Parallel Tracking and Mapping for Small AR Workspaces

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The Aim

- AR with a hand-held camera
- Visual Tracking provides registration
- Track without prior model of world
- Challenges:
  - Speed
  - Accuracy
  - Robustness
  - Interaction with real world
PTAM

- Architecture optimized for dual cores

- Tracking thread runs in real-time (30Hz)
- Mapping thread is not real-time
Method Overview

- **Tracking thread:**
  - Responsible estimation of camera pose and rendering augmented graphics
  - Must run at 30Hz
  - Make as robust and accurate as possible

- **Mapping thread:**
  - Responsible for providing the map
  - Can take lots of time per keyframe
  - Make as rich and accurate as possible
PTAM – Tracking Thread

Mapping thread

Compute pyramid
Detect FAST corners
Project points
Measure points
Update Camera Pose

Tracking Thread

Project points
Measure points
Update Camera Pose

Coarse stage
Fine stage

Draw Graphics
PTAM – Mapping Thread

Mapping Thread

- Initialization
- Wait for new key frame
- Add new map points
- Optimize map
- Map maintenance

Tracking Thread
PTAM – Example Timings

- **Tracking thread**

<table>
<thead>
<tr>
<th>Total</th>
<th>19.2 ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key frame preparation</td>
<td>2.2 ms</td>
</tr>
<tr>
<td>Feature Projection</td>
<td>3.5 ms</td>
</tr>
<tr>
<td>Patch search</td>
<td>9.8 ms</td>
</tr>
<tr>
<td>Iterative pose update</td>
<td>3.7 ms</td>
</tr>
</tbody>
</table>

- **Mapping thread**

<table>
<thead>
<tr>
<th>Key frames</th>
<th>2-49</th>
<th>50-99</th>
<th>100-149</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Bundle Adjustment</td>
<td>170 ms</td>
<td>270 ms</td>
<td>440 ms</td>
</tr>
<tr>
<td>Global Bundle Adjustment</td>
<td>380 ms</td>
<td>1.7 s</td>
<td>6.9 s</td>
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</tbody>
</table>
PTAM Video

https://www.youtube.com/watch?v=Y9HMn6bd-v8