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Nurse Following Robot Using Colour Connected Components Algorithm

Mohd Norzali Bin Hj Mohd[1*], Akmal Zaki Bin Akhbar Ali[1]

[1]Faculty of Electrical & Electronic Engineering,
Universiti Tun Hussen Onn Malaysia, Parit Raja, 86400, MALAYSIA

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Abstract: Robot implementation in daily life from industrial to personal level showing repetitive work that required physical and consistency can be replaced by automation and machine. This project emphasizes on the process of developing nurse following robot as a personal robot to ease the everyday task of a nurse. The main function of this robot is to be able to bring any equipment or medicine for the nurse when attending each patient assigned. Hence, the main objective is to develop a nurse tracking and following robot with the application of colour connected components algorithm. The vision system used in this project is Pixy2 camera. The camera sensors system has its own simple controller that is able to detect, recognize, assign and memorize up to seven different targets or signature. The colour connected components algorithm use hue, saturation and light intensity with colour-based filtering algorithm to detect the assigned target also with region growing algorithm to know the size and distance of the target which is useful as a target following robot. The microcontroller used in this robot is Arduino UNO which has suitable processing power combine with Pixy2 for the tracking and mobility of the robot. Movement of robot is supported with an acrylic chassis with two DC motors. Controlling motion of the robot comes from the microcontroller and paired up with L298N Dual H-Bridge Motor Driver to interact with the DC motors. The robot is able to move with the coloured target either in straight or curve path with the limitation for indoor application and planar ground.

Keywords: Colour Connected Components, Pixy2 Camera

1. Introduction

Following people is a highly desirable skills for mobile robots to support daily chores. To achieve robust and efficient person-following capabilities, perception, robot gaze control, and navigation need to be effectively integrated [1]. Several patented product creating a nurse robot with a stand and supporting elements for patient able to move around without direct help from another person which is practical and trouble-free [2]. Human tracking and following is very related with the research of computer vision. Depending on how the process being done, tracking algorithm are based on the developers such as motion, facial and colour detection. From the picked process able to determine how efficient the system will be distinguishing the target with another object and obstacle.

*Corresponding author: norzali@uthm.edu.my

A human following robot should have the capabilities to differentiate the target object or human from supplementary object and capture it by any method assigned to it [3]. Expanding the relationship between humans and robots from industrial sector to domestic usage that able to perform a certain amount of cooperative work. The human-following robot in this project able to focus on maintaining a certain relative positional relationship between the human and robot [4]. Robot is a tireless machine but needed the installation, calibration and maintenance which then costing the user yet a study shown otherwise which comparing a full functional lab tested robot with hospital full-time equivalent workers [5]. The robot provide assistance to human in various situation such as carrying loads by people working in airports, hospitals etc.

2. Materials and Methods

Developing of the nurse tracking and following robot will be included the hardware and method used .The materials and methods used in this study are necessary to obtain the results and analysis of the system.

2.1 Materials

Basic requirement of the prototype robot are consist of input which is camera sensor that able to detect variation of colours, next is the processor known as microcontroller which is used for receiving and processing data for the next step such as tracking or following and lastly the output which is DC motor for the movement of the robot. Specifically the material used in this study as stated below:

- Arduino UNO
- Pixy2 camera
- Robot chassis with 2 DC motors
- L298N dual H-bridge motor driver
- Pan tilt kit

The robot chassis act as the body for the whole system. As attached at the center of the chassis are the Arduino UNO with motor driver and at the front of the robot act as the eye for the system is the Pixy2 camera with pan tilt kit. The relationship of the system is shown in Figure 1.

