Movement Law of Sardines Based on MATLAB When Prey

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Abstract

Sardines are concentrated in large groups to fight the predation of dolphins. When the distance is far away, the dolphins can only use the echolocation method to determine the overall position of the fish. When the dolphins touch and even rush into the school, the fish will collide with each other, and this group behavior of sardines reduces the probability of being preyed by dolphins. Based on the law of fish swimming, we establish a mathematical model based on the equation of motion of each individual in the group, and then use the law of fish swimming: consistent law, synergistic law, inertia law, avoidance law; thus establishing a group The motion equation of each individual is finally simulated by MATLAB.

Keywords

Cluster motion, Swimming law simulation, Matlab programming.

1. Introduction

There are a large number of cluster behaviors in the animal kingdom, because individual animals are relatively weak and simple in behavior, and clusters can exhibit complex group behavior. These fauna have obvious characteristics during exercise: the individuals in the group are highly concentrated, and the direction and speed of movement are consistent. The information transfer mechanism in cluster behavior has always been the focus of bio-bionics.

2. Model Establishment and Solution

2.1 Environmental Simulation

We build a two-dimensional planar region model (Fig1), and map the real fish into a two-dimensional plane region through computer simulation. All individuals swim and forage in the region. This two-dimensional planar area and the operation of the computer clock together constitute the virtual environment in which the fish group is located.

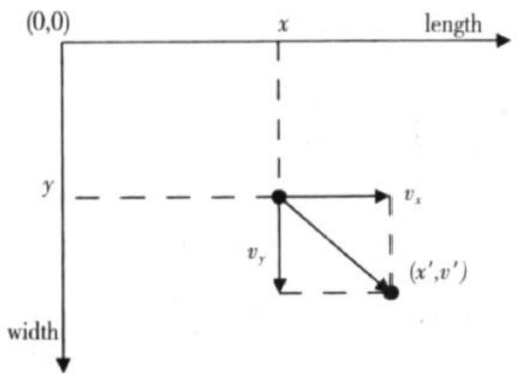


Fig. 1 Individuals and their environment

2.2 Individual Simulation

The individual's visual range is a sector with a radius of r and an angle of 300 degrees. We should also define a perceptual range of foraging, with a radius of R (R > r). Individual positions are represented by a set of coordinates (x, y). Each fish group should follow three rules (as close as possible to the center of the neighbor, try to be in the same direction as the neighbors, try to avoid collision) (Fig. 2)

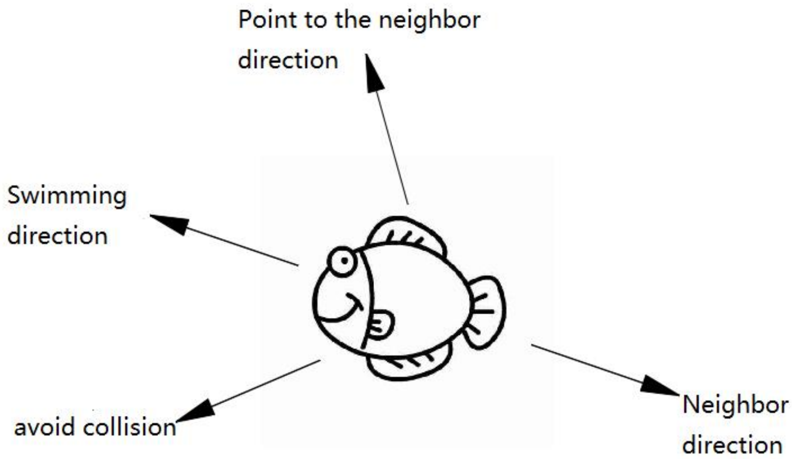


Fig. 2 Fish swimming direction

(1) Implementation of consistent laws

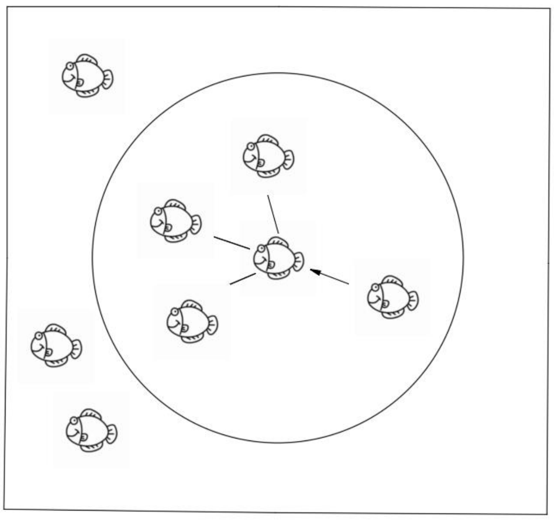
Each individual has the property of moving closer to the neighbor center, and the neighbor center is the average of the locations of the individual bodies in the observation range. The formula is expressed as: , the average of the neighbors, the current individual position, the current position of each neighbor), and D2t is the direction of the current individual (see Figure 3 (a)).

(2) Implementation of synergy law

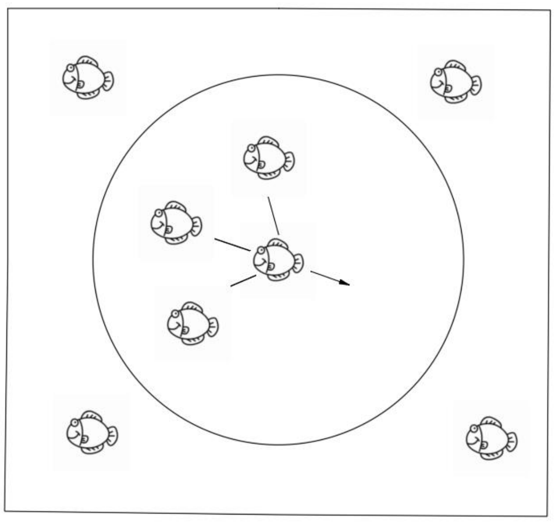
The individual will swim in the same direction as his neighbor. The formula is expressed as: for each neighbor's direction, N is the number of neighbors, and D3 t is the average direction of the neighbors (see Figure 3 (b)).

(3) Implementation of avoidance rules

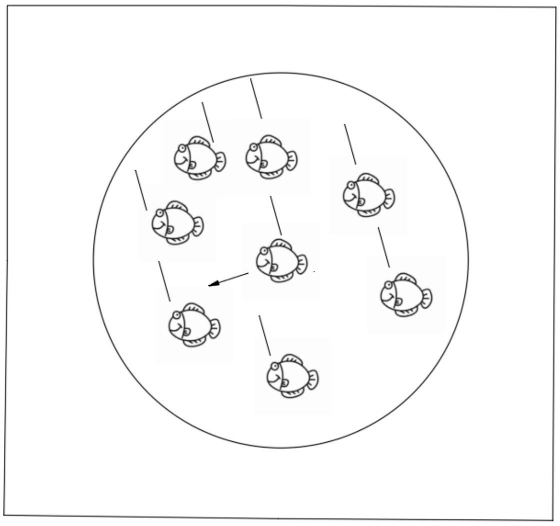
When an individual is too close to its neighbor (distance is less than the collision distance), it should be avoided automatically. The formula is expressed as:, is the average of the neighbors less than the collision distance to the current individual direction, and is the number of neighbors in the neighbor that are smaller than the collision distance (see Figure 3 (c)).



(a) Consistent rule



(b) Synergistic rule



(c) Avoidance rule

Fig.3 Description of the rules of the fish

So the final expression for the direction of the animal at the next moment is:

$$D_{t+1} = \lambda_1 D_{1t} + \lambda_2 \arctan\frac{\bar{y} - y_0}{\bar{x} - x_0} + \lambda_3 \sum \frac{D_i}{|N|} + \lambda_4 \frac{\sum \arctan\frac{y_0 - y_i}{x_0 - x_i}}{|M|}$$

2.3 Determination of the Equation of Motion of Animals

When an individual is disturbed by the outside world (considering the acceleration of the animal)

(1) Determination of animal speed:

Current speed:

$$\begin{cases} v_{xi}(t)=v_i(t)\cos(D_{ti}(t)) \\ v_{y_i}(t)=v_i(t)\sin(D_{ti}(t)) \end{cases}$$

Next moment speed:

$$\begin{cases} v_{xi}(t+1)=v_{xi}(t)+a\cos(D_{ti}(t))t \\ v_{y_i}(t+1)=v_{y_i}(t)+a\sin(D_{ti}(t))t \end{cases}$$

(2)Determination of animal motion equation:

$$\begin{cases} x_i(t+1) = x_i(t) + v_{xi}(t)t + \frac{1}{2}a\cos(D_{ti}(t))t^2 \\ y_i(t+1) = y_i(t) + v_{yi}(t)t + \frac{1}{2}a\cos(D_{ti}(t))t^2 \end{cases}$$

2.4 Simulation of Fish Evading Predator Movement:

Because the fish population is not disturbed by the outside world, the number of fish is set to n=100, the initial speed is V0=0.2, the maximum speed is maxspeed=1, the rebound speed is bouncespeed=0.3, and the minimum distance between individuals is resdist=0.05. R=0.5, the width of the virtual world is width=10, the length is 10, λ1=0.5, λ2=0.2, λ3=0.2, λ4=0.1, and the direction of the initial velocity is given randomly. The following simulation results can be obtained by Matlab.

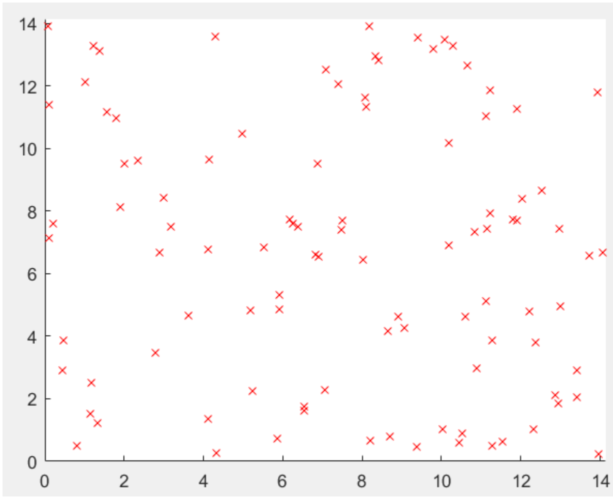


Fig. 4 Initial distribution of fish

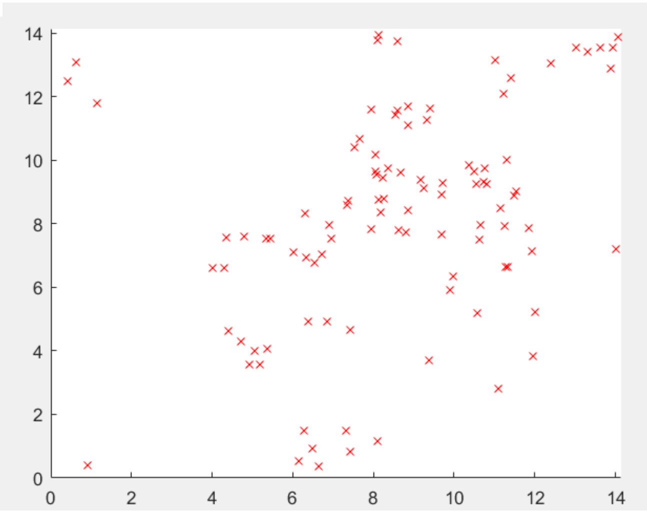


Fig. 5 Distribution of fish after predators

3. Conclusion

(1) When the dolphins prey, the sardines feel the danger signal coming. They choose the quickest way to escape the danger, swim in the opposite direction of the danger, and send a warning signal to exchange information so that nearby sardines can escape from the danger zone. .

(2) As time changes and information exchange between individuals, individual fish gradually become fish, escape from the danger zone, and individuals move together.

(3)In the process of constant escape, the fish group is subject to the same laws, synergistic laws, inertia laws, and avoidance laws. While ensuring safety, the fish movements show cluster movement behavior, and the results are the same as the facts.

References

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