1. 旋转矩阵

r =

[cos(he)*cos(ro) + sin(he)*sin(pt)*sin(ro), cos(he)*sin(pt)*sin(ro) - cos(ro)*sin(he), -cos(pt)*sin(ro)]

[cos(pt)*sin(he), cos(he)*cos(pt), sin(pt)]

[cos(he)*sin(ro)-cos(ro)*sin(he)*sin(pt), - sin(he)*sin(ro) - cos(he)*cos(ro)*sin(pt), cos(pt)*cos(ro)]

r=[r1, r2, r3; r4, r5, r6; r7, r8, r9];

```
r =
[ cos(he)*cos(ro) + sin(he)*sin(pt)*sin(ro),   cos(he)*sin(pt)*sin(ro) - cos(ro)*sin(he), -cos(pt)*sin(ro)]
[                           cos(pt)*sin(he),                           cos(he)*cos(pt),          sin(pt)]
[ cos(he)*sin(ro) - cos(ro)*sin(he)*sin(pt), - sin(he)*sin(ro) - cos(he)*cos(ro)*sin(pt),  cos(pt)*cos(ro)]
```

2. 基线向量

b=

[bx, by, bz]=

[x - xs, y - ys, z - zs]'

3. 中间表达式

```
abc =
 (cos(he)*cos(ro) + sin(he)*sin(pt)*sin(ro))*(x - xs) - (cos(ro)*sin(he) - cos(he)*sin(pt)*sin(ro))*(y - ys) - cos(pt)*sin(ro)*(z - zs)
                                                        sin(pt)*(z - zs) + cos(he)*cos(pt)*(y - ys) + cos(pt)*sin(he)*(x - xs)
 (cos(he)*sin(ro) - cos(ro)*sin(he)*sin(pt))*(x - xs) - (sin(he)*sin(ro) + cos(he)*cos(ro)*sin(pt))*(y - ys) + cos(pt)*cos(ro)*(z - zs)
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A = r1*bx + r2*by + r3*bz;

B = r4*bx + r5*by + r6*bz;

C = r7*bx + r8*by + r9*bz;

4. 共线方程

```
fx = atan(A/B) - theta;
fy = atan(sqrt(A^2 + B^2)/C) - psi;
```

5. 微分方程

vx = a11 * dx + a12 * dy + a13 * dz + a14 * droll + a15 * dpitch + a16 * dyaw – fx0

vy = a21 * dx + a22 * dy + a23 * dz + a24 * droll + a25 * dpitch + a26 * dyaw – fy0

其中：

$$\mathrm{a11}=\frac{\partial fx}{\partial x}=\frac{A*r4-B*r1}{A^2+B^2}$$

$$\mathrm{a12}=\frac{\partial fx}{\partial y}=\frac{A*r5-B*r2}{A^2+B^2}$$

$$\mathrm{a13}=\frac{\partial fx}{\partial z}=\frac{A*r6-B*r3}{A^2+B^2}$$

$$\mathrm{a14}=\frac{\partial fx}{\partial roll}=\frac{-B*C}{A^2+B^2}$$

$$\mathrm{a15}=\frac{\partial fx}{\partial pitch}=\frac{A*(tp4*by-\mathrm{tp5}*bz+\mathrm{tp6}*bx)+B*(tp1*bz+\mathrm{tp2}*by+\mathrm{tp3}*\mathrm{bx})}{A^2+B^2}$$

$$\mathrm{a16}=\frac{\partial fx}{\partial yaw}=\frac{A*(r4*by-\mathrm{r5}*bx)+B*(r2*bx-r1*by)}{A^2+B^2}$$

$$\mathrm{a21}=\frac{\partial y}{\partial x}=\frac{(A^2+B^2)*\mathrm{r7}-\mathrm{C}*(\mathrm{A}*r1+\mathrm{B}*\mathrm{r4})}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

$$\mathrm{a22}=\frac{\partial y}{\partial y}=\frac{(A^2+B^2)*\mathrm{r8}-\mathrm{C}*(\mathrm{A}*r2+\mathrm{B}*\mathrm{r5})}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

$$a23 = \frac{\partial y}{\partial z} = \frac{(A^2 + B^2) * r9 - C * (A * r3 + B * r6)}{(A^2 + B^2 + C^2) * \sqrt{A^2 + B^2}}$$

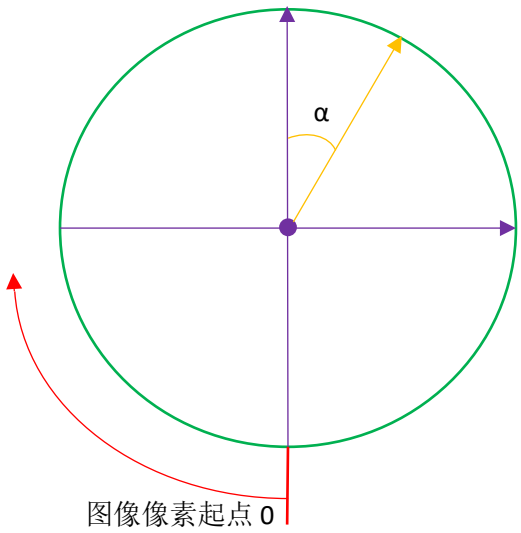
$$a24 = \frac{\partial y}{\partial roll} = -\frac{A}{\sqrt{A^2 + B^2}}$$

$$a25 = \frac{\partial y}{\partial pitch} = \frac{tp10 + tp11}{(A^2 + B^2 + C^2) * \sqrt{A^2 + B^2}}$$

$$a26 = \frac{\partial y}{\partial yaw} = \frac{tp12 + tp13}{(A^2 + B^2 + C^2) * \sqrt{A^2 + B^2}}$$

定义：

