Experimental Validation of Odometry Approaches

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Towards Persistent Vision-Only Navigation
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Experimental Comparison

• Compare 2 techniques already implemented in our lab
  – Structure from motion based (Acid Vision)
  – Patch based (RatSLAM)
  – Fusing with Wheel Odometry

• Indoors

• Caveats:
  – one camera
    • Point Grey Grasshopper 1.4MPixel, 2/3” CCD
  – no loop closing, verifying odometry only
Patch Based VO

- Uses a 64x64 pixel patch and tracks its shift between frames using Sum of Absolute Differences (SAD)
- Best fitting offset \( x \) constant = displacement
- Histogram equalization to preserve ground texture
Structure from Motion VO
Fusion Technique

- Pathological situations where VO fails
- Weighted average fusion

\[ X = \alpha X_{VO} + (1 - \alpha) X_{wheel} \]

- Confidence:

\[ \alpha = \frac{1 - d_{min}}{\bar{d}} \quad \text{Patch} \]

\[ \alpha \approx \text{structure points added} \]

- Allows us to do scale drift compensation
- Synchronization via correlation of data streams
Test Environments

Level 7
- open plan
- feature rich

Level 11
- narrow corridors
- feature poor
Performance Analysis

- Windowing analysis (Johnson et al., 2008)
- For every point on the VO trajectory ....

Ground truth

VO
Performance Analysis

- Find the corresponding point (in time) on the ground truth trajectory
Performance Analysis

- Project forward 20 metres on the ground truth to time $t$, to be compared against the VO ending at time $t$. 
Performance Analysis

- Compare the two trajectories ...
Analysis

- Error is the difference in the end points of the sub-trajectories
Level 7 Performance

Structure from Motion

Wheel Odometry

Patch
Level 7 Performance

Errors over Full Trajectory - Level 7

Position Error (m)

Angular Error (rad)
Level 11 Performance

Wheel Odometry

Fused SfM

Fused Patch
Level 11 Performance

Errors over Full Trajectory - Level 11

Position Error (m)

Angular Error (rad)

0 100 200 300 400 500 600 700 800

0 1 2 3 4 5 6 7 8 9 10

Patch VO
SFM VO
Wheel Odom
Corrupted WO
Fused Patch
Fused SFM
Box Plots - Position Error

Window Size = 20m

- FSFM11
- FP11
- CWO11
- WO11
- WO7
- SFM11 (Not Applicable)
- SFM7
- PTCH11
- PTCH7

Position Error (m)
Box Plots - Angular Error

Angular Error (rad)
Insights

• Two forms of VO fail in different ways
  – translational vs rotational accuracy
  – could be used in a complementary filter

• Fusion requires robust error estimates
  – treatment of wheel odometry needs work

• Obtaining good images indoors is challenging
  – poor illumination compared with outdoors
  – blur can be an issue, moved to larger (2/3”) CCD
  – feature based techniques require large FOV
  – exposure control an issue, inbuilt controller suboptimal
Further Work

- We are continuing to develop vision-only persistent navigation techniques.
- [www.ros.org/wiki/cyphy_vis_slam](http://www.ros.org/wiki/cyphy_vis_slam)
Questions?

Visit our lab online: tiny.cc/cyphy