ENSIAS

جامعة محمد الخامس بالرباط
Université Mohamed V de Rabat

Semester 4 Project Defense

Module : Collective Intelligence

Branch : Artificial Intelligence

Training Neural Networks with Firefly Optimization Algorithm

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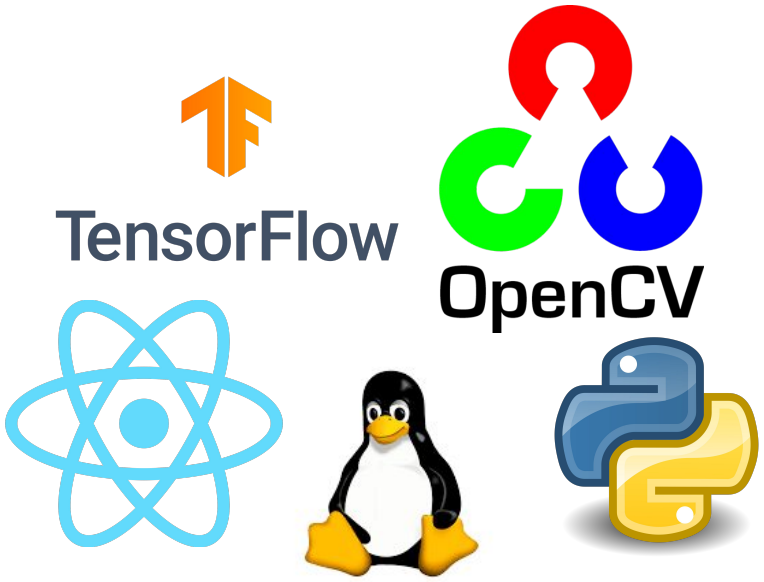
Outline

- Collective Intelligence
- Swarm intelligence optimization
- Firefly algorithm
- Neural Network
- FireFly in Neural Network
- Experimental Results
- Conclusion & Perspectives

Collective Intelligence



- Collective intelligence is the **collaboration** of a group to gather and utilize the **knowledge**, skills, and contributions of its members to **solve problems** and make decisions.
- It recognizes that the collective wisdom of a group can surpass the abilities of any individual.
- Examples include crowdsourcing, collaborative decision-making, and open-source projects.
- Waze rely on crowdsourcing where drivers **self-report accidents** and other **incidents,** providing real-time information to app users.

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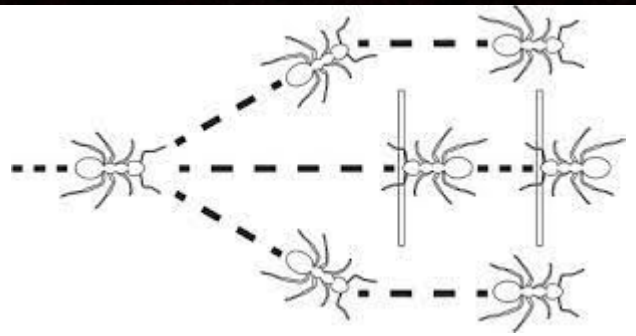
Swarm Intelligence Optimization



- Swarm intelligence optimization is a branch of **artificial intelligence** that focuses on **developing algorithms** inspired from the **cooperative behavior** of insects, birds, and other social animals
- Population examples: ants, birds, bees, fireflies etc…
- While **collective intelligence** encompasses a broader range of human endeavors, **swarm intelligence** specifically develops algorithms that mimic the behavior of social creatures for optimization purposes.

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- The Firefly Algorithm is a metaheuristic optimization algorithm that takes inspiration from the flashing behavior of **fireflies** to solve optimization problems.
- It leverages the **attractiveness** between fireflies to guide their movement in the search space and converge towards the optimal solutions.
- The attractiveness between fireflies is determined by factors such as their **brightness** and **distance**.

1. Attractiveness (brightness) expression:

$$attractiveness = \frac{\exp(-\alpha \times distance(i,j))}{(1 + beta \times distance(i,j))}$$

- **alpha:** light absorption coefficient
- **beta:** randomization parameter

2. Movement update expression:

$$newP = currentP(i) + attractiveness \times (currentP(j) - currentP(i)) + rand(-1,1)$$

