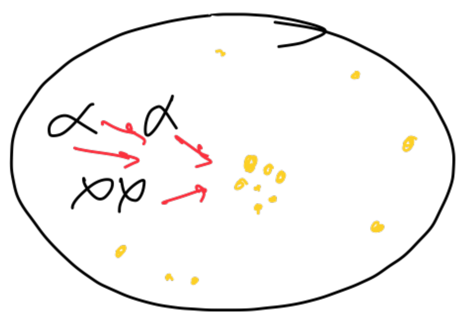
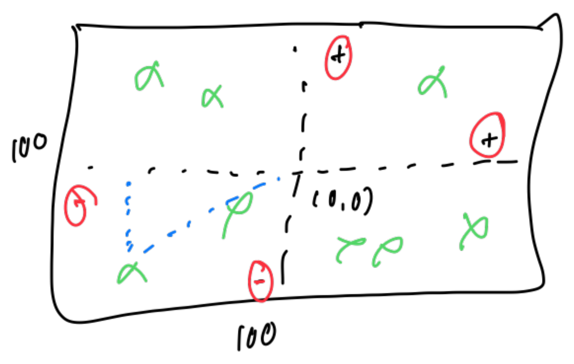
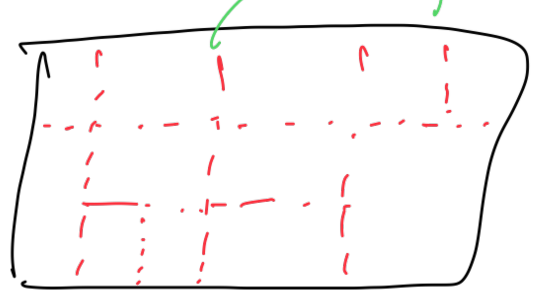


Simplied below





Initial State:

1. fish are randomly distributed → generating random numbers
2. Each fish has (x, y) coordinate
3. distance of fish from origin → $\sqrt{(x^2+y^2)}$

Simulation (Behavior of fish)

1. Simulation progress in rounds
2. Each fish will take some action in each round
3. We will orient all fishes in each round

Objective

1. Divide the lake into smaller parts and
2. computation in each part will be taken care by thread
3. No. of parts will depend on number of threads

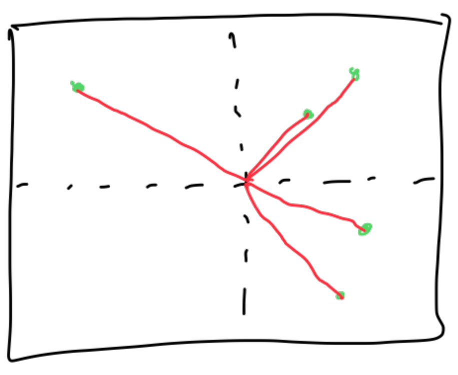
Actions of individual fish

1. Eat
2. Swim

Eat:

1. Each fish born with fixed weight 'w'
2. Weight can increase upto 2w →
3. Objective function

$$f = \sum_{i=1}^{N} \sqrt{(x^2+y^2)}$$



4. Sum is always + (+ve)
5. Reaches min when $f = 0$

   N = number of fishes in lake / square

6. Heavy computation if N is large → requires to be done by thread
7. Weight of fish i at simulation step t → $w_i(t)$

   Weight of fish i at simulation step $(t+1)$ → $w_i(t+1)$

$$w_i(t+1) = w_i(t) + \frac{\delta(f_i)}{\max(\delta(f_i))}$$

$\delta(f_i)$ → change in objective function after fish "i" has randomly swam in $(i+1)^{th}$ step

8. We have to replace co-ordinates of fish after it swims

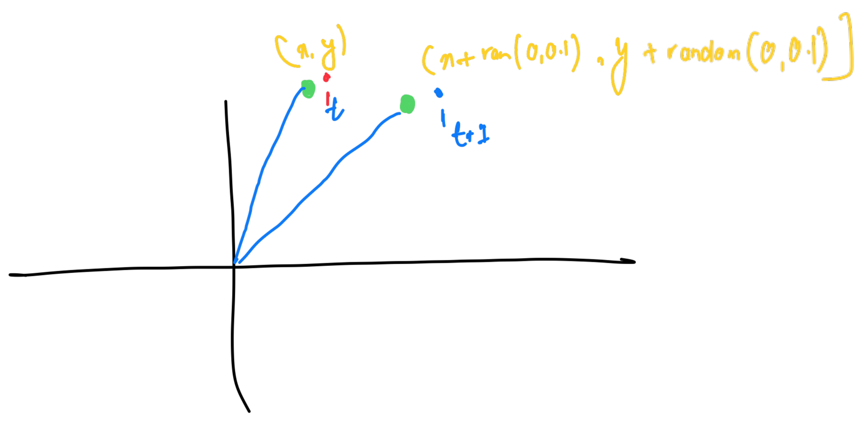
$$\delta(f_i) = f_{(i+1)} - f(i)$$

$\max(\delta(f_i))$ → maximum of such differences for all fishes

9. At initial simulation 0
   - Choose a suitable random value for $\left(\frac{\delta(f_i)}{\max(\delta(f_i))}\right)$

Swim:

1. Fish swims in random direction
   - if it can eat in the current round
2. Swimming is simulated by generating 2 random numbers betn 0 and 0.1 and adding to x and y co-ordinate of fish.

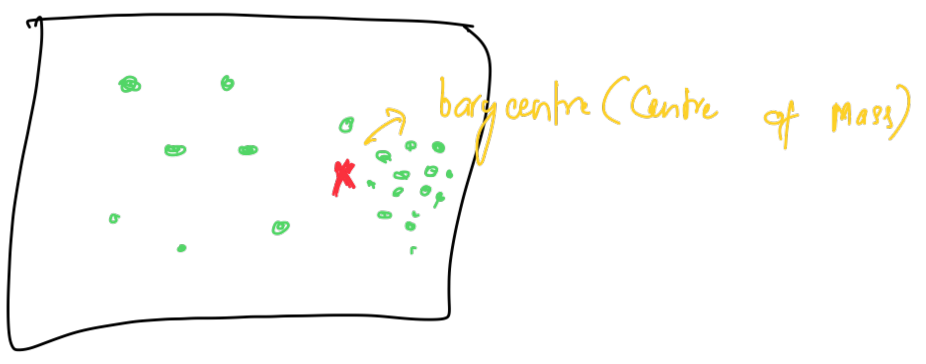


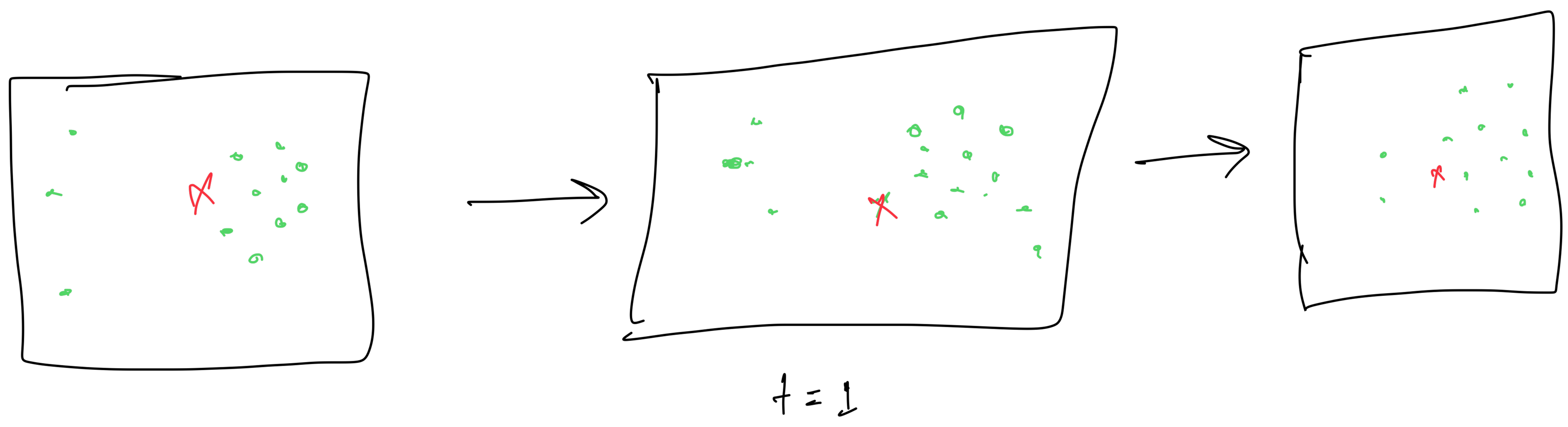
Swimming simulation

Collective action

- Orient all fishes towards barycentre of school

$$Bari = \frac{\sum_{i=1}^{N} \left(\sqrt{x_i^2 + y_i^2} \times w_i(t)\right)}{\sum_{i=1}^{N} \sqrt{x_i^2 + y_i^2}}$$





$t=0$

$t=1$

1. Run locally ??
2. or time in setonix ??