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Odometry Method and Rotary Encoder for Wheeled Soccer Robot

M Taufiqqurohman* and N F Sari

Department of Electrical Engineering, Faculty of Engineering and Marine Science, Hang Tuah University

*taufiqqurohman@hangtuah.ac.id

Abstract. The purpose of the study was to odometry method and rotary enconder for wheeled soccer robot. There are several methods to determine the accurate position of soccer robot movement in a room where the other is the best chosen odometry method. The method of determining the position of the wrong movement is used on the soccer robot. The researchers of soccer robot keep doing research and development, including the researchers from Indonesia. In Indonesia, there is a robot contest that is called Kontes Robot Indonesia (KRI) which has five categories, one of them is a Kontes Robot Sepak Bola Indonesia. In KRSBI there are 2 division. That are Humanoid robot and wheeled robot. Wheeled Soccer Robot has many ability such as searching ball, searching goal keeper, avoid the enemies, control the wheel's speed and define the robot coordinate. In this research focused to determine the position of wheeled robot in the room. In previous research, previous authors used the Global Positioning System (GPS) and only know the position of robots outdoors. If a wheeled robot is applied indoors with the GPS method having an error (0.18%). Base on that condition, author use 3 Omni-wheels as the movement tool and use odometry method to define the position of the robot. This robot used Arduino as it main controller. Besides, rotary encoder is used to produce pulse for indicating movement, position, and direction of the robot which will go to the target of the ball. The author is expected to be able determine the coordinates of the robot in accordance with the actual robot position in the room and implement the odometry method to adjust the speed of the motor. Results from this research is position of odometry method (0.13%). Conclusion of this research odometry method more higher accuracy then GPS method.

1. Introduction

Sensors are common used for get position data from a robot is a rotary encoder which is the data of this sensor will inserted in calculation odometry so produce position relatively of the robot. Odometry is use of data from motion sensors for estimate change position from time to time. Odometry this will map position of the robot inside Cartesian axis. So that will obtained position data form point coordinates (path) and direction head (heading) of the robot [1].

In a paper entitled [2] interested in studying, researching, designing and constructing an automatic wheeled robot that can move automatically to predefined places, to be able to do so this wheeled robot must be integrated with other technologies with GPS (Global Positioning System). However, the deficiency is only can used outdoors, and there are very many errors when used indoors.

IOP Conf. Series: Materials Science and Engineering **407** (2018) 012103 doi:10.1088/1757-899X/407/1/012103

Based on condition above , the author do research with using a wheeled soccer robot that drives it using 3 Omni wheels and system navigation use method Odometry and using CMPS-11 for combining corner and direction against with results of data obtained from Method Odometry .

2. Experimental method

The design of the three Omni-wheel robot is similar to the robot built in [3]. This type of structure has been chosen because it can rotate around its own axis without the need of an additional mechanism [4]. The length of trigle is measured at 450 mm with a height of 700 mm. Data acquisition, controllers, and other algorithms run on an Arduino MEGA2560 [5]. We have chosen this platform due to the large number of I/O available and processing capabilities. To control the speed and direction of the motors we use a PWM DC motor driver [6]. LM298N is a driver that has a voltage input of 5-35 V and an output of 2A. The IN1, IN2, IN3 and IN4 pins are used to control the direction of the rotation. The motor speed is controlled with the PWM pin, which receives a value between 0 and 255. The motors are connected to the drivers through the OUT+ and OUT- pins. (Figure 1)

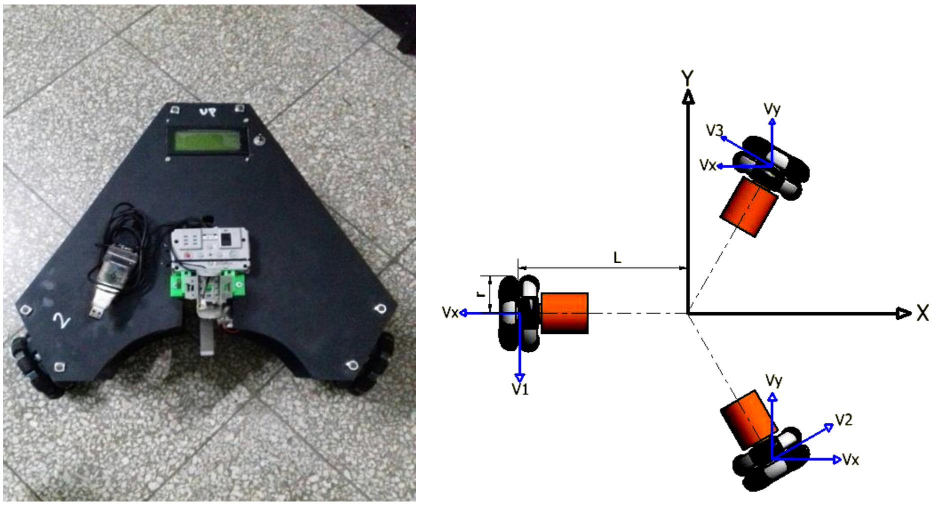

Figure 1. Wheeled robot design and kinematics 3 Omni-wheels [8].

