3D Object Modeling Using Data Fusion from Laser Sensor on Quadrotor

Iswanto[1, 2, a)], Oyas Wahyunggoro[1)], Adha Imam Cahyadi[1)]

Department of Electrical Engineering and Information Technology, Universitas Gadjah Mada
Department of Electrical Engineering, Universitas Muhammadiyah Yogyakarta

[a)]Corresponding author: iswanto.s3te13@mail.ugm.ac.id

ABSTRAK

Environmental modeling of a robot which is needed for robot navigation and path planning is in the form of planar or 2D modeling. Several previous researchers have used laser sensor to model 2D obstacles because it has data accuracy for navigation. It is in a planar shape and implemented in quadrotor thus the obstacle modeling formed is in 2D. The problem in a 2D environment is that the path planning and navigation of the robot requires a considerable time because the robot stops at loca minima and attempts to find other paths in the dimension. The problem can be solved by using combined data taken from the laser sensor. The combination of the data uses several algorithms such as graph theory and vector field histogram algorithms. Therefore, this paper presents the combination of the algorithms to model a 3D environment. By using this model, the quadrotor is able to avoid loca minima.

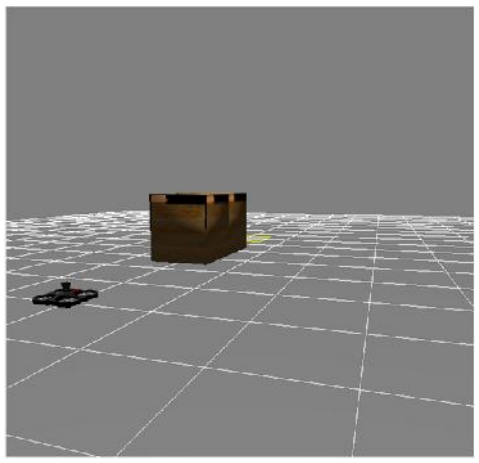
Keywords: Quadrotor; Laser sensor; Graph theory; Vector field; 3D model.

LASER SENSOR

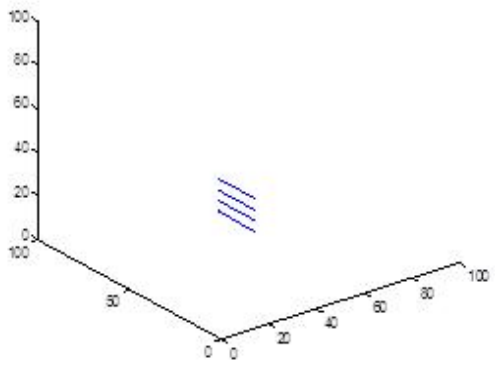
Hokuyo laser sensor is a 2D planar laser sensor which has been widely used by researchers for robot navigation as conducted by Zezhong et al. [14]. By using the sensor, robot detects an obstacle located in front of it. Babinec et al. [15] used this sensor to detect obstacles and for robot navigation by using VTH algorithm. Habermann & Garcia [16] used 2D laser for detecting and tracking objects. Kondaxakis et al. [17] used a laser sensor for tracking many targets by using JPDA-IMM algorithm.

FIGURE 2. Hokuyo laser sensor

RESULT AND DISCUSSION



(A)



(B)

FIGURE 4. Simulation Quadrotor with an obstacle

The first experiment carried out in this paper is to detect an obstacle object by using laser sensor. The sensor is mounted above quadrotor as shown in Fig. 5(A). The object which will be detected by the sensor is in a square shape by using VFH algorithm. Then it is modeled in 2D by using graph algorithms. By using the 3-D Model Shape algorithm, a model as shown in fig 5(B) is created.

Fig. 5(B) shows a graph of simulation as the results of 3D modeling of an obstacle. It is seen in the figure wall-shaped obstacles with a height of 1 meter and length of 1 meter. Such obstacle model cannot be in the form of square-shape obstacle as the original one because the laser will scan it in the form of planar, consequently it is not known whether the object is a triangular or square.

INTRODUCTION

The laser sensor is a sensor that has a very far distance of sensor range and not affected by sunlight interference. Many researchers have used laser sensor as a laser for wheeled robot navigation such as Morales et al [1]. By using the sensor they made a path tracking with pure pursuit algorithm. Other researchers such as Dekan & Vitko [2] also used a laser sensor to navigate a wheeled robot. By using it, they made an environment mapping for the robot. Laser sensor was used by Lingemann et al [3] for wheeled robot localization.

Researchers such as Gu et.al [4] combined laser sensor with an inertial sensor. The laser sensor was combined with odometry sensor as conducted by Yoshida et al [5]. The other researchers such as Kirsch & Rohrig [6] with research entitled "Position tracking using sensor fusion of a wireless network and a laser range finder" used fusion sensor to combine wireless network with a laser sensor.

Some researchers who examined the environment and obstacles modeling in 3D are Mohottala et.al [7]. They used laser sensors in combination with camera sensor for pattern recognition. They used graph algorithms to form a 3D object shape. Other researchers such as Bok et al [8] experienced a problem in the merger between the laser sensors with camera sensors. Gruyer et al. [9] conducted research by combining a laser sensor with a camera. Another researcher for modeling 3D objects is Solea et al. [10]. They modeled an obstacle and environment into a 3D object.

