M – 7

PATH PLANNING OF UNMANNED AERIAL VEHICLE USING DUBINS GEOMETRY WITH AN OBSTACLE

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Abstract

Motivation: Unmanned Aerial Vehicles (UAV) is an aircraft that is controlled without the use of human beings crew. One of main problem of Unmanned Aerial Vehicle's (UAV) flight is guide. UAV need a guide who can direct the movement of aircraft to arrive at the destination, so it takes planning trajectory (path planning) appropriate to the aircraft can be controlled in accordance with the objectives and can pass the desired trajectory. Given two points on a 2-dimensional plane, the two points are coordinates the initial and final coordinates to be taken by UAV. And between the two points is given a obstacle in the form circle. Planning algorithm trajectory using Dubins geometry. Results obtained from this paper are path planning to produce path between two points with the shortest distance and shortest time. The first track is the track without a obstacle and the second path is the path to the obstacle. Differences in distance on the second track is provided.

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1 INTRODUCTION

Unmanned Aerial Vehicle(UAV) is an aircraft that is controlled without using human crew. The aircraft can also be equipped with cameras, sensors, radar, and other equipment with weights that depend on the weight of the aircraft. UAV can be used among others for the connaissance role and intelligence data collection including combat missions, mapping, and aerial observation. Additionally UAV has been applied to civilian purposes for example disaser mitigation, theft sea sand, forest fire monitoring. UAV could be an alternative solution which has ability to perform the same function with satellite and manned by level of the operational state of the smaller and to minimize accidents and casualties. The Ability of UAV can be controlled remotely or even be in the program it self with certain path will be beneficial to the cost and time more effective and efficient.

UAV requires navigation system, guide, and control who is able to direct the plane to move to the destination . Navigation cost is the process of directing the aircraft position from one point to point others safely and smoothly to avoid obstacles flight . Flight navigation process is coordination of planning, sensing , and control . Problems navigation . The simplest is to find the path from the initial position to the target and through without a collision and avoid obstacle that exist . Based on the position or location , produce trajectory guide must be followed . While control consists of an actuator that can Puna follow a desired trajectory.

Trajectory planning is very important in navigation, guidance, and control flight. In the trajectory planning UAV can be used various methods. Trajectory planning algorithm will generate trajectories a safe and a trajectory with a minimum length and neglect any obstacles that block. So it can produce the optimal time also in the process of flight.

Trajectory planning model unmanned aircraft has been widely studied with various methods one Dubins geometry method. Plan track to more than one Puna also has done is path planning made to detect , models , and keep track of the cloud boundary contaminated (Subchan et al , 2008). Different research proves that method Dubins shows the optimal

trajectory by using optimal control principle of Pontryagin (Shkel and Lumelsky, 2001) .
Excess methods
Dubins geometry because it can generate curvature of the line by interpolation.

In this paper applied trajectory planning algorithm using geometry Dubins and simulation in MATLAB software that will be able to help direct the movement of Puna. So as to facilitate control of UAV flight trajectory.

2 METHODS

2.1 Path Planning

Path planning is the process of planning a trajectory that will be passed by the robot , or plane from the initial position towards targets to obtain the optimal trajectory . trajectory the optimal shortest path and the trajectory
are free from obstruction . Path planning in general can
written as follows:

$$P_s(x_s, y_s, \theta_s) \rightarrow P_f(x_f, y_f, \theta_f)$$

where :

P_s : start position
P_f : Posisi akhir Pesawat
x_s , x_f : start and finish position on absis
y_s, y_f : start and finish position on ordinat
θ_s, θ_f : start and finish angle

The main problem in planning the trajectory is navigation is the coordination of planning, sensing, and control. In planning navigation desired is to the destination without getting lost or so that a collision can be found trajectory optimal and can pass through. Things that are included in
navigation issues include:

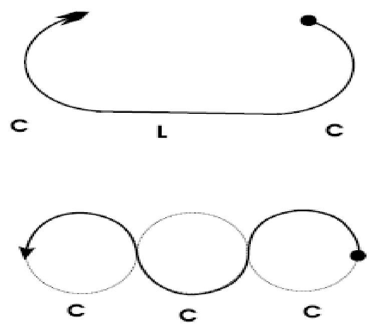
1. Mapping and modeling area
2. Planning trajectory
3. Follow the path (path -following) and subsequent trajectory analysis

2.2 Dubins Method

Dubins is one of the methods in designing the model trajectory is the shortest path connecting the two configurations in a plane under the constraints that bound the trajectory curvature . Line is the shortest distance between two points and an arc which is a change of curvature of the shortest . Planning Dubins path is formed by a series of two circular arc with a tangent or with three lines tangential arc.

