Some Formulae (continued on next page)

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

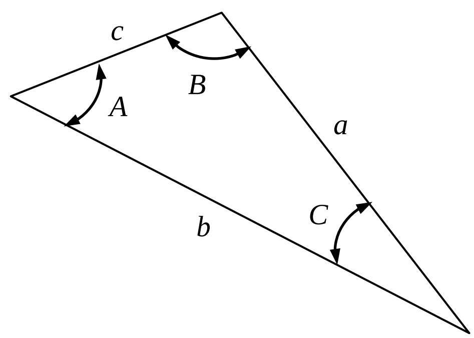
$$\mathrm{Rot}(Y,\theta)=\begin{bmatrix}\mathrm{C}\theta&0&\mathrm{S}\theta&0\\0&1&0&0\\-\mathrm{S}\theta&0&\mathrm{C}\theta&0\\0&0&0&1\end{bmatrix}$$

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

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

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

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



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

$$S\theta_1C\theta_2+C\theta_1S\theta_2=S(\theta_1+\theta_2)=S\theta_{12}$$

$$C\theta_1C\theta_2-S\theta_1S\theta_2=C(\theta_1+\theta_2)=C\theta_{12}$$

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

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

$$J(q)=\begin{bmatrix}\frac{\partial p_x(q)}{\partial q_1}&\frac{\partial p_x(q)}{\partial q_2}&\frac{\partial p_x(q)}{\partial q_3}\\\frac{\partial p_y(q)}{\partial q_1}&\frac{\partial p_y(q)}{\partial q_2}&\frac{\partial p_y(q)}{\partial q_3}\\\zeta_1t_1&\zeta_2t_2&\zeta_3t_3\end{bmatrix}$$

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

$$J(q)=\begin{bmatrix}\frac{\partial p_x(q)}{\partial q_1}&\frac{\partial p_x(q)}{\partial q_2}&\cdots&\frac{\partial p_x(q)}{\partial q_n}\\\frac{\partial p_y(q)}{\partial q_1}&\frac{\partial p_y(q)}{\partial q_2}&\cdots&\frac{\partial p_y(q)}{\partial q_n}\\\frac{\partial p_z(q)}{\partial q_1}&\frac{\partial p_z(q)}{\partial q_2}&\cdots&\frac{\partial p_z(q)}{\partial q_n}\\\hdashline\zeta_1z_0(q)&\zeta_2z_1(q)&\cdots&\zeta_nz_{n-1}(q)\end{bmatrix}$$

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

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

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

$$p_{new} = \begin{cases} 1 & \text{if } T_{lower} \le p_{old} \le T_{upper} \\ 0 & \text{otherwise} \end{cases}$$

$$\bar{x} = \frac{1}{\text{area}} \sum_{i=1}^{N_{row}} \sum_{j=1}^{N_{col}} j p_{ij} \quad \text{and} \quad \bar{y} = \frac{1}{\text{area}} \sum_{i=1}^{N_{row}} \sum_{j=1}^{N_{col}} i p_{ij}$$

$$\theta = \tfrac{1}{2}\,\text{atan2}(2M_{xy},\ M_{xx} - M_{yy})$$

$$M_{xx} = \frac{1}{\text{area}} \sum_{i=1}^{N_{row}} \sum_{j=1}^{N_{col}} (j - \bar{x})^2 p_{ij}$$

$$M_{yy} = \frac{1}{\text{area}} \sum_{i=1}^{N_{row}} \sum_{j=1}^{N_{col}} (i - \bar{y})^2 p_{ij}$$

$$M_{xy} = \frac{1}{\text{area}} \sum_{i=1}^{N_{row}} \sum_{j=1}^{N_{col}} (j - \bar{x})(i - \bar{y}) p_{ij}$$

The End