웨이포인트 최적화 방법에 대한 UAV 시뮬레이션 모델의 디자인

니욘사바 에릭* · 장종욱*

*동의대학교

A design of UAV Simulation model for waypoint optimization method

Niyonsaba Eric* · JongWookJang**

*Dong-Eui University

E-mail : niyonsabaeric@gmail.com, jwjang@deu.ac.kr

요 약

최근에, UAV는 위험하거나 파일럿이 필요하지 않는 지역인 군사 또는 민간 활동으로 부터 발전되어 왔다. 하지만, UAV는 감시활동 또는 어떠한 지역 이미지/영상을 찍는 것과 같은 그것의 임무 활동 능력에 높은 요구가 필요하다. 그러므로, 무사히 임무완료하는 UAV로 부터 파워 소비량을 줄이는 기법의 방아쇠가 필요한 상황이다. 방법중 하나는 소비량 파워를 낮추는 적합한 이 웨이포인트를 통해 비행하는 최소한의 길을 찾는 웨이포인트의 사전지정을 가짐으로써 나누어 주는 최적한 절차 웨이포인트를 사용한다. 본 논문은 UAV에 기인하는 항공우주 산업 패케지 분석연구, Aerosim Blockset 그리고 UAV에 사용되는 MATLAB Simulink의 디자인 시뮬레이션 모델, 분석적인 모델로 대표적인 불가능을 만드는 여러 학문 분야에 걸친다. 그 시뮬레이션 모델은 UAV로부터 최소화 될수 있는 파워소비 백분율에 측정되는 순서에 웨이포인트(비행경로)를 가지는 알고리즘을 따라 좀더 최적화 연결을 한다.

ABSTRACT

In recent years, Unmanned Aerial Vehicles (UAV) have been developed for both military and civilian activities in regions where the presence of onboard human pilots is risky or not necessary. However, UAV require a high demand of power to achieve its missions such as taking images/videos in a certain area or surveillance activities. Therefore, this situation triggers the need of techniques to reduce power consumption for UAV to complete its mission safely. One of the methods is to use a waypoint optimization procedure which deals with a pre-specified set of waypoints to find a minimum route to fly through those waypoints in order to reduce power consumption.

In this paper, due to the UAV' s multidisciplinary which makes it impossible to be represented as an analytical model, we design a simulation model of UAV using MATLAB Simulink and AeroSim Blockset, an analysis package in aerospace industry. The simulation model is then coupled with optimization algorithms along with a set of waypoints (flight path) in order to measure at which percentage power consumption can be minimized for UAV.

키워드

Optimization algorithm, Waypoint optimization, Aerosim Blockset, Unmanned Aerial Vehicles

Ⅰ. Introduction

The development of unmanned aerial vehicles (UAV) has brought new opportunities with their low cost comparing to manned aircraft or satellites and to operate in regions like hostile territory where the presence of onboard human pilots is either too risky or unnecessary for both military and civilian activities such as reconnaissance, surveillance, aid relief and monitoring tasks. Furthermore, among various applications enabled by UAVs, some of researchers expect a high-speed wireless connectivity in future communication systems for devices without infrastructure coverage due to severe shadowing by urban or mountainous terrain or damage to the communication infrastructure caused by natural disaster [1]. UAVs more popular know as drones still the focus of many discussions in the technology field in different aspects such as applications, management, autonomy, energy efficiency and so on. In this perspective, the capabilities of new generation drones require a high demand of power that traditional batteries cannot support. This still the main issue for UAV to achieve its mission safely and this situation triggers the need of strategies to promote efficient energy usage to reduce the power consumption [2]. UAVs are also classified into two categories named fixed wing and rotary wing and are using depending on goals. Therefore, fixed-wing UAVs usually have high speed and heavy payload but they can maintain a continuous forward motion in the air but they are not suitable for stationary applications like surveillance tasks whereas rotary-wing which support limited payload are able to move in any direction as well as to remain stationary aloft. But, in order to make energy aware systems, it is important to realize how UAVs spends energy to achieve assigned missions. Mostly, battery life depends on the drone you are flying, wind velocity and the equipment you have on it such as cameras, sensors, communications tools or other payloads according to the goal. Enegy on UAV is an essential resource to its functioning, often needed to achieve the operational goals, endurance and other specific mission requirements. Mainly, three methods of energy optimization onboard the UAV are encountered which are optimization of mission waypoints, Hybrid-Electric propulsion system onboard the UAV and effective power management systems [3]. The complexities of most real-word problems make the evaluation of performance measures and finding optimal decision variables analytically very difficult. Instead of representing a system's performance as a mathematical model, using computer simulations of real-word events enables a complex problem to be examined and analyzed in an efficient , safe and cost-effective manner. In this paper, we design a simulation environment which represent a small fixed-wing to be used in waypoint optimization method as a real fixed-wing UAV in flight in order to minimize fuel consumption by finding a minimum route within given series of waypoints which the UAV has to fly through. The simulation environment is made by using MATLAB Simulink environment and Aerosim Blockset [4] which provides a set of tools for development of aircraft model.

