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

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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

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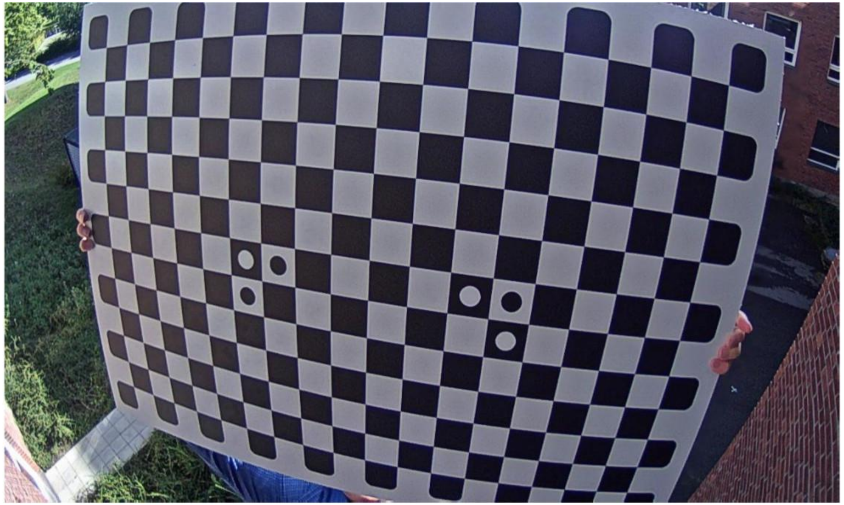
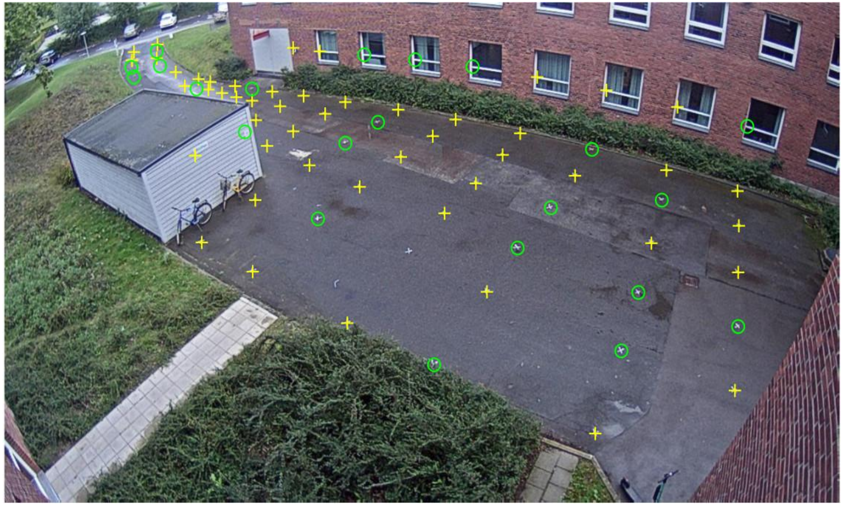
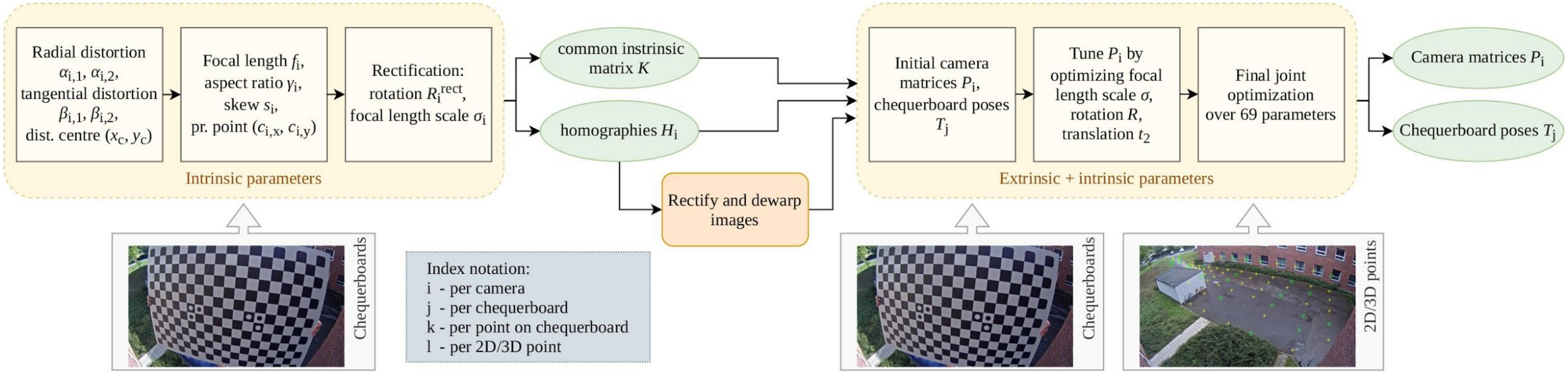
Setup





