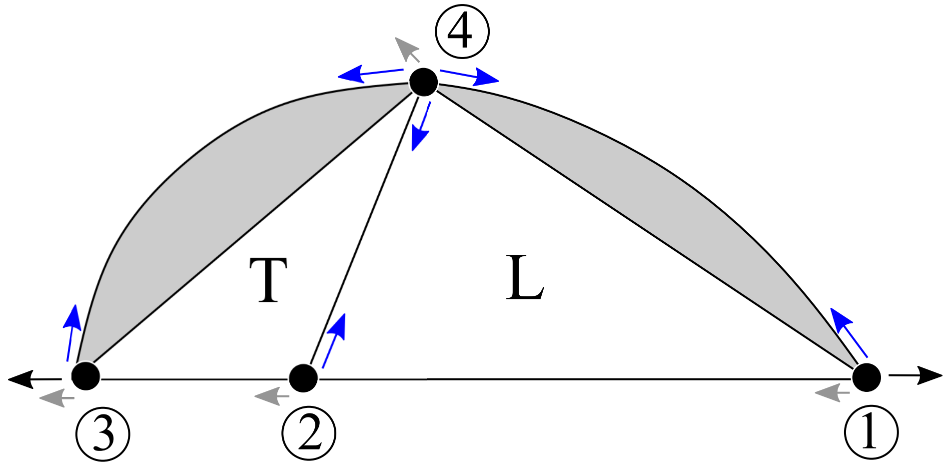


- Find area of triangles defined by nodes 1,2,4 (leader) and 2,3,4 (trailer) — done numerically.

- Due to area conservation, loop over θ, r combinations until $A_\Delta + A_{segment} > 1$

  $$A_{segment} = \frac{\theta - \sin\theta}{2}\, r^2$$

  Result of the loop: r_L , r_T , $(\alpha_L + \beta_L)$, and $(\alpha_T + \beta_T)$

- Find center of circles:

  Formula based on rhombus enclosed for two points (x_1, y_1) and (x_2, y_2) lie on a circle of radius r.

  $$x_a = \frac{1}{2}(x_2 - x_1) \qquad y_a = \frac{1}{2}(y_2 - y_1)$$

  $$x_0 = x_1 + x_a \qquad y_0 = y_1 + y_a$$

  $$a = \sqrt{x_a^2 + y_a^2} \qquad b = \sqrt{r^2 - a^2}$$

  $$x_c = x_0 \pm \frac{b y_a}{a} \text{ and } y_c = y_0 \mp \frac{b x_a}{a}$$

- Find and isolate angles $\alpha_L, \alpha_T, \beta_L, \beta_T$ since

  $$\sin\alpha_L = \frac{x_c - x_1}{r_L}$$

  $$\sin\alpha_T = \frac{x_3 - x_c}{r_T}$$

- Compute the cell-cell interface geometry:

  $$r_{cc} = \frac{t_{cc}}{t_T/r_T - t_L/r_L}$$

As above find the center of the circle defined by radius r_{cc} and nodes 2 and 4.

Lastly find the <u>angle of opening</u> (aka $2x$):

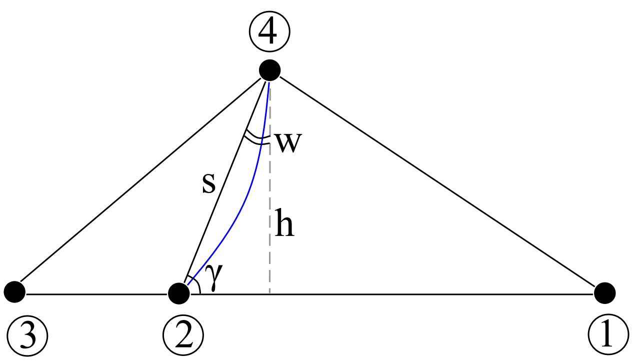
$$s^2 = 2r_{cc}^2 - 2r_{cc}^2\cos(2x) = 2r_{cc}^2\left(1 - \cos(2x)\right)$$

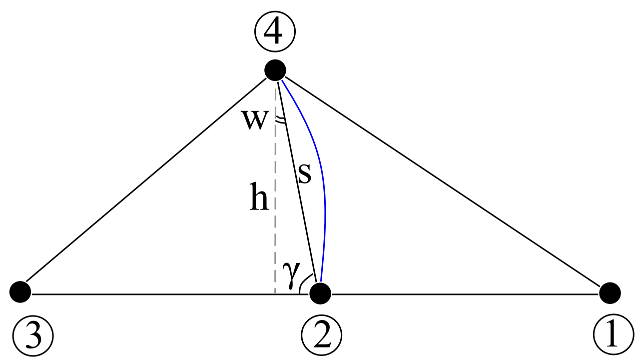
$$x = \frac{1}{2}\cos^{-1}\left(1 - \frac{s^2}{2r_{cc}^2}\right)$$

$\gamma = \ldots$ since $\sin(\gamma) = \dfrac{h}{s}$

$w = \ldots$ since $\dfrac{\pi}{2} = \gamma + w$

At this point the <u>morphology is known</u>.





- **Force balance @ nodes**

(1) $F_p - \xi_1 v_1 - t_L\cos\alpha_L = 0$ where $F_p = (1+f)\left(1 - \dfrac{t_L}{t_0+\tau}\right)$

(3) $-F_r - \xi_3 v_3 + t_T\cos\alpha_T = 0$ where $F_r = (1-f)\left(1 - \dfrac{t_T}{t_0-\tau}\right)$

If $x_2 - x_4 \leq 0$:

(2) $F_{cc}\cos(\gamma - x) - \xi_2 v_2 = 0$

(4) $t_L\cos\beta_L - t_T\cos\beta_T - t_{cc}\sin(w - x) - \xi_4 v_{4x} = 0$
$t_L\sin\beta_L + t_T\sin\beta_T - t_{cc}\cos(w - x) - \xi_4 v_{4y} = 0$

Else if $x_2 - x_4 > 0$:

(2) $F_{cc}\cos(\gamma + x) - \xi_2 v_2 = 0$

(4) $t_L\cos\beta_L - t_T\cos\beta_T + t_{cc}\sin(w + x) - \xi_4 v_{4x} = 0$

$$t_L \sin \beta_L + t_T \sin \beta_T - t_{cc} \cos(w + x) - \xi_4 v_{4y} = 0$$

<u>Move the points according to their velocity from the force balance</u>

$$x_i = x_i + v_i \Delta t$$

- **Proceed with the routine**

This is the vertex model with 8 unknowns | if $v_1 = v_2 = v_3 = v_4 = \sqrt{v_{4x}^2 + v_{4y}^2} = v$ *then 5 unknowns.*