Second Laboratory Work: Detection and Tracking of Vessels in Oceanographic Airborne Images

I. Introduction

There has been growing interest in the topic of maritime surveillance, specially due to the European migrant crisis of 2015 [1] [2]. Frontex is an agency of the European Union that manages the cooperation between national border authorities securing Europe's external borders [3]. The surveillance of large portions of sea usually requires high investments and Frontex struggles with lack of equipment and human resources to perform an acceptable surveillance task [4]. There is a need to create an affordable system, easy to deploy, with few infrastructure requirements, that enables a better surveillance of the maritime environment. Recent cases of aviation disasters at sea, where there is the need to locate aircraft's wreckage [5], and the case of pirate populated waters on the Somali coast and Malacca Straight [6] [7], are further evidence of the maritime surveillance problem. Nevertheless, great investments have been made on technologies for maritime surveillance such as coastal radar, satellite imagery and aircraft patrols. Recently, Unmanned Aerial Vehicles (UAVs) have been used by different fields of expertise with variable applications. The maritime surveillance is one of those fields, but there is still room for improvements and further investigation in order to provide an efficient and robust real-time method that is able to detect and track multiple vessels from the images obtained using UAVs. What is proposed in this work is the use of UAVs with an integrated software based on algorithms of image processing and computer vision to allow the detection and tracking of vessels using camera sensors on board the aircraft. The objective is to develop a semi-autonomous system able to communicate with the respective coastal station and send only relevant detections to be evaluated by an human operator. Given the introductory nature of this work the focus is to develop a detection and tracking algorithm and then ascertain about its performance using some evaluation metrics as it will be detailed further.

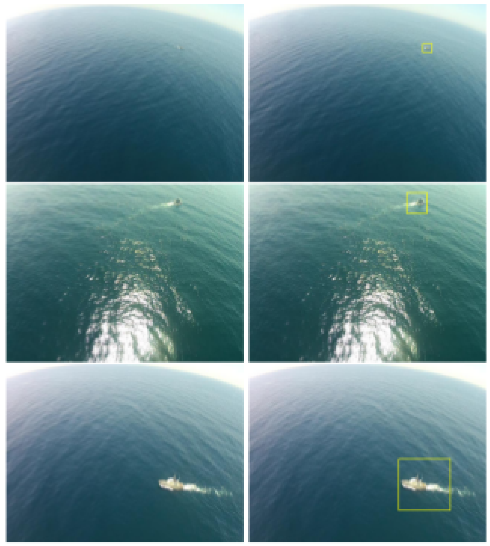

Figura 1. Images showing the original images of the vessel in the sea (left) and with the estimated position with yellow bounding boxes (right).

References:

[1] Wikipedia, “List of migrant vessel incidents on the mediterranean sea,” https://en.wikipedia.org/wiki/ List of migrant vessel incidents on the Mediterranean Sea, 2015, online; accessed: 21-12-2015.

[2] N. FRENZEN, “Frontex prepared to immediately expand air surveillance,” http://migrantsatsea.org/2015/04/23/frontex-prepared-to-immediately-expand-air-surveillance/, accessed: 21-12-2015.

[3] “Frontex: Mission and tasks,” http://frontex.europa.eu/about-frontex/mission-and-tasks/, accessed: 21-12-2015.

[4] N. Mathiason, V. Parsons, and T. Jeory, “Europe’s refugee crisis: Is frontex bordering on chaos?” http://labs.thebureauinvestigates.com/is-frontex-bordering-on-chaos/, accessed: 21-12-2015.

[5] “Search for mh370,” http://jacc.gov.au/search/index.aspx, accessed: 21-12-2015.

[6] V. Anastasia and C. Popescu, “Piracy in the gulf of aden - a problem of our days,” Constanta Maritime University Annals, vol. 13, no. 1, pp. 45-50, 2010. [Online]. Available: http://EconPapers.repec.org/RePEc:cmc:annals:v:13:y:2010:i:1:p:45-50

[7] H. Kang, “Gulf of aden vs malacca strait: Piracy and counterpiracy efforts,” 2009. [Online]. Available: http://www.ipcs.org/issue-brief/terrorism/ gulf-of-aden-vs-malacca-strait-piracy-and-counter-piracy-135.html

II. Goals

1) The first step is to built the ground truth of the sequence using the interface available for this purpose. This should be done along with the read of the paper [A] in which a possible solution is provided.
2) Implementation of the algorithm in [A]. Notice that the students are welcome to provide other solutions regarding the baseline provided. Value, in the final grade, will be given to alternative solutions, as well as the improvement over the baseline algorithm in [A].
3) After this stage, the students are in conditions to show both the ground truth and the estimated bounding boxes provided by the algorithm.
4) Now, evaluation must be done. To accomplish this, the following metrics are suggested:
   a) Provide a precision-recall curve. The precision and recall (for a given frame in the sequence) are defined as follows:

$$precision = \frac{true\ positives}{true\ positives + false\ positives} \tag{1}$$

$$recall = \frac{true\ positives}{true\ positives + false\ negatives} \tag{2}$$

   This should be done integrated the above measures through the sequence, obtaining the corresponding curve.

   b) Provide the Intersection over union measure (IoU) or the *success* measure over the sequence. The IoU measure is defined as follows:

$$IoU = \frac{R_d \cap R_{gt}}{R_d \cup R_{gt}} \tag{3}$$

   where R_d is the detected region estimated by the algorithm and R_{gt} is the ground truth (manual labeled) region.

   Compute the IoU or the *success* plot. The IoU (or the success) plot shows the percentage of frames whose bounding box overlap ratio is higher than a given threshold. For threshold values ranging from 0 to 1, with step of 0.05. The value of 1, means a perfect match, the value of 0 meas that the target is lost.

   c) Temporal Robustness Evaluation (TRE) metric.

   The TRE consists in initializing the tracker at different frames. That is, given one initial frame together with the ground-truth bounding box of the target, the tracker is initialized and runs to the end of the sequence, i.e., one segment of the entire sequence. The tracker is evaluated on each segment, and the overall statistics are tallied. For instance, each sequence can be evaluated by initializing the tracker in 20 different frames. The initial frame can be the first one, the others can be obtained by stepping them at a regular interval. In the above example, the step is approximately the number of frames of the sequence divided by 20.

Now, perform the success plot of the TRE.

d) Spacial Robustness Evaluation (SRE) metric.

The SRE consists in introducing an error by shifting the bounding box by 10% of the target size in 8 different directions, and scaling it by 0.8, 0.9, 1.1 and 1.2 of the ground truth size. This results in 12 different initializations.

Now, perform the success plot of the SRE.

Material to deliver:

- It is MANDATORY to deliver the ground truth file generated by the interface made available for generating the ground truth of the sequence
- Delivery of the graphics of the metrics above mentioned. A PDF file containing the graphics will be enough.

III. Reading material

The students are welcome to read the following paper:

[A] J. S. marques, A. Bernardino, G. Cruz and M. Bento, "An algorithm for the detection of vessels in aerial images", *11th Int. Conf. on Advanced Video and Signal based Surveillance* (AVSS), pp. 295-300, 2014.

In this paper, it is available a possible solution for the problem. However, the students are welcome to follow other research guidelines, or to improve the available solution. In these case a reward will be given.

EVALUATION:

The evaluation of this work will take place at the same Lab 11, at June 5th (Tuesday) and June 7th (Thursday). Thus, we have the following group distribution:

- **Tuesday 5th: Groups 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 11, and 12**
- **Thursday 7th: Groups 13, 14, 15, 16, 17, 18, 19, 20 and 21**