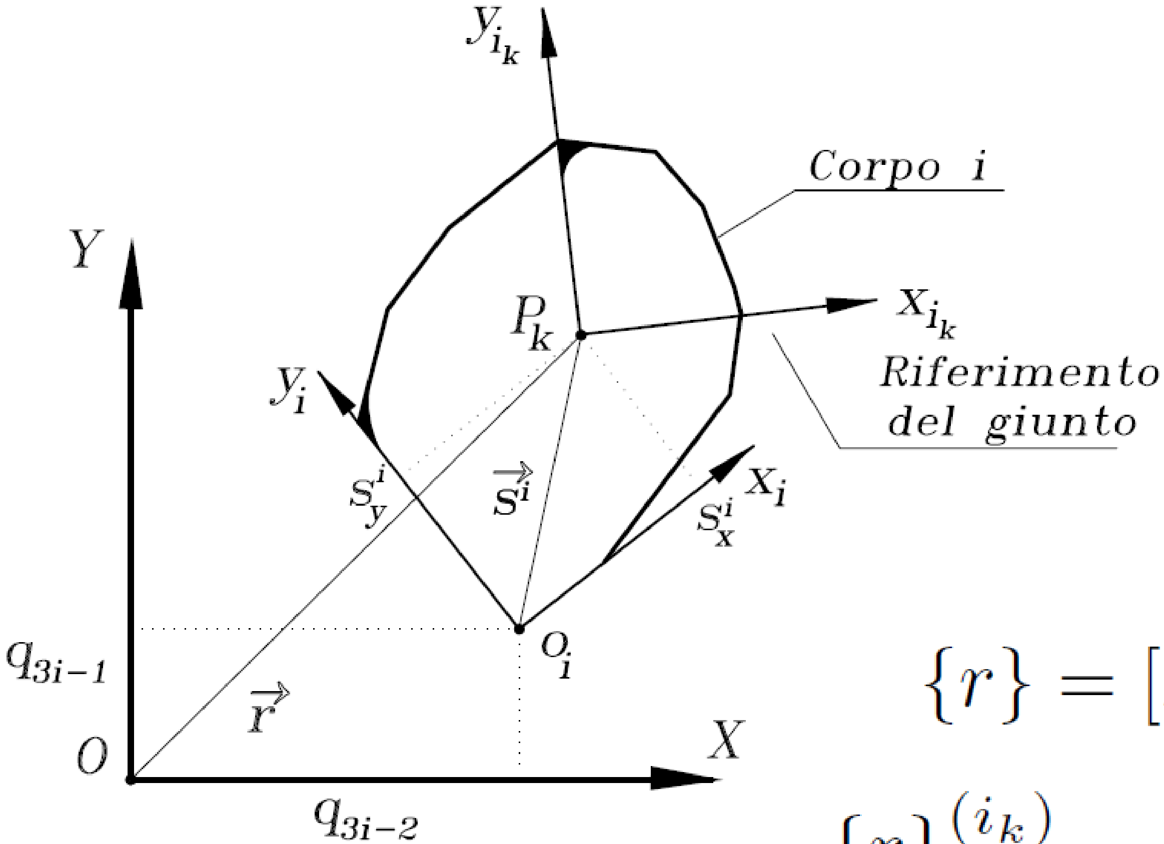
$$\{\ddot{q}\} + [\Psi_q]^T \{\lambda\} = \{F_e\} \ ,$$
$$[\Psi_q]\{\ddot{q}\} = \{\gamma\}$$



$$\{r\} = [A_i]\left[C^i_{i_k}\right]\{r\}^{(i_k)} \quad ,$$

$$\{r\}^{(i_k)} = \left[C^i_{i_k}\right]^T [A_i]^T \{r\} \quad .$$

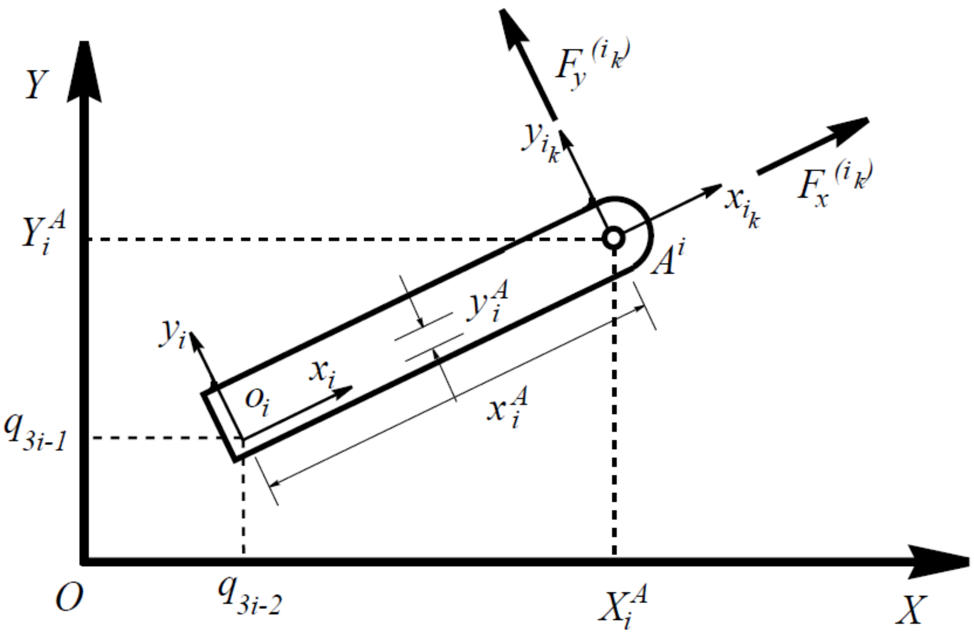
$$\delta W_0 = -\left\{ \begin{array}{ccc} \delta q_{3i-2} & \delta q_{3i-1} & \delta q_{3i} \end{array} \right\} \left[\begin{array}{cc} \Psi^k_{q_{3i-2}} & \Psi^{k+1}_{q_{3i-2}} \\ \Psi^k_{q_{3i-1}} & \Psi^{k+1}_{q_{3i-1}} \\ \Psi^k_{q_{3i}} & \Psi^{k+1}_{q_{3i}} \end{array} \right] \left\{ \begin{array}{c} \lambda_k \\ \lambda_{k+1} \end{array} \right\},$$

