Automated Landing Place Assessment in Man-Made Environments

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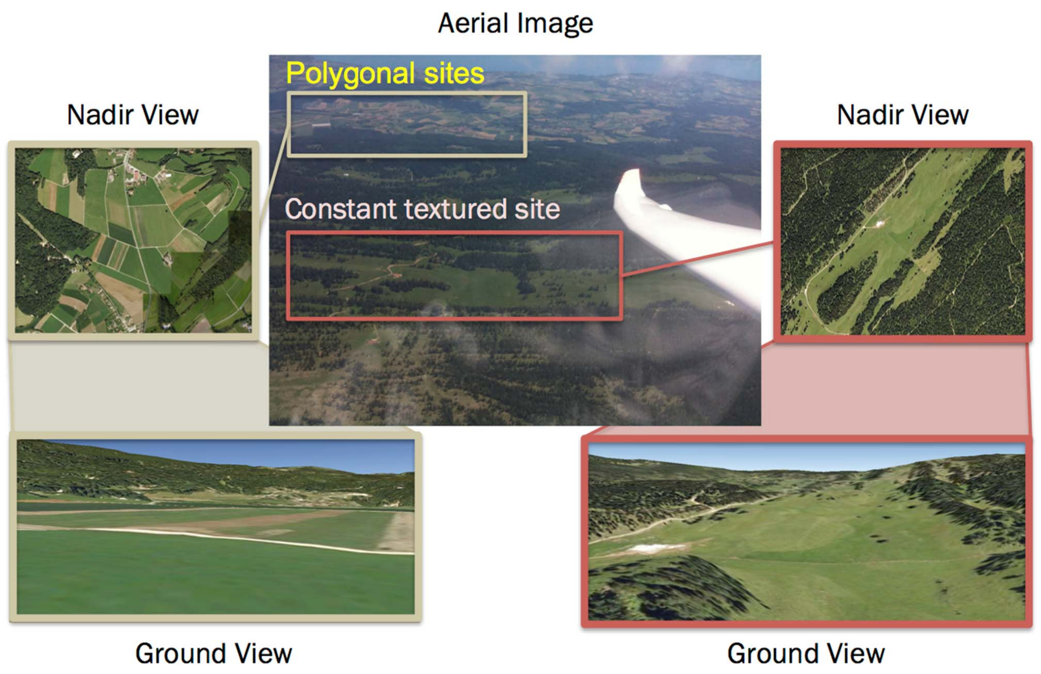
Motivation

We propose an efficient algorithm to quickly detect candidate landing sites in man-made environments.

Key idea: Search for unobstructed areas having a regular (polygonal) shape.

Advantages:

- Does not require detailed 3D geometry or appearance cues.
- Can be computed efficiently.



Related Work

Prepared landing sites:
Apply template matching to extracted line features for the detection of runways and landing pads.

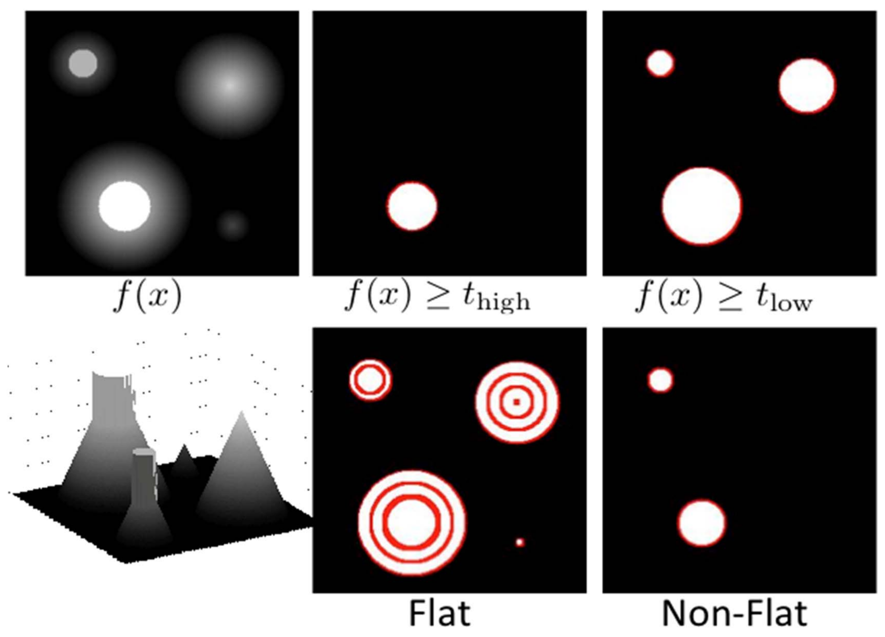
Unprepared landing sites:
Exploit 3D geometry and texture cues to detect flat unobstructed landing sites.

