARI hexapod robot still often happened problems on the HC-SR04 sensor, so it is essential sensor check before running the robot, so the systems and algorithms on the robot can walk without There are constraints. Using the battery on the AL-JAZARI hexapod robot is very important for supplying all the voltage on the robot. If a lack of voltage, the battery on the robot will significantly affect the performance and stability of the robot.

4. CONCLUSIONS

Based on the results of research and some testing that has been done can take conclude that the AL-JAZARI hexapod robot can do victim rescue with victim detection input using a Pixy Camera and output for victim rescue form manipulator arm that has designed and provided control efficient movement in rescue victims in the KRSRI competition (Indonesian Robot Search and Rescue Contest). With the results, the robot can run on the victim rescue track by pushing the start button. Then the robot will move autonomously with level success casualty rescue by 85% at good lighting and level lighting success dim by 80%. The movement of the manipulator robot arm still needs to be refined to power stand from the servo on the manipulator's arm that can be used for a while.

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