$$\delta W_{i_k} = \left\{ \delta r_x^{(i_k)} \; \delta r_y^{(i_k)} \right\} \left\{ \begin{array}{c} F_x^{(i_k)} \\ F_y^{(i_k)} \end{array} \right\} + \delta q_{3i} T_z^{(i_k)}$$

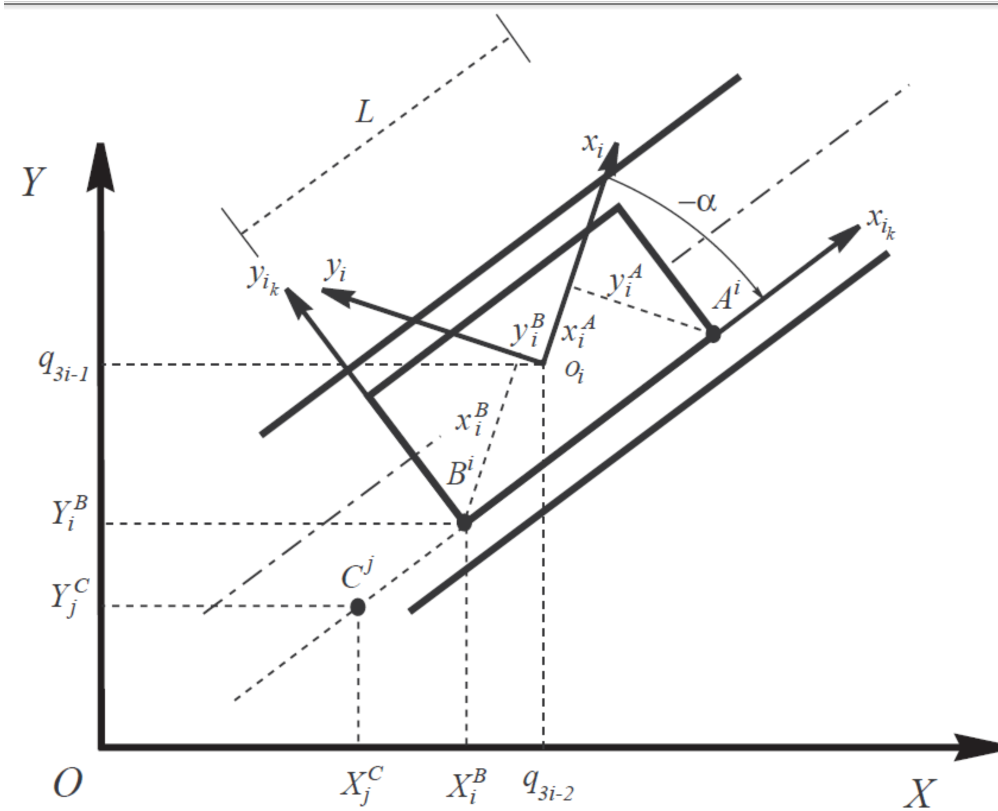
$$\{r\} = \left\{ \begin{array}{c} q_{3i-2} \\ q_{3i-1} \end{array} \right\} + [A_i] \left\{ \begin{array}{c} s_x^{(i)} \\ s_y^{(i)} \end{array} \right\},$$

$$\left\{ \begin{array}{c} F_x^{(i_k)} \\ F_y^{(i_k)} \end{array} \right\} = -\left[C^i_{i_k}\right]^T [A_i]^T \left[\begin{array}{cc} \Psi^k_{q_{3i-2}} & \Psi^{k+1}_{q_{3i-2}} \\ \Psi^k_{q_{3i-1}} & \Psi^{k+1}_{q_{3i-1}} \end{array} \right] \left\{ \begin{array}{c} \lambda_k \\ \lambda_{k+1} \end{array} \right\}, \tag{9}$$