- Estimating 3D is generally expensive, requires reliable feature tracking.
- Texture analysis methods have been largely based on a simple image thresholding.

Background

Simple image thresholding is an example of flat connected filtering. The component tree is a non-flat filter that considers the relationship between connected components as they evolve across an entire threshold range.

Maximally Stable Extremal Regions (MSERs) are an example of component tree filtering that have been shown effective for detecting feature-less regions characterized by dominant image boundaries.

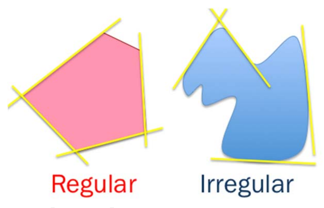


Our Approach

Candidate landing sites are detected as **Polygonal MSERs** computed efficiently using component tree filtering. We encode shape regularity and temporal consistency into the signature design, and exploit multiple image features.

Shape Regularity:
Combines the linearity score L(n) and the stability score g(n), which is

$$s(n) = \frac{L(n)}{1 + \exp\left(-\frac{\mu - g(n)}{\sigma}\right)},$$



where $L(n) = \sum_{\min\{N,M\}} p_i$, expressing whether its contour could be well approximated by N lines, and g(n) is area variation. L(n) is computed using either the region contour or its convex hull.

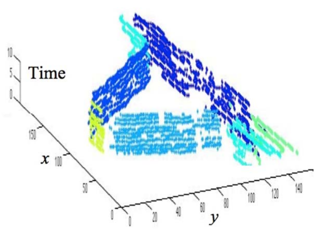
Tree Filter Expression:

$$\blacksquare \text{ is } \begin{cases} \text{active}, & \text{if } g(n(C_{t,n})) = \min\{g(n(C_{k,m})) : \\ & C_{k,m} \in \blacksquare(n(C_{t,n}))\} \text{ and} \\ & s(n(C_{t,n})) \geq \blacksquare \\ \text{not active}, & \text{otherwise.} \end{cases}$$

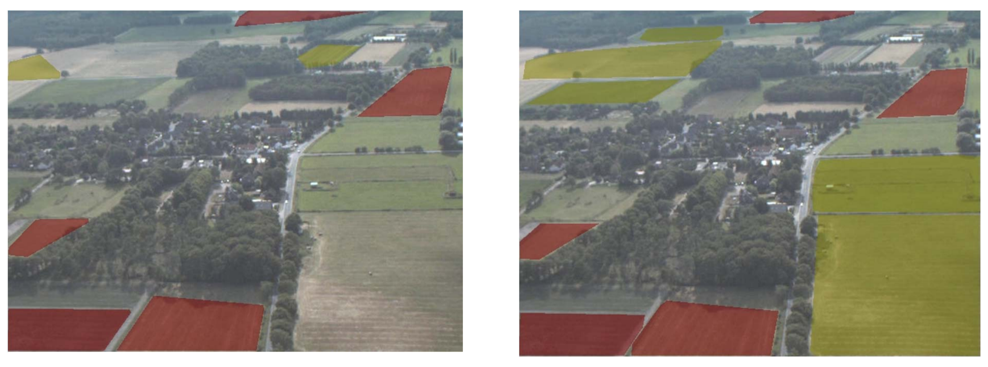
nth Connected Component — *Tree Branch* — *Detection Threshold*

Temporal Consistency:
Planar structures are detected in Spatio-Temporal MSERs, which is the dominant components in video sequences, using a volume variation.

$$g_v(n_t) = \frac{\mathcal{V}(n_{t+\Delta}) - \mathcal{V}(n_{t-\Delta})}{\mathcal{V}(n_t)}.$$