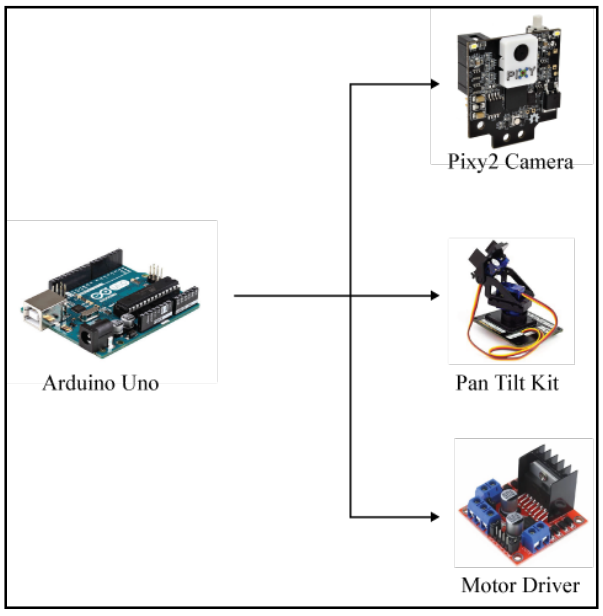


Figure 1: Relationship of the target tracing and following robot

2.2 Methods

Based on the flowchart shown in Figure 2, the robot will be started by booting up the Arduino UNO and also the Pixy2 camera, the robot will have to search and detect the target using color code recognition algorithm. The robot will then move towards the target until it reach the suitable distance between the robot and the target person. In the meantime, avoiding any obstacle in the process. When the target person starts to move away, automatically the robot will follow and maintaining the distance. If the target starts to lose away, the robot will have to search and detect back the target. The robot will then continue to proceed its objectives on following the target or be turned off.

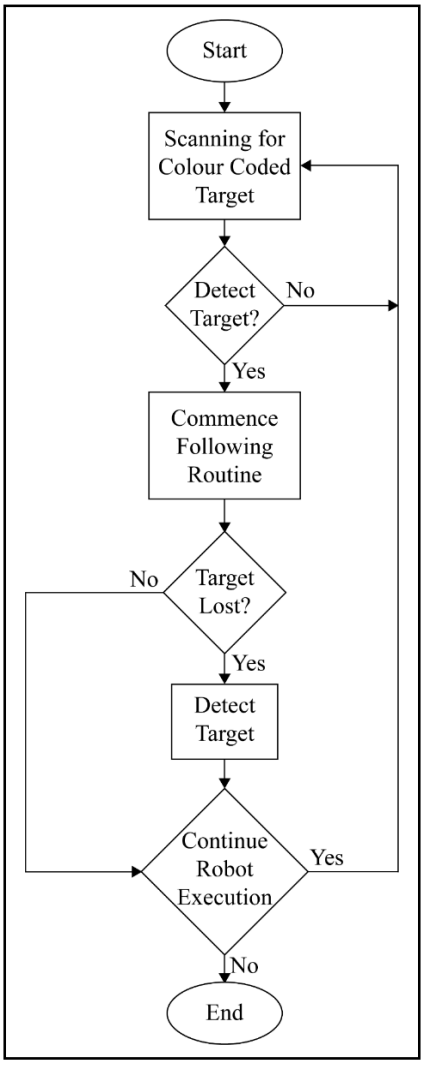


Figure 2: Process flowchart of the robot system

3. Results and Discussion

The prototype for Nurse Following Robot shown the result of detecting and tracking the coloured target through the colour connected components algorithm using Pixy2 camera sensor. From the data given by camera sensor, the microcontroller which is Arduino UNO will control the movement of the robot using DC motors with motor driver. The movement of forward and reverse of the robot are determined by the size of the target while for left and right dictate by the position of the target using x and y axes from the camera sensor. Overview of the Nurse Following Robot shown in Figure 3.