[H] Firefly Algorithm

Input: Population size, maximum number of iterations, alpha (light absorption coefficient), beta (randomization parameter)
Output: The best solution found among the fireflies
Initialization:
Initialize firefly population randomly within the search space
Calculate the fitness (objective function value) for each firefly in the population
Repeat for a specified number of iterations:
for each firefly (i) **do**
  for each other firefly (j) **do**
    if the fitness of firefly j is greater than the fitness of firefly i **then**
      Calculate the attractiveness (brightness) between fireflies i and j using the formula:
      attractiveness = $\exp(-\alpha \times \text{distance(i, j)})/(1 + \beta \times \text{distance(i, j)})$
      Move firefly i towards firefly j with a step size determined by attractiveness and randomization:
      newPosition = currentPosition(i)+attractiveness×(currentPosition(j)−currentPosition(i))+ rand(-1, 1)
      if The fitness of the new position is better than the fitness of firefly i **then**
        Update firefly i's position to the new position
      end if
    end if
    Calculate the fitness of the updated firefly i
  end for
end for
Output: The best solution found among the fireflies

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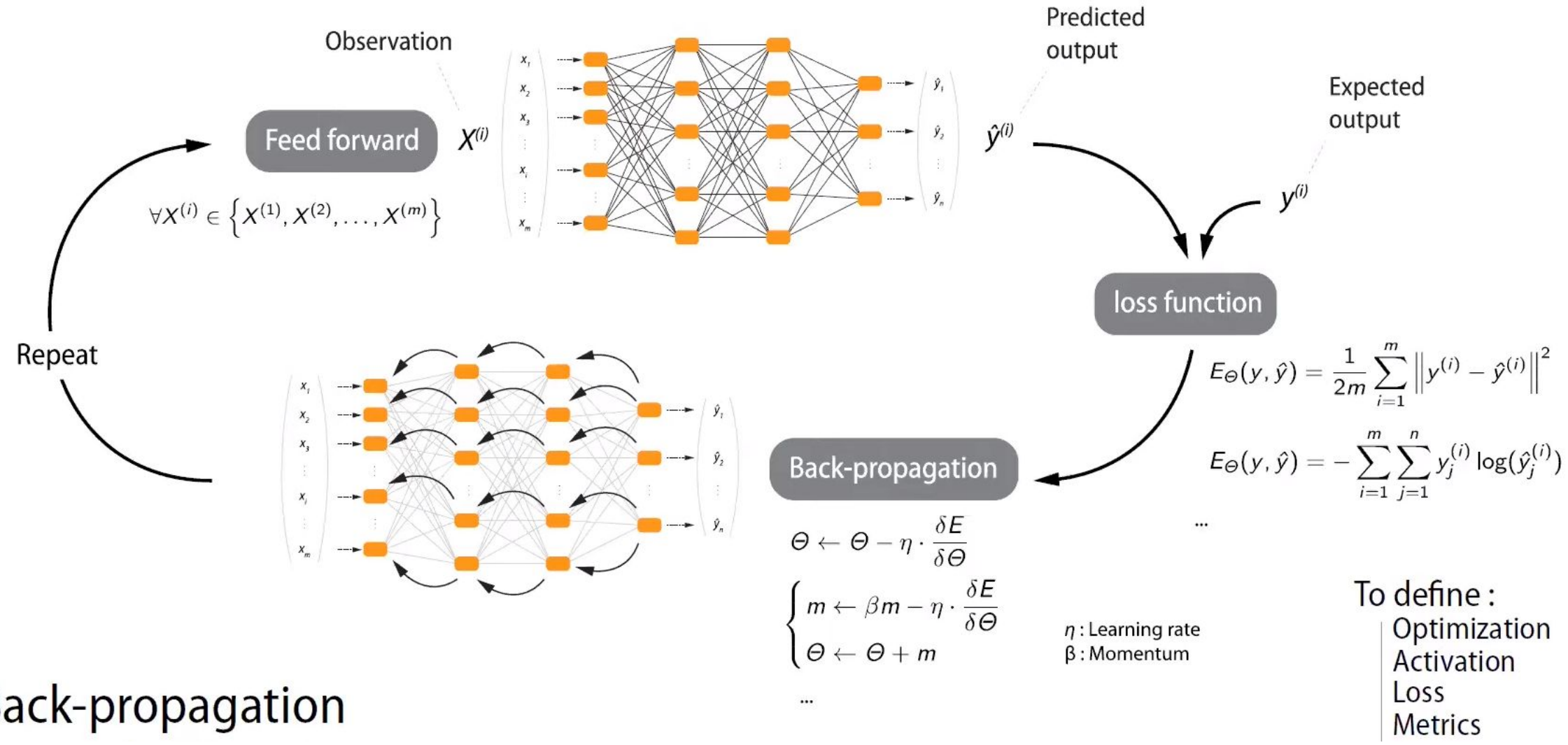

