IMU Wheel 融合

这是是采用比较简单的方式

IMU的陀螺仪输出的角速度结合轮式计的线速度进行融合

这里假设IMU和轮式计之间是通过 T_{wheel}^{imu} 进行固练

v_{wheel} 代表轮式计输出的速度

$v_{imu} = T_{wheel}^{imu} v_{wheel}$
v_{imu} 代表转化到imu系的速度

状态量递推

之后，就可以套入预积分的公式

$$\alpha_{b_i b_{k+1}} = \alpha_{b_i b_k} + exp(\theta_{b_i b_k}) v_{imu} \Delta t$$
$$\theta_{b_i b_{k+1}} = In(exp(\theta_{b_i b_k}) exp[(\omega_m - b_{gk}) \Delta t])$$
$$b_{gk+1} = b_{gk}$$

为了方便之后，对于Bias 展开的需求

这个通过对每一个IMU进行泰勒展开，合并起来，最终得到用于对Bias泰勒展开的J_{ij}

因为α 和 b_g 已经是一个线性的关系，所以只对 θ 展开即可

$$\begin{aligned}\theta_{b_i b_{k+1}} &= In(exp(\theta_{b_i b_k}) exp[(\omega_m - b_{gk}) \Delta t]) \\ &= J_{\theta_{b_i b_k}}^{\theta_{b_i b_{k+1}}} (\theta_{b_i b_k} - \hat{\theta_{b_i b_k}}) + J_{b_{gk}}^{\theta_{b_i b_{k+1}}} (b_{gk} - \hat{b_{gk}}) + c\end{aligned}$$

$$
\begin{aligned}
\theta_{whole} &= In(exp(\theta_{b_ib_k}\hat{)}exp[(\omega_m - b_{gk}\hat{)}\Delta t]) \\
J^{\theta_{b_ib_{k+1}}}_{\theta_{b_ib_k}} &= \frac{d\theta_{b_ib_{k+1}}(\delta\theta)}{d\delta\theta} \\
&= \frac{In(exp(\theta_{b_ib_k}\hat{)}exp(\delta\theta)exp[(\omega_m - b_{gk}\hat{)}\Delta t])}{d\delta\theta} \\
&= J_r^{-1}(exp(\theta_{whole}))(exp[(\omega_m - b_{gk}\hat{)}\Delta t])^T
\end{aligned}
$$

$$
\begin{aligned}
J^{\theta_{b_ib_{k+1}}}_{b_{gk}} &= \frac{d\theta_{b_ib_{k+1}}(\delta b_{gk})}{d\delta b_{gk}} \\
&= \frac{In(exp(\theta_{b_ib_k}\hat{)}exp[(\omega_m - b_{gk}\hat{} - \delta b_{gk})\Delta t])}{d\delta b_{gk}} \\
&= -J_r^{-1}(exp(\theta_{whole}))J_r(exp[(\omega_m - b_{gk}\hat{)}\Delta t])\Delta t
\end{aligned}
$$

c 是常数项

之后就有了

$$
X_{k+1} = F_kX_k + ...
$$

在不断的迭代之后，$J^{\alpha}_{b_g}$ 等 就可以从迭代得到的J 里面取了。

方差估计

因为最后的估计是最大后验

$$
p(x|z) = p(z|x)p(x)
$$

$p(x)$ 是先验部分，属于另外一个误差项，这里就不用关心了。
$p(z|x)$ 当高斯分布来看

$$
In(p(z|x)) = (z - Cx)^T\Sigma^{-1}(z - Cx)
$$

从之前的课程来看

$$
z - Cx = \delta z
$$

且这里C是一个单位阵

$$\delta z = \delta x_{imu}$$

所以,可以使用之前在ESKF 的时候的误差状态分析,在这里对方差进行分析。

$$\begin{aligned}
\dot{p} &= exp(\theta)v_{imu} \\
\dot{p} + \dot{\delta p} &= exp(\theta)exp(\delta\theta)(v_{imu} + n_v) \\
\dot{\delta p} &= -exp(\theta)[v_{imu}] \times \delta\theta + exp(\theta)n_v \\
exp(\dot{\theta}) &= exp(\theta)[\omega_m - b_g]\times \\
(exp(\theta)\dot{exp}(\delta\theta)) &= exp(\theta)exp(\delta\theta)[\omega_m - b_g - \delta b_g + n_\omega]\times \\
\dot{\delta\theta} &= -[\omega_m - b_g] \times \delta\theta - \delta b_g + n_w \\
\dot{bg} &= 0 \\
(bg \dot{+} \delta b_g) &= n_{gwalk} \\
\delta\dot{b}_g &= n_{gwalk}
\end{aligned}$$

得到

$$\delta\dot{X} = F\delta X + BN$$

不断进行迭代进行方差计算了。

r求导

最后就是对于r的求导

$$r_{\alpha_{bjbi}} = p_{bj} - p_{bi} - \alpha_{bjbi} - J^{\alpha}_{b_{gbi}}(b_{gbi} - \hat{b_{gbi}})$$

$$\frac{\partial r_{\alpha_{bjbi}}}{\partial p_{bj}} = I$$

$$\frac{\partial r_{\alpha_{bjbi}}}{\partial p_{bj}} = -I$$

$$\frac{\partial r_{\alpha_{bjbi}}}{\partial b_{gbi}} = -J^{\alpha}_{b_{gbi}}$$

$$r_{\theta_{bjbi}} = In[R_j^T R_i exp(\theta_{b_j b_i} + J^{\theta_{b_j b_i}}_{b_{gi}}(b_{gbi} - b^{linearized}_{gbi}))]$$

$$\theta_{whole} = In[\hat{R_j}^T \hat{R_i} exp(\theta_{b_j b_i} + J^{\theta_{b_j b_i}}_{b_{gi}}(\hat{b_{gbi}} - b^{linearized}_{gbi}))$$

$$\frac{\partial \theta_{bjbi}}{\partial R_j} = -J_l^{-1}(exp(\theta_{whole}))$$

$$\frac{\partial \theta_{bjbi}}{\partial R_i} = J_r^{-1}(exp(\theta_{whole}))(exp(\theta_{b_j b_i} + J^{\theta_{b_j b_i}}_{b_{gi}}(\hat{b_{gbi}} - b^{linearized}_{gbi})))^T$$

$$\frac{\partial \theta_{bjbi}}{\partial b_{gki}} = J_r^{-1}(exp(\theta_{whole}))J_r(exp(\theta_{b_j b_i} + J^{\theta_{b_j b_i}}_{b_{gi}}(\hat{b_{gbi}} - b^{linearized}_{gbi})))$$