iFMI Method
• Rotation is the same in time and frequency domain
• Scaling between two images in frequency domain can be described as

\[ |G(a_1^2)| = \sigma^{-2} |G(\sigma^{-1}a_2^2)| \]  

(1)
• Eq. (1) can be expressed as Eq. (2) with iFMI descriptor

\[ V_G(a_l) = \sigma^{-2} e^{-j2\pi r(\theta,s)} V_G(a_r^2) \]  

(2)

CONTRIBUTIONS
• Using the iFMI method to estimate motion between omni-images; hence
• Allowing 3D registration instead of 2D for iFMI;
• Proposing a motion model based on sub-image patches to compensate for omni-images non-linear distortions;
• Providing baseline comparisons against commonly used registration feature-based methods.

 IMPLEMENTATION

Algorithm: Proposed iFMI-based rotation estimation
1: Input: Omni images \( I_1^1, I_2^1 \);
   Noise filter thresholds \( th_{pr}, th_{pnr} \)
2: Obtain panorama images \( I_1^p, I_2^p \) of size \( W \times H \) by cartesian-to-polar transformation
3: Extract sub-image set \( \mathbb{A}^1, \mathbb{A}^2 \) from \( I_1^p \) and \( I_2^p \)
4: for all sub-images \( a_1^1 \in \mathbb{A}^1, a_2^2 \in \mathbb{A}^2 \) do
5: Compute relative motion
   \( m_l = \text{iFMI}(a_1^1, a_2^2, th_{pr}, th_{pnr}) = [s, \theta, t_x, t_y]^T \)
6: Select pixel \( p_{l_1}^1 \) = \((c_x + \delta, c_y + \delta), \) where \( \delta > 0 \)
7: Find motion pixel pair \( F_l = (p_{l_1}^1, p_{l_2}^2) \)
8: Convert \( F_l \) to omnni-image coordinates polar-to-Cartesian(\( F_l \))
9: Find camera ray pair \( (P_{1_l}, P_{2_l}) = \pi^{-1}(F_l) \)
10: Add \( (P_{1_l}, P_{2_l}) \) to correspondences set \( \mathbb{S} \)
11: end for
12: Transformation \( T_2^1 = \text{STEWENIUS-5-Points}(\mathbb{S}) \)
13: Output: \( T_2^1 \)

RESULTS

Table 1. Average orientation root mean square error (RMSE) and computation time per frame from all datasets samples

<table>
<thead>
<tr>
<th>Method</th>
<th>Roll ( \epsilon [\text{rad}] )</th>
<th>Pitch ( \epsilon [\text{rad}] )</th>
<th>Yaw ( \epsilon [\text{rad}] )</th>
<th>( \mu(\epsilon) [\text{rad}] )</th>
<th>( \mu(t) [\text{s}] )</th>
</tr>
</thead>
<tbody>
<tr>
<td>iFMI(Ours)</td>
<td>0.058 ± 0.056</td>
<td>0.166 ± 0.078</td>
<td>0.128 ± 0.044</td>
<td>0.080 ± 0.025</td>
<td>0.12</td>
</tr>
<tr>
<td>ORB</td>
<td>0.075 ± 0.080</td>
<td>0.300 ± 0.337</td>
<td>0.153 ± 0.058</td>
<td>0.219 ± 0.071</td>
<td>0.11</td>
</tr>
<tr>
<td>AKAZE</td>
<td>0.075 ± 0.080</td>
<td>0.300 ± 0.337</td>
<td>0.153 ± 0.058</td>
<td>0.219 ± 0.071</td>
<td>0.11</td>
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