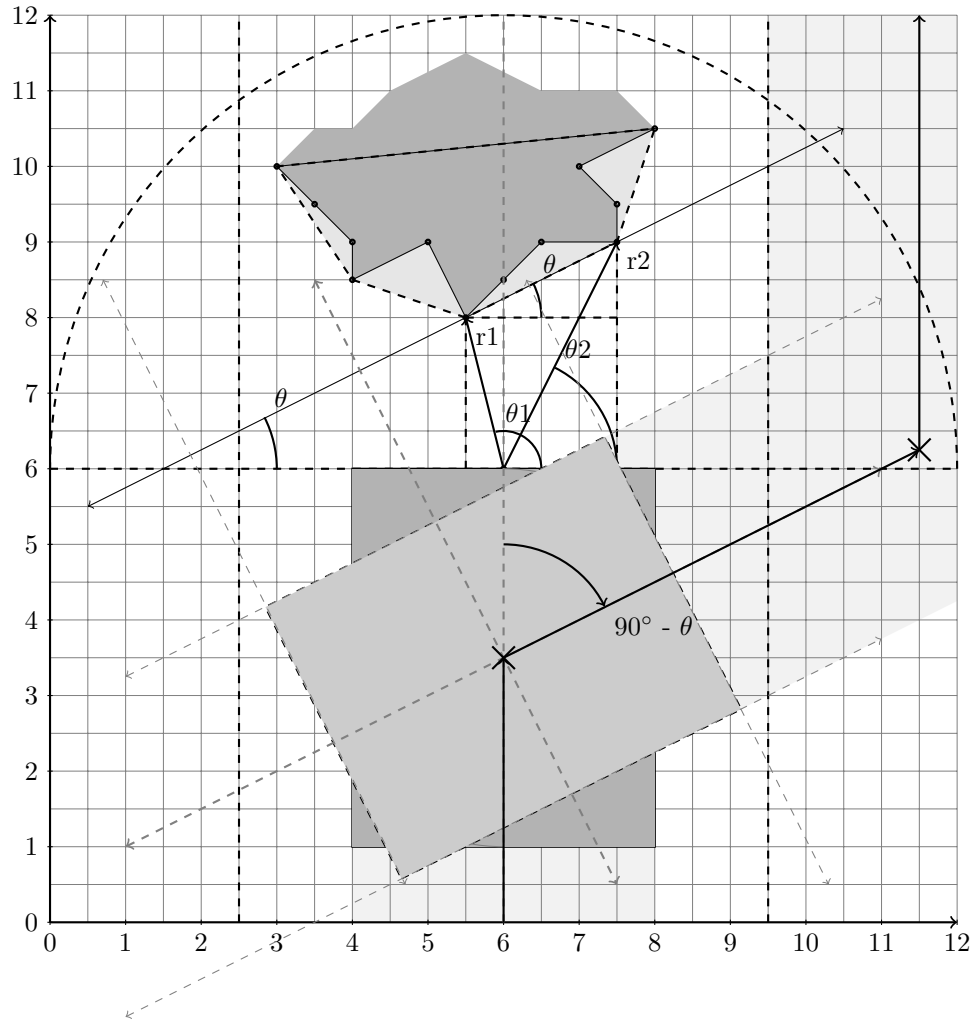


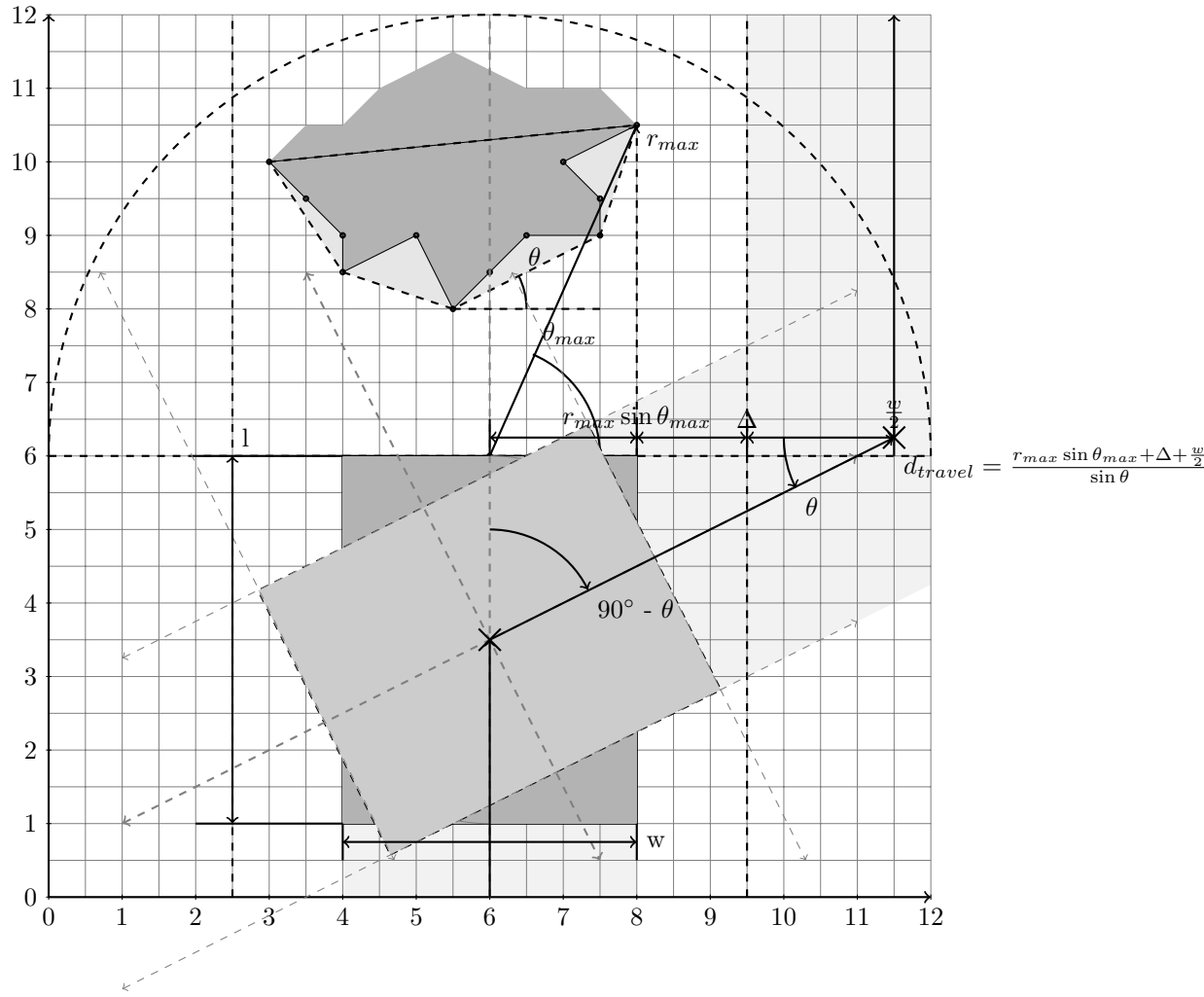
$$\tan\theta = \frac{h_2 - h_1}{w_2 - w_1} \tag{1}$$

$$= \frac{r_2\cos\theta_2 - r_1\cos\theta_1}{r_2\sin\theta_2 - r_1\sin\theta_1} \tag{2}$$

$$\theta = \arctan\frac{r_2\cos\theta_2 - r_1\cos\theta_1}{r_2\sin\theta_2 - r_1\sin\theta_1} \tag{3}$$

