Formulas

$$\mathrm{Rot}(X,\theta)=\begin{bmatrix}1 & 0 & 0 & 0\\ 0 & \mathrm{C}\theta & -\mathrm{S}\theta & 0\\ 0 & \mathrm{S}\theta & \mathrm{C}\theta & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

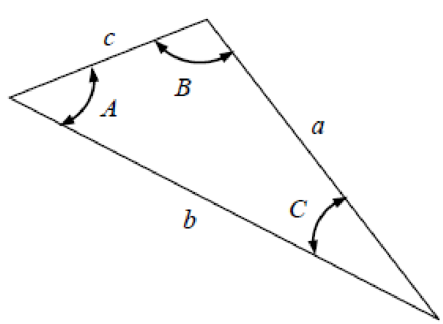
$$\mathrm{Rot}(Y,\theta)=\begin{bmatrix}\mathrm{C}\theta & 0 & \mathrm{S}\theta & 0\\ 0 & 1 & 0 & 0\\ -\mathrm{S}\theta & 0 & \mathrm{C}\theta & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

$$\mathrm{Rot}(Z,\theta)=\begin{bmatrix}\mathrm{C}\theta & -\mathrm{S}\theta & 0 & 0\\ \mathrm{S}\theta & \mathrm{C}\theta & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1\end{bmatrix}$$

$$\mathrm{Trans}(a,b,c)=\begin{bmatrix}1 & 0 & 0 & a\\ 0 & 1 & 0 & b\\ 0 & 0 & 1 & c\\ 0 & 0 & 0 & 1\end{bmatrix}$$

$$T^{-1}=\begin{bmatrix}n_x & n_y & n_z & -\vec{P}\bullet\vec{n}\\ o_x & o_y & o_z & -\vec{P}\bullet\vec{o}\\ a_x & a_y & a_z & -\vec{P}\bullet\vec{a}\\ 0 & 0 & 0 & 1\end{bmatrix}$$

$$A_{n+1}={}^{n}T_{n+1}=\begin{bmatrix}\mathrm{C}\theta_{n+1} & -\mathrm{S}\theta_{n+1}\mathrm{C}\alpha_{n+1} & \mathrm{S}\theta_{n+1}\mathrm{S}\alpha_{n+1} & a_{n+1}\mathrm{C}\theta_{n+1}\\ \mathrm{S}\theta_{n+1} & \mathrm{C}\theta_{n+1}\mathrm{C}\alpha_{n+1} & -\mathrm{C}\theta_{n+1}\mathrm{S}\alpha_{n+1} & a_{n+1}\mathrm{S}\theta_{n+1}\\ 0 & \mathrm{S}\alpha_{n+1} & \mathrm{C}\alpha_{n+1} & d_{n+1}\\ 0 & 0 & 0 & 1\end{bmatrix}$$



$$\cos A=\left(b^2+c^2-a^2\right)\big/\left(2bc\right)$$

$$S\theta_1 C\theta_2 + C\theta_1 S\theta_2 = S(\theta_1+\theta_2) = S\theta_{12}$$

$$C\theta_1 C\theta_2 - S\theta_1 S\theta_2 = C(\theta_1+\theta_2) = C\theta_{12}$$

if $a=\sin\theta$ and $b=\cos\theta$ then $\theta=\mathrm{atan2}(a,b)$

$$J(q)=\begin{bmatrix}\dfrac{\partial p_x(q)}{\partial q_1} & \dfrac{\partial p_x(q)}{\partial q_2}\\ \dfrac{\partial p_y(q)}{\partial q_1} & \dfrac{\partial p_y(q)}{\partial q_2}\end{bmatrix}$$

$$J(q)=\begin{bmatrix}\dfrac{\partial p_x(q)}{\partial q_1} & \dfrac{\partial p_x(q)}{\partial q_2} & \dfrac{\partial p_x(q)}{\partial q_3}\\ \dfrac{\partial p_y(q)}{\partial q_1} & \dfrac{\partial p_y(q)}{\partial q_2} & \dfrac{\partial p_y(q)}{\partial q_3}\\ \zeta_1 t_1 & \zeta_2 t_2 & \zeta_3 t_3\end{bmatrix}$$