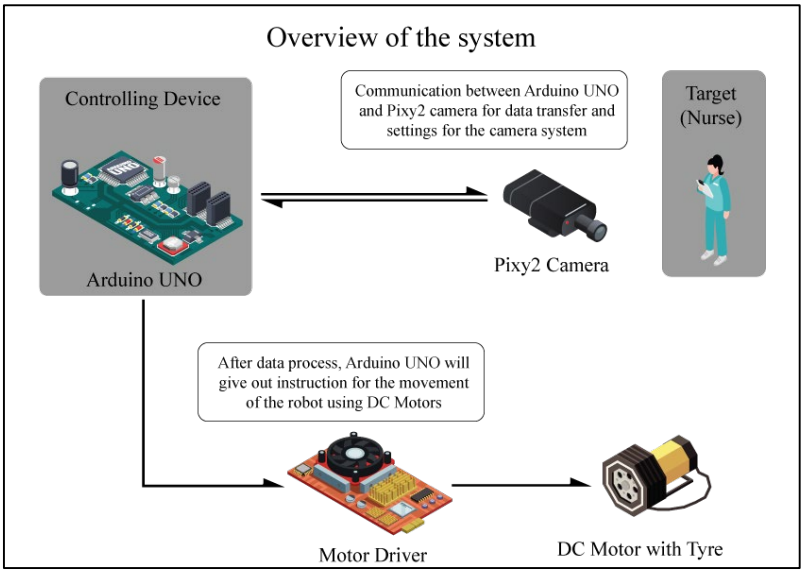


Figure 3: Overview of nurse following robot

3.1 Results

The design of the prototype robot can be seen in Figure 4. The Pixy2 camera sensor is placed at the front of the robot to detect the target at close range from 10cm to 30cm. The effectiveness of the target tracking at the given range are suitable as if the lower than the range may cause the tracking system become erratic but will stop the robot movement as it is close enough meanwhile higher than the range may cause the loss of sight for the target tracking. The effectiveness level is tested from the detection distance and the movement of the robot which are shown from the result in this section. The camera sensor also equipped with pan tilt kit consist of 2 servo motors that can be adjusted through the controller. The microcontroller which is Arduino UNO are installed at the rear end while the motor driver L298N at the middle of the robot chassis. The power supply is placed at the bottom side of the robot between 2 DC motors to power up the whole robot system through the motor driver

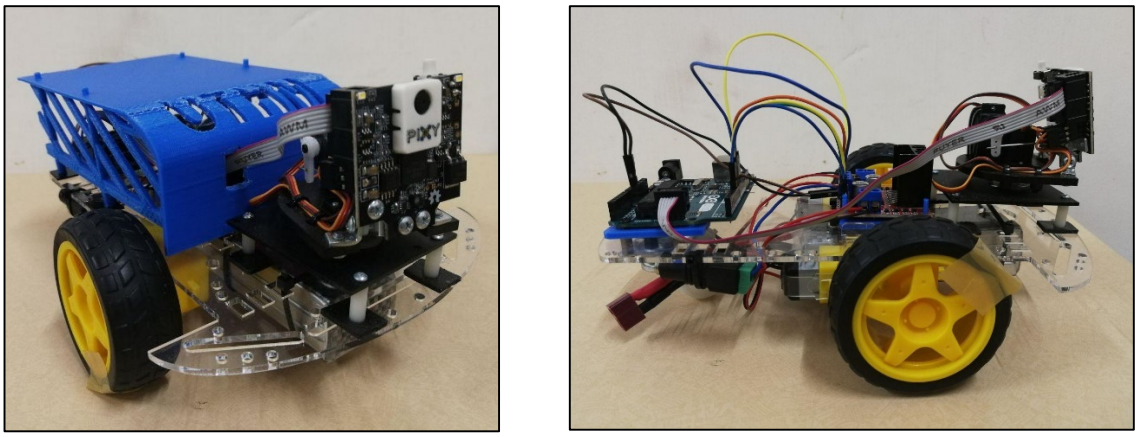


Figure 4: Nurse following prototype robot

Several test are being conducted to find out the effecetiveness of the robot based on the vision system of the camera sensor and the processing limitation related with the images taken for the controller to understand. The first test is the detection angle of the Pixy2 camera which is to know the field of view for the robot. The data given by the camera sensor for the movement right to left are depending on x and y axes of whereabout of the target colour while disabling the movement of the robot to know the limit angle it can detect. Several tests using RGB colour have been done with initial vantage

point of the target perpendicular to the camera sensor which is 90° then move to 0° for left-side field of view and repeat to 180° for the right-side field of view. The result of the tests is shown in Table 1 where the "1" indicate the target are detected while "0" otherwise.

Table 1: Detection angle of the pixy2 camera test

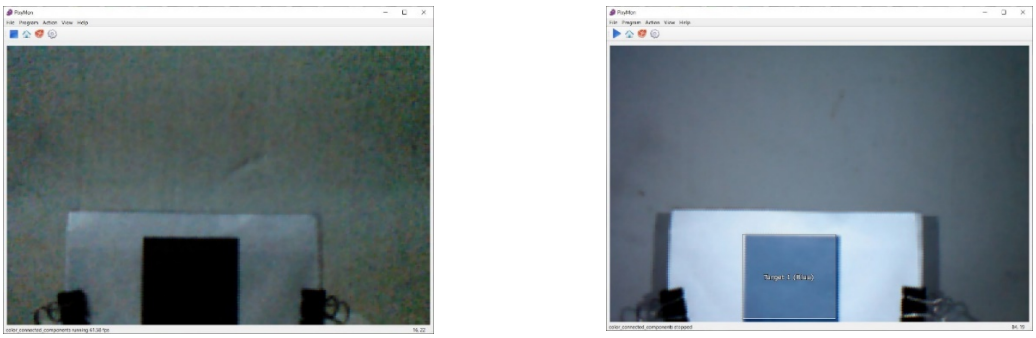
Colour	Degree of Angle (°)												
	30	40	50	60	70	80	90	100	110	120	130	140	150
Red	0	0	1	1	1	1	1	1	1	1	1	0	0
Green	0	0	1	1	1	1	1	1	1	1	1	0	0
Blue	0	0	1	1	1	1	1	1	1	1	1	0	0

