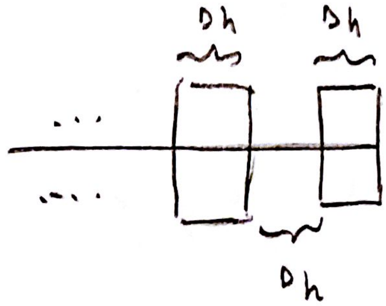
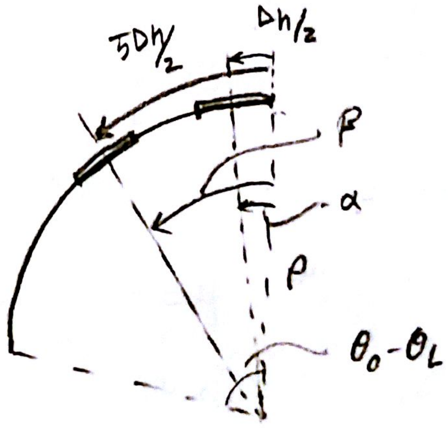
Derivation of homogenous transforms of TURBT Robot

- This is for vtk visualization.

- Let us assume that all spacer disks are equi-distance and each segment disks include spacer disks + end disk and they both have the same height. and the distance is the same as Dh.

$N_{seg} = \text{ceil}\left\{0.9 * \text{round}\left(\frac{L}{Dh}\right)\right\}$ number of disks in each segment





$$\begin{cases} \rho\alpha = \frac{Dh}{2} \Rightarrow \alpha = \frac{1}{2\rho} Dh \\ \rho\beta = \frac{5Dh}{2} \Rightarrow \beta = \frac{5}{2\rho} Dh \\ \vdots \end{cases}$$

where $\rho = \frac{L}{\theta_0 - \theta_L}$

Therefore, the direct kinematic for each disk is as follows

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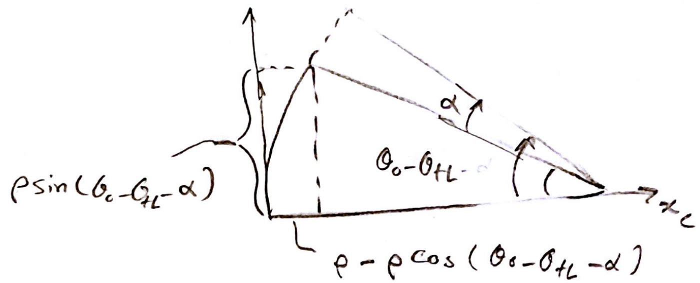
End disk

$$ {}^{bt}P_{tL} = {}^{bt}R_{ct} \begin{bmatrix} \rho - \rho\cos(\theta_0 - \theta_{tL} - \alpha) \\ 0 \\ \rho \sin(\theta_0 - \theta_{tL} - \alpha) \end{bmatrix} $$

where



$$ R_{ct} = Rot(\hat{z}_{tb}, -\delta_t) $$

$$ \rho = \frac{L_t}{\theta_0 - \theta_{tL}} $$

$$ \alpha = \frac{Dh}{2} \frac{\theta_0 - \theta_{tL}}{L_t} $$

AND $\quad {}^{bt}R_{disk} = Rot(\hat{z}_{tb}, -\delta_t)\, Rot(\hat{y}_{tc}, \theta_0 - \theta_{tL} - \alpha)\, Rot(\hat{z}_{tc}, \delta_t)$

Spacer disk before end disk

$$ {}^{bt}P_{tL} = {}^{bt}R_{ct} \begin{bmatrix} \rho - \rho\cos(\theta_0 - \theta_{tL} - \beta) \\ 0 \\ \rho \sin(\theta_0 - \theta_{tL} - \beta) \end{bmatrix} $$

where $\beta = \frac{5Dh}{2} \frac{\theta_0 - \theta_{tL}}{L_t}$

AND $\quad {}^{bt}R_{disk} = Rot(\hat{z}_{tb}, -\delta_t)\, Rot(\hat{y}_{tc}, \theta_0 - \theta_{tL} - \beta)\, Rot(\hat{z}_{tc}, \delta_t)$

* To generalize for all disks:

$$ {}^{bt}P_{tL} = \rho\, {}^{bt}R_{ct} \begin{bmatrix} 1 - \cos(\theta_0 - \theta_{tL} - \gamma) \\ 0 \\ \sin(\theta_0 - \theta_{tL} - \gamma) \end{bmatrix}, \quad {}^{bt}R_{disk} = Rot(\hat{z}_{tb}, -\delta_t)\, Rot(\hat{y}_{tc}, \theta_0 - \theta_{tL} - \gamma)\, Rot(\hat{z}_{tc}, \delta_t) $$

where $\gamma = \left\{ \frac{1+4(N-n)}{2} \right\} D_h \frac{\theta_o - \theta_{tL}}{L_t}$

N number of disks

n disk number ($n = N$ is the end disk)