The Whale Optimization Algorithm

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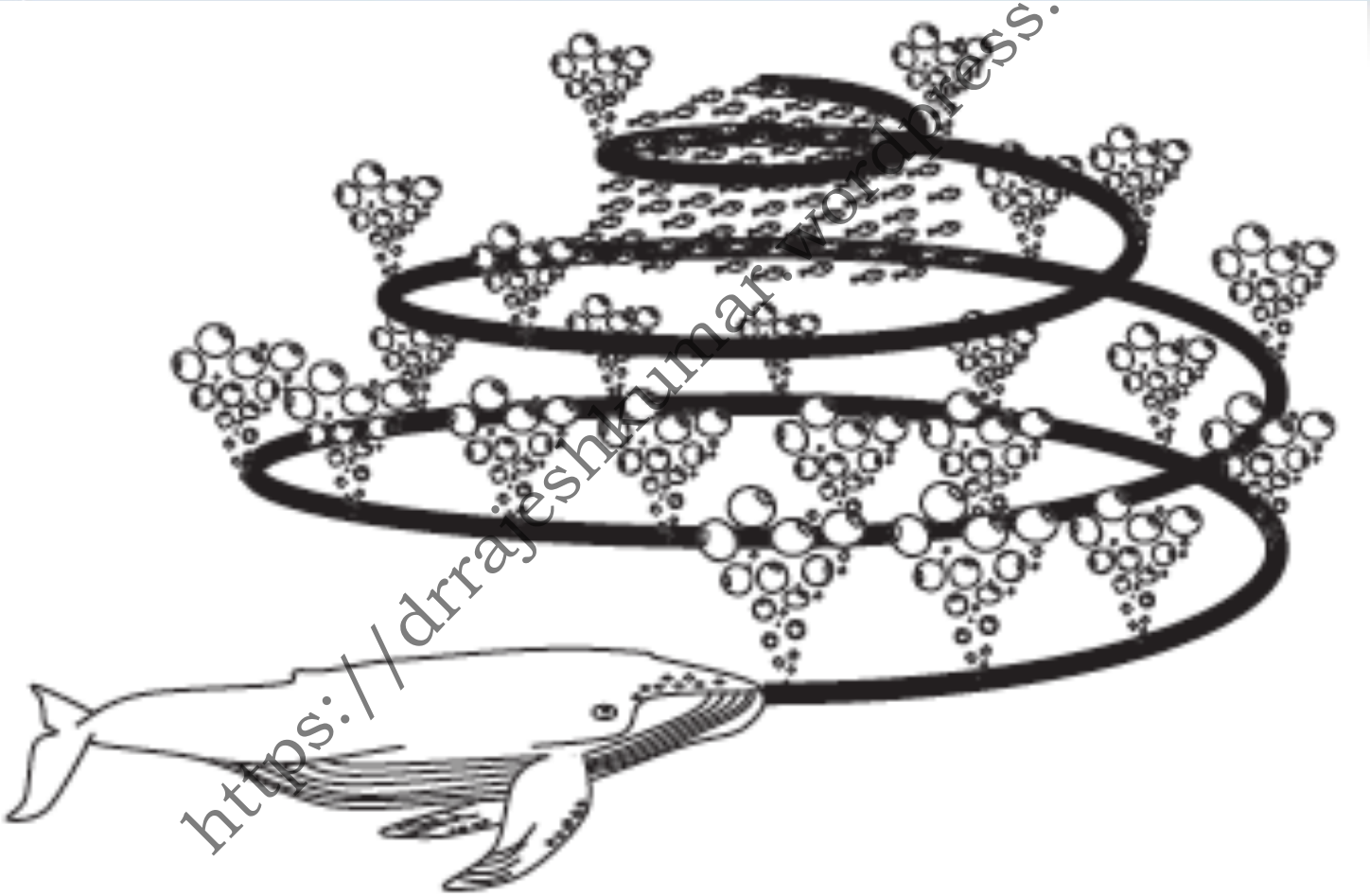
About Whale

- They are considered as the biggest mammals in the world.
- An adult whale can grow up to 30 m long and 180 t weight.
- Whales are mostly considered as predators.
- They never sleep because they have to breathe from the surface of oceans. In fact, half of the brain only sleeps.
- The interesting thing about the whales is that they are considered as highly intelligent animals with emotion.
- According to Hof and Van Der Gucht, whales have common cells in certain areas of their brains similar to those of human called spindle cells.
- These cells are responsible for judgment, emotions, and social behaviors in humans.