```
tp1 = sin(pt)*sin(ro);
tp2 = cos(he)*cos(pt)*sin(ro);
tp3 = cos(pt)*sin(he)*sin(ro);
tp4 = cos(he)*sin(pt);
tp5 = cos(pt);
tp6 = sin(he)*sin(pt);
tp7 = cos(ro)*sin(pt);
tp8 = cos(he)*cos(pt)*cos(ro);
tp9 = cos(pt)*cos(ro)*sin(he);
tp10=C*(A*(tp1*bz+tp2*by+tp3*bx)-B*(tp4*by-tp5*bz+tp6*bx));
tp11=(A^2+B^2 )*(tp7*bz+tp8*by+tp9*bx);
tp12=C*(A*(r2*bx-r1*by)+B*(r5*bx-r4*by));
tp13=(A^2+B^2 )*(-r8*bx+r7*by);
```



其中：

$$\mathrm{a11}=\frac{\partial x}{\partial x}=\frac{A*\sin(he)*\cos(pt)-B*(\cos(he)*\cos(ro)+\sin(he)*\sin(pt)*\sin(ro))}{A^2+B^2}$$

$$\mathrm{a12}=\frac{\partial x}{\partial y}=\frac{A*\cos(he)*\cos(pt)+B*(\sin(he)*\cos(ro)-\cos(he)*\sin(pt)*\sin(ro))}{A^2+B^2}$$

$$\mathrm{a13}=\frac{\partial x}{\partial z}=\frac{A*\sin(pt)+B*\cos(pt)*\sin(ro)}{A^2+B^2}$$

$$\mathrm{a14}=\frac{\partial x}{\partial roll}=\frac{-B*C}{A^2+B^2}$$

$$\mathrm{a15}=\frac{\partial x}{\partial pitch}=\frac{tp1-tp2}{A^2+B^2}$$

其中：

$$tp1=B*(\sin(pt)\sin(ro)\,bz+\cos(he)\cos(pt)\sin(ro)\,by+\cos(\mathrm{pt})\sin(\mathrm{he})\sin(\mathrm{ro})\,\mathrm{bx})$$

$$tp2=-A*(\cos(he)*\sin(pt)*by-\cos(pt)*bz+\sin(he)*\sin(pt)*bx)$$

$$\mathrm{a16}=\frac{\partial x}{\partial yaw}$$

$$=-\frac{A*(\cos(he)*\cos(pt)*bx-\cos(pt)*\sin(he)*by)+B*(tp3*bx+tp4*by)}{A^2+B^2}$$

其中：

$$\mathrm{tp3}=\cos(\mathrm{ro})*\sin(\mathrm{he})-\cos(\mathrm{he})*\sin(\mathrm{pt})*\sin(\mathrm{ro})$$

$$\mathrm{tp4}=\cos(\mathrm{he})*\cos(\mathrm{ro})+\sin(\mathrm{he})*\sin(\mathrm{pt})*\sin(\mathrm{ro})$$

$$\mathrm{a21}=\frac{\partial y}{\partial x}=\frac{tp5+tp6}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

其中：

$$\mathrm{tp5}=-\mathrm{C}*(\mathrm{A}*(\cos(\mathrm{he})*\cos(\mathrm{ro})+\sin(\mathrm{he})*\sin(\mathrm{pt})*\sin(\mathrm{ro}))+\mathrm{B}*\cos(\mathrm{pt})*\sin(\mathrm{he}))$$

$$\mathrm{tp6}=(A^2+B^2)*(\cos(\mathrm{he})*\sin(\mathrm{ro})-\cos(\mathrm{ro})*\sin(\mathrm{he})*\sin(\mathrm{pt}))$$