Ⅱ. Waypoint optimization system

An UAV is deployed to carry out a specific mission through a set of waypoints from the initial waypoint to the destination point. Waypoints are defined in terms of longitude and latitude.

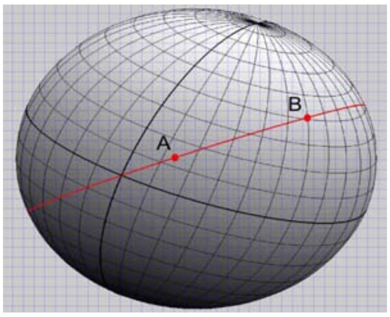

Figure1. Waypoint representation on Earth sphere

Waypoint optimization system follows the flight path from the waypoint A to waypoint B. Here, for given GPS coordinates of those two points, the navigation function calculates the minimum distance between those points and the bearing which is the angle orientation from initial point to the destination.

For a set of many points, the minimum route that connects the defined set of waypoints can be found in order to minimize fuel consumption onboard of UAV by using an optimization algorithm such as evolutionary algorithm to find an optimal solution.

Results from navigation function are passed to the UAV as input along with optimization algorithm for further outputs such as fuel consumption.

Ⅲ. UAV simulation model environment

As mentioned above, we simulate a fixed-wing UAV using MATLAB Simulink and Aerosim blockset library in order to use it as a real UAV in our simulations on how fuel consumption is decreased from one waypoint to another. Aerosim blockset is used aircraft simulation and analysis package in the aerospace industry which provides a set of tools for development of nonlinear 6-DOF aircraft dynamic models and includes environment model such as standard atmosphere, background wind, turbulence, and earth model(geoid reference, gravity and magnetic field). It is based in the development of dynamic models for unmanned air vehicles.

The library provides complete aircraft models built using Aerosim blocks, and which can be customized to particular aircraft by editing an aircraft parameter file. Here, among those aircraft model, 6-DOF aircraft model was chosen for a small fixed-wing UAV.

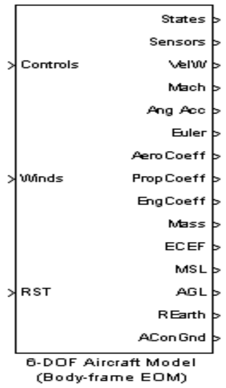

Figure 2. Aircraft Model in Aerosim Blockset

The aircraft model is the main component of UAV operations which consists of Aerodynamic, propulsion, Atmosphere, Aircraft Inertia, Acceleration and moments, Equations of Motion and Earth models. On the far left are aircraft control inputs such as control surfaces, throttle, mixture, ignition and wind velocities(figure 2). The outputs on the far right are the aircraft states including left fuel consumption and aircraft coefficients·The complete simulation model is constructed around of course the chosen aircraft at which are added flight planner and air control modules to simulate unmanned operations.