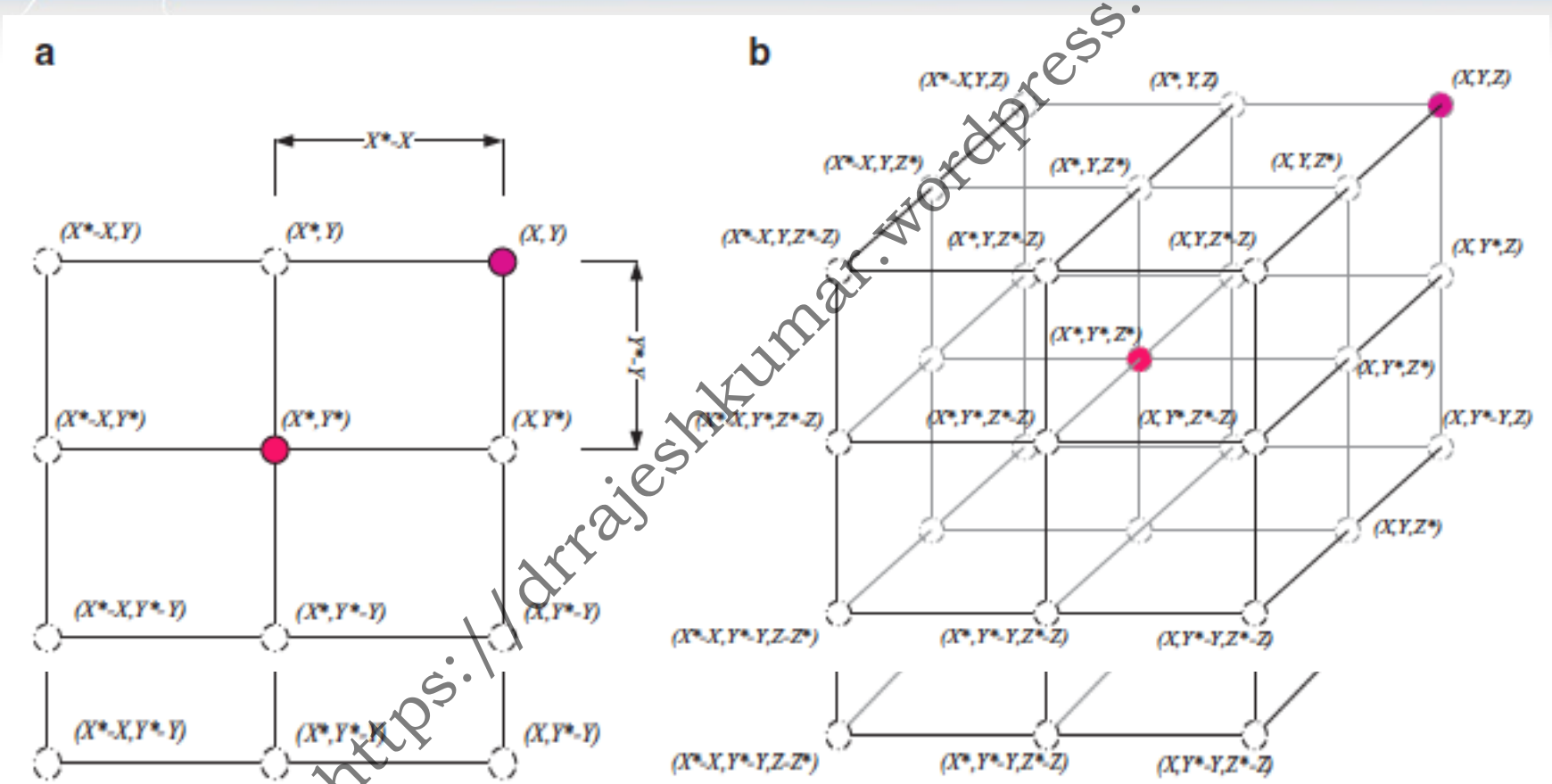
Humpback Whale



Humpback Whales

- The most interesting thing about the humpback whales is their special hunting method.
- This foraging behavior is called bubble-net feeding method.
- Humpback whales prefer to hunt school of krill or small fishes close to the surface.
- It has been observed that this foraging is done by creating distinctive bubbles along a circle or '9'-shaped.
- They captured 300 tag-derived bubble-net feeding events of 9 individual humpback whales.
- They found two maneuvers associated with bubble and named them 'upward-spirals' and 'double- loops'.