$$\mathrm{a22}=\frac{\partial y}{\partial y}=-\frac{tp7+tp8}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

$$\mathrm{tp7}=\mathrm{C}*(-\mathrm{A}*(\sin(\mathrm{he})*\cos(\mathrm{ro})-\cos(\mathrm{he})*\sin(\mathrm{pt})*\sin(\mathrm{ro}))+\mathrm{B}*\cos(\mathrm{pt})*\cos(\mathrm{he}))$$

$$\mathrm{tp8}=(A^2+B^2)*(\sin(\mathrm{he})*\sin(\mathrm{ro})+\cos(\mathrm{ro})*\cos(\mathrm{he})*\sin(\mathrm{pt}))$$

$$\mathrm{a23}=\frac{\partial y}{\partial z}-\frac{C*(B*\sin(pt)-A*\cos(pt)*\sin(ro))-(A^2+B^2)*\cos(pt)*\cos(ro)}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

$$\mathrm{a24}=\frac{\partial y}{\partial roll}=\frac{-A*C^2-A*(A^2+B^2)}{(A^2+B^2+C^2)\sqrt{A^2+B^2}}$$

$$\mathrm{a25}=\frac{\partial y}{\partial pitch}=-\frac{tp9-tp10}{(A^2+B^2+C^2)*\sqrt{A^2+B^2}}$$

$$\mathrm{tp9}=\mathrm{C}*(-\mathrm{A}*(\sin(\mathrm{pt})*\sin(\mathrm{ro})*\mathrm{bz}+\cos(\mathrm{he})*\cos(\mathrm{pt})*\sin(\mathrm{ro})*\mathrm{by}+\cos(\mathrm{pt})*\sin(\mathrm{he})*\sin(\mathrm{ro})*\mathrm{bx})+\mathrm{B}*((\cos(\mathrm{he})*\sin(\mathrm{pt})*\mathrm{by}-\cos(\mathrm{pt})*\mathrm{bz})*\sin(\mathrm{he})*\sin(\mathrm{pt})*\mathrm{bx}))$$

$$\mathrm{tp10}=(A^2+B^2)*(\cos(\mathrm{ro})*\sin(\mathrm{pt})*\mathrm{bz}+\cos(\mathrm{he})*\cos(\mathrm{pt})*\cos(\mathrm{ro})*\mathrm{by}+\cos(\mathrm{pt})*\cos(\mathrm{ro})*\sin(\mathrm{he})*\mathrm{bx})$$

$$\mathrm{a26} = \frac{\partial y}{\partial yaw} - \frac{tp11 + tp12}{(A^2 + B^2 + C^2) * \sqrt{A^2 + B^2}}$$

$$\mathrm{tp11} = \mathrm{C} * (-\mathrm{A} * (-\mathrm{r2} * \mathrm{bx} + \mathrm{r1} * \mathrm{by}) + \mathrm{B} * (\cos(\mathrm{he}) * \cos(\mathrm{pt}) * \mathrm{bx} - \cos(\mathrm{pt}) * \sin(\mathrm{he}) * \mathrm{by}))$$

$$\mathrm{tp12} = (A^2 + B^2) * (-\mathrm{r8} * \mathrm{bx} + \mathrm{r7} * \mathrm{by})$$