Those modules are built around aircraft model using Simulink blocks. Flight planner module comprises a MATLAB function which carries out the task of waypoint navigation. Way point navigation function calculates the distance and the bearing with a given set of waypoints in their GPS coordinates (Latitude, Longititude) along with altitude. The function uses a basic algorithm of great- circle navigation method which calculates the shortest distance following the curvature of the Earth and the bearing between two points. Thus, the aircraft can fly through the series of waypoints by flying a sequence of direct, curved paths from one point to another. Aircraft control module is used to control the angular orientation of UAV to adjust the flight controls to enable unmanned operations onboard the UAV. Therefore, aircraft control module inputs are passed to the aircraft model and some of the outputs of aircraft model are passed to flight planner during flight from one waypoint to another. Thus we can get in aircraf states how much left fuel after UAV mission. Here two waypoints in their GPS coordinates are chosen around GMAE international Airport in order to validate our UAV simulation model that can be able to compute left fuel after UAV' s mission.

Initial waypoint : Latitude=35° 10′ 15.90″ N
Longitude=128° 56′ 50.78″ E
DestinationWaypoint:Latitude=35° 11′ 48.42″ N
Longitude=128° 55′ 46.60″ E

Initial waypoint is included in the aircraft model configuration as shows figure 3.

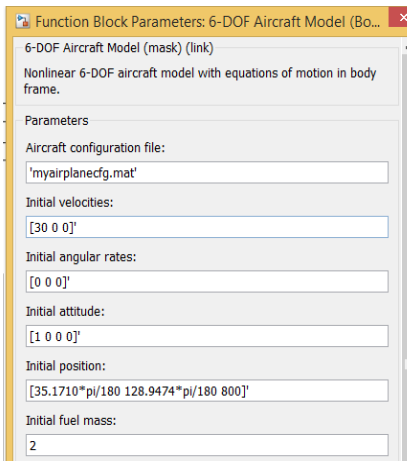

Figure 3. Aircraft Model configuration

Aircraft configuration file is MATLAB file which includes all parameters of aircraf model's different parts (Aerodynamic, propulsion, Atmosphere, Aircraft Inertia, Acceleration and moments, Equations of Motion and Earth models). Initial position represents initial waypoint in radians along with altitude and the initial fuel is 2 kg.

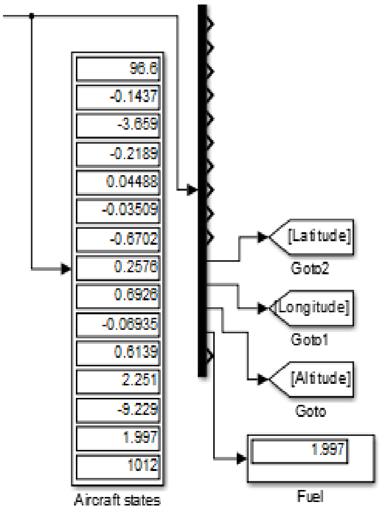

Figure 4. Output part of UAV Simulation Model

As shows figure 4,the outputs are destination waypoint coordinates and left fuel consumption. This let us to validate the UAV simulation model as it can compute fuel consumption from waypoint to another.This UAV simulation environment can be used for a given waypoints which represent flight path in order to minimize fuel consumption by coupling with an optimization algorithm such as evolutionnary algorithm to find an optimal solution for a shortest distance considering a set of given waypoints in GPS coordinates.

Ⅳ. Conclusion and Future work

In this paper, we design an UAV simulation environment for a real fixed-wing UAV in order to use it in further computations for minimizing fuel consumption with a given flight path made by sequence of waypoints. The simulation model was built using Aerosim Blockset Library and MATLAB Simulink to be able to compute fuel consumption. Future work will focus on how to minimize the fuel consumption with an optimization algorithm with many waypoints in flight path.

Acknowledgment

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