2.1. Odometry algorithm

According to Figure 2, the derivate ion of each Omni-directional wheel velocity is can be determined based on the analysis in [7]. The result is shown in (1).

$$V_w = V_r \cos\left(\theta_{ref} - \alpha\right) \quad (1)$$

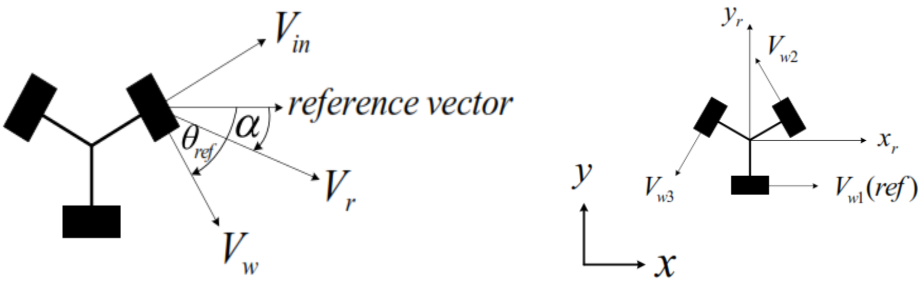

Figure 2. Omnidirectional wheel velocity and mobile robot in world coordinate [8].

If linear velocity y of one wheel is forced to align with a reference axis in robot frame as shown in Fig. 5, odometry wheel linear velocities for all three can be obtained as shown in (2), (3) and (4). Where α is the angle of robot's velocity with respect to the reference axis, L is the distance from the center of mass to the center of the odometry wheel and ω is the angular velocity of the odometry wheel [8].

$$V_{w1} = V_r \cos\alpha + L\omega \tag{2}$$

$$V_{w2} = V_r \left(\frac{-1}{2}\cos\alpha + \frac{\sqrt{3}}{2}\sin\alpha\right) + L\omega \tag{3}$$

$$V_{w3} = V_r \left(\frac{-1}{2}\cos\alpha - \frac{\sqrt{3}}{2}\sin\alpha\right) + L\omega \tag{4}$$

Hence, the odometry wheels angular velocity vector can be written as a function of linear and angular velocities of the mobile robot in matrix. Moreover, it is simple to see that linear and angular velocities of the mobile robot can be obtained by solving inverse matrix. As a consequence, the current position and heading of the mobile robot can be determined by integration. Nonetheless, to obtain the angle ϕ_1,ϕ_2 and ϕ_3 from encoders, conversion must be done, where r is the radius of the Omni-directional wheel The result is (5), (6) and (7) [8].

$$x = r\left(\frac{2}{3}\phi_1 - \frac{1}{3}\phi_2 - \frac{1}{3}\phi_3\right) \tag{5}$$

$$y = r\left(\frac{1}{\sqrt{3}}\phi_2 - \frac{1}{\sqrt{3}}\phi_3\right) \tag{6}$$

$$\theta_{robot} = \frac{r}{3L}(\phi_1 + \phi_2 + \phi_3) \tag{7}$$

The current robot position and goal points are defined by (x_r, y_r) and (x_G, y_G) respectively. Hence, the distance and the angle to reach the destination point can be determined by (8) and (9) accordingly. Meanwhile, the heading of the mobile robot can be specified and calculated with respect to the x-axis in a global frame [8].

$$S = \sqrt{(dx)^2 + (dy)^2} \tag{8}$$

$$\alpha = \tan^{-1}\left(\frac{dy}{dx}\right) \tag{9}$$

2.2. *Rotary encoder*

Rotary encoder is device electromechanical can monitor movement and position. Rotary encoder generally using optical sensors for generate serial pulses that can interpreted be movement, position, and direction. So that position corner something axis object spinning could processed be information form digital code by rotary encoder for forwarded by circuit control. Rotary encoder generally used on control of robots, motor drives, and soon [9].