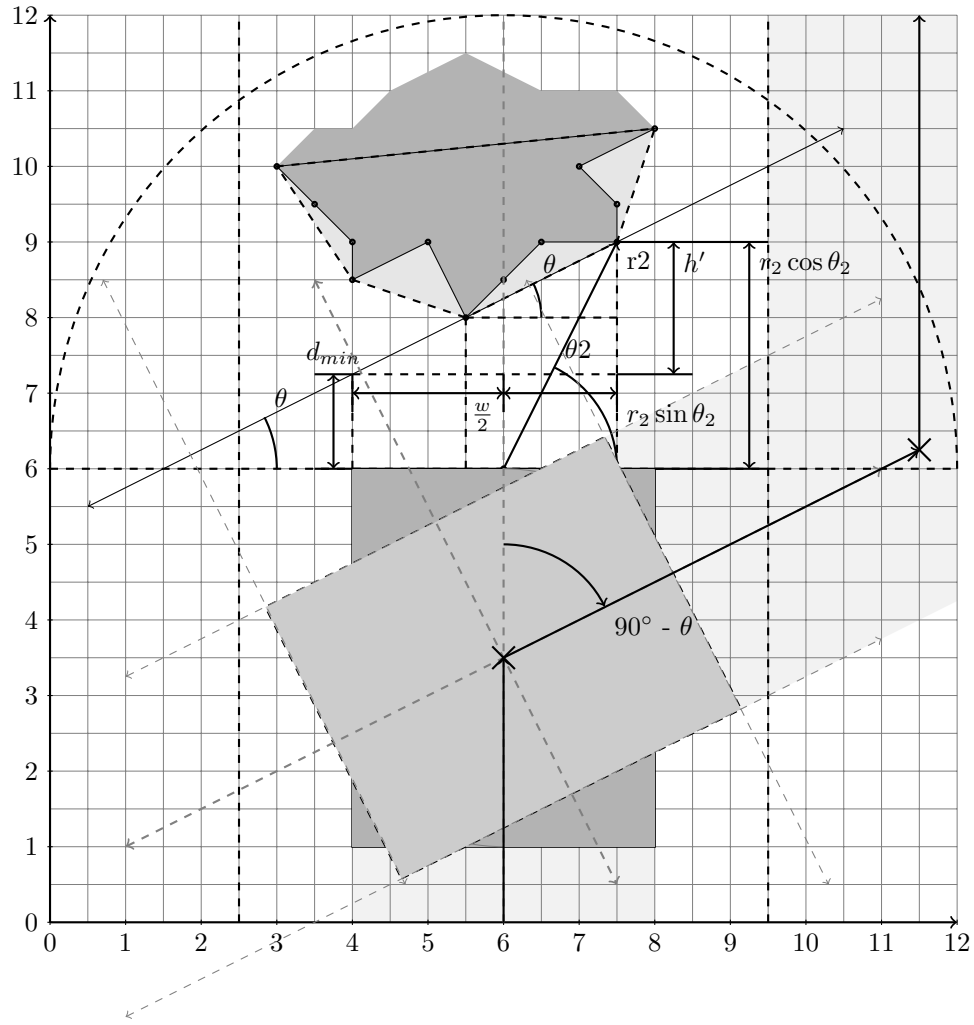
$$\alpha = 90^\circ - \theta \tag{4}$$

$$= \arctan\frac{r_2\sin\theta_2 - r_1\sin\theta_1}{r_2\cos\theta_2 - r_1\cos\theta_1} \tag{5}$$



$$d_{travel} \sin \theta = r_{max} \sin \theta_{max} + \Delta + \frac{w}{2} \tag{6}$$

$$d_{travel} = \frac{r_{max} \sin \theta_{max} + \Delta + \frac{w}{2}}{\sin \theta} \tag{7}$$


r2
h'
$n_2 \cos\theta_2$
θ
$\theta 2$
d_{min}
θ
$\frac{w}{2}$
$r_2 \sin\theta_2$
90° - θ

$$h' = \left(\frac{w}{2} + r_2 \sin\theta_2\right) \tan\theta \tag{8}$$

$$d_{min} = r_2 \cos\theta_2 - h' \tag{9}$$

$$= r_2 \cos\theta_2 - \left(\frac{w}{2} + r_2 \sin\theta_2\right) \tan\theta \tag{10}$$

$$= r_2 \cos\theta_2 - \left(\frac{w}{2}\right) \tan\theta - r_2 \sin\theta_2 \tan\theta \tag{11}$$

$$= r_2 \cos\theta_2 - r_2 \sin\theta_2 \left(\frac{\sin\theta}{\cos\theta}\right) - \left(\frac{w}{2}\right) \tan\theta \tag{12}$$

$$= \frac{r_2}{\cos\theta} \left(\cos\theta_2 \cos\theta - \sin\theta_2 \sin\theta\right) - \left(\frac{w}{2}\right) \tan\theta \tag{13}$$