Encircling Prey



Encircling Prey

The mathematical model of the encircling behaviour is represented by the equations:

$$D = |CX_p - AX(t)| \quad (1)$$

$$X(t+1) = X_p(t) - AD \quad (2)$$

A and C are coefficient vectors given by:

$$A = 2ar_1 a \quad (3)$$

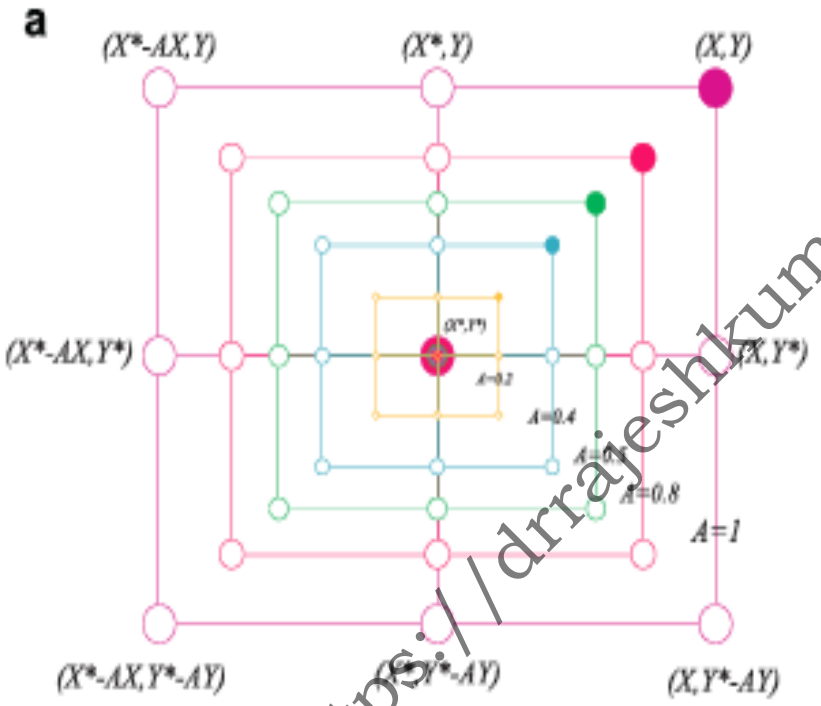
$$C = 2r2 \quad (4)$$

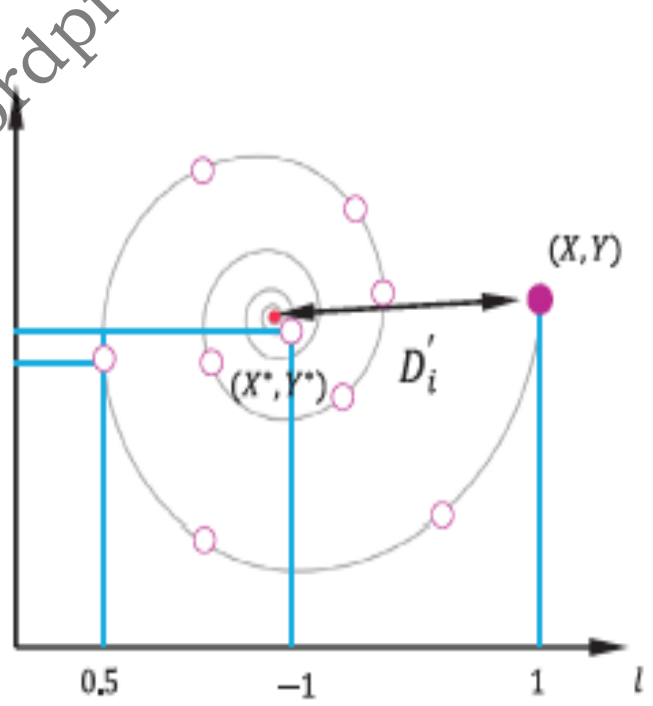
t is the current iteration

X is the position vector of a wolf

r_1 and r_2 are random vectors $\in [0, 1]$ and a linearly varies from 2 to 0

Bubble Net Attacking Method





Bubble Net Attacking Method

- Shrinking Method

Vary "a" and hence "A"

