1. Motion Term Details

In this section, we provide details on the motion term $\mu(\xi_t, \xi_{t-1})$ as introduced in Sec. 3.3.1 of the paper. In particular, we derive the covariance matrix $\Sigma$ introduced in Eq. 8. We start with the motion model $g(\cdot)$ which predicts the next pose of a vehicle at time $t$ based on its current pose at time $t-1$. In our formulation $\delta t$ is the time that passes between $t-1$ and $t$.

The motion model $g$ for movement on a circular arc (first case) is given by

$$
g(\begin{bmatrix} t_x & t_z & \theta & v & \omega \end{bmatrix}^\top) = \begin{bmatrix}
t_x - \frac{v}{\delta t} \cos \theta + \frac{v}{\delta t} \cos (\theta + \omega \delta t) \\
t_z + \frac{v}{\delta t} \sin \theta - \frac{v}{\delta t} \sin (\theta + \omega \delta t) \\
\theta + \omega \delta t \\
v \\
\omega
\end{bmatrix}.
$$

(1)

We now assume known covariances $\sigma_v^2$ and $\sigma_\omega^2$ for the translational velocity $v$ and angular velocity $\omega$ respectively, which leads to the covariance matrix

$$
\Sigma_{(v, \omega)} = \begin{bmatrix} \sigma_v^2 & 0 \\
0 & \sigma_\omega^2
\end{bmatrix}.
$$

(2)

From here, we can approximate the covariance matrix $\Sigma$ using first-order error propagation as

$$
\Sigma \approx J \Sigma_{(v, \omega)} J^\top
$$

(3)

where $J$ is the Jacobian matrix $\nabla_{(v, \omega)} g|_{(v, \omega)}$ evaluated at $(v, \omega)$. The derivation is similar for the second case i.e. the movement on a straight line.

**Ground Plane Prior.** The energy term for the ground plane prior is given by

$$
||t_y - t_{y_{gp}}||_{\Sigma_{gp}}
$$

(4)

where we assume that the vertical translation $t_y$ of a tracked vehicle is normally distributed with mean $t_{y_{gp}} \in \mathbb{R}$ and covariance matrix $\Sigma_{gp} \in \mathbb{R}$. Here $t_{y_{gp}}$ is the altitude of the estimated ground plane at the current position $(t_x, t_z)$ of the vehicle.

2. Quantitative Evaluation Sequences

We used the following sequences of the KITTI Stereo 2015 training dataset: