Determination of uncertainty

In the camera pose tracking process of ORB SLAM2, $\mathrm{g^2o}$ [1] is used to solve the graph optimization problem. In the $\mathrm{g^2o}$ paper [2], 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 p and 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 $\mathrm{g^2o}$ 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 σ^2 is the scale factor and must be positive.

[1] https://github.com/RainerKuemmerle/g2o

[2] https://www.researchgate.net/publication/224252449_G2o_A_general_framework_for_graph_optimization