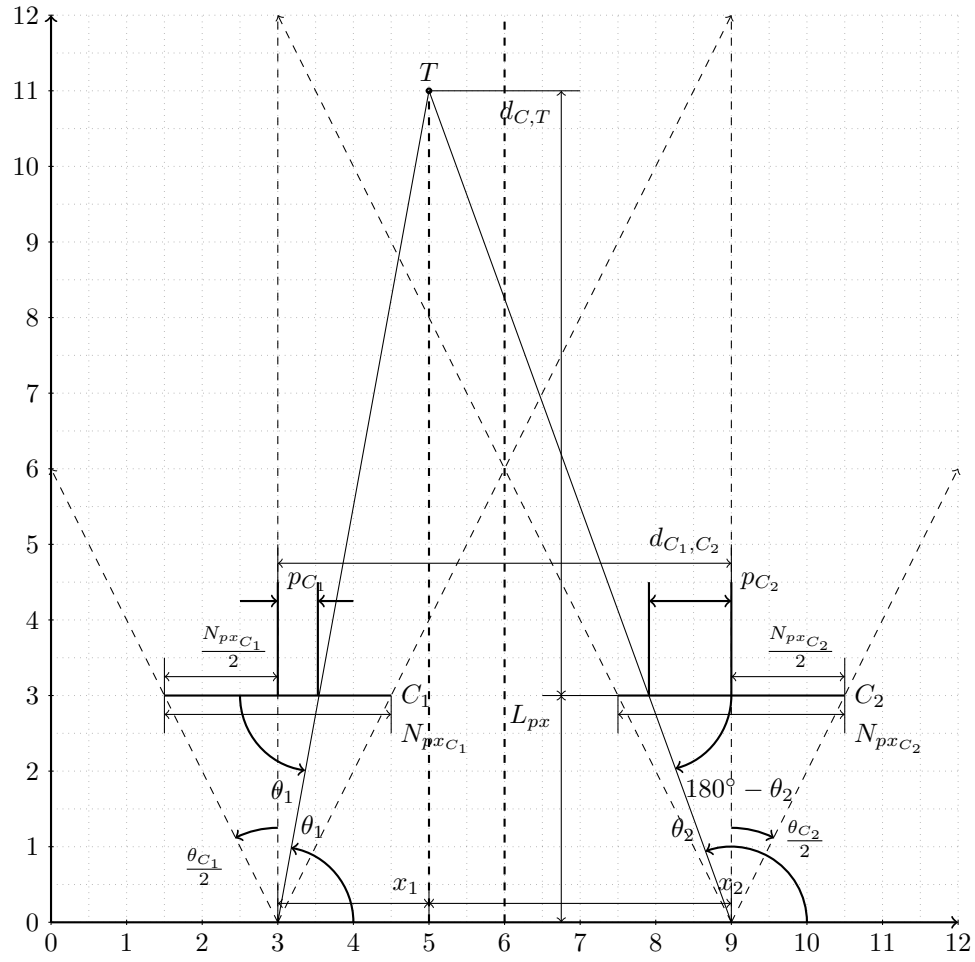
$$= \left(\frac{r_2}{\cos\theta}\right) \cos\left(\theta_2 + \theta\right) - \left(\frac{w}{2}\right) \tan\theta \tag{14}$$

$$d_{min} = \left(r_2 \cos\left(\theta_2 + \theta\right) - \left(\frac{w}{2}\right) \sin\theta\right) \frac{1}{\cos\theta} \tag{15}$$