$$J(q)=\begin{bmatrix}\dfrac{\partial p_x(q)}{\partial q_1} & \dfrac{\partial p_x(q)}{\partial q_2} & \dfrac{\partial p_x(q)}{\partial q_3}\\ \dfrac{\partial p_y(q)}{\partial q_1} & \dfrac{\partial p_y(q)}{\partial q_2} & \dfrac{\partial p_y(q)}{\partial q_3}\\ \dfrac{\partial p_z(q)}{\partial q_1} & \dfrac{\partial p_z(q)}{\partial q_2} & \dfrac{\partial p_z(q)}{\partial q_3}\end{bmatrix}$$

$$J(q)=\left[\begin{array}{cccc}\dfrac{\partial p_x(q)}{\partial q_1} & \dfrac{\partial p_x(q)}{\partial q_2} & \cdots & \dfrac{\partial p_x(q)}{\partial q_n}\\ \dfrac{\partial p_y(q)}{\partial q_1} & \dfrac{\partial p_y(q)}{\partial q_2} & \cdots & \dfrac{\partial p_y(q)}{\partial q_n}\\ \dfrac{\partial p_z(q)}{\partial q_1} & \dfrac{\partial p_z(q)}{\partial q_2} & \cdots & \dfrac{\partial p_z(q)}{\partial q_n}\\ \hline \zeta_1 z_0(q) & \zeta_2 z_1(q) & \cdots & \zeta_n z_{n-1}(q)\end{array}\right]$$

$$z_i={}^{0}R_i\begin{bmatrix}0\\0\\1\end{bmatrix}\quad\text{where } {}^{0}R_i=\prod_{k=1}^{i}{}^{k-1}R_k$$

if $A=\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}$ then

$$A^{-1}=\frac{1}{a_{11}a_{22}-a_{12}a_{21}}\begin{bmatrix} a_{22} & -a_{12} \\ -a_{21} & a_{11} \end{bmatrix}$$

$$\det(J)=j_{11}(j_{33}j_{22}-j_{32}j_{23})-j_{21}(j_{33}j_{12}-j_{32}j_{13})+j_{31}(j_{23}j_{12}-j_{22}j_{13})$$

$$\begin{bmatrix} v_x \\ v_y \\ v_z \\ \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}=J(q)\begin{bmatrix} \dot{q}_1 \\ \dot{q}_2 \\ \vdots \\ \dot{q}_n \end{bmatrix}$$

$$\tau=J(q)^T F$$

$$F_i=\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{x}_i}\right)-\frac{\partial L}{\partial x_i}$$

$$\tau_i=\frac{\partial}{\partial t}\left(\frac{\partial L}{\partial \dot{\theta}_i}\right)-\frac{\partial L}{\partial \theta_i}$$

$$K_j=\tfrac{1}{2}m_j v_{cj}{}^2+\tfrac{1}{2}I_j\omega_j{}^2$$

$$P_j=-m_j G^T p_{cj}$$

$$\dot{\theta}_{\max}=\frac{\theta_h-\theta_b}{t_h-t_b}=\ddot{\theta}_d t_b$$

$$t_b=\frac{t_f}{2}-\frac{\sqrt{\ddot{\theta}_d{}^2 t_f{}^2-4\ddot{\theta}_d(\theta_f-\theta_i)}}{2\left|\ddot{\theta}_d\right|}$$

$\theta(t)=\theta_i+\tfrac{1}{2}\ddot{\theta}_d t^2$, $\dot{\theta}(t)=\ddot{\theta}_d t$,
and $\ddot{\theta}(t)=\ddot{\theta}_d$

$\theta(t)=\theta_i+\tfrac{1}{2}\ddot{\theta}_d t_b{}^2+\ddot{\theta}_d t_b(t-t_b)$, $\dot{\theta}(t)=\ddot{\theta}_d t_b$,
and $\ddot{\theta}(t)=0$

$\theta(t)=\theta_f-\tfrac{1}{2}\ddot{\theta}_d(t_f-t)^2$, $\dot{\theta}(t)=\ddot{\theta}_d(t_f-t)$,
and $\ddot{\theta}(t)=-\ddot{\theta}_d$

Gaussian $M=\begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$, Mean $M=\begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}$

Lap1 $M=\begin{bmatrix} 0 & -1 & 0 \\ -1 & 5 & -1 \\ 0 & -1 & 0 \end{bmatrix}$, Lap2 $M=\begin{bmatrix} 1 & -2 & 1 \\ -2 & 5 & -2 \\ 1 & -2 & 1 \end{bmatrix}$

Sobel $M_h=\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix}$ and $M_v=\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix}$

Prewitt $M_h=\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$ and $M_v=\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$

$$F=A+c(A-F_{smooth})$$

The End