The second test is to know the efficiency of the distance between camera and target. This also has effect on the robot movement as if it gets farther until the target become undetected will cause the robot stay still and searching for new target that in the field of view and range of the camera sensor. The Pixy2 camera has its own limitation to distinguish target colour at farther away that may cause by the environment or surrounding colour which is maybe have similar hue, saturation with light intensity. Identifying this limitation have been done by executing several tests with RGB colours at variable distance start from 10cm until 50cm with disabling the movement of the robot. This range are used to indicate from the shortest safe distance to the longest distance to avoid any interference between the robot and the target. Furthermore, to evaluate the effectiveness of the colour connected component algorithm, the test is conducted with time taken for the camera sensor to recognize each colours at designated ranges. The result of the tests is shown in Table 2.

Table 2: Detection distance of the pixy2 camera test

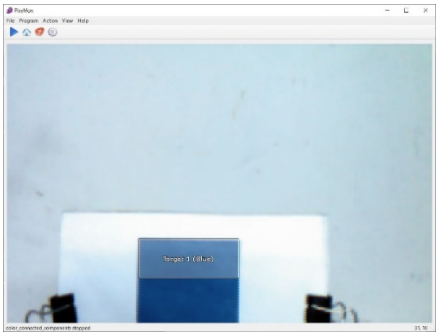
Colour	Time taken to detect at given range (seconds)				
	10cm	20cm	30cm	40cm	50cm
Red	0.5	1	1	2	3
Green	0.5	1	1.5	2.5	3
Blue	0.5	1	1	2	2

The final test to understand the limitation of the prototype robot operating in different light intensity. The Pixy2 camera have built-in LED lighting which able to illuminate sufficiently its own field of view especially for the target. The test conducted in a space with adequate lighting and with low lighting condition. At the same time with the LED lighting from Pixy2 is enable and disable for better understanding the efficiency of the colour connected components algorithm in detecting target in various light intensity. Controlled variable of this test is the distance of the robot to the target which is 30cm in the range of effective colour coded target.

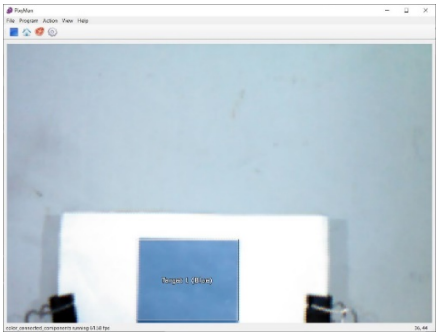


Direct LED = Off Direct LED = On

Figure 5: Blue target detection with low light intensity



Direct LED = Off



Direct LED = On

Figure 6: Blue target detection with low light intensity

Based on result shown on Figure 5, the left image in low lighting condition without LED lighting are unable to detect the target colour meanwhile at the right image is when aided with LED lighting the camera sensor able to recognize the target. If compared to Figure 6 with adequate lighting condition on the left image without LED lighting, the camera sensor will have trouble to detect the whole colour target but at the right image with LED lighting, Pixy2 camera able to detect the target colour better.

3.2 Discussions

Through the findings recorded in this project with the vision system of the prototype robot allow to understand the limitation of using the colour connected components algorithm when detecting and recognizing a target. The limitation angle of detection from the Pixy2 camera is 50° to 130° in front of it. If coloured target have been recognized and detected, to avoid the target moving out of the field of view, the robot movement should be triggered depending on the whereabout of the target which is have to be inside the angle of detection from the Pixy2 camera or otherwise robot will lose the target.

Track and follow a target at safe distance are very crucial to avoid any mishap to the robot, user and surrounding area. At the same time does not affecting the efficiency to detect the target. Through the test of distance between camera sensor and coloured target indicate the effective colour which is blue and acceptable range of distance from 10cm to 50cm in front of the robot. As the robot does not have the ability to avoid obstacle and depending on the movement of the target, which is logically at given range if the target avoiding an obstacle, the robot too will follow except the obstacle causing the target to move out of its field of view. Then the robot will automatically stop moving to avoid any collision and waiting until the target appear on the camera sensor which then continued its main task.

