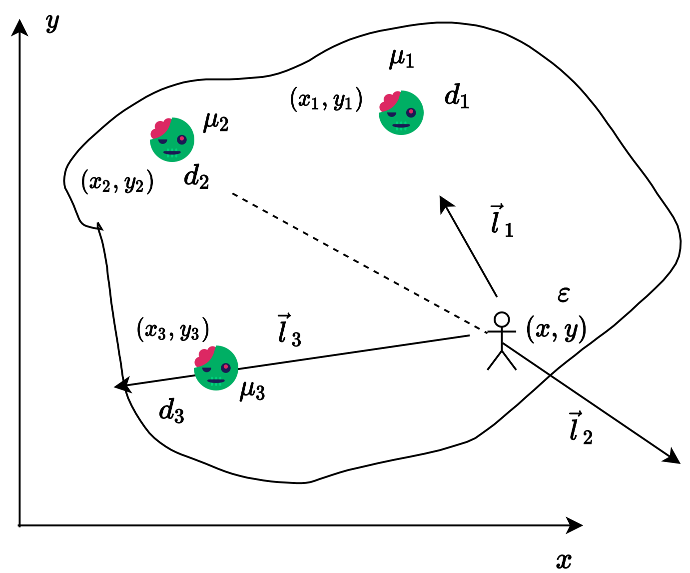
HUMANS STRATEGY

Humans' strategy **consists of two** main **components**. First, they tend to choose the direction which brings them closer to weak zombies and further from the strong ones. The second component is to choose the direction which brings them closer to strong humans and further from weak ones. Proportion between **these two priorities is weighted by the first of three numerical coefficients** which parametrize humans' strategy. **The second and the third coefficient determine tendency to speeding up or slowing down in certain conditions**. Vector of three numerical parameters - $\vec{p} = [p_1, p_2, p_3]$ - which specifies mathematical formulation of humans' strategy can be tuned and optimized to improve making decision processes.



1. First component

First component of humans' strategy is based on result of a single clash between a human and a zombie. The result is obtained comparing *battle points* (BP) of both characters. For each zombie i we can calculate μ_i parameter which is a difference between the human's and the zombie's BP. Considering μ_i, distance d_i between the human and zombie i and human's 'eye' property we can calculate vector $\vec{l}_i$ which determines how much keen is the human to follow this direction. Finally we sum all $\vec{l}_i$ vectors and multiply the result by $p_1 \in [0, 1]$ parameter to obtain $\vec{w}_1$ - the vector associated with the first component of human's velocity direction in a given iteration.

$$\vec{l}_i = \frac{\mu_i}{d_i^{\epsilon}} \cdot \hat{j}_i = \mu_i \cdot \left(\frac{x_i - x}{d_i^{\epsilon+1}}, \frac{y_i - y}{d_i^{\epsilon+1}} \right)$$

$$\boxed{\vec{w}_1 = p_1 \cdot \sum_{i=1}^{Z} \vec{l}_i = p_1 \cdot \left(\sum_{i=1}^{Z} \mu_i \left(\frac{x_i - x}{d_i^{\epsilon+1}} \right), \sum_{i=1}^{Z} \mu_i \left(\frac{y_i - y}{d_i^{\epsilon+1}} \right) \right)}$$