2.2.1 *Flyable path* Dubins

Dubins trajectory on the plane dbangun by straight lines and circles can be CLC , then CCC , and the last CC , LC , or CC , with a description of C is arc and L is a straight line . By combining the two curves are then formed the shortest path . In building models Dubins path there are two approaches , namely the euclidean geometry and differential geometry . In euclidean geometry approach is more in focus for CLC trajectory shape , while the differential geometry using CCC with the shape of the trajectory can be illustrated as in Figure 2.3



Sumber: Shanmugavel,M., 2007

Gambar 2.1 Dubins path CLC dan CCC

2.2.2 Geometry Dubins Path

In analytic geometry , Dubins trajectory generated by drawing a tangent between two arcs . In general tangent arcs connecting between the external and internal arc. Chances Dubins geometry path formed there are four kinds of trajectories that LSL , LSR , RSR , and RSL with information L is left (left) and R is Right (right) [6,9] .

Marking the beginning and end of the movement can be determined by describing each round to the right or left . By paying attention to each position , positive or negative rotation will be defined by the curved lines of each movement . The input parameters in the track geometry Dubins as follows :

UAV starting position $P_s(x_s, y_s, \theta_s)$

UAV final position $P_f(x_f, y_f, \theta_f)$

The determination of the radius of the initial position r_s

The determination of the radius of the end position r_f

The process of calculating the length of the track geometry Dubins as follows:

1.) Determine the expected input parameters are the initial and final position of the aircraft.
2.) Determine the coordinates of the circle center point of beginning O_s (x_{cs} , y_{cs}) and center point of final circle O_f(x_{cf} , y_{cf})
3.) $(x_{cs,} y_{cs}) = x_s \pm r_s \cos(\theta_s \pm {}^{\pi}/_{2}), y_s \pm r_s \sin(\theta_s \pm {}^{\pi}/_{2})$
    $(x_{cf,} y_{cf}) = x_f \pm r_f \, cos\, (\theta_f \pm {}^{\pi}/_{2}), y_f \pm r_f sin\, (\theta_f \pm {}^{\pi}/_{2})$
4.) The distance between the center of the circle Of O_s and connected by a line called the center line *c* which can be calculated by Euclidean geometry.
5.) Determine the position coordinates of the entry tangent T_{en} (x_{Ten}, y_{Ten}) and exit tangent T_{ex} (x_{Tex}, y_{Tex}). Tangent exit is the exit point of the trajectory longitude circle and beginning of the track line. While the tangent point of entry is the end of the track line and the beginning of the second circular arc to be formed. Prior to determining the need to coordinate the entry angle calculation $\emptyset_{en}$dan $\emptyset_{ex}$ exit angle.
6.) From the above it can be calculated Dubins path length as follows:
    $L_{Dubins} = L_{(arc,start)} + L_{(tangent)} + L_{(arc,finish)}$
    $L_{Dubins} = f\ (r_s, r_f)$

2.2.3 Eksistence Geometry Dubins Path

Before to calculate the length of the track , it is important to know the possible trajectories to be passed by the aircraft . It will save time in the computing system . Existence path between two characters Dubins path etermined by the tangent of the arc . Externally tangent and tangent exit determine the existence of trajectories RSR and MSM , while the presence of the RSL and LSR trajectory determined by the internal tangents . Externally tangent

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lost when the main loop is included with each other . Internally tangent lost when the main circle intersect each other . Both conditions are determined by the distance of the center c and radius - turning r_s and r_f . But the main center of the circle defined by the radius and curvature [6] . Therefore Dubins path relies on a function of the radius as follows :
Internal tangent : $(c + r_s) > r_f,\ r > r_s$
External tangent : $c > (r_s + r_f),\ r_f > r_s$

2.3 ***Flyable Paths*** **dan** ***Feasible Paths***

Flyable paths is apath where the path is located inside or do not exceed the maximum limit of curvature . As a proportional curve , very important for a track meet with a maximum limit of the curve of the track Puna . So that at any point of the track will not be greater than the maximum limit of the desired curve . This can be written as follows :

$$|\,\kappa_i\,| < k_{max}$$

With κ_i information is on track curve ke- i and k_{max} is the maximum limit of the curve on the track .

Feasible Paths is a trajectory that is flyable and safe . So it is possible that the path can be traversed by the UAV . A path is feasible if there is no intersection with the same length and meet the minimum curvature

3 RESULTS

Table 2. Parameter input and output

P_s	P_f	LSL	RSR	RSL	LSR
[4 0 0 1]	[0 0 30 1]	11.3088	9.2621	12.8811	15.4680
[3 3 60 1]	[0 1 30 1]	8.8592	10.9212	12.439	20.2170
[0 0 0 1]	[5 -3 135 1]	15.0101	9.7787	8.9560	21.6305

From the table above , can be obtained by comparing the shortest path from each path length formed and then plot the shortest path.

from the first row shows that the trajectory of the RSR is the shortest path . then lintasna that in the plot is the type path RSR

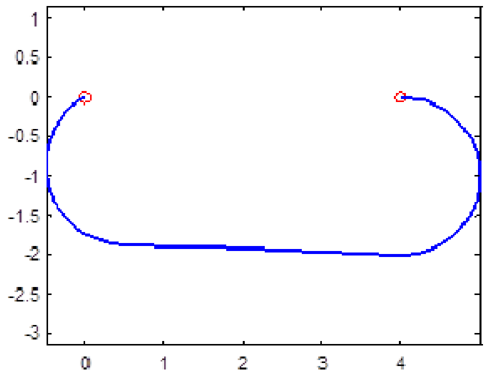


Figure 2.2 RSR path

from the second row shows that the trajectory of the LSL is the shortest path . then lintasna that in the plot is the type path LSL

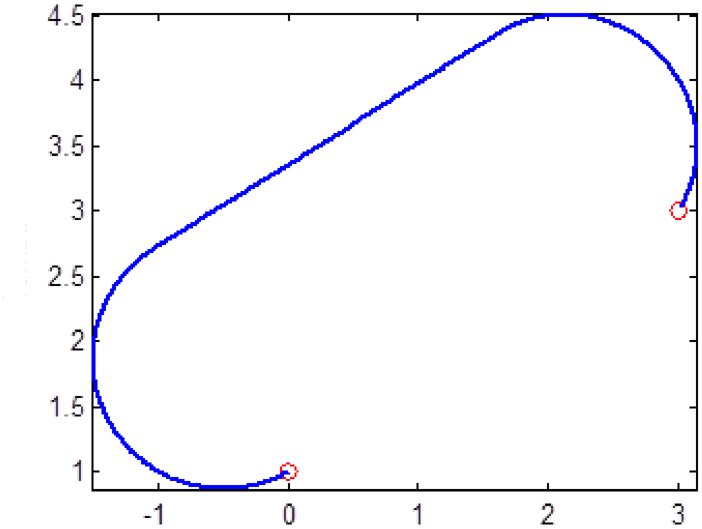


Figure 2.2 LSL path

from the second row shows that the trajectory of the RSL is the shortest path . then lintasna that in the plot is the type path RSL

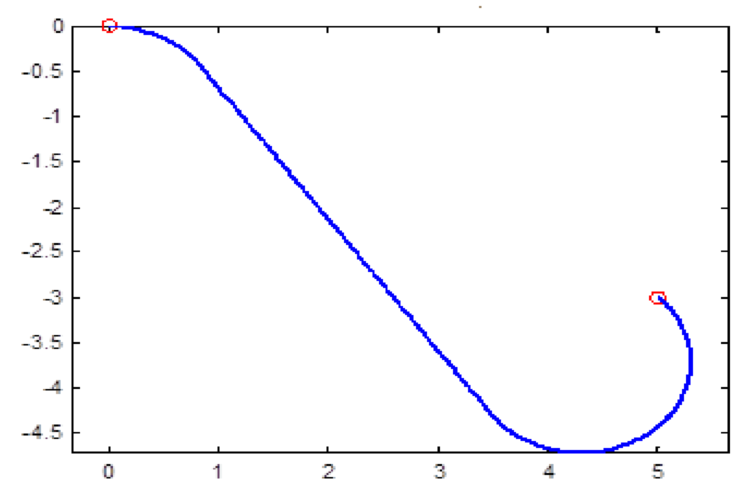
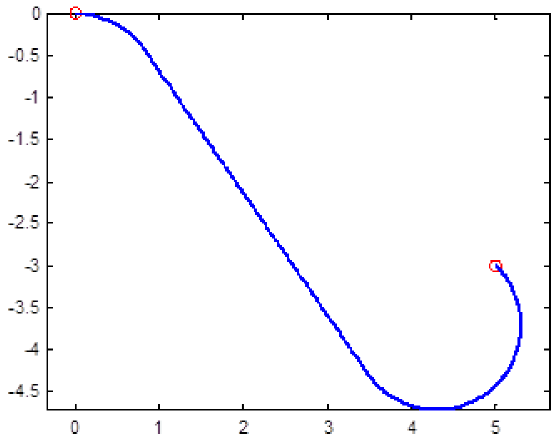


Figure 2.2 RSL path

4. Conclusion

The central idea developed in this work is that the problem of finding the shortest path between two configurations. The main idea in the development of this trajectory planning is to facilitate the UAV in order to fly the shortest path and efficient. determining the shortest path based on calculations that depend on the angle facing, radius of curvature, and also the starting position, this method is known as Dubins geometry .

In addition, the benefits of this trajectory planning is finding a safe path for dilaluipesawat to function as the function that facilitate human performance



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