Besides that, the surrounding area able to affect the detection process as low lighting condition cause the target colour have different hue and saturation as the camera sensor unable to recognize the target. Pixy2 camera equipped with LED lighting able to overcome this limitation even though the target moves into a dark indoor space, as its direct lighting able to illuminate the target in front of the robot.

4. Conclusion

From the prototype of Nurse Following Robot using colour connected components algorithm that being develop for this project shown the objectives are achieved with limitation and improvement that can be implemented for future upgrades. Developing a target tracking and following prototype robot must take account several factors such as the vision system used and the type of mobility for the robot. The vision system chosen for this project are colour connected components algorithm that proven able to detect, recognize and track a coloured target with rapid and unpredictable movement which is suit with human movement itself. The hardware used for the vision system of the prototype robot are Pixy2 camera sensor which comes with many functions that constructed mainly on the colour connected components algorithm. The Pixy2 camera are very suitable for this project as the robustness to detect

multiple coloured target at long period of time with quick respond and data transfer for the microcontroller.

Designing a robot following movement that able to calibrate with the vision system have to consider the communication between the processor and camera sensor. The camera sensor must have rapid and continuous input data transfer as the whereabout of the target into the microcontroller to be process to avoid the target move out of sight. Besides that, the microcontroller, Arduino UNO have to process the input data as fast as possible to calibrate the movement of the robot which is to control the motors. The interaction between Arduino UNO and Pixy2 camera using Serial Peripheral Interface (SPI) which able to transfer up to 1Mbits/seconds of data into the processor. Thus, the robot system able to calibrate its following movement with the vision system.

Several tests are being conducted to strengthen the objective especially for the camera sensor. This test able to measure and show the functionality of the robot and the performance of detecting a target which is mainly nurse using colour connected components algorithm. The robot able to execute the task given accordingly with some limitations that can be overcome or tune based on the ability of the camera sensor and the robot movement. Some withdraws have to been made such as limiting the range of target with the robot to optimize the detection task avoiding any obstacle or unrelated object interfering with the process.

The microcontroller, Arduino UNO able to sync up the movement of the robot with the colored target with high motor speed. This mean if the target (nurse) move at normal to high pace, the robot able to follow accordingly but by doing so as if the target make a sudden stop will cause the robot to overshoot then reverse back to its set distance. Lowering the motor speed to avoid overshoot can cause to robot to slowed down and eventually can lost it target as a normal human pace are much faster than the robot.

Improving this project have to be considered several aspects. Firstly, the hardware considering Arduino UNO able to connect with Pixy2 camera sensor using SPI protocol through In Circuit Serial Programming (ICSP) connection. Meanwhile the Pixy2 camera can be connected with Universal Serial Bus (USB) which is much faster but cannot be accommodate by Arduino UNO. Upgrading the processor with better function and faster processor such as Raspberry Pi that able to interact with the Pixy2 camera and connected with internet which is can be add new function for example viewing what the robot sees through mobile application. Moreover, with improved processor able to attach multiple camera sensor which then widen the field of view for the robot giving better understanding of surrounding and helping the movement of the robot.

Nevertheless, the prototype robot able to accomplish the objective as stated but some recommendation and change or add in the hardware can be made to improve the performance and ability of the robot. As the colour connected components algorithm shown the ability to detect, recognize and tracking multiple coloured target through the tests with the flexibility of changing the target easily using designated software.

The conclusion should summarize the main findings of the study, and restate the key points inferred from trends observed and discussed regarding the data. Some suggestions should be included to encourage the continuation of the current research.

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References

[1] M. Kim et al., “An Architecture for Person-Following using Active Target Search,” 2018. [Online]. Available: http://arxiv.org/abs/1809.08793

[2] P. Examiner and A. Grosz, “(12) United States Patent,” vol. 1, no. 12, 2004

[3] B. Ilias, S. A. Abdul Shukor, S. Yaacob, M. H. Mohd Razali, and A. H. Adom, “A nurse following robot with high speed kinect sensor,” ARPN J. Eng. Appl. Sci., vol. 9, no. 12, pp. 2454–2459, 2014

[4] K. Morioka, J. Lee, and H. Hashimoto, “Human-Following Mobile Robot in a Distributed,” IEEE Trans. Ind. Electron., vol. 51, no. 1, pp. 229–237, 2004

[5] J. F. Engelberger, “Health-care robotics goes commercial: The ‘HelpMate’ experience,” Robotica, vol. 11, no. 6, pp. 517–523, 1993, doi: 10.1017/S0263574700019354