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INTELLIGENT ALGORITHMS FOR UAV AUTOMATIC LANDING ON-BOARD A MOVING PLATFORM

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Preamble

- ✓ **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 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.**
- ✓ **In RF denied environments, such techniques cannot be used and this work presents a survey of methods using 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.**

Importance of this study

- ✓ The efficiency of Machine Learning techniques is compared to standard techniques such as Hough transformation, Kalman filtering, etc. [1-3] for automatic landing of a UAV on a Moving platform in denied GPS environment using Vision only sensors.
- ✓ Both Kalman and particle filters are demonstrated to be efficient tools for detection and tracking during automatic landing. Interesting results are carried out. [1-3].
- ✓ Circle fitting in the image, ellipse fitting as well as complex object edges are also deeply explored.
- ✓ To overcome the limitations of Kalman and Particle Filters, machine learning techniques are explored to recognize environment for intelligent detection.

Problem defined

- ✓ **Development of such algorithms which do not rely on external navigation agencies for autonomous detection and tracking of landing site on a moving platform.**
- ✓ **To develop an autonomous landing system for a UAV**

Experimental Methodology

- ✓ A marine moving platform is considered with heli-station supposed to be detected and tracked for automatic landing by rotor-craft UAV.
- ✓ Experimental work was processed on AR.Drone2.0 in Indoor environment.
- ✓ Detection and Tracking were essentially based on least square algorithms and Kalman filtering approaches.
- ✓ Initially, the feature extraction is performed on various images using standard but powerful signal processing techniques such as Hough Transform and Canny Edge detection.
- ✓ To increase the accuracy of detection Hough transform is modified and adapted to the circular forms and ellipsoid detection.
- ✓ The robustness of the algorithm is checked and was observed that many times with change of image, the algorithm requires some tuning as per the image.
- ✓ Then the developed image processing algorithms is applied for video processing to detect a moving landing platform, animated 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 and successful object recognition has achieved.

Fig. 1. Circular Hough Transformation with Kalman filtering approaches for circular landing zone on a mobile platforms on the right. On the left, real tests done inside ETS, with moving platform and AR.DRONE2.0.

Results and Discussion

Runway Detection and Tracking

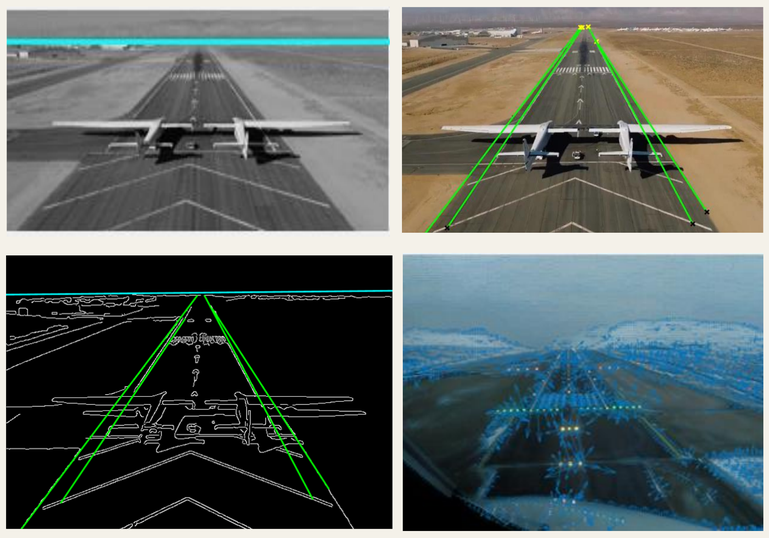

Fig. 2. Automatic detection and tracking of horizon and landing lines, Hough Transformation and Kalman filtering were developed in a fusion framework.

- ✓ The blue line represents the Horizon and the green lines are required track field detection lines.
- ✓ Using the Horizon detection line and the track field lines all the features like attitude, velocity can be extracted.
- ✓ To extract the features Particle filter, Kalman filter and Optical flow can be used.

Heli-Deck Detection and Tracking

Fig. 3. Automatic detection and tracking of heli-deck using Circular Hough Transformation (on the left) and Circular Ellipse fitting (on the right).