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



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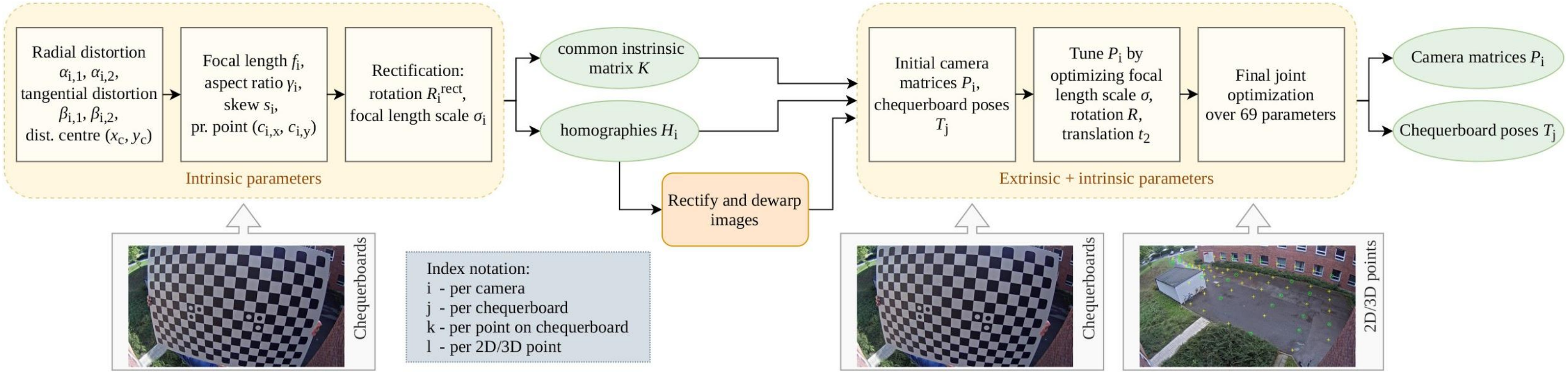
$$x_u = x_c + \frac{x_r}{1 + \alpha_1 r^2 + \alpha_2 r^4} + \beta_1 (r^2 + 2x_r^2) + 2\beta_2 x_r y_r,$$
$$y_u = y_c + \frac{y_r}{1 + \alpha_1 r^2 + \alpha_2 r^4} + 2\beta_1 x_r y_r + \beta_2 (r^2 + 2y_r^2),$$



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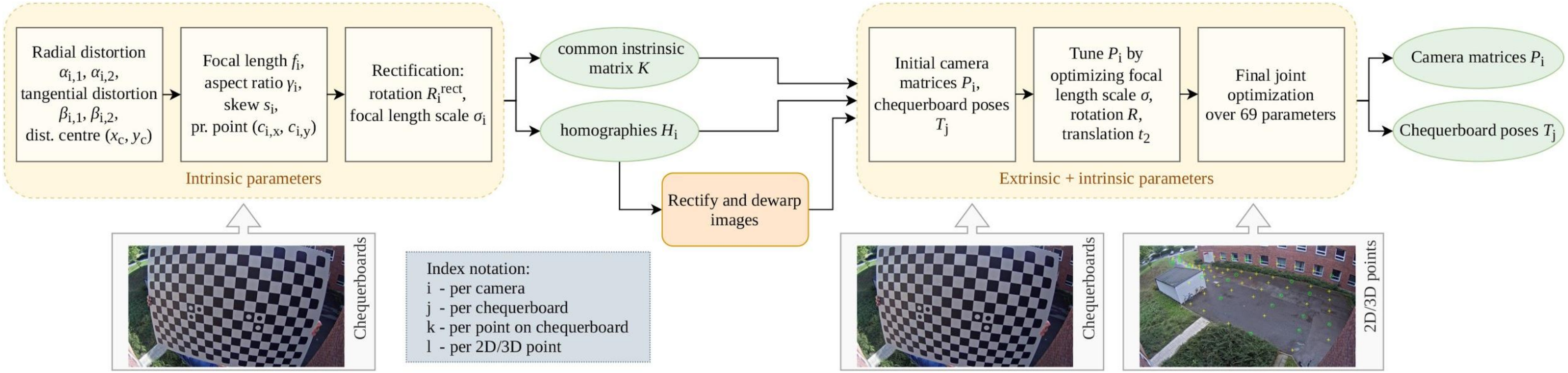
$$K_i^{(0)} = \begin{bmatrix} f_i \cdot \gamma_i & s_i & c_{i,x} \\ 0 & f_i & c_{i,y} \\ 0 & 0 & 1 \end{bmatrix}$$



