Shadow-SLAM

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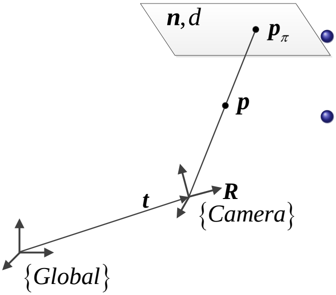
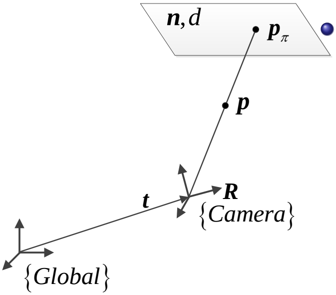
Occluded Point坐标计算



- 平面：$\boldsymbol{n}^T, d$
- $\{Camera\}$坐标系到$\{Global\}$坐标系的变换为$\{\boldsymbol{R}, \boldsymbol{t}\}$
- $\{Camera\}$坐标系原点与occluding point $\boldsymbol{p}$确定的直线与该平面的交点坐标为

$$\boldsymbol{p}_\pi = \frac{\boldsymbol{n}^T\boldsymbol{t} + d}{\boldsymbol{n}^T(\boldsymbol{t} - \boldsymbol{p})}\boldsymbol{p} + \frac{\boldsymbol{n}^T\boldsymbol{p} + d}{\boldsymbol{n}^T(\boldsymbol{p} - \boldsymbol{t})}\boldsymbol{t} \tag{1}$$

Occluded Point坐标计算



- $\boldsymbol{p}_\pi$在$\{Camera\}$坐标系中的坐标为($\boldsymbol{R}_{cg} = \boldsymbol{R}^T, \boldsymbol{t}_{cg} = -\boldsymbol{R}^T\boldsymbol{t}$)

$$
\begin{aligned}
{}^{C}\boldsymbol{p}_\pi &= \boldsymbol{R}_{cg}\boldsymbol{p}_\pi + \boldsymbol{t}_{cg} \\
&= \frac{\boldsymbol{n}^T\boldsymbol{t} + d}{\boldsymbol{n}^T(\boldsymbol{p} - \boldsymbol{t})}\boldsymbol{R}^T(\boldsymbol{t} - \boldsymbol{p})
\end{aligned} \tag{2}
$$

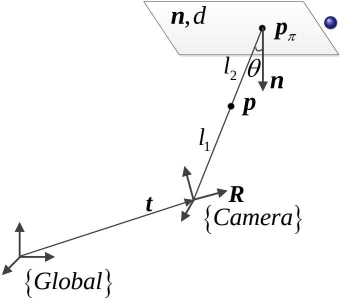
相机运动对Occluded point坐标的影响

- Jacobian of ${}^{C}\boldsymbol{p}_{\pi}$ w.r.t. $\{\boldsymbol{R},\boldsymbol{t}\}$

$$
\begin{aligned}
\boldsymbol{J}_{p\pi} &= \frac{\partial {}^{C}\boldsymbol{p}_{\pi}}{\partial \xi} = \left[\frac{\partial {}^{C}\boldsymbol{p}_{\pi}}{\partial \boldsymbol{t}}, \frac{\partial {}^{C}\boldsymbol{p}_{\pi}}{\partial \omega} \right] \\
\frac{\partial {}^{C}\boldsymbol{p}_{\pi}}{\partial \boldsymbol{t}} &= \frac{\boldsymbol{n}^{T}\boldsymbol{p}+d}{\left(\boldsymbol{n}^{T}(\boldsymbol{p}-\boldsymbol{t})\right)^{2}} \boldsymbol{R}^{T}(\boldsymbol{t}-\boldsymbol{p})\boldsymbol{n}^{T} + \frac{\boldsymbol{n}^{T}\boldsymbol{t}+d}{\boldsymbol{n}^{T}(\boldsymbol{p}-\boldsymbol{t})} \boldsymbol{R}^{T} \\
\frac{\partial {}^{C}\boldsymbol{p}_{\pi}}{\partial \omega} &= \frac{\boldsymbol{n}^{T}\boldsymbol{t}+d}{\boldsymbol{n}^{T}(\boldsymbol{p}-\boldsymbol{t})} \boldsymbol{R}^{T}[\boldsymbol{t}-\boldsymbol{p}]_{\times}
\end{aligned}
\tag{3}
$$

where $[\boldsymbol{t}-\boldsymbol{p}]_{\times}$ is the skew-symmetric matrix corresponding to $\boldsymbol{t}-\boldsymbol{p}$.

相机运动对Occluded point坐标的影响



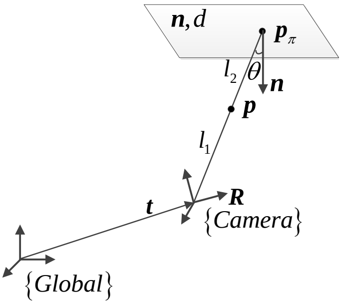
- 令$l_1 = \|\boldsymbol{p} - \boldsymbol{t}\|_2, l_2 = \|\boldsymbol{p}_\pi - \boldsymbol{p}\|_2$, $l = l_1 + l_2 = \|\boldsymbol{p}_\pi - \boldsymbol{t}\|_2$，$\theta$角如图所示，则有

$$\begin{aligned} \boldsymbol{n}^T(\boldsymbol{p} - \boldsymbol{t}) &= -l_1 \cos\theta \\ \boldsymbol{n}^T\boldsymbol{p} + d &= l_2 \cos\theta \\ \boldsymbol{n}^T\boldsymbol{t} + d &= l \cos\theta \end{aligned} \tag{4}$$

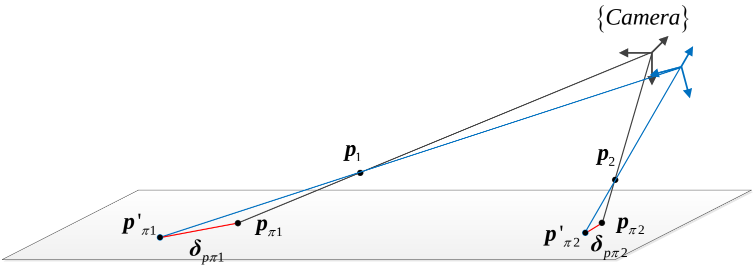
相机运动对Occluded point坐标的影响

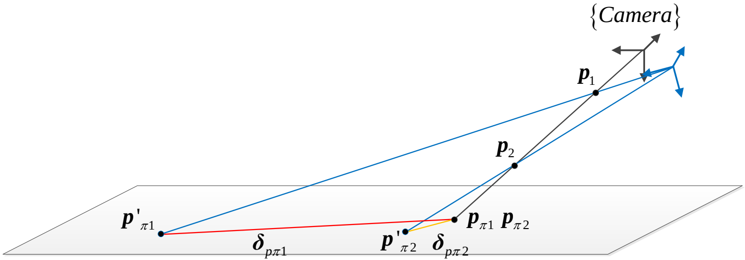
- 代入式(3)，Jacobian $\boldsymbol{J}_{p\pi}$可以写为

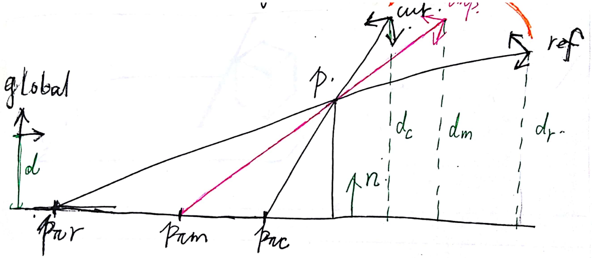
$$\begin{aligned}\boldsymbol{J}_{p\pi} &= \left[\frac{l_2}{l_1^2 \cos\theta}\boldsymbol{R}^T(\boldsymbol{t}-\boldsymbol{p})\boldsymbol{n}^T - \frac{l}{l_1}\boldsymbol{R}^T \quad -\frac{l}{l_1}\boldsymbol{R}^T[\boldsymbol{t}-\boldsymbol{p}]_\times\right] \\ &= \left[\frac{l_2}{l_1^2 \cos\theta}\boldsymbol{R}^T(\boldsymbol{t}-\boldsymbol{p})\boldsymbol{n}^T \quad \boldsymbol{0}\right] - \frac{l}{l_1}\boldsymbol{R}^T\left[\boldsymbol{I} \quad [\boldsymbol{t}-\boldsymbol{p}]_\times\right]\end{aligned} \tag{5}$$



相机运动对Occluded point坐标的影响







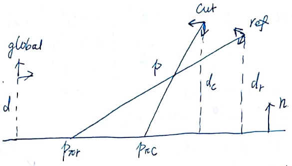
$$ {}^r p_{\pi c}^{(2)} = p_{\pi c}(g=r) = \frac{{}^r n^T t_{rc} + d_r}{{}^r n^T (t_{rc} - {}^r p)} \cdot {}^r p + \frac{{}^r n^T\, {}^r p + d_r}{{}^r n^T ({}^r p - t_{rc})} \cdot t_{rc} $$

calculated in {ref}

intersection of ${}^r\pi$ plane and ${}^r O_{cur}\,{}^r p$ line.

$$ {}^c p_{\pi c} \Leftrightarrow T_{cr}({}^r p_{\pi c}^{(2)}) $$

measured in {cur}



$p_{rr} = \mu(p, t_{gr}, n, d)$
$p_{rc} = \mu(p, t_{gc}, n, d)$
${}^r p_{rr} = T_{rg}(p_{rr})$
${}^c p_{rc} = T_{cg}(p_{rc})$

${}^c p = T_{cg}(p)$ ${}^r p = T_{rg}(p)$

${}^c p'$, ${}^r p'$ } — measurements.
${}^c p_{rc}'$, ${}^r p_{rr}'$
${}^c n'$ ${}^c d_c'$
${}^r n'$ ${}^r d_r'$

T_{cr} : $\{R_{cr}, t_{cr}\}$ — variable.

