Penalty Matrix

The penalty matrix Ω in **??** is a combination of three sub matrix Ω_1, Ω_2 and Ω_3, which are in the following form

$$\Omega^{(1)}_{k,k} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{00}(t)}{dt^2} \frac{d^2 h^{(k)}_{00}(t)}{dt^2} dt = \frac{12}{\Delta_k^3}$$

$$\Omega^{(1)}_{k,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{00}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{01}(t)}{dt^2} dt = \frac{-12}{\Delta_k^3}$$

$$\Omega^{(1)}_{k+1,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k+1)}_{01}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{01}(t)}{dt^2} dt = \frac{12}{\Delta_k^3}$$

$$\Omega^{(2)}_{k,k} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{10}(t)}{dt^2} \frac{d^2 h^{(k)}_{10}(t)}{dt^2} dt = \frac{4}{\Delta_k^2}$$

$$\Omega^{(2)}_{k,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{10}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{11}(t)}{dt^2} dt = \frac{2}{\Delta_k}$$

$$\Omega^{(2)}_{k+1,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k+1)}_{11}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{11}(t)}{dt^2} dt = \frac{4}{\Delta_k}$$

$$\Omega^{(3)}_{k,k} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{00}(t)}{dt^2} \frac{d^2 h^{(k)}_{10}(t)}{dt^2} dt = \frac{6}{\Delta_k^2}$$

$$\Omega^{(3)}_{k,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{00}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{11}(t)}{dt^2} dt = \frac{6}{\Delta_k^2}$$

$$\Omega^{(3)}_{k+1,k} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k)}_{10}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{01}(t)}{dt^2} dt = \frac{-6}{\Delta_k^2}$$

$$\Omega^{(3)}_{k+1,k+1} = \int_{t_k}^{t_{k+1}} \frac{d^2 h^{(k+1)}_{01}(t)}{dt^2} \frac{d^2 h^{(k+1)}_{11}(t)}{dt^2} dt = \frac{-6}{\Delta_k^2}$$