Geo-referencing for UAV Navigation using Environmental Classification

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Contribution

- The proposed method enables drift free localization of UAVs without the use of GPS.
- The method provides an absolute position reference, expressed as a standard measurement equation.

Geo-referencing

UAV localization from on-board vision is by now a well studied problem. The process of visual odometry (VO) has been shown to enable accurate pose estimates. However, without any absolute position reference the estimated position will always suffer from a drift. In this work, we provide a way of using *existing maps* of the environment for absolute position referencing, by matching the on-board images with the map.

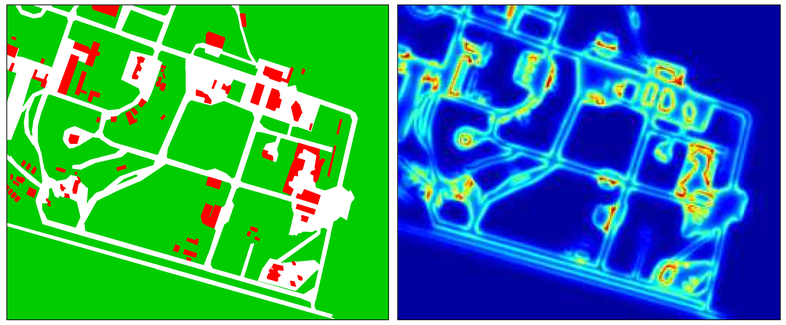
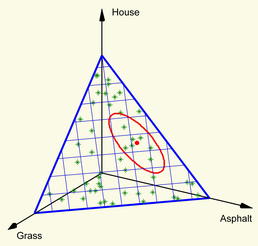


Fig. 1. Preclassified map (left) and measurement likelihood computed for each position in this map (right).



Histogram (from image) ↓ Classification uncertainty ↓

$$y_t = h(x_t) + e_t$$

↑ Reference map

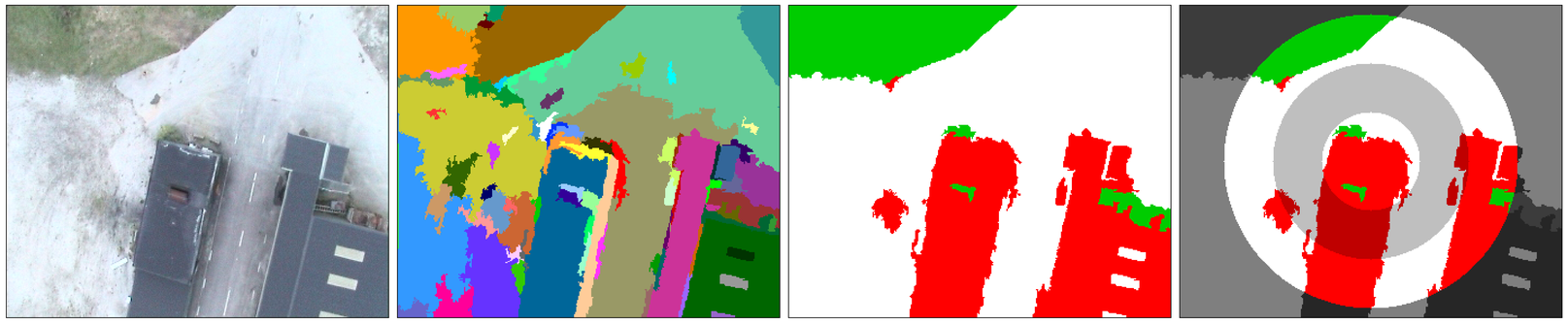


Fig. 2. From left to right; on-board image, superpixels, classified image, circular regions used for histogram computation.

Environmental Classification

To be insensitive to different weather conditions, seasonal variations etc. we propose to use environmental classification (see Fig. 2).

- The image is first segmented into uniform regions, called *superpixels*.
- Color and texture cues (d_i) are extracted from each superpixel, i.
- Based on these cues, each superpixel is classified as either grass, asphalt or house, using a neural network classifier. This gives the class probabilities for the different classes C^k

$$p_i(C^k|d_i) = P(\text{“superpixel } i\text{”} = C^k).$$

These classified images can then be matched with a preclassified map of the operational environment (see Fig. 1).

Probabilistic Template Matching

For computational reasons we only perform the matching in two dimensions (horizontal position). We therefore induce rotational invariance.

This is done by dividing the images into circular regions (see Fig. 2), each for which a probabilistic class histogram is computed. These histograms can then be matched with the map, which results in a standard measurement equation, as shown to the left.

Experimental Results

When the proposed measurement is combined with VO, the drift is efficiently reduced (see Fig. 3). However, some drift still remains in the direction parallel to the road over which the UAV is flying. We are currently working on methods to remove this drift as well.

Fig. 3. Localization results w and w/o geo-referencing.

Summary

- Images from an on-board camera are matched with preexisting maps.
- The method results in a standard measurement equation and can easily be incorporated into any nonlinear filter.
- Environmental classification is used to raise the level of abstraction in the matching.