$$d_{min} \geq \Delta_{min} \tag{16}$$

$$t_{hit} = \frac{d_{min}}{v_{robo}} \tag{17}$$

$$\implies t_{decision} \leq t_{hit} \tag{18}$$


T
$d_{C,T}$
d_{C_1,C_2}
p_{C_1}
p_{C_2}
$\frac{N_{px_{C_1}}}{2}$
$\frac{N_{px_{C_2}}}{2}$
C_1
C_2
$N_{px_{C_1}}$
$N_{px_{C_2}}$
L_{px}
θ_1
θ_1
$180° - \theta_2$
θ_2
$\frac{\theta_{C_1}}{2}$
$\frac{\theta_{C_2}}{2}$
x_1
x_2

$$\tan\left(\frac{\theta_{C_1}}{2}\right) = \frac{\left(\frac{N_{px_{C_1}}}{2}\right)}{L_{px}} \tag{19}$$

$$\implies L_{px} = \left(\frac{N_{px_{C_1}}}{2}\right)\frac{1}{\tan\left(\frac{\theta_{C_1}}{2}\right)} \tag{20}$$

$$= \frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)} \tag{21}$$

$$\tan\theta_1 = \frac{L_{px}}{p_{C_1}} \tag{22}$$

$$= \frac{\left(\frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)}\right)}{p_{C_1}} \tag{23}$$

$$= \frac{N_{px_{C_1}}}{2p_{C_1}\tan\left(\frac{\theta_{C_1}}{2}\right)} \tag{24}$$

$$\implies \frac{1}{\tan\theta_1} = \frac{2p_{C_1}\tan\left(\frac{\theta_{C_1}}{2}\right)}{N_{px_{C_1}}} \tag{25}$$

$$\tan\left(180^\circ - \theta_2\right) = \frac{L_{px}}{p_{C_2}} \tag{26}$$

$$= \frac{\left(\frac{N_{px_{C_2}}}{2\tan\left(\frac{\theta_{C_2}}{2}\right)}\right)}{p_{C_2}} \tag{27}$$

$$= \frac{N_{px_{C_2}}}{2p_{C_2}\tan\left(\frac{\theta_{C_2}}{2}\right)} \tag{28}$$

$$\implies \tan\theta_2 = -\left(\frac{N_{px_{C_2}}}{2p_{C_2}\tan\left(\frac{\theta_{C_2}}{2}\right)}\right) \tag{29}$$

$$\implies \frac{1}{\tan\theta_2} = -\left(\frac{2p_{C_2}\tan\left(\frac{\theta_{C_2}}{2}\right)}{N_{px_{C_2}}}\right) \tag{30}$$

$$Let : \sigma_{px/unit} be density of pixels per unit of measurement \tag{31}$$

$$Let : L_{units} = \frac{L_{px}}{\sigma_{px/unit}} \tag{32}$$

$$\tan\theta_1 = \frac{d_{C,T} + L_{units}}{x_1} \tag{33}$$

$$\tan\theta_1 = \frac{d_{C,T} + L_{units}}{x_1} \tag{34}$$

$$\implies x_1 = \frac{d_{C,T} + L_{units}}{\tan\theta_1} \tag{35}$$

$$\tan\left(180^\circ - \theta_2\right) = \frac{d_{C,T} + L_{units}}{x_2} \tag{36}$$

$$\implies x_2 = \frac{d_{C,T} + L_{px}}{\tan\left(180^\circ - \theta_2\right)} \tag{37}$$

$$\implies x_1 + x_2 = \frac{d_{C,T} + L_{units}}{\tan\theta_1} + \frac{d_{C,T} + L_{units}}{\tan\left(180^\circ - \theta_2\right)} \tag{38}$$

$$= \left(d_{C,T} + L_{units}\right)\left(\frac{1}{\tan\theta_1} + \frac{1}{\tan\left(180^\circ - \theta_2\right)}\right) \tag{39}$$

$$= \left(d_{C,T} + L_{units}\right)\left(\frac{1}{\tan\theta_1} - \frac{1}{\tan\theta_2}\right) \tag{40}$$

$$= \left(d_{C,T} + L_{units}\right)\left(\frac{\tan\theta_2 - \tan\theta_1}{\tan\theta_1\tan\theta_2}\right) \tag{41}$$