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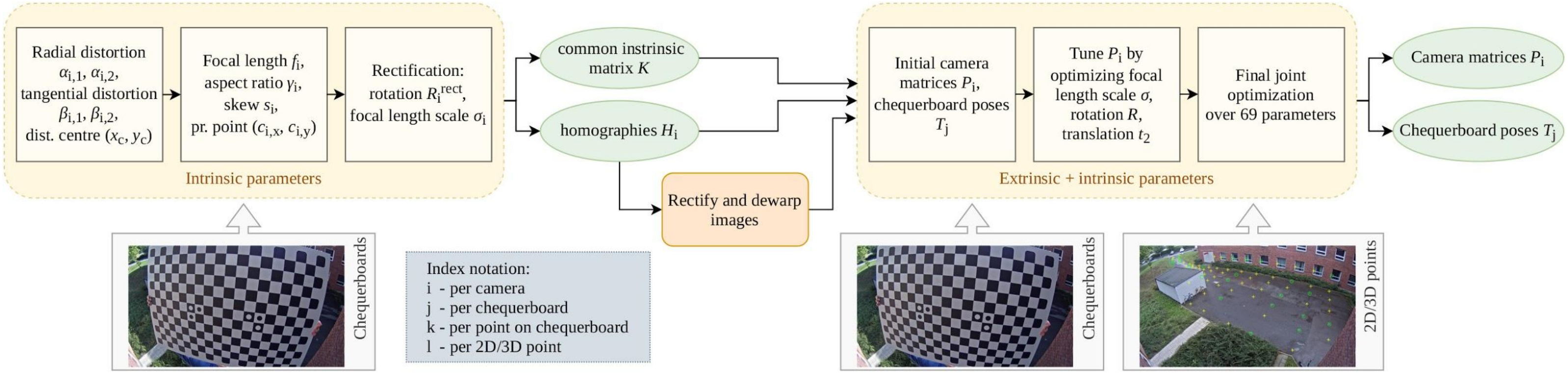
$$H_i = K \cdot R_i \cdot \tilde{K}_i^{-1},$$

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

$$K = \begin{bmatrix} f \cdot 3^{\alpha} & 0 & c_x \\ 0 & f \cdot 3^{\alpha} & c_y \\ 0 & 0 & 1 \end{bmatrix}$$



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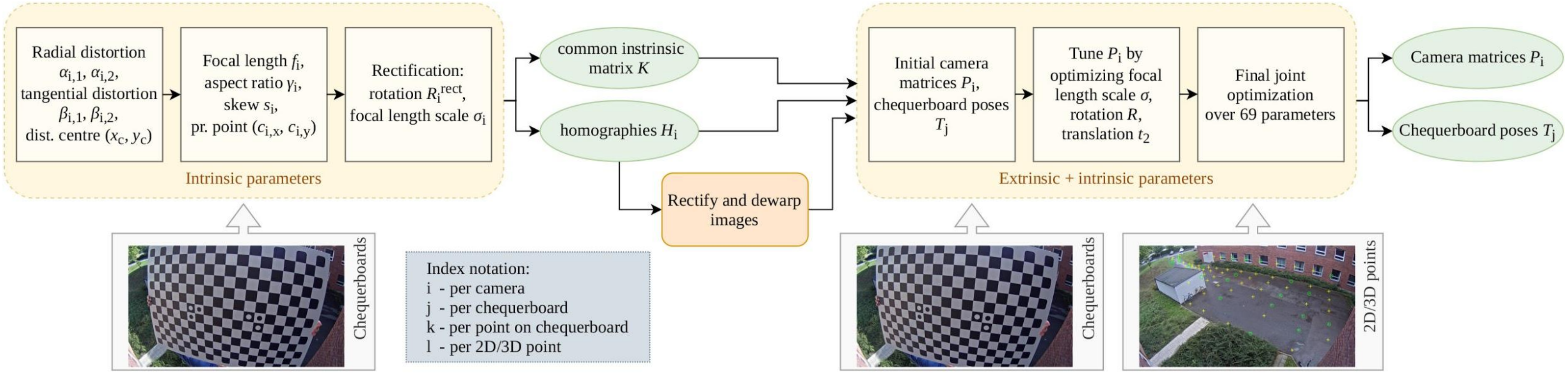
$$\lambda x = K[R \;\; t_2]X$$



