Indirect vs. Direct

- Keypoints
- Image Intensities
Photometric Error

- Vignetting
- Exposure Time – intensity
- Small (8) Pixel Neighbourhood
- Gradient Dependent weighting
Total Photometric Error

\[ E_{\text{photo}} := \sum_{i \in \mathcal{F}} \sum_{p \in \mathcal{P}_i} \sum_{j \in \text{obs}(p)} E_{p_j}. \]

- All Frames
- All points in Frame \( i \)
- All frames where \( p \) is visible
- Difference in pixel Intensity
Photometric Error

\[ E_{pj} := \sum_{p \in \mathcal{N}_p} w_p \left\| \left( I_j[p'] - b_j \right) - \frac{t_j e^{a_j}}{t_i e^{a_i}} \left( I_i[p] - b_i \right) \right\|_\gamma \]

- **Pixel Neighbourhood**
- **Gradient Dependent Weight**
- **Exposure Time**
- **Reference Frame**
- Target Frame \( p' \) contains transformation matrices
Gauss Newton Optimization

\[ \mathbf{H} = \mathbf{J}^T \mathbf{W} \mathbf{J} \quad \text{and} \quad \mathbf{b} = -\mathbf{J}^T \mathbf{W} \mathbf{r}, \]

\[ \mathbf{J}_k = \frac{\partial r_k((\delta + x) \oplus \zeta_0)}{\partial \delta}. \]

\[ \mathbf{J}_k = \begin{bmatrix} \partial I_{j} \left[ \frac{\partial \mathbf{p}'}{\partial \mathbf{p}'} \right] \frac{\partial \mathbf{p}'}{\partial \delta_{\text{geo}}} \mathbf{J}_I & \frac{\partial r_k((\delta + x) \oplus \zeta_0)}{\partial \delta_{\text{photo}}} \mathbf{J}_{\text{photo}} \end{bmatrix}, \]

\[ \delta = \mathbf{H}^{-1} \mathbf{b}, \quad x^{\text{new}} \leftarrow \delta + x. \]
Keyframes

• Up to 7 Keyframes (5-10/s)

• Project active points into new Keyframes

• RMSE, if failed, 27 small rotations to recover
Keyframes II

- Keep latest 2 Keyframes
- Drop frames with < 5% visible Keypoints
- Maximize distribution of Keypoints
Points

- Around 2000 active Points
- New points may be added from previous (but active) Keyframes
- Depending on distribution and image gradient
Video

- Video, doesn’t work in pdf, will have the slides with me.