$$\tag{42}$$

$$x_1 + x_2 = d_{C_1,C_2} \tag{43}$$

$$\implies d_{C_1,C_2} = (d_{C,T} + L_{units}) \left(\frac{\tan\theta_2 - \tan\theta_1}{\tan\theta_1 \tan\theta_2} \right) \tag{44}$$

$$\implies d_{C,T} + L_{units} = d_{C_1,C_2} \left(\frac{\tan\theta_1 \tan\theta_2}{\tan\theta_2 - \tan\theta_1} \right) \tag{45}$$

$$= \frac{d_{C_1,C_2} \tan\theta_1 \tan\theta_2}{\tan\theta_2 - \tan\theta_1} \tag{46}$$

$$\implies d_{C,T} = \frac{d_{C_1,C_2} \tan\theta_1 \tan\theta_2}{\tan\theta_2 - \tan\theta_1} - L_{units} \tag{47}$$

$$\implies d_{C,T} = \frac{d_{C_1,C_2} \tan\theta_1 \tan\theta_2}{\tan\theta_2 - \tan\theta_1} - \frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)\sigma_{px/unit}} \tag{48}$$

$$\implies d_{C,T} = \frac{d_{C_1,C_2}}{\left(\frac{1}{\tan\theta_1} - \frac{1}{\tan\theta_2}\right)} - \frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)\sigma_{px/unit}} \tag{49}$$

$$= \frac{d_{C_1,C_2}}{\left(\frac{1}{\tan\theta_1} - \frac{1}{\tan\theta_2}\right)} - \frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)\sigma_{px/unit}} \tag{50}$$

$$= \frac{d_{C_1,C_2}}{\left(\frac{2p_{C_1}\tan\left(\frac{\theta_{C_1}}{2}\right)}{N_{px_{C_1}}} + \frac{2p_{C_2}\tan\left(\frac{\theta_{C_2}}{2}\right)}{N_{px_{C_2}}} \right)} - \frac{N_{px_{C_1}}}{2\tan\left(\frac{\theta_{C_1}}{2}\right)\sigma_{px/unit}} \tag{51}$$

$$Let : \tan\left(\frac{\theta_{C_1}}{2}\right) = \tan\left(\frac{\theta_{C_2}}{2}\right) = \tan\left(\frac{\theta_C}{2}\right) \tag{52}$$

$$Let : N_{px_{C_1}} = N_{px_{C_2}} = N_{px_C} \tag{53}$$

$$\implies d_{C,T} = \frac{d_{C_1,C_2}}{\left(\frac{2p_{C_1}\tan\left(\frac{\theta_C}{2}\right)}{N_{px_C}} + \frac{2p_{C_2}\tan\left(\frac{\theta_C}{2}\right)}{N_{px_C}}\right)} - \frac{N_{px_C}}{2\tan\left(\frac{\theta_C}{2}\right)\sigma_{px/unit}} \tag{54}$$

$$= \frac{d_{C_1,C_2}}{\left(\frac{2\tan\left(\frac{\theta_C}{2}\right)}{N_{px_C}}\right)(p_{C_1} + p_{C_2})} - \frac{N_{px_C}}{2\tan\left(\frac{\theta_C}{2}\right)\sigma_{px/unit}} \tag{55}$$

$$= \frac{d_{C_1,C_2}N_{px_C}}{2\tan\left(\frac{\theta_C}{2}\right)(p_{C_1} + p_{C_2})} - \frac{N_{px_C}}{2\tan\left(\frac{\theta_C}{2}\right)\sigma_{px/unit}} \tag{56}$$

$$= \left(\frac{N_{px_C}}{2\tan\left(\frac{\theta_C}{2}\right)}\right)\left(\frac{d_{C_1,C_2}}{p_{C_1} + p_{C_2}} - \frac{1}{\sigma_{px/unit}}\right) \tag{57}$$

$$If : \frac{1}{\sigma_{px/unit}} \ll \frac{d_{C_1,C_2}}{p_{C_1} + p_{C_2}} \tag{58}$$

$$d_{C,T} \approx \frac{N_{px_C}d_{C_1,C_2}}{2\tan\left(\frac{\theta_C}{2}\right)(p_{C_1} + p_{C_2})} \tag{59}$$