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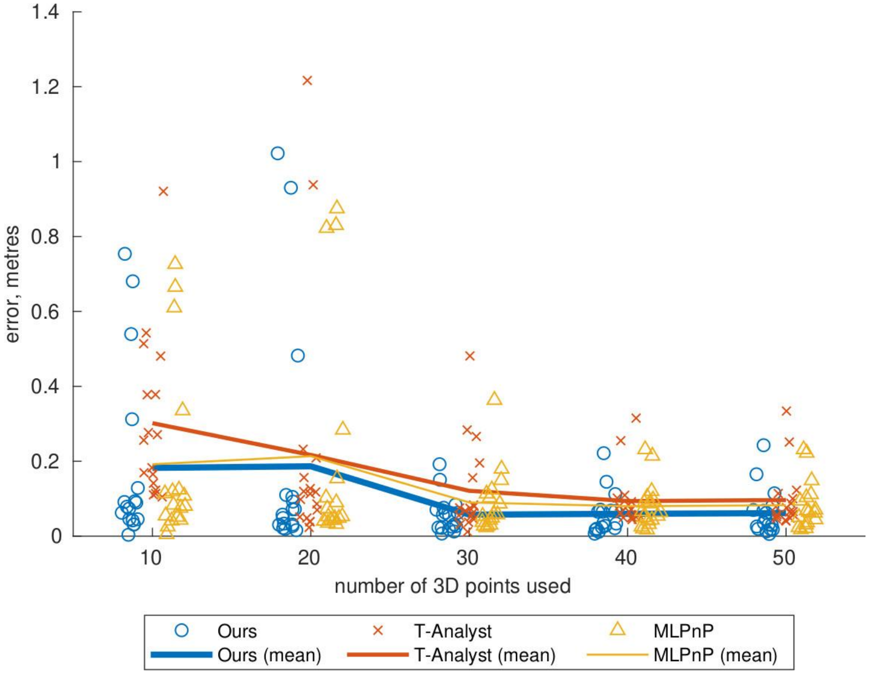
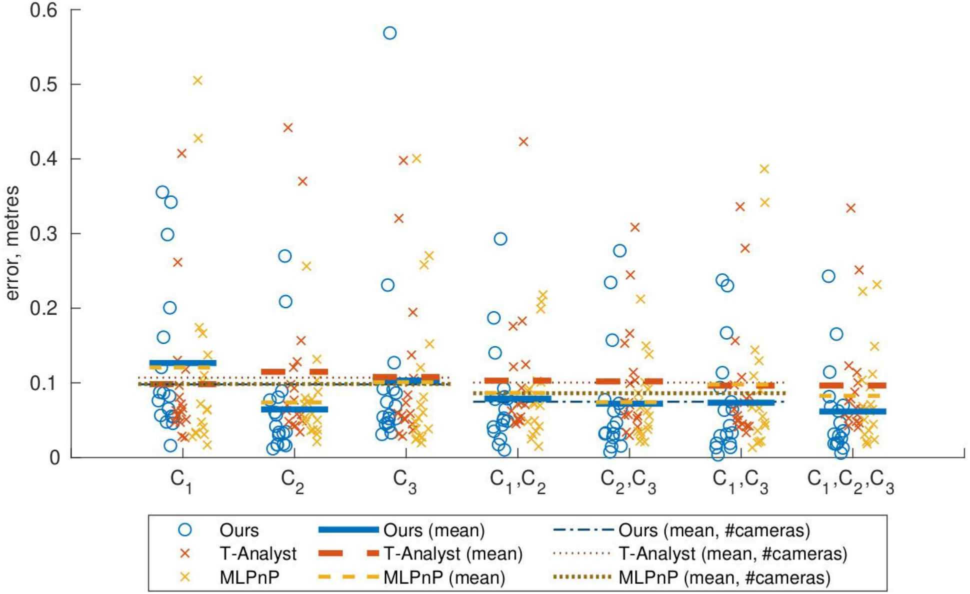
$$
\begin{aligned}
C_2 &= -R^T \cdot t_2, \\
P_1 &= K[R, \quad -R \cdot (C_2 + (d_{2,1} + \epsilon_{2,1}) R_1)], \\
P_2 &= K[R, \quad -R \cdot C_2], \\
P_3 &= K[R, \quad -R \cdot (C_2 - (d_{2,3} + \epsilon_{2,3}) R_1)],
\end{aligned}
$$

$$
\begin{aligned}
res_{1x} &= (P_i V_l)_x / (P_i V_l)_z \; - \; (v_{il})_x / (v_{il})_z, \\
res_{1y} &= (P_i V_l)_y / (P_i V_l)_z \; - \; (v_{il})_y / (v_{il})_z, \\
res_{2x} &= (P_i T_j U_k)_x / (P_i T_j U_k)_z \; - \; (u_{ijk})_x / (u_{ijk})_z, \\
res_{2y} &= (P_i T_j U_k)_y / (P_i T_j U_k)_z \; - \; (u_{ijk})_y / (u_{ijk})_z,
\end{aligned}
$$