This paper presents the algorithm of graph theory with vector field histogram to form a 3D object from the sensor. The sensor used in this paper is laser sensor which is mounted in a quadrotor. In addition, graph algorithms to model a 3D environment with a data fusion of laser sensor is used.

SENSOR FUSION

Sensor fusion is an algorithm combining several data from many sensors or a sensor. Modeling an object as an obstacle can be conducted by using sensor fusion algorithm. The examples of algorithms used for sensor fusion algorithms are fuzzy by Tan et al. [18], graph theory algorithm by Mohottala et al. [7] and Vector algorithm by Babinec et al. [15]. This paper presents the combination of graphs and Vector Field algorithms.

Vector field

Vector field algorithm is the one which uses a basic principle of a vector. Ulrich & Borenstein [19] applied the algorithm to detect obstacles. Behrens et al. [20] used field vector algorithm to create a path for multi-agent navigation. Bresler [21] created optimum visual with vector field algorithms and multi-sensor fusion. Kwon & Chwa [22] made the wheeled robot formation with a vector field algorithm.

Graph theory

Graph theory is a theory that is used by some researchers to search the shortest path [23]. Graph theory has been developed to be applied in several path planning. This theory can also be implemented to analyze a laser sensor and multi-sensors. Yu & LaValle [24] used graph theory to optimize multi robot path planning. Grigoryan & Harutyunyan [25] conducted research to find the shortest path. A search for the shortest path they have conducted used graph knodel algorithms. Yang & Sun [26] processed multi-sensor robot data underwater by using graph theory. They combined graph theory with fuzzy. Mohottala et al. [7] conducted research by using laser sensors and cameras. For object recognition in the form of cars, they used graph algorithms. Graph G consists of a non-empty set of an element called the point (E), and a path between points is called the side or line (V). A graph G is denoted as G = (V, E). The graph used in this paper is a weighted and undirected graph. The weight of the graph is an object point obtained from equation 12. Figure 4 is an obstacle distance point obtained from equation 12. In this figure it is seen that the distance point of E1 and E2 will be equal to the distance point of E2 and E3. Distance from all points is obtained by calculating equation 8.

RESULT AND DISCUSSION

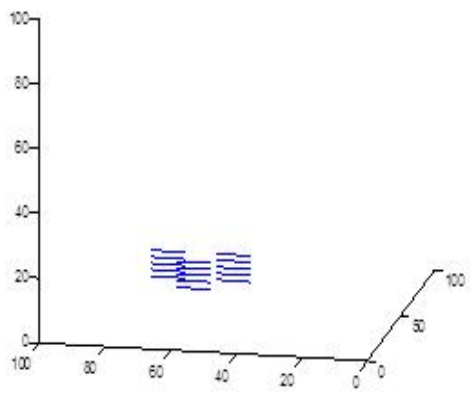


FIGURE 5. Simulation Quadrotor with three obstacles

The second experiment uses 3 square-shaped obstacles. An obstacle is placed at position point (60; 60).Then two other obstacles placed behind the first one at position point (60; 60), and (60; 70) as shown in Fig. 5(A). This experiment also uses quadrotor mounted in a laser sensor. Obstacles saw in Fig. 5(A) are created in a 3D model. The shape of obstacle objects is seen in Fig. 5(B).

CONCULUTION

In robot navigation, an obstacle modeling is necessary for the robot to be able to avoid obstacles. In UAV robot modeling in 3 dimensions is required for navigation. This modeling uses VFH and graph theory. By using the combination of the two algorithms, it is obtained a 3D model of obstacles.

QUADROTOR MODELING

Robot model presented in this paper is a model of flying robots with rotary wing type. Rotary wing type is a type of robot that can perform VTOL and hover. Hover is a position of a UAV that is stable at a high altitude. Research on hover has been much conducted by researchers such as Shin et al. [11]. They conducted research by using a ducted fan to hover at particular altitudes. Other researchers such as Sandino et al. [12] used a helicopter to hover.

In this paper, a quadrotor model is used which was first studied by Pounds et al. [13] that created a dynamic and kinematic model for quadrotor that could lift weights of 4kg. The model of the quadrotor is shown in Fig 1.

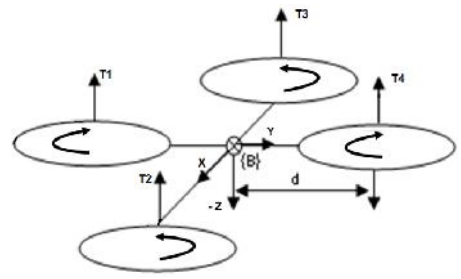
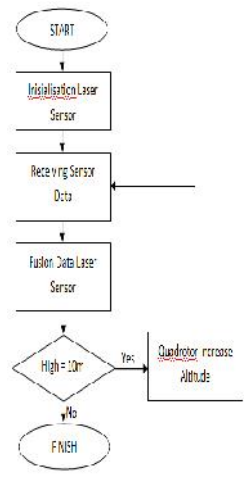


FIGURE 1. Quadrotor Modeling

3-DIMENSIONAL MODEL



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