- Spiral Updating Method

$$\vec{X}(t+1) = \vec{D}' \cdot e^{bl} \cdot \cos(2\pi l) + \vec{X}^*(t)$$

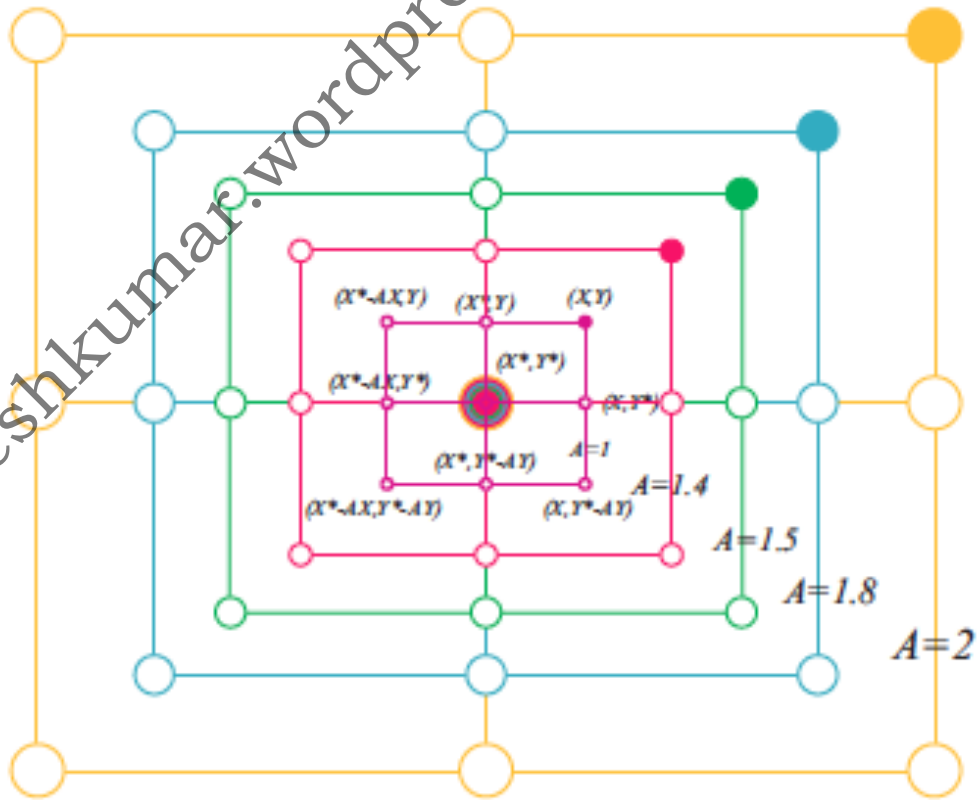
$$\vec{D}' = |\vec{X}^*(t) - \vec{X}(t)|$$

$$\vec{X}(t+1) = \begin{cases} \vec{X}^*(t) - \vec{A} \cdot \vec{D} & if \quad p < 0.5 \\ \vec{D}' \cdot e^{bl} \cdot \cos(2\pi l) + \vec{X}^*(t) & if \quad p \geq 0.5 \end{cases}$$

Search for Prey

$$\vec{D} = |\vec{C} \cdot \overrightarrow{X_{rand}} - \vec{X}|$$

$$\vec{X}(t+1) = \overrightarrow{X_{rand}} - \vec{A}.\vec{D}$$



Pseudo Code

```
Inittialtze the whales population Xi (t = 1, 2, ..., n)
Calculate the fitness of each search agent
X*=the best search agent
while (t < maxtmum number of tterations)
    for each search agent
    Update a, A, C, l, and p
        if1 (p<0.5)
            if2 (|A| < 1)
                Update the posttion of the current search agent by the Eq. (2.1)
            else if2 (|A| ≥ 1)
                Select a random search agent (X_rand)
                Update the position of the current search agent by the Eq. (2.8)
            end if2
        else if1 (p≥0.5)
                Update the posttion of the current search by the Eq. (2.5)
        end if1
    end for
    Check if any search agent goes beyond the search space and amend tt
    Calculate the fitness of each search agent
    Update X* if there is a better solution
    t=t+1
end while
return X*
```

Thank You