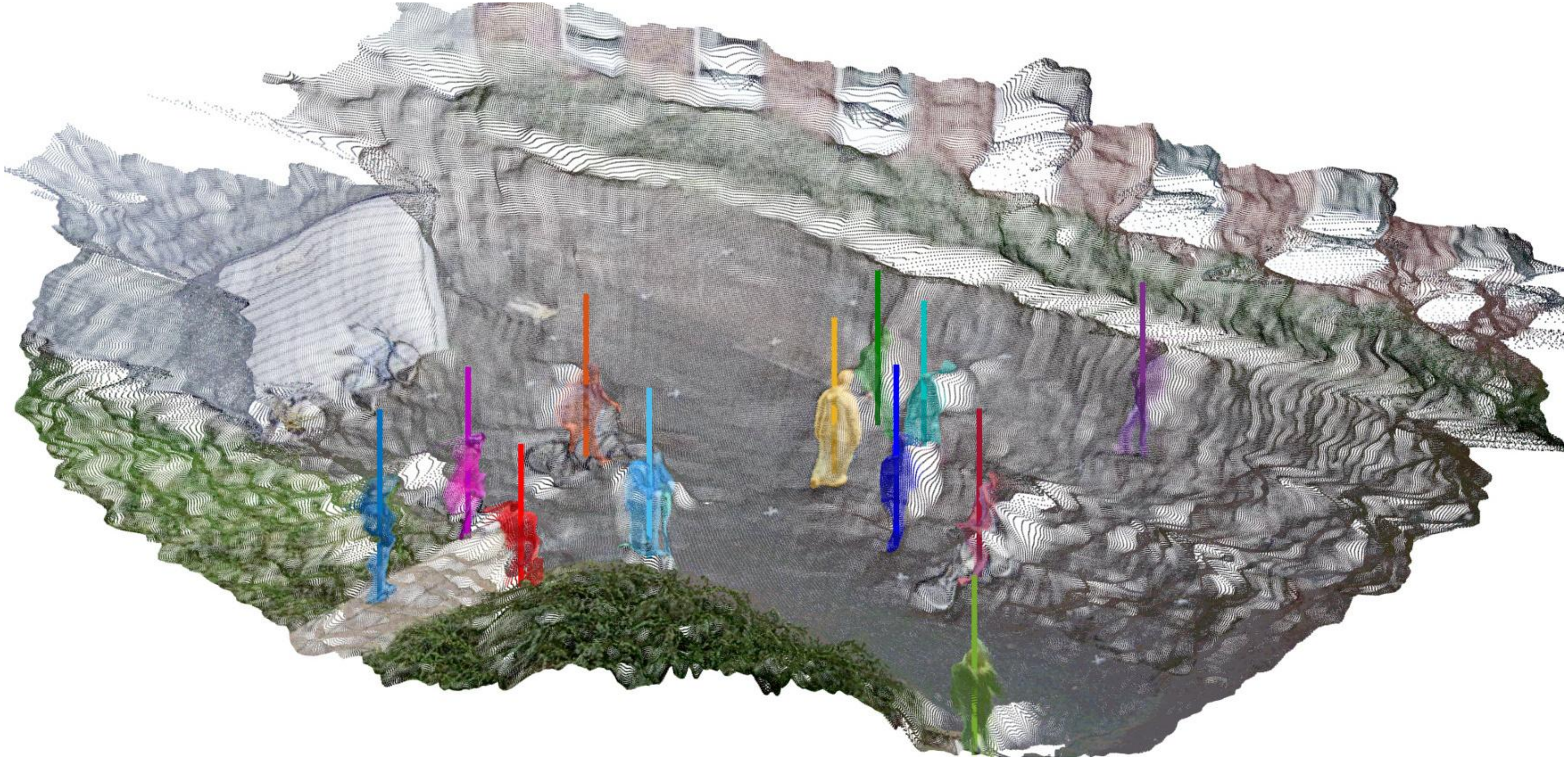
Results

Triangulation along ground surface





Demo application



Thank you for listening!

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