Video Tracking of Small Unmanned Aerial Vehicle
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Motivation
Filming of UAV with a smartphone is a daunting task given the size of UAV, especially at a distance. This project sets out to assist a user by tracking a small UAV in a live video stream on android using OpenCV.

Can you spot the UAV?

Tracking Technique

Video Frame
\[ F_t = \text{frame time } t \] (current)
\[ F_{t-1} = \text{frame time } t - 1 \] (previous)

Optical Flow
\[ V_t = \text{target's velocity time } t \]
\[ V_{t-1} = \text{target's velocity time } t - 1 \]

Template Matching
\[ T_t = \text{template time } t \]
\[ T_{t-1} = \text{template time } t - 1 \]

Motion Model
\[ \epsilon = I_t + \dot{V}_t + \epsilon \]
\[ f = f + \Delta I_t \]

Algorithm Overview
1. User selects initial frame
2. Motion model to predict location of target
3. Template match over predicted location
4. Determine velocity of target using optical flow for next time step — back to 1.

Motion Update Model:
- Use motion model to find probability of next template location
- Gaussian model template matching on the narrowed search area
- Final result reduces false positive rate with motion weight
- Use max likelihood estimate template location in next frame

Template Matching

Why update the template?
Vehicle perspective changes over time

Significant background changes effects template matching

Experimental Results

Android Live Video Runtimes

<table>
<thead>
<tr>
<th>Method</th>
<th>Search Area</th>
<th>Approximate Frame Rate (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optical flow</td>
<td>Entire image</td>
<td>3-4</td>
</tr>
<tr>
<td>Optical flow</td>
<td>Motion limited</td>
<td>13-15</td>
</tr>
<tr>
<td>Template Matching</td>
<td>Entire image</td>
<td>3-4</td>
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<tr>
<td>Template Matching</td>
<td>Motion limited</td>
<td>10-12</td>
</tr>
<tr>
<td>Optical Flow + Template Matching</td>
<td>Motion limited</td>
<td>10+</td>
</tr>
</tbody>
</table>

Future
Live video downlink with tracking