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AIRCRAFT BASED ON FUZZY LOGIC IN TF AND TA MANOEUVRES

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An Unmanned Aerial Vehicle (UAV) is an aircraft that flies autonomously or other automated guidance system. The modern use of unmanned aircraft often followed a consistent operational pattern described for dangerous, dirty and dull. Dangerous being that someone is either trying to bring down the aircraft or where the life of the pilot may be at undue risk operationally. Dirty is where the environment may be contaminated by chemical, biological or radiological hazards precluding human exposure. Dull is where the task requires long hours in the air making manned flight fatiguing, stressful and therefore not desirable. In this paper approach an Aircraft terrain following flight using fuzzy logic. This fuzzy controller presented in this work decides where and how the aircraft needs to change its altitude and airspeed. The altitude error is the difference between the desired altitude and the current altitude of the airplane and the airspeed is the current speed of the vehicle. The fast decision-making nature of this method promises real- time applications even for tough terrains in terms of shape and peculiarities. In the current approach, the system tries simple commands based on terrain pattern derived from detailed terrain data in a quick manner. Indeed, working mathematically with the pattern of the existing terrain as human eyes do, is a goal. Demonstrate that remembering terrain patterns allows pilot or autopilot to quickly decide on how to guide the aircraft. In approach, fuzzy logic is used as the mathematical calculation to achieve this goal. Nevertheless, the application of fuzzy logic to fly over mountainous areas, as explained in the current work.

Introduction

The flight missions have demonstrated the benefits of small UAVs. They are cheaper, convenient planes because of their size and do not risk the lives of the pilots. In feature, even the name unmanned aircraft assigned to unoccupied aircraft has changed over the years viewed by aircraft manufacturers, civil aviation authorities and the military. Aerial torpedoes, radio controlled, remotely piloted, remote control, autonomous control, pilotless vehicle and drone are but some of the names used to describe a flying machine absents of humans.

In previous research, an optimization technique that effectively generates a robust, optimum terrain following (TF)/terrain avoidance (TA) trajectory. For achieving this goal, dynamic programming is used. A systematic search for optimal trajectory is performed and the algorithm uses a complete data of real terrain and the terrain is discretized in spatial coordinate. Computational complexity increases by increasing the number of discretized intervals. There are some difficulties in using dynamic programming in real-time applications due to excessive time and processor memory for generating the optimal trajectory.

In fact, the performance of this algorithm is not suitable for real time applications. So fuzzy logic approach to the problem. The required fuzzy approach to accommodate such logic to find a set of rules which could guarantee a safe low-level flight in such areas. The fuzzy controller decides the change of altitude and airspeed that aircraft needs. The change of altitude error indicates whether the aerial vehicle is approaching the desired altitude. The linguistic value corresponding to the linguistic variable change of altitude error are [Negative change, Stable, Positive change]. The air speed is the current speed of the aerial vehicle. The linguistic values that represent the linguistic variable airspeed are [Small airspeed, Medium airspeed, Large airspeed]. The fuzzy controller evaluates the flight path flight condition and structural information simultaneously. It process the gathered information and determines the proper flight characteristics. The use of vision sensors on UAVs for the detection and tracking of mountainous region as well as the use of such sensors to control airspeed. Taking into account the large amount of forces needed to cover the huge area of terrain region with UAVs.

METHODS TO SOLVE THE SITUATION

The method could always assist to design trajectories in an off-line manner.

(1) Plan (2) Observe (3) Practical implications (4) originality

Plan : To achieve the fore mentioned goal, the method effectively incorporates the dynamics of the aircraft. Basically the mathematical method employs special relationships among existing slope of the terrain and its derivative together with aircraft flying speed and height above the ground to construct suitable fuzzy rules.

Findings : Different case studies conducted for flights in a plane . show the effectiveness of the method as compared to other existing methods. The results illustrate a good tracking based on fuzzy approach and only minor changes in the solution.

Practical implications : The current works offers a new approach in low-level flights where maintaining a suitable height above the ground is essential. This is especially important for civil aircraft approaching an airport with low or non-visibility and during aborted landing manoeuvres. The domain of the current work is however confined to only planning of TF manoeuvres . Nevertheless, the work could be expanded onto TF/terrain avoidance and three-dimensional manoeuvres which are not in the scope of the current work.