- ✓ Objective is to detect and track the center point of the heliport, so that the drone can target the point to land.
- ✓ Different detection techniques (Line detection, Circular detection, ellipse detection) is used together to increase the accuracy.
- ✓ The yellow circle is drawn taking the center of the landing platform as circle's center.
- ✓ Using Ellipse Fitting, the yellow and navy blue ellipses are obtained which focuses about the landing platform.
- ✓ The accuracy of ellipsoid detection is quite higher than the circular of line detection

Moving Landing Platform Detection and Tracking

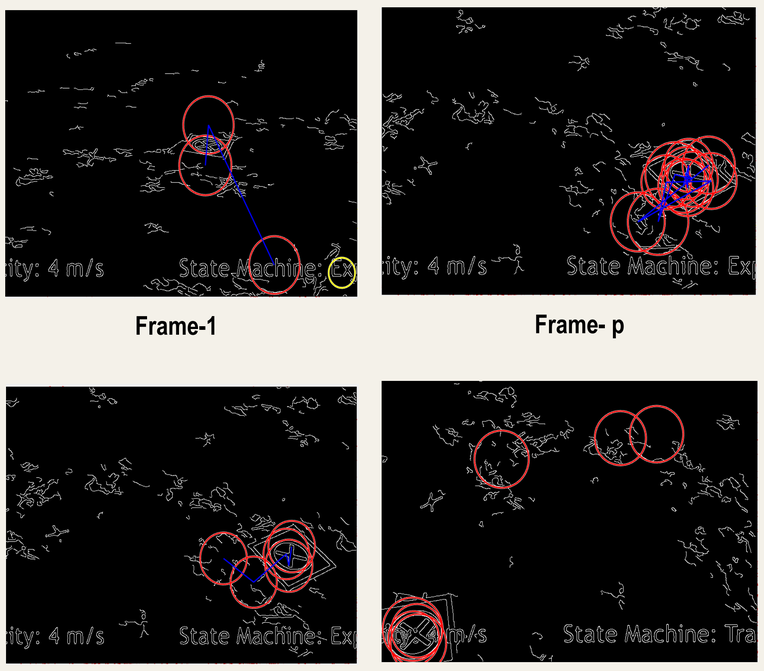

Fig. 4. Circular Hough Transform performed to detect moving Landing Platform for post processing on an animated video.

- ✓ p, k lies in (1,167) & 1 < p < k < 167
- ✓ The frames are from video of moving landing platform.
- ✓ Total frames = 167 for 5 seconds video.
- ✓ The red circles focuses on the landing platform.
- ✓ Through the red circles, the landing platform can be detected and tracked.
- ✓ More tuning of algorithm is required to remove the outliers.
- ✓ The algorithm can be useful for post processing tasks.

Results and Discussion

Real-Time Detection of Landing Platform

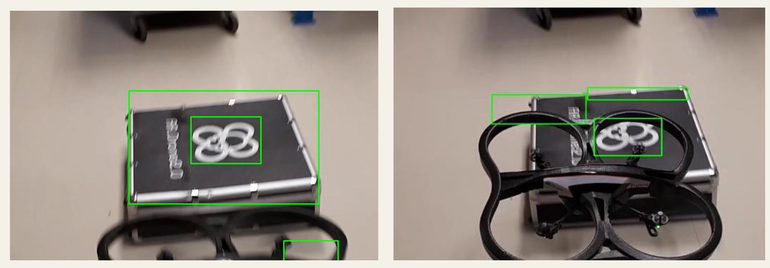

Fig. 5. Machine learning algorithm used to recognize the Landing mark and borders during real flight test.

- ✓ Carry case used as Landing Platform.
- ✓ The coding is done in Python with the help of openCV.
- ✓ The algorithm is nicely detecting the landing platform (The black box with white symbols).
- ✓ Still there is need to tune the parameters to remove the noise.
- ✓ This algorithm would be added with tensor flow Machine Learning technique, so that the drone would intelligently recognize the landing site.

Intelligent recognition of Moving Ship

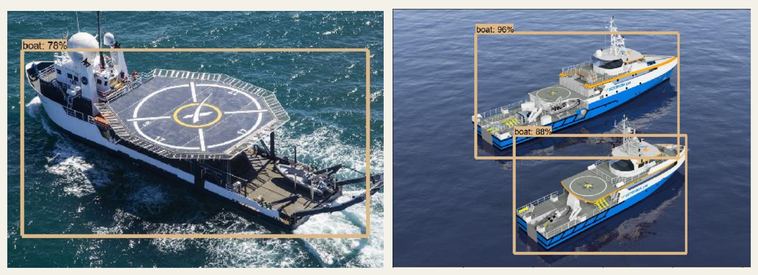

Fig. 6. Machine learning algorithm used to recognize the Landing vehicle in Marine environment.

- ✓ The ship is successfully detected and recognized.
- ✓ To overcome the limitations of Kalman and Particle Filters, we investigated explore other techniques such as machine learning, to recognize environment for intelligent detection.
- ✓ Using Tensor Flow in Python- algorithm is developed for object detection by image processing.
- ✓ Algorithm of Tensorflow is used with openCV for real-time, intelligent object detection.
- ✓ Training of algorithm is required for more accurate object recognition.
- ✓ Using the more trained algorithm the landing platform can be identified.

Conclusions

- ✓ 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.
- ✓ The Forced implementation of standard signal processing techniques contain outliers which increases the entropy during feature extraction and reduces accuracy.
- ✓ 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.

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