Back-propagation

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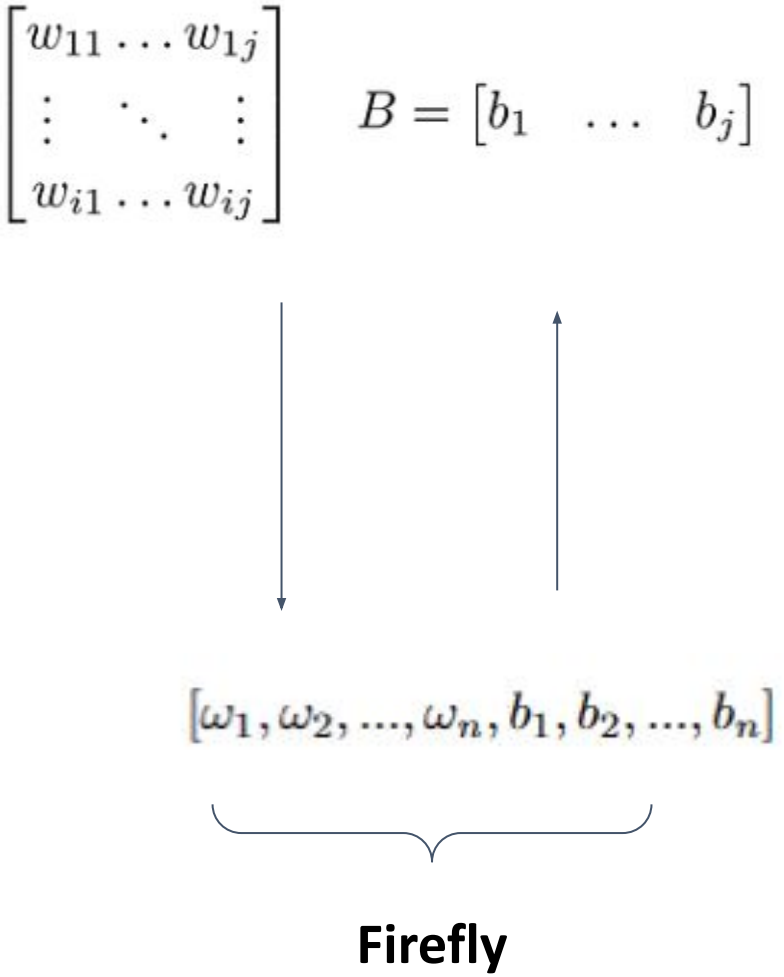
FireFly in Neural Networks

- Population: flatten and stack weights and biases in t order W1b1W2b2…Wnbn
- Fitness function: 1-loss = Accuracy
- The FireFly Algorithm will replace replace the **BackPropagation** Algorithm
- Firefly hyperparameters: (hyper-parameters)
    1. **selection_range**
    2. **num_fireflies**
    3. **num_iterations**
    4. **alpha**
    5. **beta**



