Shadow SLAM

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OUTLINE

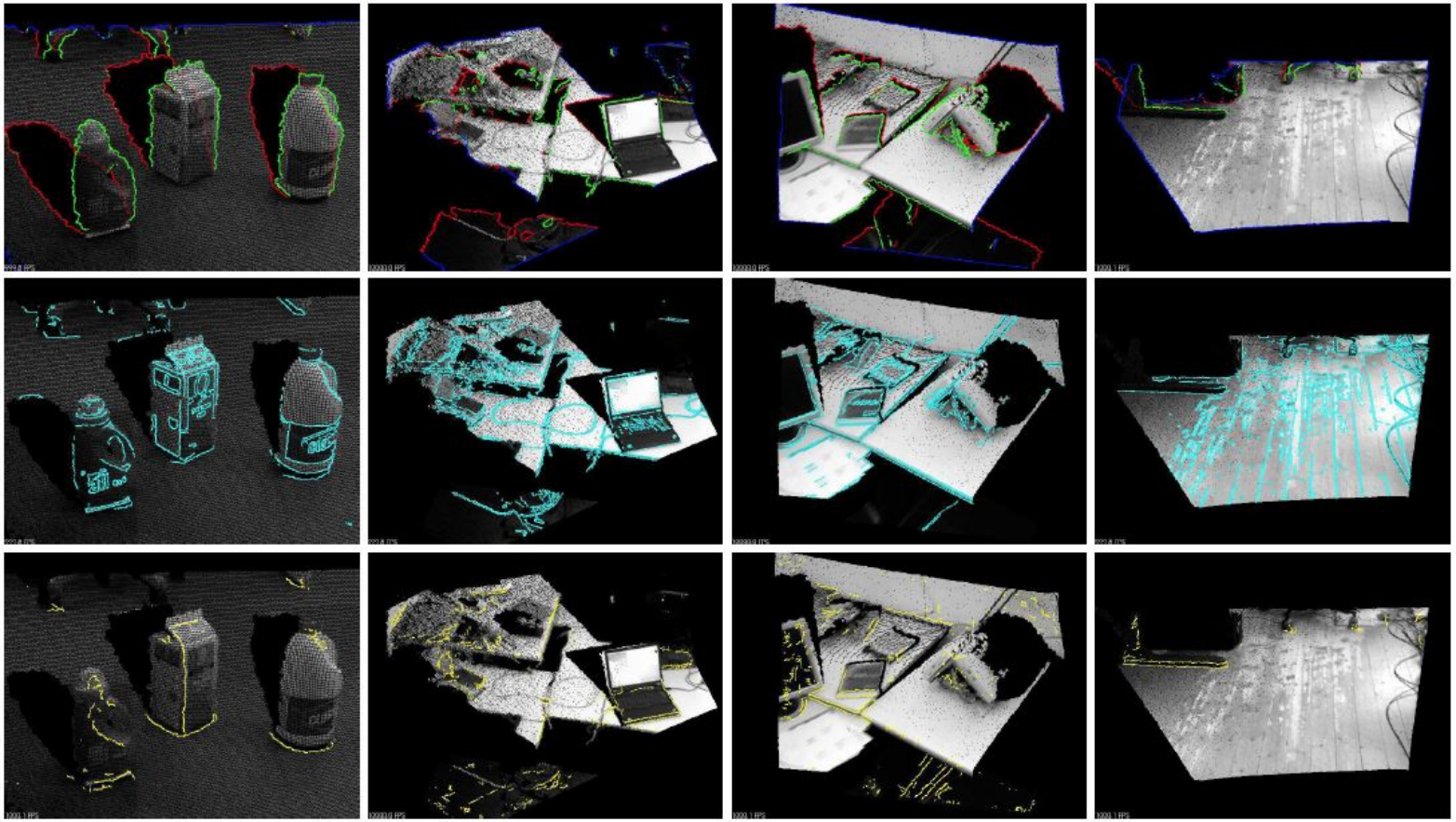
RGB-D Edge Detection Method [1]

Five types of edges can be extracted from an RGB-D scan:

- Occluding Edges,
- Occluded Edges,
- Boundary Edges,
- RGB Edges,
- and High Curvature Edges.

[1] RGB-D Edge Detection and Edge-based Registration, ICRA, 2013.

