A benchmark data generation tool using walking simulation and virtualized reality models for evaluating AR visual tracking

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KJMR2012
(April 13-15, 2012)
Camera parameter estimation for AR/MR

Ground truth data of camera parameters and feature points are needed for benchmarking.

ARToolKit
(Kato, et al, IWAR99)

DTAM(*)
(R. A. Newcombe, et al, ICCV2011)
TrakMark~
Benchmark Test Schemes for AR/MR Geometric Registration and Tracking Methods

Benchmark

Image Sequence Set No.2 were uploaded on April 28, 2011.

* If download speed is too slow, please contact the following address. We can send a blu-ray disk that contains all of the data files.

E-Mail: info@trakmark.net

- Image Sequence Set No.1
  - Film Studio Package 01
  - NAIST Campus Package 01
  - Conference Venue Package 01
- Image Sequence Set No.2
TrakMark~
Benchmark Test Schemes for AR/MR Geometric Registration and Tracking Methods

Film Studio Package

NAIST Campus Package

Conference Venue Package
Generation of ground truth

- For benchmarking
  - Ground truth is needed.
    - Robot arms for obtaining extrinsic camera parameters

- Range sensors for obtaining 3D positions of feature points

Making ground truth data is costly in real environment.
Our goal

Developing a tool to generate data sets for benchmark using virtualized reality models

Merits of using virtualized reality models

✔ Making ground truth data
✔ Any camera path and any feature points
Outline of the tool

Interface to generate camera parameters

The user sets control points with mouse clicks.

Generated images
A sample of virtualized reality model

The Venue of ISMAR2009

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>The area of the floor</td>
<td>1217 m²</td>
</tr>
<tr>
<td>Time for taking pictures</td>
<td>45 min</td>
</tr>
<tr>
<td>Time for modeling</td>
<td>6.5 h</td>
</tr>
</tbody>
</table>
Model-utilization for related applications

3D MODEL for various applications

- 3D model for image based tracking
  
- 3D model for map matching

3D model

Image generation

Before

After

Coarse Estimation

Feature based matching

Real image

AV view

3D model for Augmented Virtuality
Functions of the tool

Camera parameters generation with human walking motion

Interest points generation

Output of depth data
Camera parameters generation with human walking motion
Head and hand movements with human walking
Parameters for setting camera effects

The user sets vertical and horizontal variances.
Example of a sequence

Parameter settings
- Basic height 1600 [mm]
- Vertical variance 50 [mm]
- Horizontal variance 80 [mm]
- Walking step length 650 [mm]
- Walking speed 900 [mm]
Interest points generation
Outline of the data sets

- **Time** ($t$)
  - $t_1$, $t_2$, ..., $t_n$
- **Extrinsic Camera Parameter** ($EP$)
  - $EP_{t_1}$, $EP_{t_2}$, ..., $EP_{t_n}$
- **Intrinsic Camera Parameter** ($IP$)
  - $IP_{t_1}$, $IP_{t_2}$, ..., $IP_{t_n}$
- **Generated Image** ($I$)
  - $I_{t_1}$, $I_{t_2}$, ..., $I_{t_n}$
- **Tracking Data** ($TD$)
  - $TD_{t_1}$, $TD_{t_2}$, ..., $TD_{t_n}$
Outline of the data sets

<table>
<thead>
<tr>
<th>Time ($t$)</th>
<th>Extrinsic Camera Parameter ($EP$)</th>
<th>Intrinsic Camera Parameter ($IP$)</th>
<th>Generated Image ($I$)</th>
<th>Tracking Data ($TD$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_1$</td>
<td>$EP_{t_1}$</td>
<td>$IP_{t_1}$</td>
<td>$I_{t_1}$</td>
<td>$TD_{t_1}$</td>
</tr>
<tr>
<td>$t_2$</td>
<td>$EP_{t_2}$</td>
<td>$IP_{t_2}$</td>
<td>$I_{t_2}$</td>
<td>$TD_{t_2}$</td>
</tr>
<tr>
<td>$\cdots$</td>
<td>$EP_{t_n}$</td>
<td>$IP_{t_n}$</td>
<td>$I_{t_n}$</td>
<td>$TD_{t_n}$</td>
</tr>
</tbody>
</table>

Model space

Generated images

$$ (x, y, z) $$

$$ (u_0, v_0) $$

$$ I_0 $$

$$ (u_1, v_1) $$

$$ I_1 $$

$$ (u_n, v_n) $$

$$ I_n $$
Example of interest points
Comparative result of interest points generation

Successive matching

Majority vote
Applications
Simulations of 3D reconstructions
Generating data sets with additional contents
Released contents in TrakMark
Released contents ~ ISMAR2009
Released contents ~ ISMAR2010
Released contents ~ Nursing home
Released contents ~ Japanese restaurant
Conclusion

The tool for generating benchmark data sets

- Using virtualized reality models
- Generating camera parameters with human walking motion
- Manual and automatic interest points generation
- Output of depth data
Future works

• Additional functions of the tool
  – Motion sensors’ data for camera parameter generation
  – Introducing camera effects
    • Blurring, Defocus, Specular, …
  – Additional object in model environment
    • Markers for visual tracking
    • Occluders (walking person, …)
Future works

• **How to distribute the data sets**
  – Which format is better for 3D models?
  – How to distribute the tool?
    • Good data sets generated by the tool are to be added in TrakMark data sets
    • Provisions of parameter sets (for example, camera parameters) are acceptable for the tool
    • Too many versions of the tool / data sets are to be prevented …
Acknowledgements

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Appendix:
a formula for calculating vertical translation of a camera

\[
H(H) = \begin{cases} 
\frac{h(\theta)}{1-\alpha} & \text{if } h(\theta) < (1-\alpha)A \\
A & \text{if } h(\theta) \geq (1-\alpha)A
\end{cases}
\]

\[
h(\theta) = A|\sin \theta|
\]

\[\alpha = 0.2\]

\[\alpha = 0.8\]