μ_i - difference between BP of the human and zombie i

d_i - distance between the human and zombie i

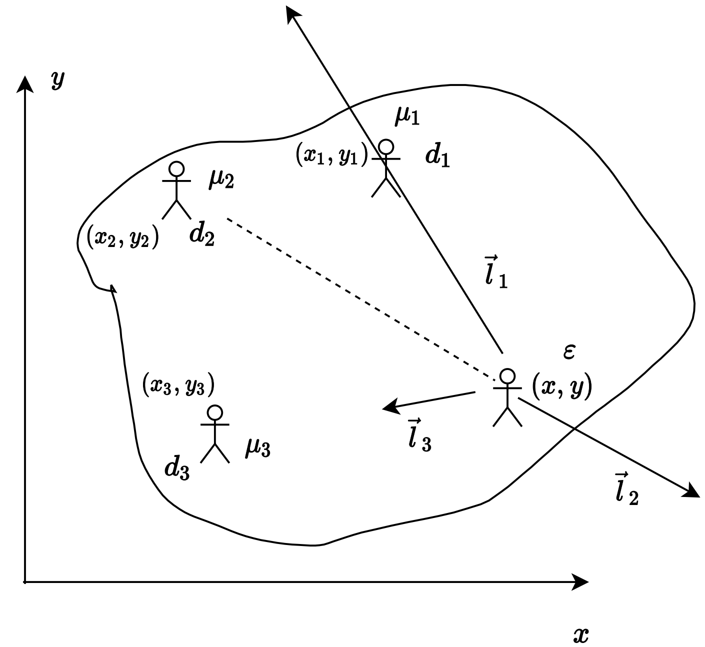
ε - eye property of the human

$\hat{j}_i$ - unit radius vector of a zombie i relative to the human

p_1 - first coefficient parametrizing humans' strategy

Z - number of zombies

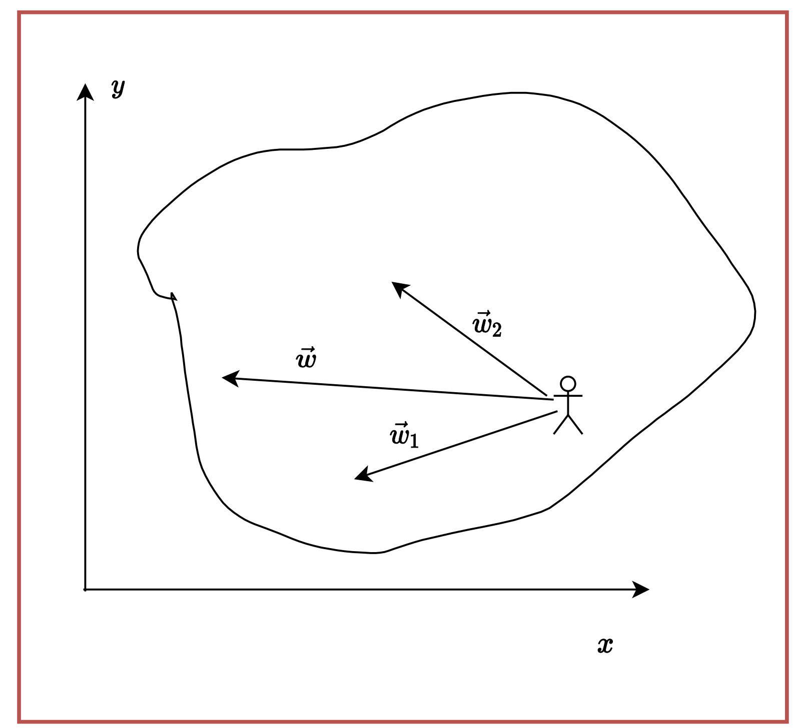
2. Second component



The second component of human's displacement is analogous, but instead of looking for weak zombies and avoiding the strong, a human wants to reach strong companions and avoid the weak ones. The resultant vector is weighted by $(1 - p_1)$ so that sum of weights of both components is equal to 1 and p_1 determines the proportian between these components' importance.

$$\vec{l}_i = -\frac{\mu_i}{d_i^{\epsilon}} \cdot \hat{j}_i = -\mu_i \cdot \left(\frac{x_i - x}{d_i^{\epsilon+1}}, \frac{y_i - y}{d_i^{\epsilon+1}} \right)$$

$$\vec{w}_2 = (1 - p_1) \cdot \sum_{i=1}^{\mathrm{H}} \vec{l}_i = -(1 - p_1) \cdot \left(\sum_{i=1}^{\mathrm{H}} \mu_i \left(\frac{x_i - x}{d_i^{\epsilon+1}} \right), \sum_{i=1}^{\mathrm{H}} \mu_i \left(\frac{y_i - y}{d_i^{\epsilon+1}} \right) \right)$$



