# Determination of uncertainty

In the camera pose tracking process of ORB SLAM2, g2o is used to solve the graph optimization problem. In the g2o paper, the linear system for the optimization is introduced in equation (24)

$$\begin{pmatrix} H_{\mathrm{pp}} & H_{\mathrm{pl}} \\ H_{\mathrm{pl}}^T & H_{\mathrm{ll}} \end{pmatrix} \begin{pmatrix} \Delta\mathbf{x}_{\mathrm{p}}^* \\ \Delta\mathbf{x}_{\mathrm{l}}^* \end{pmatrix} = \begin{pmatrix} -\mathbf{b}_{\mathrm{p}} \\ -\mathbf{b}_{\mathrm{l}} \end{pmatrix},$$

where subscripts $\mathrm{p}$ and $\mathrm{l}$ represent pose and landmark, $H$ is Hessian, $\Delta\mathbf{x}^*$ is the increment, and $\mathbf{b}$ is the gradient. Hessian regarding the pose increment $\mathbf{x}_{\mathrm{p}}^*$ is formed by taking the Schur complement as

$$(H_{\mathrm{pp}} - H_{\mathrm{pl}} H_{\mathrm{ll}} H_{\mathrm{pl}}^{-1}) \Delta\mathbf{x}_{\mathrm{p}}^* = -\mathbf{b}_{\mathrm{p}} - H_{\mathrm{pl}} H_{\mathrm{ll}}^{-1} \mathbf{b}_{\mathrm{l}}.$$

This is equation (25) of the g2o paper. Here, we define $H$ as

$$H \overset{\mathrm{def}}{=} H_{\mathrm{pp}} - H_{\mathrm{pl}} H_{\mathrm{ll}} H_{\mathrm{pl}}^{-1}.$$

Then, we determine the uncertainty, i.e., covariance matrix, of the estimate by ORB SLAM2 as

$$R = \frac{1}{\sigma^2} H^{-1},$$

where $\sigma^2$ is the scale factor and is must be positive.