Constraints:

1) ${}^c p' \leftrightarrow T_{cr}({}^r p') = R_{cr}\,{}^r p' + t_{cr}$.
aligning the occluding points (meas.)

2). $\begin{bmatrix} {}^c n' \\ {}^c d_c' \end{bmatrix} \leftrightarrow T_{cr}^{-T} \begin{bmatrix} {}^r n' \\ {}^r d_r' \end{bmatrix}$ — aligning the planes (meas.)

3) ${}^c p_{rc}' \leftrightarrow$ intersection of the plane (n, d) and the line through p and t_{gc}.
(described in cur)
${}^r p_{rr}' \leftrightarrow$ intersection of the plane (n, d) and the line through p and t_{gr}.
(described in ref)

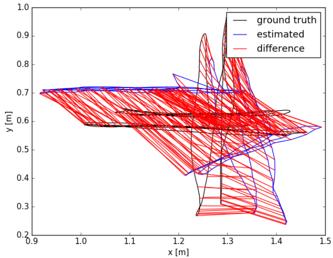
4). ${}^c p'$, ${}^r p'$ } $\leftrightarrow$ intersection of.
{ line through p_{rc} and t_{gc}
{ line through p_{rr} and t_{gr}.

实验

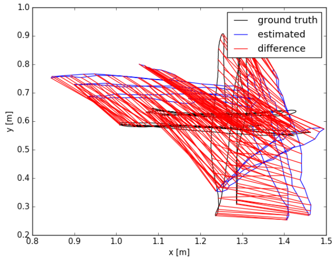
Table:

	edge only (ATE)	edge only (RPE)	edge_shadow (ATE)	edge_shadow (RPE)
fr1_xyz	0.169 m	0.014 m/0.708 deg	0.223 m	0.014 m/0.954 deg
fr2_desk	0.065 m	0.003 m/0.336 deg	0.308 m	0.006 m/0.396 deg
fr3_office	0.167 m	0.004 m/0.369 deg	0.372 m	0.019 m/1.142 deg

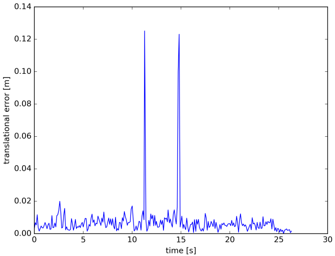
实验

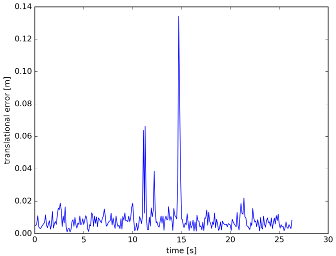


(a) edge only (ATE)



(b) edge_shadow (ATE)





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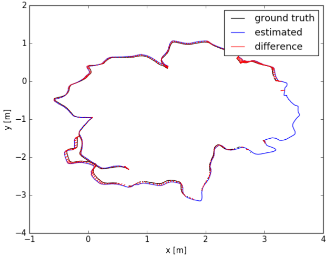

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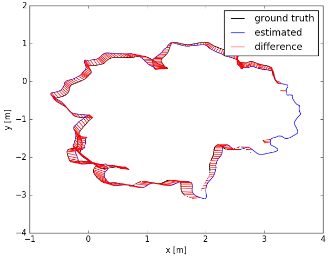
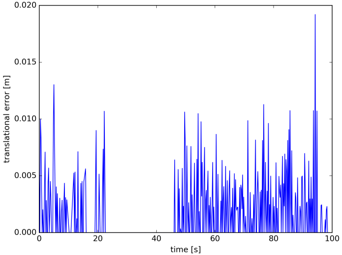
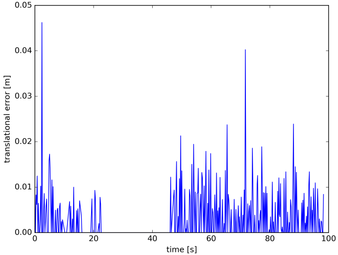


(b) edge_shadow (ATE)





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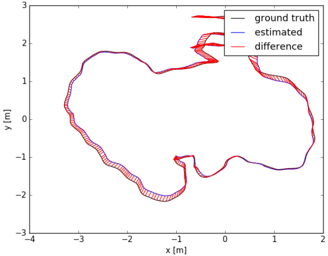

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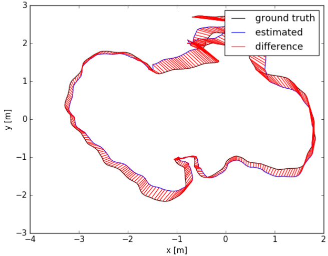

(b) edge_shadow (ATE)