**2D-3D Feature Matching**

**Coarse Place Recognition**
- DAISY matching → clustering voting.
- Matched descriptors from images not in selected cluster, pruned → less outliers during RANSAC.

**Global Matching**
- k-NN query for a set of DAISY descriptors \(\{q_i\}\).
- Priority search on single kd-tree (\(d = \sim\)).
- \(V_{\text{ref}}, k\) descriptors \(\{d_{ij}\}\) retrieved; sorted by distance \(s_{ij}\) from \(q_i, d_{ij}\) is 1-NN.
- Matching strength for each \(d_{ij}, m_{ij} = s_{ij}/s_{\text{th}}\).
- All descriptors vote for clusters; votes weighted by strengths \(m_{ij}\). Top-scoring cluster(s) selected.
- Prune \(\{d_{ij}\}\) based on selected clusters.

**Guided Matching**
- Incrementally update the selected location cluster.
- Exploit known 2D-3D matches (and pose) to accelerate priority search on kd-tree.
- Out-of-scope descriptors pruned during back-tracking step in kd-tree query. Lot faster than pruning afterwards.
- 1-to-many matches geometrically disambiguated using camera pose estimate in previous frame.

**Online Localization**

**Algorithm**

- P ← COMPUTE-POST (\(j, T, M\))
- \(C\) ← MATCH-2D-3D-PAIRS (\(j, T, \{d\}\))
- if \(\hat{C}_{ij} \neq \emptyset\)
  - \(P_{\text{match}}\) ← ESTIMATE-POSE (\(C_{ij}\))
  - \(P_{\text{match}}\) ← GUIDED-MATCHING (\(P, j, T, \{d\}\))
- \(P_{\text{return}}\) ← P

**Advantages**
- Place recognition prunes outliers efficiently.
- BRIEF tracking efficiently propagates 2D-3D matches.
- Direct 2D-3D matching faster than keyframe matching.
- DAISY + kd-tree query computation minimized.
- Descriptor computation spread over multiple frames.

**References**


**Results**

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Frames</th>
<th>TP (ms)</th>
<th>Time (ms)</th>
<th>TP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab</td>
<td>237</td>
<td>26,437 (90%)</td>
<td>19.4</td>
<td>100%</td>
</tr>
<tr>
<td>Lab</td>
<td>3705</td>
<td>3738 (90%)</td>
<td>18.3</td>
<td>100%</td>
</tr>
<tr>
<td>Outdoor</td>
<td>1000</td>
<td>1000 (100%)</td>
<td>17.2</td>
<td>100%</td>
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<tr>
<td>Lab</td>
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<td>1206 (50%)</td>
<td>17.5</td>
<td>100%</td>
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<tr>
<td>Hall</td>
<td>732</td>
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<tr>
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<tr>
<td>Hall</td>
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<td>281 (100%)</td>
<td>18.6</td>
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<tr>
<td>Outdoor</td>
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</tr>
<tr>
<td>Outdoor</td>
<td>685</td>
<td>685 (100%)</td>
<td>27.1</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Real-time Image-based 6-DOF Localization in Large-Scale Environments**

**Real-time Image-based 6-DOF Localization in Large-Scale Environments**

- **Hyon Lim**
- **Sudipta N. Sinha**
- **Michael F. Cohen**
- **Matthew Uyttendaele**

1 Seoul National University
2 Microsoft Research Redmond

**Multi-scale Feature Extraction**
- Harris corners extracted at multiple scales.
- T2-8a-2r6-32d DAISY descriptors [2], [32 dim] extracted, needed for 2D-3D feature matching.
- A bag of DAISY descriptors extracted from different images is associated with each 3D point.
- Global kd-tree index for all DAISY descriptors.
- Descriptors tagged with cluster + 3D point-id.
- Avoids online scale-invariant keypoint detection.

**Off-Line Map Construction**
- Images → 3D points + calibrated cameras
- Camera clustering
- Clustered based on visibility of 3D points.
- Overlapping clusters used for coarse localization.

**Structure from Motion**
- Images → 3D points + calibrated cameras
- Camera clustering
- Clustered based on visibility of 3D points.
- Overlapping clusters used for coarse localization.

**Keypoint Tracking**
- Harris corners extracted (at a single scale).
- Tracking by re-detection and local matching.
- Hamming distances computation + ratio test.
- Tracks updated after 2D-3D pose estimation.

**Online Localization**

**Algorithm**

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