Vision Based Navigation of Aerial Drones over The Rain Forest: Extracting and Tracking Natural Landmarks

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***Abstract*—There is a sort of important scenarios, such as long endurance missions, where an autonomous drone would be very effective. One of these scenarios of applications is the long term monitoring of the Amazon rain forest. The uniform pattern of the canopy defines a mission difficult to be performed by a human operator. In such situation, an embedded vision system capable to drive the vehicle while taking decision of what is not fitting to a standard canopy pattern plays a critical role on both remotely operated and autonomous navigation modes. This work presents a scheme based on image processing able to extract natural landmarks in forest areas, and to track them during posterior missions over the same area, as reference for the onboard navigation system. The scheme is composed of two main steps: nonrelevant features suppression based on wavelet, to eliminate the canopy uniform pattern and keypoints extraction by SIFT algorithm, to track natural landmarks. Preliminary results demonstrated that this system can increase the robustness of mission execution in scenarios where usually only GPS references are available.**

Keywords-component: natural landmark tracking; feature suppression; wavelet transform; unmanned aerial systems

I. Introduction

The Unmanned Aerial System (UAS) term is typically applied to more than just an unmanned aerial vehicle (UAV). Its field of applications spans from military to civil domains and can cover a dozen of different types of missions, including border security, combat, environmental monitoring, industrial inspection, among many others.

For the Amazon rain forest area, a relevant problem to be faced when considering navigating by vision is the uniformity of the canopy pattern. The all-equal treetops view from above makes the autonomous navigation by vision a difficult task even with good weather and long range visibility. In the occurrence of fog or a cloudy weather (not mentioning rain) the complexity increases dramatically. In such a situation, landmarks on the ground play an important role in navigation systems, giving to the vehicle references to be followed. As landmarks one may have clearings, river branches, or any element that contrasts from the uniform pattern of the canopy.

The degree of autonomy that an aerial vehicle can achieve with an embedded vision system helps to solve unexpected critical situations, e.g., loss of Global Positioning System (GPS) signal, and the ability to interact with the environment using natural landmarks [1]. This paper presents a vision system that track natural landmarks tagged with geodesic information.

II. Problem Statement

The problem can be briefly stated as follows: given an UAS, an onboard computer, a monocular camera pointed to the ground, and software development tool, define vision based navigation system capable to track a trajectory based on sequence of natural landmarks previously defined by a mission planner.

The main goal of the proposed system is to prepare the UAS to be able to execute a mission entirely defined by a image sequence of natural landmarks tagged with geodesic coordinates.

This cooperation between GPS and vision based navigation is very convenient for missions subject to temporary loss of GPS signal, or where images are part intrinsic of the performed task, like environmental monitoring or industrial inspection.

III. Tracker of Natural Landmark based on Keypoints Matching

The tracking of a trajectory defined as a sequence of landmarks applies wavelet transform (to eliminate the canopy pattern) and the SIFT algorithm [2] to the online video. The SIFT output keypoints are compared with the landmark results (previously computed). It is important to notice that the reference trajectory may be provided offline from previous flights over the same area, in this case the UAV is overflying the same area more than once during the same mission. See the block diagram in Fig. 1.

Initially, the canopy pattern is eliminated via multiresolution analysis of images based on wavelet transform, to extract the LL sub-band using *Haar* family. In this case, at a larger scale it is possible to extract only the salient features and suppress the nonrelevant ones [3].

Afterwards, SIFT algorithm is used to automatically identify keypoints of the acquired video frames (processed online), and lastly perform the matching process using the information about these keypoints and the ones at the reference image (previously processed). It is important to say that the reference images were captured by a human operator in a previous flight.

Using the keypoints previously found, a search is started for matching the keypoints that represent the same scene in reference image and sensed video frame.

SIFT variant methods, such as SURF [4] and ASIFT [5] were also evaluated. However, SURF performance is poor when considering image rotation, and the computational effort to implement ASIFT does not compensate the gain in number of matches.

Therefore, as confirmed by the experimental results in the next section, SIFT is the best suite method for feature matching to our scenario of application.

IV. PRELIMINARY RESULTS

The software application was implemented using Matlab 7.8 over Windows 7. The images used were obtained by GEOMA/MCT project [6].

The results are obtained after the matching process between the reference image containing the natural landmark and the sensed frame that simulated the online video frame of the UAV; these input data were obtained in different time, angles and altitudes.

In the tracking test example (Fig. 2), some mismatches can be found along the video frames, or some correct matches can be found but the video frame is not always the best frame to represent the natural landmark. Therefore, the match with more number of correspondences becomes the new reference image for the sensed natural landmark, which will be used to track this same natural landmark and support the next navigation.

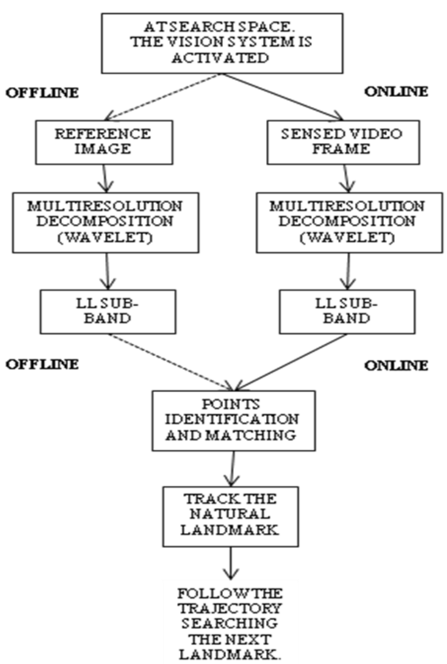

Figure 1. Natural landmark tracker module scheme.

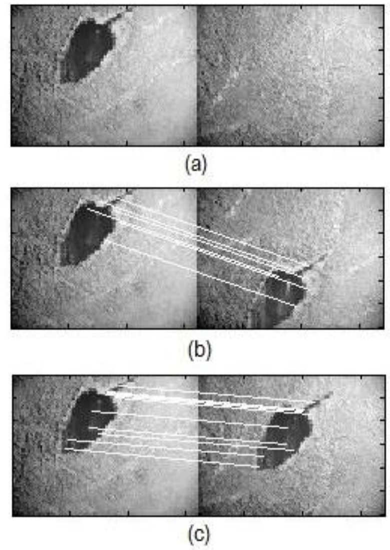

Figure 2. Tracking: (a) Any matches were found, the frame contains tree pattern; (b) the natural landmark starts to appear in video frames ;(c) the natural landmark is tracked.

V. CONCLUSION

This paper intends to integrate the algorithm as a navigation support for an UAS based on mini-UAVs.

In the keypoints identification phase, the results were encouraging in defining a scheme that finds feasible trajectories for a given aerial vehicle. Moreover, this method has the potential to be the basis of a more complete framework to detect non-expected or even illegal interference in the deep jungle, like deforestation, drug dealer's landing strip, or any type of aggression.

Next steps include the creating (including the image acquisition module in the tests) of the database of images, to improve the configuration of the filters parameters. The goal is to do these improvements in one year time frame.

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