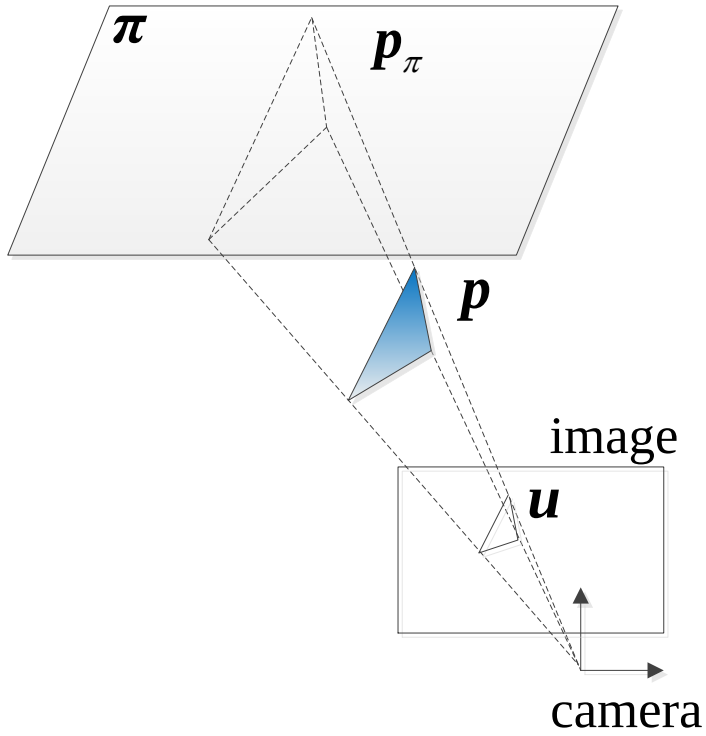
RGB-D Edge Detection Method



Shadows on a Plane

For a 3D point in the camera coordinate frame $\boldsymbol{p}$ (a point on the *occluding edge*), its projection on plane $\pi = [\boldsymbol{n}, d]^T$ is $\boldsymbol{p}_\pi$ (a point on the *occluded edge*).

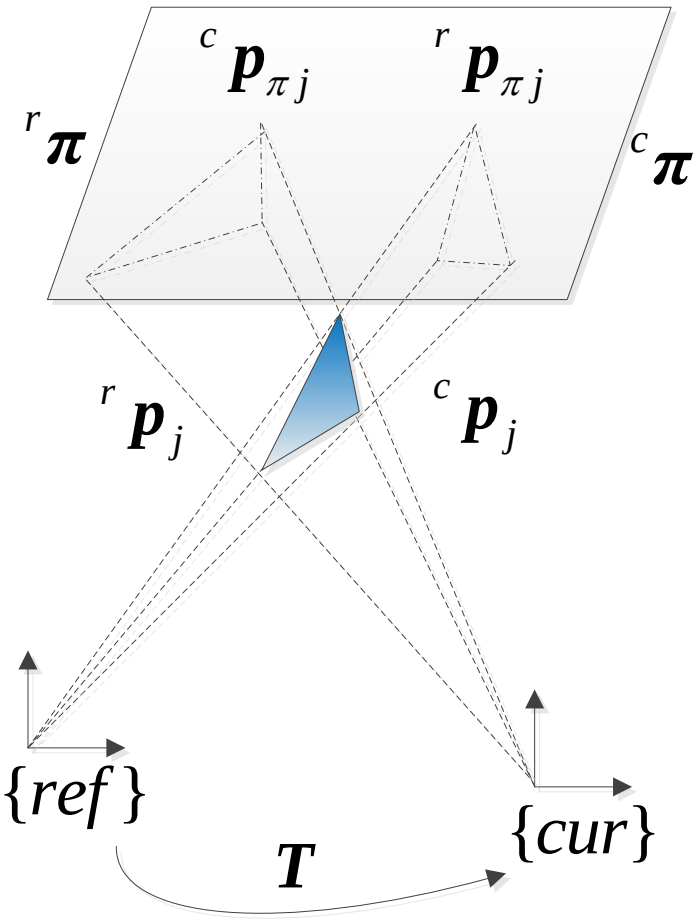
$$\boldsymbol{p}_\pi = \mu(\pi, \boldsymbol{p}) = -\frac{d}{\boldsymbol{n}^T \boldsymbol{p}} \boldsymbol{p} \qquad (1)$$



Scan Alignment

The motion of the camera between two successive frames is represented by $\xi = [t^T, \omega^T]^T \in \mathbb{R}^6$. The exponential of $\hat{\omega} \in \mathfrak{so}(3)$ ($\hat{\omega}$ is the skew-symmetric matrix associated with $\omega \in \mathbb{R}^3$) is a 3D rotation denoted by $\boldsymbol{R} \in \mathbb{SO}(3)$. And $\boldsymbol{t} \in \mathbb{R}^3$ is the translation vector. $T(\xi, {}^r\boldsymbol{p})$ represents the transformation from the reference frame to the current frame.

$$T\left({}^r\boldsymbol{p}_j, \xi\right) = \boldsymbol{R} \cdot {}^r\boldsymbol{p}_j + \boldsymbol{t} \qquad (2)$$



Scan Alignment

${}^r\pi$ and ${}^c\pi$ are matched planes.
${}^r\boldsymbol{p}_j$ and ${}^c\boldsymbol{p}_j$ are matched occluding points.
${}^r\boldsymbol{p}_{\pi j}$ and ${}^c\boldsymbol{p}_{\pi j}$ are the occluded points corresponding to ${}^r\boldsymbol{p}_j$ and ${}^c\boldsymbol{p}_j$, respectively.
The objective function is

$$F(\xi) = \left\| {}^c\boldsymbol{p}_j - T({}^r\boldsymbol{p}_j, \xi) \right\|^2 + \left\| {}^c\boldsymbol{p}_{\pi j} - \mu\left({}^c\pi, T({}^r\boldsymbol{p}_j, \xi)\right) \right\|^2 \quad (3)$$