Supplementary Material for
SAMP: Shape and Motion Priors for 4D Vehicle Reconstruction

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1. Motion Term Details

In this section, we provide details on the motion term $\mu(\boldsymbol{\xi}_t, \boldsymbol{\xi}_{t-1})$ as introduced in Sec. 3.3.1 of the paper. In particular, we derive the covariance matrix $\boldsymbol{\Sigma}$ 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 δt 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

$$g\left(\begin{bmatrix} t_x & t_z & \theta & v & \omega \end{bmatrix}^\top \right) = \begin{bmatrix} t_x - \frac{v}{\omega} cos\theta + \frac{v}{\omega} cos(\theta + \omega\,\delta t) \\ t_z + \frac{v}{\omega} sin\theta - \frac{v}{\omega} sin(\theta + \omega\,\delta t) \\ \theta + \omega\,\delta t \\ v \\ \omega \end{bmatrix}. \tag{1}$$

We now assume known covariances σ_v^2 and σ_ω^2 for the translational velocity v and angular velocity ω respectively, which leads to the covariance matrix

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

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

$$\boldsymbol{\Sigma} \approx \mathbf{J}\boldsymbol{\Sigma}_{(v,\omega)}\mathbf{J}^\top \tag{3}$$

where $\mathbf{J}$ is the Jacobian matrix $\nabla_{(v,\omega)}g|_{(v,\omega)}$ evaluated at (v, ω). 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

$$||t_y - t_{y_{gp}}||_{\boldsymbol{\Sigma}_{gp}}^2 \tag{4}$$

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 $\boldsymbol{\Sigma}_{gp} \in \mathbb{R}$. 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:
8, 9, 10, 11, 12, 16, 18, 19, 20, 21, 23, 25, 26, 31, 35, 43, 44, 46, 47, 48, 52, 54, 55, 57, 59, 62, 67, 71, 75, 77, 81, 83, 84, 86, 87, 88, 89, 96, 97, 99, 100, 102, 109, 110, 117, 119, 121, 122, 128, 129, 131, 132, 133, 134, 136, 138, 140, 141, 143, 144, 145, 147, 148, 149, 150, 151, 153, 156, 160, 162, 165, 167, 168, 169, 170, 171, 172, 173, 174, 175, 176, 177, 186, 188, 191, 192, 193, 194, 195, 196, 197, 198, 199.