3. Design system from wheeled robot

The robot input comes from the numbers entered by researchers on the keypad in soccer berodea robot. Then will processed at Arduino Mega 2560 along with calculation from method odometry. Results the then will combined with results in the form of a rotary encoder sensor pulse per cm accordingly with dish on the rotary encoder sensor. Directions against position the beginning of this robot faced at 0 ° or facing to north.

On Fig.3 shows a flowchart from systems that use method odometry. It starts from input data x, y and theta which is data for towards the target, the data x, y and theta will be at initiation for later moving its rotary encoder will produce pulse and convert it be distance take the robot. After is known distance take the robot, then will processed with calculation method odometry from third wheels Omni wheels. Results from method odometry will produce direction face the robot, then will be filtered by CMPS-11 for produce angle that has a small error. If corresponding with the target, the robot will stop. If target not found, will back to calculation method odometry. (Figure 3)

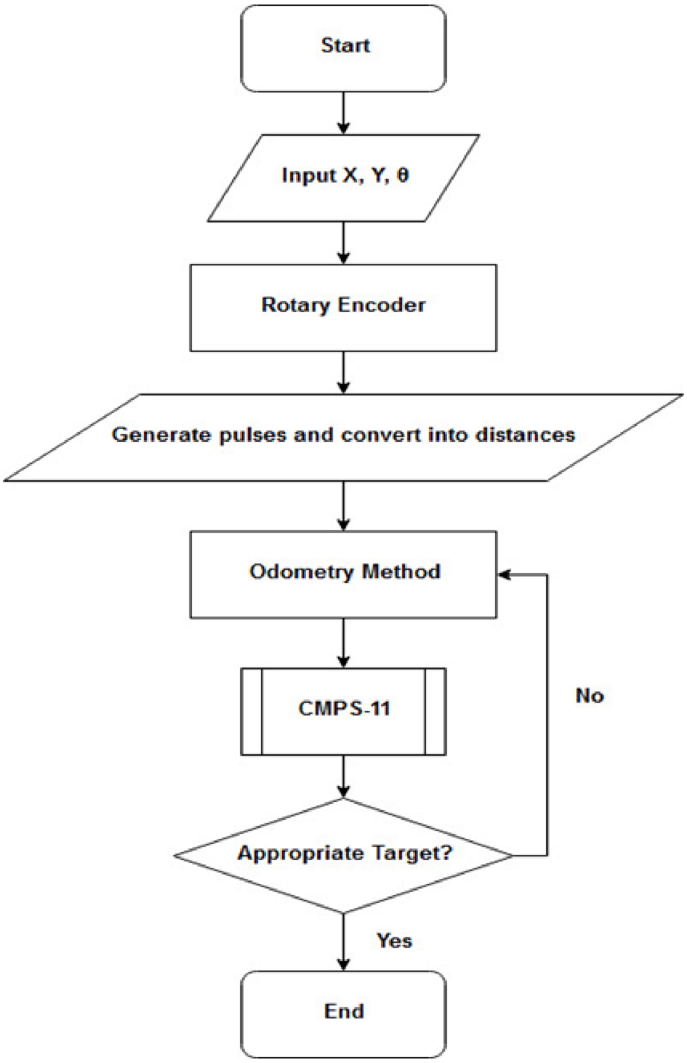

Figure 3. Flowchart wheeled robot system.

4. Results and discussion

Table 1. Position data of robots using GPS.

Target		Data Real		Error	
x	y	x	y	x	y
0	0	0	0	0	0
10	0	9.75	0	0.25	0
20	0	19.7	0	0.3	0
30	0	29.72	0	0.28	0
40	0	39.85	0	0.15	0
50	0	49.98	0	0	0

IOP Conf. Series: Materials Science and Engineering **407** (2018) 012103 doi:10.1088/1757-899X/407/1/012103

Table 2. Testing movement of the robot towards the target then results originated from calculation method odometry.

Target distance of robot (cm)		Read Data		Error (cm)	
x	y	x	y	x	y
0	0	0	0	0	0
10	0	9.78	0	0.22	0
20	0	19.8	0	0.2	0
30	0	29.87	0	0.16	0
40	0	39.9	0	0.1	0
50	0	49.99	0	0.01	0

In tables 1 and 2 are the results of the X mileage using GPS and Odometry Methods. Retrieval of robots to the target is filled in sequence so as to produce data that if made comparison will produce a graph as below. (Figure 4)

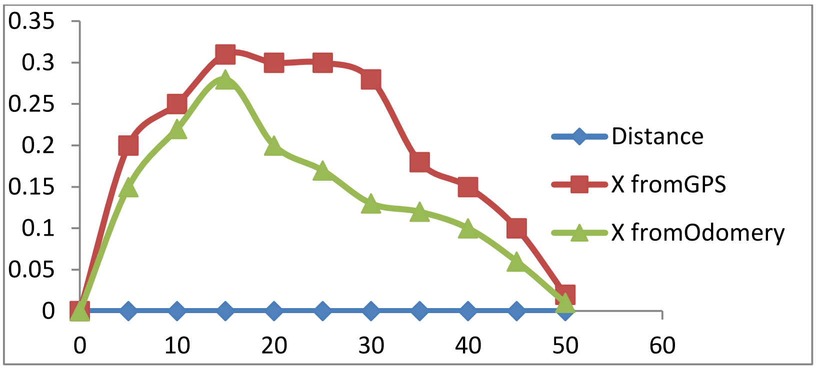

Figure 4. Comparison of distance between GPS and Odometry method.

Table 3. Testing movement of the robot towards the target then results originated between GPS calculation method odometry.

Target		Data GPS		Data Odometry	
x	y	x	y	x	y
0	0	0	0	0	0
100	0	103.9	0.55	99.95	0.03
100	100	102.54	102.54	100.98	100.24
0	100	0.87	101.89	0.67	100.03
0	0	0.4	0.1	0.1	0.23

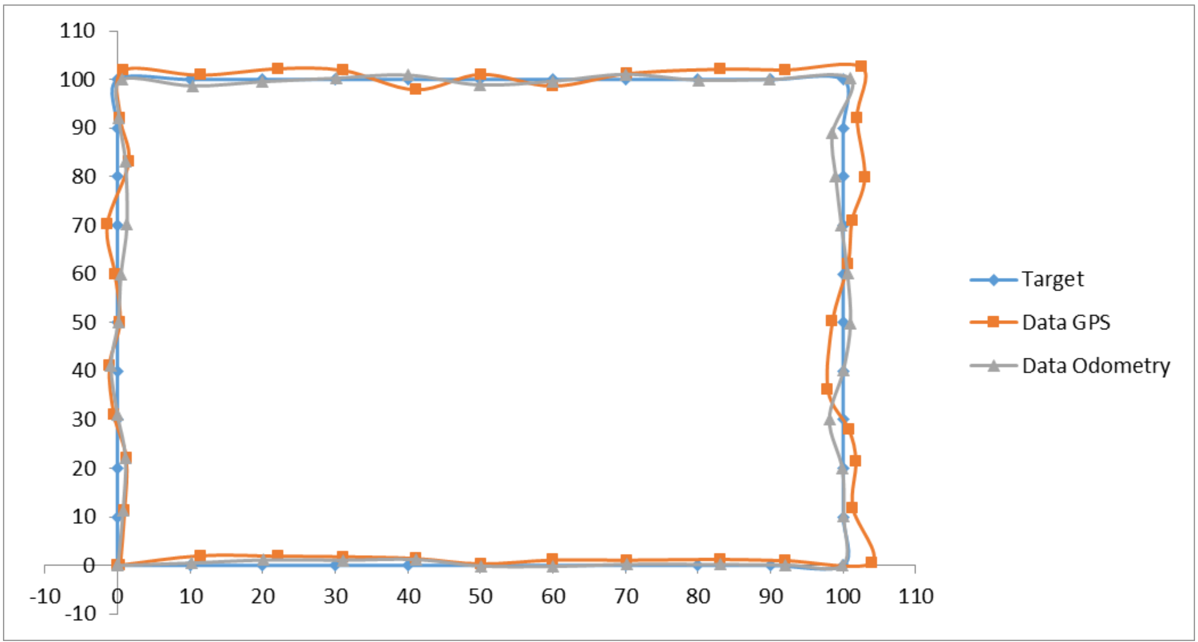

Figure 5. Results of data between odometry method and GPS with rectangular path.

Figure 5 is a comparison between the distance from the GPS data and the distance from the odometry method. In here, we can see that by using odometry method, wheeled robot is more accurate to the target than using GPS.

5. Conclusion

At a distance from GPS it has an average error (0.18%) of some data retrieval. While the distance from the data Odometry method has a little error than the GPS of (0.13%) of some data retrieval. So it can be concluded that to determine the distance to the target robot more accurate using odometry method than GPS.

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