$$\dot{x} = Ax + Bu$$

where
$$\dot{x} = \begin{bmatrix} \dot{x} \\ \dot{y} \\ \dot{\theta} \\ \dot{w}_L \\ \dot{w}_R \end{bmatrix}$$

$$F = \frac{T_L}{r} + \frac{T_R}{r} - k_f \cdot mg$$

$$a = \frac{T_L}{rm} + \frac{T_R}{rm} - k_f g$$

$$V = \frac{w_R r + w_L r}{2}$$

① $$\dot{x} = \frac{w_R r + w_L r}{2} \cos\theta$$

② $$\dot{y} = \frac{w_R r + w_L r}{2} \sin\theta$$

③ $$\dot{\theta} = \frac{R}{L}(w_R - w_L)$$

④ $$\dot{W}_L = \frac{T_L}{I}$$

⑤ $$\dot{W}_R = \frac{T_R}{I}$$

$$\boxed{\begin{aligned}
x(k+1) &= x(k) + \left(V(k) + \tfrac{1}{2} a(k)\, dt\right) \cos\theta(k)\, dt \\
y(k+1) &= y(k) + \left(V(k) + \tfrac{1}{2} a(k)\, dt\right) \sin\theta(k)\, dt \\
w_R(k+1) &= w_R(k) + \left(\tfrac{T_R}{I}\right) dt \\
w_L(k+1) &= w_L(k) + \left(\tfrac{T_L}{I}\right) dt \\
\theta(k+1) &= \theta(k) + \tfrac{R}{L}\left(w_R(k) - w_L(k)\right) dt
\end{aligned}}$$

① $$\dot{x} = \frac{w_R r + w_L r}{2} \cos\theta$$

② $$\dot{y} = \frac{w_R r + w_L r}{2} \sin\theta$$

③ $$\dot{\theta} = \frac{R}{L}(w_R - w_L)$$

④ $$\dot{W}_L = \frac{T_L}{I}$$

⑤ $$\dot{w}_R = \frac{T_R}{I}$$

⑥ $$\ddot{x} = \left(\frac{T_L}{rm} + \frac{T_R}{rm} - k_f g\right) \cos\theta$$

⑦ $$\ddot{y} = \left(\frac{T_L}{rm} + \frac{T_R}{rm} - k_f g\right) \sin\theta .$$

$$x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} = \begin{bmatrix} x \\ y \\ \theta \\ w_L \\ w_R \\ \dot{x} \\ \dot{y} \end{bmatrix}$$

$$u = \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} = \begin{bmatrix} T_L \\ T_R \end{bmatrix}$$

Rewriting the state-space equations:

$$\dot{x}_1 = r\frac{x_5 + x_4}{2}\cos(x_3)$$

$$\dot{x}_2 = r\frac{x_5 + x_4}{2}\sin(x_3)$$

$$\dot{x}_3 = \frac{r}{L}(x_5 - x_4)$$

$$\dot{x}_4 = \frac{U_r}{I}$$

$$\dot{x}_5 = \frac{U_2}{I}$$

$$\dot{x}_6 = \left(\frac{U_1}{rm} + \frac{U_2}{rm} - k_f g\right)\cos(x_3)$$

$$\dot{x}_7 = \left(\frac{U_1}{rm} + \frac{U_2}{rm} - k_f g\right)\sin(x_3)$$

① $$\dot{x} = \frac{w_R r + w_L r}{2}\cos\theta$$

② $$\dot{y} = \frac{w_R r + w_L r}{2}\sin\theta$$

③ $$\dot{\theta} = \frac{R}{L}(w_R - w_L)$$

④ $$\dot{W}_L = \frac{T_L}{I}$$

⑤ $$\dot{W}_R = \frac{T_R}{I}$$

⑥ $$\ddot{x} = \left(\frac{T_L}{rm} + \frac{T_R}{rm} - k_f g\right)\cos\theta$$

⑦ $$\ddot{y} = \left(\frac{T_L}{rm} + \frac{T_R}{rm} - k_f g\right)\sin\theta .$$