Intelligent Algorithms for UAV Automatic Landing on-board a Moving Platform

1st Lokesh Bansal
Aerospace Engineering Department
Punjab Engineering College
Chandigarh, India
lokeshbansal.beaero16@pec.edu.in

2nd Hamza Benzerrouk, Rene.Jr Landry
Electrical Engineering Department
LASSENA, (ETS)
Montreal, Canada
hamza.benzerrouk@lassena.etsmtl.ca

***Abstract*—To develop a fully autonomous UAV it is important that it can detect the environmental conditions, so that autonomous Navigation and Guidance can be achieved. Detection of environment can be done using various techniques and broadly can be categorized in two divisions, one is in Radio Frequency environment and another is in Radio Frequency denied environment. In RF environments detection can be done using radio waves based tools such as GPS and Radiolink between the platform and the UAV, however, in RF denied environments, such techniques cannot be used and this work presents a survey of methods using in image and signal processing, carrying out an intelligent approach based on Artificial intelligence and machine learning. Such techniques would be very robust and can work in any kind of environmental and geographical situations. There are many application fields of UAV where radio waves are not available such as in jammed environment, uncovered areas, landing applications in marine environments, surveillance in remote locations etc.**

***Index Terms*—AI, machine leaning,autonomous systems, UAV, Particle filter, Hough.**

I. Introduction

Autonomous UAV driven by Artificial Intelligence to perform different tasks is demonstrated in this work. The research and development in the field of Computer Vision, object detection, visual parameter estimation as well as object target tracking became an attractive application since now many years. Circle fitting in the image, ellipse fitting as well as complex object edges were also deeply explored in robotics, intelligent computing systems, automation control, navigation etc. In this work, we consider a marine moving platform with heli-station supposed to be detected and tracked for automatic landing by rotor-craft UAV. This problem remains very attractive and challenging during the last decades and for many reasons is still challenging. In many cases where nonlinearity is faced, nonlinear least square such us Levemberg Marquardt variants and Weighted NLS were introduced for object shape parameters estimation offline, and then, online during recent processing development. In the same period and in addition, Kalman filtering and particle filtering were then introduced to track any object based on its color, edge, or a combination of criteria and their associated parameters. In this work, both Kalman and particle filters were demonstrated to be efficient tools for detection and tracking during automatic landing. Interesting results are carried out. [1-3].

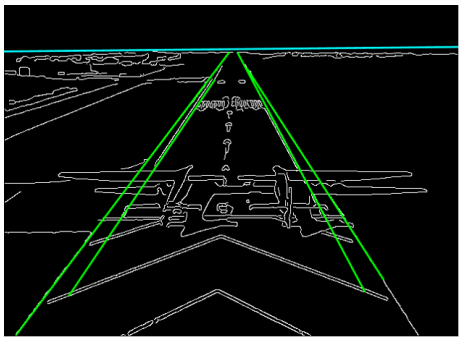

Fig. 1. Automatic detection and tracking of horizon and landing lines, Hough Transformation and kalman filtering were developed in a fusion framework.

II. State of the Art and Challenges

Development of such algorithms which do not rely on external navigation agencies such as satellites and radio signals, need to be very robust and powerful that can work in real-time. Implementation of standard signal processing techniques does not provide much efficient results in real-time and can be ideally used in post processing tasks, such as demonstrated in this work. The Forced implementation of standard signal processing techniques contain outliers which increases the entropy during feature extraction and reduces accuracy. To overcome the limitations of Kalman and Particle Filters, we investigated explore other techniques such as machine learning, to recognize environment for intelligent detection. Supervised Machine Learning Platforms like openCV and TensorFlow API are used, although the API contains a large set of dataset and the openCV library can provide results in real-time but more training and tuning of the algorithm is required to improve the detection. In this work, we have demonstrated the efficiency of using Machine Learning, compared to standard techniques such as Hough transformation, Kalman filtering, etc. [1-3].

A. Methodology of Autonomous Landing Intelligent Algorithms

Detection and Tracking were essentially based on least square algorithms and Kalman filtering approaches. More specifically, to detect special object or features in the image,

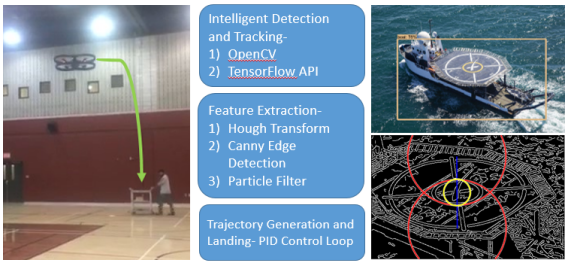

Fig. 2. Circular Hough Transformation with Kalman filtering approaches for circular landing zone on a mobile platforms on thr right. On the left, real tests done inside ETS, with moving platform and AR.DRONE2.0.

