Calibration and Absolute Pose Estimation of Trinocular Linear Camera Array for Smart City Applications

Authors
Martin Ahrnbom (presenter)
Mikael Nilsson
Håkan Ardö
Kalle Åström
Oksana Yastremksa-Kravchenko
Aliaksei Laureshyn
Trinocular Linear Camera Array (TLCA)

- Stereo rig with three lenses on a straight line
- Joint rectification
- Provides more depth info than stereo
Calibration and Absolute Pose

- 2D <-> 3D conversion of points
- 3D coordinates in external, given coordinate system
- Compatibility with bigger Smart City system
Calibration and Absolute Pose

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Calibration and Absolute Pose

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Setup
Calibration system

1. Radial and tangential distortion
2. Intrinsics
3. Rectification
4. DLT estimates for camera and checkerboard poses
5. Preliminary optimization of camera pose
6. Joint optimization
Calibration system

1. **Radial and tangential distortion**
2. **Intrinsics**
3. **Rectification**
4. **DLT estimates for camera and checkerboard poses**
5. **Preliminary optimization of camera pose**
6. **Joint optimization**

\[
x_u = x_c + \frac{x_r}{1 + \alpha_1 r^2 + \alpha_2 r^4} + \beta_1 (r^2 + 2x_r^2) + 2\beta_2 x_r y_r,
\]

\[
y_u = y_c + \frac{y_r}{1 + \alpha_1 r^2 + \alpha_2 r^4} + 2\beta_1 x_r y_r + \beta_2 (r^2 + 2y_r^2),
\]
Calibration system

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\[
K_i^{(0)} = \begin{bmatrix}
    f_i \cdot \gamma_i & s_i & c_{i,x} \\
    0 & f_i & c_{i,y} \\
    0 & 0 & 1
\end{bmatrix}
\]
Calibration system

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\[ H_i = K \cdot R_i \cdot \tilde{K}_i^{-1}, \]

\[ \tilde{K}_i = \begin{bmatrix}
    f_i \cdot \gamma_i \cdot 3^\alpha_i & s_i & c_{i,x} \\
    0 & f_i \cdot 3^\alpha_i & c_{i,y} \\
    0 & 0 & 1
\end{bmatrix} \]

\[ K = \begin{bmatrix}
    f \cdot 3^\alpha & 0 & c_x \\
    0 & f \cdot 3^\alpha & c_y \\
    0 & 0 & 1
\end{bmatrix} \]
Calibration system

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\[ \lambda x = K [R \ t_2] X \]
Calibration system

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\[
\begin{align*}
C_2 &= -R^T \cdot t_2, \\
P_1 &= K[R, -R \cdot (C_2 + (d_{2,1} + \epsilon_{2,1})R_1)], \\
P_2 &= K[R, -R \cdot C_2], \\
P_3 &= K[R, -R \cdot (C_2 - (d_{2,3} + \epsilon_{2,3})R_1)], \\
res_{1x} &= (P_i V_i)_x/(P_i V_i)_z - (v_{il})_x/(v_{il})_z, \\
res_{1y} &= (P_i V_i)_y/(P_i V_i)_z - (v_{il})_y/(v_{il})_z, \\
res_{2x} &= (P_i T_j U_k)_x/(P_i T_j U_k)_z - (u_{ijk})_x/(u_{ijk})_z, \\
res_{2y} &= (P_i T_j U_k)_y/(P_i T_j U_k)_z - (u_{ijk})_y/(u_{ijk})_z.
\end{align*}
\]
Results

Triangulation along ground surface
Demo application
Thank you for listening!