Originality : The current work addresses the problems associated with low-level flight; such as TF using artificial intelligence and fuzzy logic. The provided intelligence helps the aircraft conduct TF manoeuvres by understanding the general patterns of the existing terrain . The method is fast energy to be applied for real-time applications.

Using above things consider as an input vector. The basic configuration of a fuzzy system consist of a fuzzifier, a fuzzy rule base, a fuzzy inference engine and a defuzzifier. The fuzzy inference engine uses the fuzzy if-then rules to perform a mapping from an input vector to an output scalar. In the present paper, a terrain is recognized based on fuzzy logic so the small changes in terrain are omitted automatically. The following figure 1 shows a decision-making algorithm which commands the aircraft based on the existing terrain profile together with the aircraft speed, its position and orientation.

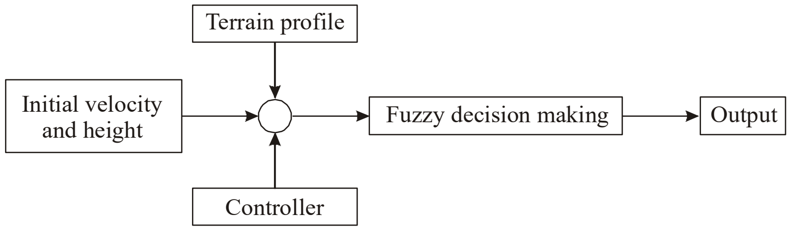

Fig. 1

The aircraft should perform a *TF* manoeuvre in vertical plane, but based on some conditions the vehicle can perform a *TA* manoeuvre in horizontal plane automatically.

Aircraft Terrain Based on Fuzzy Logic : TRN systems generally use a suitable combination for input including aircraft inertial navigation system data, height above ground level, altitudes above mean sea level and finally terrain heights from the stored map data to provide high-precision drift-free navigation.

Terrain-referenced navigation (TRN) techniques currently used in some aerial vehicles provides relatively accurate position registration relative to a given terrain map database .

TRN combined with "fuzzy logic" is expected to play an important role in the field of aircraft navigation and guidance in terminal phases; especially for airports situated in mountainous area. There is, however, a need for a fast TF algorithm and apparatus to fly an aircraft, which can effectively assist pilot or act as a complementary mode for the autopilot. Fuzzy logic is the key concept here, as it is well known that fuzzy decision making is fast and relatively accurate for critical situations such as flying in the vicinity of the ground where quick-approximate algorithms are more vital as oppose to slow-accurate ones.

In general, the objective of *TF*/terrain avoidance (*TA*) flight path that maximized survivability while satisfying appropriate path constraints. Chance of survival of an unmanned aerial vehicle in low-level flights depends on its height and speed. Obviously, for long-range/endurance flights atmospheric conditions play a considerable role in the mission success.

In fact, local phenomenon close to terrains might be very serve and need to be accounted for. This is an attempt to quick manner which otherwise could drastically increase the computation time us fuzzy logic to stay off the local atmospheric effects.

***TF*/*TA* manoeuvres :** The trajectory planning in *TF*/*TA* manoeuvres, the vehicle is expected to independently perform either *TF* or *TA* at any time during the flight. A suitable logic decides whether the vehicle is able to pass over the existing terrain (*TF* manoeuvers) or it should switch to pass around it (*TA* manoeuvres). This process usually requires a considerable planning to find the most appropriate speed and flight altitude so as to guarantee a solution for either manoeuvre in timely manner or it would not be applicable for arbitrary type of terrain.

In a more general *TF*/*TA* manoeuvre, a trajectory consisting of series of curves in the three-dimensional space could be developed to support the flight. The curves could have simple forms in vertical (longitudinal) and horizontal (lateral-directional) planes connected with some transitional curves as figure 2shows. Basically such trajectory planning is used in this research in order to develop specific rules to be used in a fuzzy decision-making controller is used to provide. Then, the controller is used to provide trajectories for a quite arbitrary terrain.