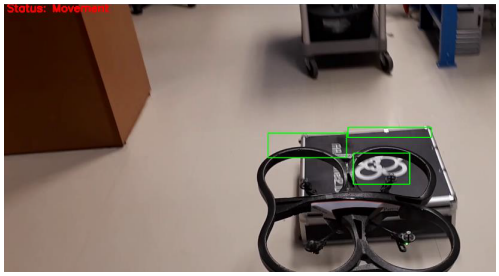

Fig. 3. Machine learning algorithm used to recognize the Landing mark and borders during real flight test inside Lassena laboratory (Situation-1)

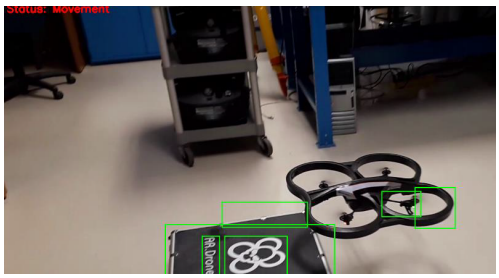

Fig. 4. Machine learning algorithm used to recognize the Landing mark and borders during real flight test inside Lassena laboratory(Situation-2)

different advanced techniques are used, the most famous method Hough Transformation is used, this technique was developed by Hough and proposed to detect any line in the image, with a pre-processed filtering for edge detection, as a condition for carrying out the best results in line detection tasks. An interesting evolution of the Hough transform is the modification and adaptation to the circular forms and ellipsoid detection. This makes the use of this technique very attractive in our application related to automatic landing on a Moving platform in denied GPS environment using Vision only sensors.

Starting from standard signal processing algorithms and the state of the art in computer vision approaches, advanced algorithms using Kalman filtering and particle filters as well as combination with Hough Transformation have been analyzed. To overcome the inconvenient of such approaches, and for real time implementation of Automatic Landing on a moving platform, Machine learning platform (Tensor Flow) was used for Features extraction and identification of the landing mark in a heterogeneous environment.Experimental work was processed on AR.Drone2.0 in Indoor environment carrying out interesting and promising results. [1-3].

1) Implementation results: The development starts with the implementation of standard but powerful signal processing techniques Hough Transform and Canny Edge detection, to increase the accuracy of detection different methods of Hough Transform are used such as Linear Hough Transform, Circular fitting Hough Transform and ellipse fitting Hough Transform. Initially, the algorithms are applied for image. processing, various images are used to check the robustness of the algorithm, and it was observed that many times with change of image, the algorithm requires some tuning as per the image and the introduction of adaptive and intelligent algorithms. Then the developed image processing algorithms based on Hough Transform is applied for video processing to detect a moving landing platform, real videos are used for validation. Further the algorithm is used with Kalman and Particle Filter and quite good feature extraction is achieved by video processing. To make the algorithm to work in real-time, machine learning platform is used with TensorFlow API is used and successful object recognition has achieved. Further training and tuning of the algorithm is required to increase the accuracy of the detection and tracking of the objects. Results are compared, analyzed and discussed.

B. Future work

Goal is to develop a technique that would be very robust, work in real-time, implemented with similarity analysis so that it can work in any kind of environment. It would be based on both supervised and unsupervised learning. For supervised learning powerful techniques like those that openCV and TensorFlow API would be used and for unsupervised technique the tools like LIDAR and other visual sensors like on-board camera would be used for efficient multisensory fusion. For this a metric is need to be developed that would be based on distance or information divergence, using this metrics the machine would be able to distinguish between two objects by implementing new similarity or dissimilarity functions. Particle and Kalman Filter would be used to minimize the entropy and increase the accuracy. In addition, further training of the machine-learning algorithm would be explored for efficient object recognition, classification and identification.

REFERENCES

[1] Polvara, R., Sharma, S., Wan, J., Manning, A., Sutton, R. (2019). Autonomous Vehicular Landings on the Deck of an Unmanned Surface Vehicle using Deep Reinforcement Learning. Robotica, 37(11), 1867-1882.

[2] Rodríguez Ramos, Alejandro Sampedro Pérez, Carlos Bavle, Hriday de la Puente, Paloma Campoy, Pascual. (2018). A Deep Reinforcement Learning Strategy for UAV Autonomous Landing on a Moving Platform. Journal of Intelligent Robotic Systems. 10.1007/s10846-018-0891-8.

[3] Lee, Daewon et al. "Autonomous landing of a VTOL UAV on a moving platform using image-based visual servoing." 2012 IEEE International Conference on Robotics and Automation (2012): 971-976.