Resultant vector

$$\vec{w} = \vec{w}_1 + \vec{w}_2$$

will be used to obtain the velocity vector. If v_0 is a nominal value of human's velocity and $a \in [0, 2]$ is a coefficient determining speeding up or slowing down in specific cases, then velocity vector $\vec{v}$ is the following:

$$\vec{v} = v_0 \cdot a \cdot \frac{\vec{w}}{|\vec{w}|}$$

Coefficient a enables humans to change their speed from 0 to doubled nominal speed value when needed. a gets higher when w_1 and w_2 have similar direction and smaller when they show opposite directions (component 1). It's also decreased when stamina decreases (component 2). a can be thus defined in a following manner:

$$a = 2 \cdot max(a_1 - a_2, 0)$$

a_1

It is about how keen a human is to speed up when needed

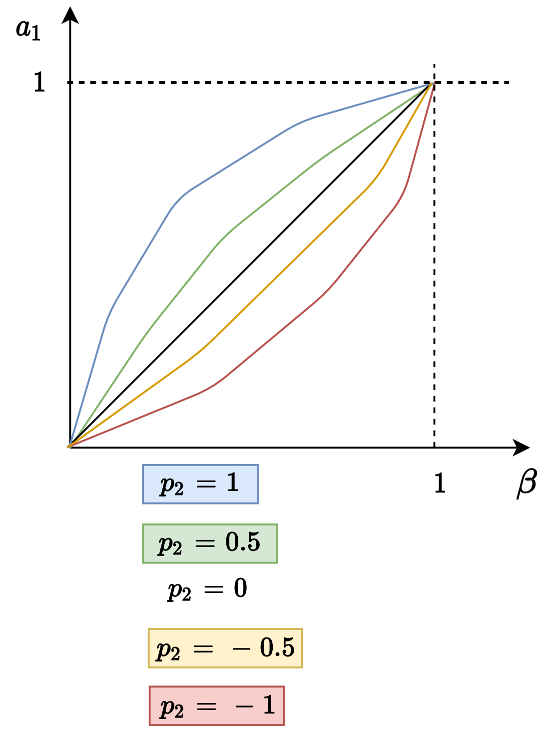
Let's define an auxiliary coefficent $\beta : \beta \in [0, 1]$. It describes how much sure a human is to go in direction of $\vec{w}$

$$\beta = \frac{|\vec{w}_1 + \vec{w}_2|}{|\vec{w}_1| + |\vec{w}_2|}$$

$$\boxed{a_1 = \beta - p_2(\beta - 1/2)^2 + \frac{p_2}{4}}$$

$p_2 \in [-1, 1]$

If p_2 parameter is positive, humans will tend to speed up faster when β increases. If p_2 is negative, speeding up is slower when β increases

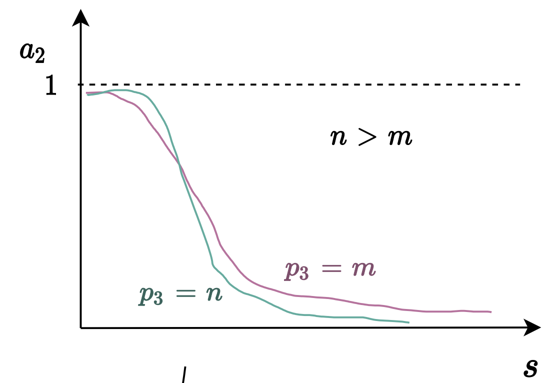


a_2

It is about how keen a human is to slow down when stamina goes down

$$\boxed{a_2 = \frac{1}{s^{p_3} + 1}}$$

s - stamina



In each time step stamina changes based on current value of a and p_2

$$s_t = s_{t-1} - \frac{p_3}{100} \cdot (a - 1)$$

$$a = 2 \cdot max(a_1 - a_2, 0)$$

$$\vec{v} = v_0 \cdot a \cdot \frac{\vec{w}}{|\vec{w}|}$$

$$\vec{r} = \vec{v} \cdot \Delta t$$