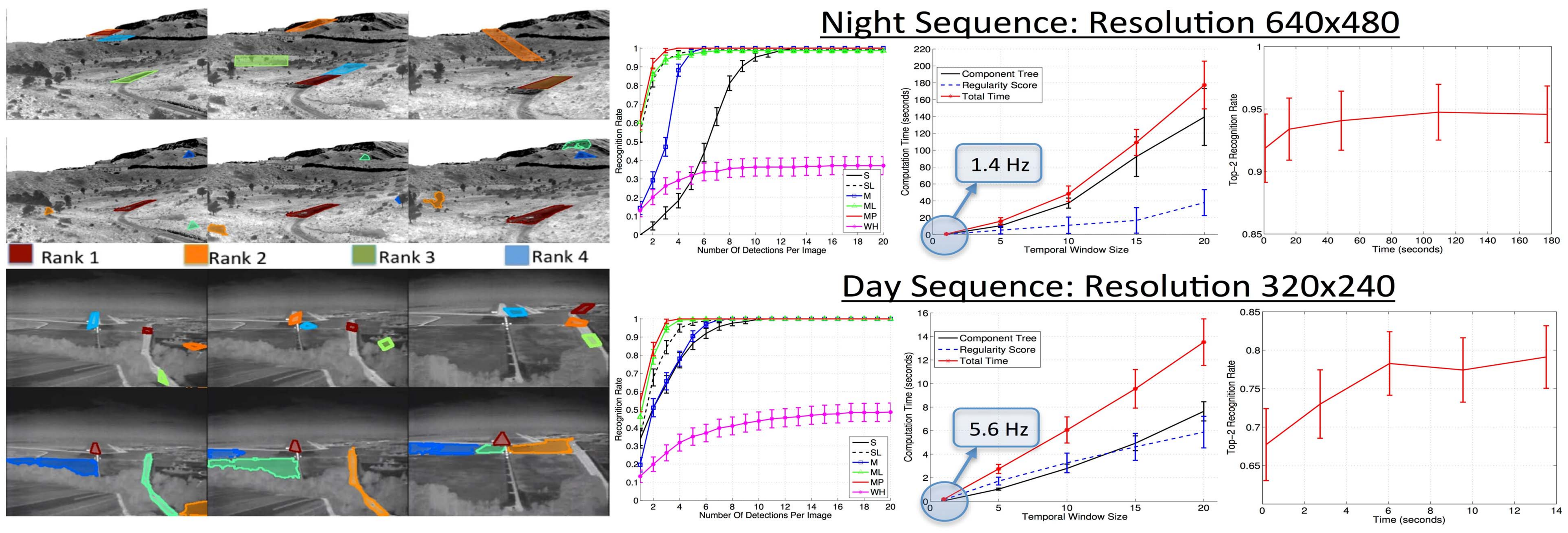
Multiple Feature MSERs:
We detect MSERs across multiple feature channels: intensity, intensity and color gradients, and their combination.



Intensity MSERs Gradient MSERs

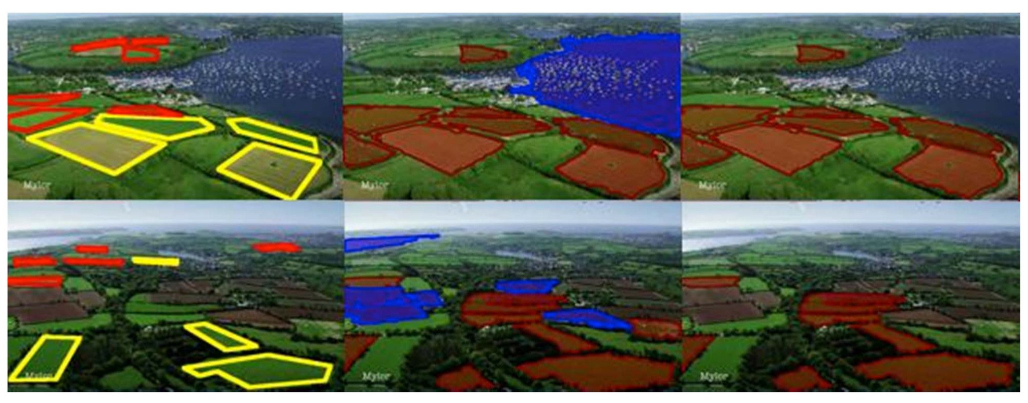
Runway Detection

We tested different settings of our approach on infrared runway video sequences, which are: (S) single-frame and (M) multi-frame component tree segmentation without shape regularity, (SL) single-frame segmentation using line detection, (ML) multi-frame segmentation with line detection, and (MP) our full approach using plane detection. Compared to the windowed Hough Voting baseline(WH), our approach more consistently and accurately detects the runways.



Landable Fields

Polygonal regions are detected in aerial sequences of an aircraft flying over a rural fields.



Landable Fields

Rooftops are detected as candidate landing places for helicopter in urban environments.

Landing Site Detection on the FHS Helicopter

Our multi-feature Polygonal MSER algorithm detects many candidate landing sites including the ones shown below.

Rural Fields Building Rooftops Airport Runways Helipads

mycopter

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