$$T_z^{(i_k)} = \left(\left\{ \begin{array}{cc} s_x^{(i)} & s_y^{(i)} \end{array} \right\} [B_i]^T \left[\begin{array}{cc} \Psi^k_{q_{3i-2}} & \Psi^{k+1}_{q_{3i-2}} \\ \Psi^k_{q_{3i-1}} & \Psi^{k+1}_{q_{3i-1}} \end{array} \right] - \left[\begin{array}{cc} \Psi^k_{q_{3i}} & \Psi^{k+1}_{q_{3i}} \end{array} \right] \right) \left\{ \begin{array}{c} \lambda_k \\ \lambda_{k+1} \end{array} \right\} \tag{10}$$



$$\left\{ \begin{array}{c} F_x^{(i_k)} \\ F_y^{(i_k)} \\ T_z \end{array} \right\} = - \left\{ \begin{array}{c} \lambda_k \cos q_{3i} + \lambda_{k+1} \sin q_{3i} \\ -\lambda_k \sin q_{3i} + \lambda_{k+1} \cos q_{3i} \\ 0 \end{array} \right\} .$$

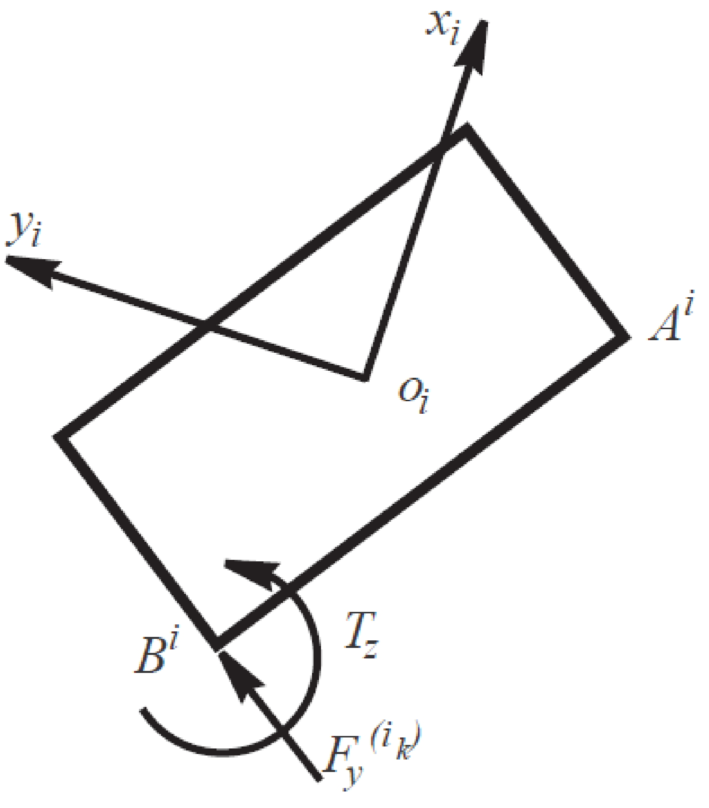


$$\left\{ \begin{array}{c} F_x^{(i_k)} \\ F_y^{(i_k)} \\ T_z \end{array} \right\} = \left\{ \begin{array}{c} K_1 \\ K_2 \\ K_3 \end{array} \right\},$$

$$K_1 = 0 \ ,$$

$$K_2 = \lambda_k \left[\left(Y_i^B - Y_i^A \right) \sin\left(q_{3i} + \alpha \right) - \left(X_i^A - X_i^B \right) \cos\left(q_{3i} + \alpha \right) \right]$$

$$K_3 = \lambda_k \left[\left(q_{3i-1} - Y_i^B \right) \left(Y_i^B - Y_i^A \right) \right.$$
$$\left. + \left(X_i^B - q_{3i-2} \right) \left(X_i^A - X_i^B \right) - H_1 \right] - \lambda_{k+1} \ .$$


x_i
y_i
A^i
o_i
B^i
T_z
$F_y^{(i_k)}$

$$
\begin{aligned}
[M]\{\ddot{q}\} + [\Psi_q]^T\{\lambda\} &= \{F\} \\
\{\Psi(q,t)\} &= \{0\} \quad .
\end{aligned}
$$

$$
[\Psi_q]\{\ddot{q}\} = \{\gamma\}
$$

$$\begin{bmatrix} M & \Psi_q^T \\ \Psi_q & 0 \end{bmatrix} \begin{Bmatrix} \ddot{q} \\ \lambda \end{Bmatrix} = \begin{Bmatrix} F_e \\ \gamma \end{Bmatrix}, \tag{14}$$

$$\{\dot{q}\}_{(i+1)\triangle t} = \{\dot{q}\}_{i\triangle t} + \{\ddot{q}\}_{i\triangle t}\,\triangle t\ ,$$

$$\{q\}_{(i+1)\triangle t} = \{q\}_{i\triangle t} + \{\dot{q}\}_{i\triangle t}\,\triangle t + \frac{1}{2}\,\{\ddot{q}\}_{i\triangle t}\,\triangle t^2$$