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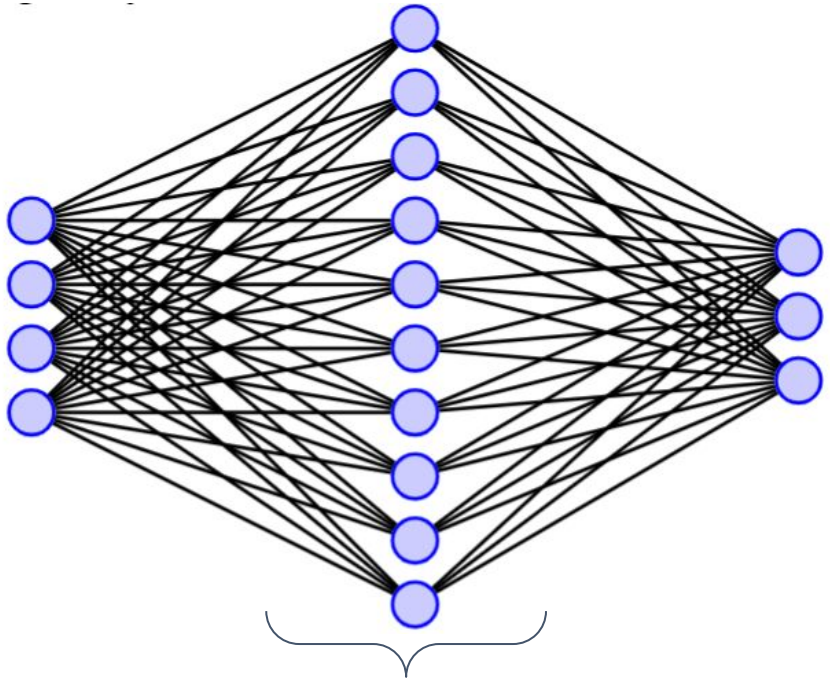
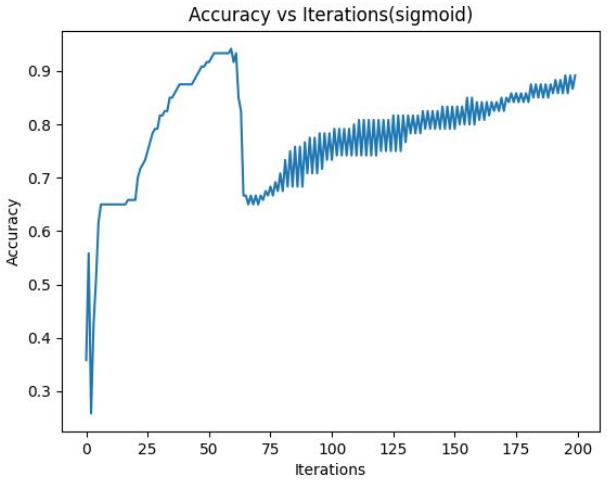
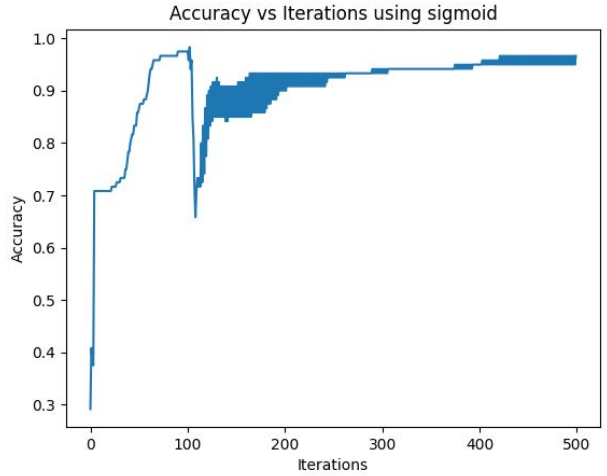
Attribute Information:

1. sepal length in cm
2. sepal width in cm
3. petal length in cm
4. petal width in cm
5. class: Iris Setosa, Iris Versicolour, Iris Virginica

Id	SepalLengthCm	SepalWidthCm	PetalLengthCm	PetalWidthCm	Species
1	5.1	3.5	1.4	0.2	Iris-setosa
2	4.9	3	1.4	0.2	Iris-setosa
3	4.7	3.2	1.3	0.2	Iris-setosa
4	4.6	3.1	1.5	0.2	Iris-setosa
5	5	3.6	1.4	0.2	Iris-setosa


input layer
hidden layer
output layer


Accuracy vs Iterations(sigmoid)
Accuracy
Iterations
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
25
50
75
100
125
150
175
200


Accuracy vs Iterations using sigmoid
Accuracy
Iterations
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0
100
200
300
400
500

1. number of fireflies :

num_fireflies	**5**	**20**	**50**
Time Expended	12.1	1m15s	5m11s
Accuracy	0.4387	0.593	0.6458

2. number of iterations:

num_iterations	**100**	**1000**	**10000**
Time Expended	8.7s	1m14s	13m4s
Accuracy	0.5725	0.5908	0.6083

3. the parameter alpha

α	**0.01**	**0.2**	**2**
Time Expended	1m13s	1m15s	1m10s
Accuracy	0.6012	0.6074	0.5608

4. the parameter beta

β	**0.01**	**1**	**10**
Time Expended	1m13s	1m9s	1m13s
Accuracy	0.5654	0.6220	0.5520

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num_fireflies	**5**	**20**	**50**
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Accuracy	0.4387	0.593	0.6458

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Accuracy	0.6012	0.6074	0.5608

4. the parameter beta

β	**0.01**	**1**	**10**
Time Expended	1m13s	1m9s	1m13s
Accuracy	0.5654	0.6220	0.5520

- **num_fireflies = 50**
- **num_iterations = 10000**
- **alpha = 0.2**
- **beta = 1**

- NN best accuracy : 88 %
- Firefly best accuracy : 64 %

Algorithm	Backpropagation	FireFly
Time expended	0.2s	5m11s
Accuracy	88%	70%

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Conclusion & Perspectives

- Try the firefly on a big dataset where it can outperform GD
- try another form of fitness function
- Explore more the differents parameters (num_iterations , num_fireflies)
- hybridization of FOA and GD to train NN

Thank You