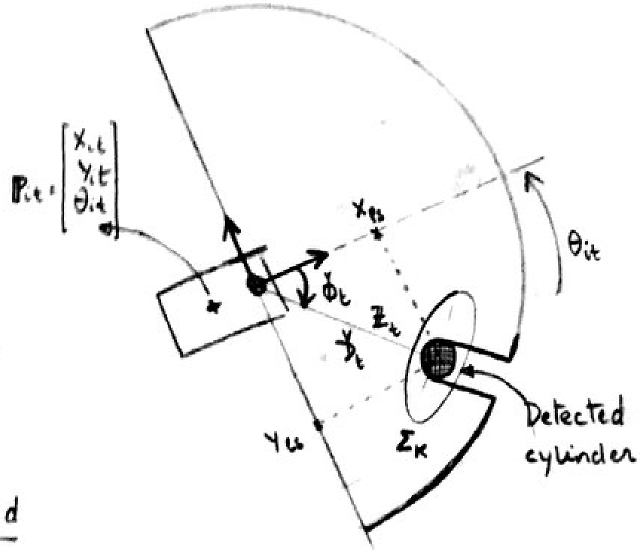
(3) Initialize a new landmark



After computing the likelihood for the landmark in the picture the algorithm determines that this landmark is a new landmark and it should be incorporated into the list of landmarks for the particle the algorithm is working with.

$$\underbrace{(x_{\ell k}, y_{\ell k})}_{m_k} = \underbrace{h^{-1}(\mathbb{P}_{it}, sd, z_t)}$$

- With $\mathbb{P}_{it}$ and sd compute the scanner's pose.
- With z_t compute (x_{sk}, y_{sk}), i.e, the landmark's coordinates in the scanner's (sensor) reference frame.
- Invoke legoLogfile.scanner_to_world (scanner_pose, (x_{sk}, y_{sk}))

$$H_{tk} = \frac{\partial h}{\partial m_k}\Big|_{(x_{\ell k}, y_{\ell k})} = \begin{bmatrix} \frac{\partial D_{tk}}{\partial x_{\ell k}} & \frac{\partial D_{tk}}{\partial y_{\ell k}} \\ \frac{\partial \phi_{tk}}{\partial x_{\ell k}} & \frac{\partial \phi_{tk}}{\partial y_{\ell k}} \end{bmatrix}$$

translates (propagates) the uncertainty in the landmark's position, Σ_K, into an uncertainty in the expected measurement, Q_{tk}.

Now, the situation is different. The robot takes a scan and the algorithm makes an observation in the scan (detects a cylinder), i.e, $z_t = \begin{pmatrix} \check{D}_t \\ \check{\phi}_t \end{pmatrix}$. The uncertainty in this observation, Q_z, translates into an uncertainty (error) in the landmark's position, Σ_K.

So we need the jacobian of $h_t^{-1}(.)$, i.e, the inverse of $H_{tk} \Rightarrow H_{tk}^{-1}$

$$\Sigma_K = H_{tk}^{-1} \cdot \underbrace{Q_z}_{\begin{bmatrix} \sigma_{\check{D}t}^2 & 0 \\ 0 & \sigma_{\check{\phi}t}^2 \end{bmatrix}} \cdot (H_{tk}^{-1})^T \quad \left[= (V_\parallel \; V_\perp) \cdot \begin{bmatrix} \lambda_\parallel^2 & 0 \\ 0 & \lambda_\perp^2 \end{bmatrix} \cdot (V_\parallel \; V_\perp)^T \right]$$

$\alpha_\parallel = \operatorname{atan}\left(\frac{V_{\parallel y}}{V_{\parallel x}}\right)$

$\alpha_\perp = \alpha_\parallel \pm 90°$ or $= \operatorname{atan}\left(\frac{V_{\perp y}}{V_{\perp x}}\right)$

$V_\parallel$: Eigenvector showing the direction of the ellipse axis parallel to the scan ray.

$V_\perp$: EigenVector showing the direction of the ellipse axis perpendicular to the scan ray.

$\lambda_\parallel$: Semilength of the ellipse axis parallel to the scan ray.

$\lambda_\perp$: Semilength of the ellipse axis perpendicular to the scan ray.