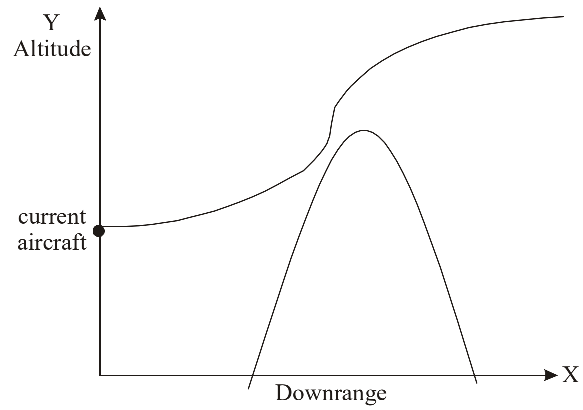

Fig. 2

In fact, fuzzy logic employed to extract a set of suitable rules resulting from off-line computation to suit the quick response needed for real-time applications while flying over unknown terrains.

It is well noted that the terrain data could be based on any forward looking radar or stored terrain maps. In conventional TF/TA method, trajectory design is based on fairly accurate terrain modelling. In such cases, designers try to model details of terrains and algorithm needs to have sufficient data of the terrain a head of the aircraft. This reflects a very cumber some task and is sometimes impractical to use all the terrain information for the entire flight. However, this research use a much less volume of data and it is not sensitive to small changes in terrains as they have little effects on the aircraft control logic.

Vision-Based UAV Control : There are many visual serving applications for UAVs present in the literature. Different vision-based algorithms have been used to follow a car from a UAV. Visual terrain following (TF) methods have been developed for a vertical take-off and landing (VTOL) UAVs. A vision-based algorithm to follow and land on a moving platform and other related tasks are proposed. A cooperative strategy has been presented for multiple UAVs topursue a moving target in an adversarial environment. The low-altitude road-following problem for UAVs using computer vision technology.

This work is based on the control of the lateral, longitudinal, vertical and heading velocities of the quadrotor to modify its position to follow and land on a predefined platform. Related to the autonomous landing, there exists previous work that is focused on the theoretical control part of this problem, which has been examined in simulated environments. This presents a classical PID control using the SIFT vision algorithm, proving the feasibility of this algorithm for this specific task and testing the controllers in a simulated environment. In the use of visual information at different stages of a UAV control system, including a visual controller and a pose estimation for autonomous landing using a chessboard pattern. A visual system is used to detect, identify a landing zone (helipad) and confirm the landing direction of the vehicle. The landing with a VTOL aircraft makes use of a fusion sensor control system using GPS to localize the landmark, vision to track it and sonar for the last three meters of the autonomous landing task.

The work is used a method to fuse visual and inertial information in order to controlan autonomous helicopter landing on known landmarks. The results of a fusion sensor of GPS, compass and vision with a PID controller to track and follow the landinglocation and land on a landmark. Overall, all of the aforementioned works are related to fixed wingaircraft or helicopters. A visual system is used to estimate a vehicle position relative to a landing place. Recently, shown two different methods to be used with micro-UAVs for autonomous takeoff, tracking and landing on a moving platform. This work is based on optical flow and IR landmarks to estimate the aircraft's position. The work displays the experiments of the autonomous landing of an AR. Drone on a landing pad mounted on top of a terrain region.

Conclusion

The control approach was done using fuzzy logic techniques, and the controllers were initially tuned in a simulated environment. A series of tests for the following and landing on a moving target was presented in this paper. The use of vision tracking algorithms is the next step to improve this vision-based control approach.

For ensuring that pilot is assisted in a timely manner to enhance safety during flight close to the ground, advisory information is needed. Moreover, in unmanned vehicles providing advisory information is not needed.

As a consequence using technology derived from TRN and TF new systems have been developed which react automatically such systems are called ground collision avoidance system, which use a terrain database to determine if the aircraft is in danger of flying too close to the terrain, or obstacles and then to react automatically.

In this work, now fuzzy approach could be used for TF flights. The necessary pitch communal are generated based on understanding both aircraft speed and altitude as well as terrain patterns in a fuzzy manner, one might conclude that the fuzzy approach serve as a fast near-optimal solution to the TF problem. It is therefore expected to be suitable for on-line applications demand a thorough investigation on the necessary hardware including the effect of sensors.

The current work could be extended to include TA flights to have a complete three-dimensional fuzzy controller for flights in the vicinity of the ground. Such a controller could effectively decide whether to accept a pitch command to flyover a terrain or to go-around it.

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