Feature Selection Method Based on Grey Wolf Optimization for Coronary Artery Disease Classification

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What is Grey wolf optimizer(GWO)

- Grey wolf optimizer (GWO) is a recently proposed swarm intelligence optimization method inspired by hunting behavior of grey wolves.

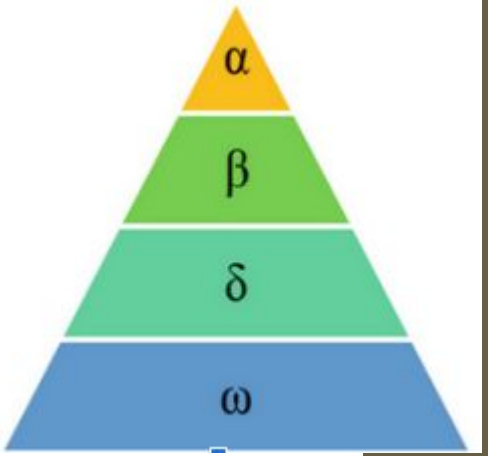
- It is a population based metaheuristics algorithm that simulates the leadership hierarchy and hunting mechanism of gray wolves in nature proposed by Mirjalili in 2014.

- Grey wolves prefer to live in a groups (packs), each group contains 5-12 members on average

Social hierarchy of GWO

The social hierarchy consists of four levels as follow.

- The first level is called Alpha (α). The alpha wolves are the leaders of the pack.
- The second level is Beta, which acts as a substitute for alpha wolves.
- The third level is Delta, which consists of scouts, hunters caretakers etc.
- The last one is Omega, which is weakest of all and follow other wolves.



Grey wolf encircling prey

- During the hunting, the grey wolves encircle prey.
- The mathematical model of the encircling behavior is presented in the following equations.

$$X(t+1) = X_p(t) - A \cdot D$$

$$D = |C \cdot X_p(t) - A \cdot X(t)|$$

- t is current iteration
- A and C are coefficient vectors
- Xp is the position vector of the prey
- X indicates the position vector of a grey wolf.

- The vectors A and C are calculated as follows

$$\vec{A} = 2\vec{a} \cdot \vec{r_1} - \vec{a} \qquad C = 2 \cdot r_2$$

Grey wolf Hunting

- The hunting operation is usually guided by the alpha. The beta and delta might participate in hunting occasionally.

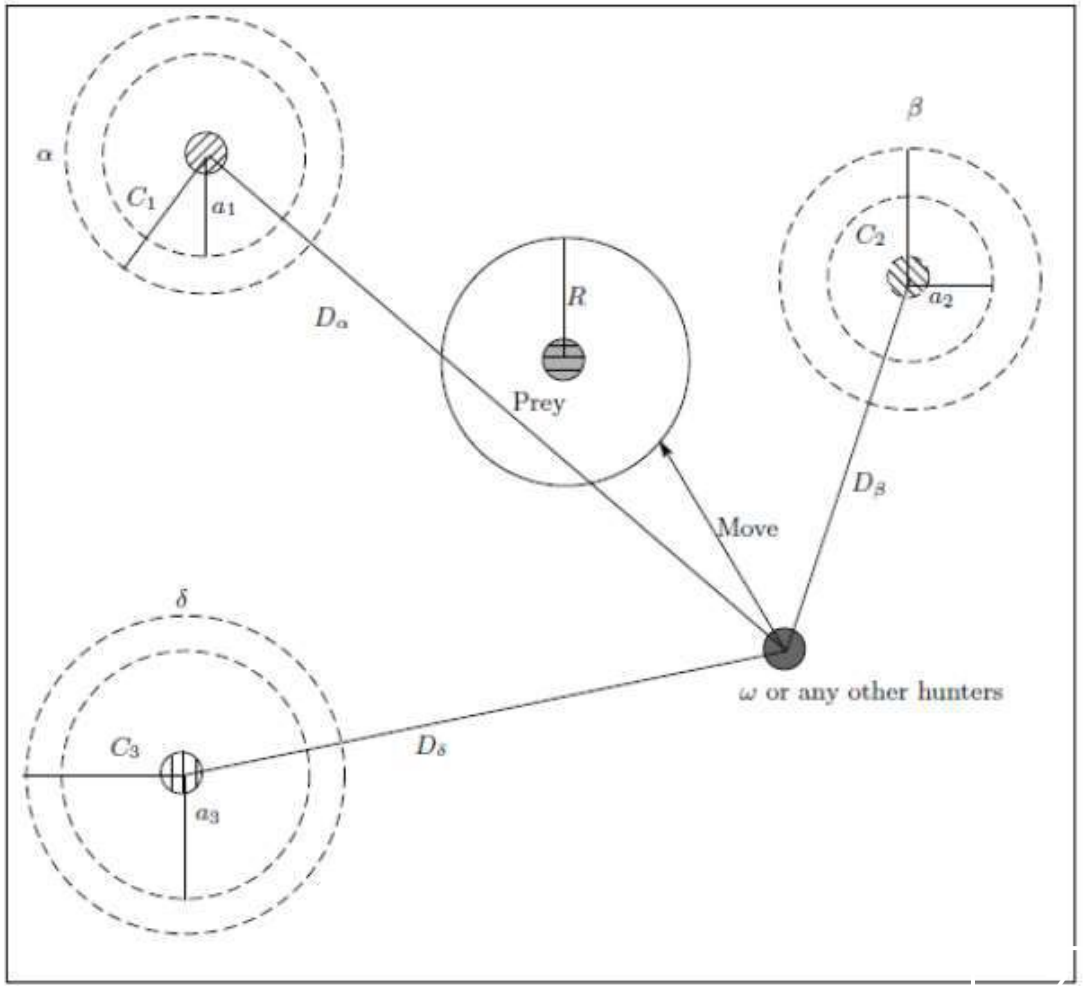
- In the mathematical model of hunting behavior of grey wolves, we assumed the alpha , beta and delta have better knowledge about the potential location of prey.

- The first three best solutions are saved and the other agent are obliged to update their positions according to the position of the best search agents as shown in the following equations.

$$D_\alpha = |C_1.X_\alpha - X|,$$
$$D_\beta = |C_2.X_\beta - X|,$$
$$D_\delta = |C_3.X_\delta - X|$$

$$X_1 = X_\alpha - A_1 \cdot (D_\alpha),$$
$$X_2 = X_\beta - A_2 \cdot (D_\beta),$$
$$X_3 = X_\delta - A_3 \cdot (D_\delta),$$

$$X(t+1) = \frac{X_1 + X_2 + X_3}{3},$$



Search for prey (exploration)

- The exploration process in GWO is applied according to the position , and , that diverge from each other to search for prey and converge to attack prey.
- The exploration process modeled mathematically by utilizing A with random values greater than 1 or less than -1 to oblige the search agent to diverge from the prey.
- When |A| > 1, the wolves are forced to diverge from the prey to find a fitter prey.

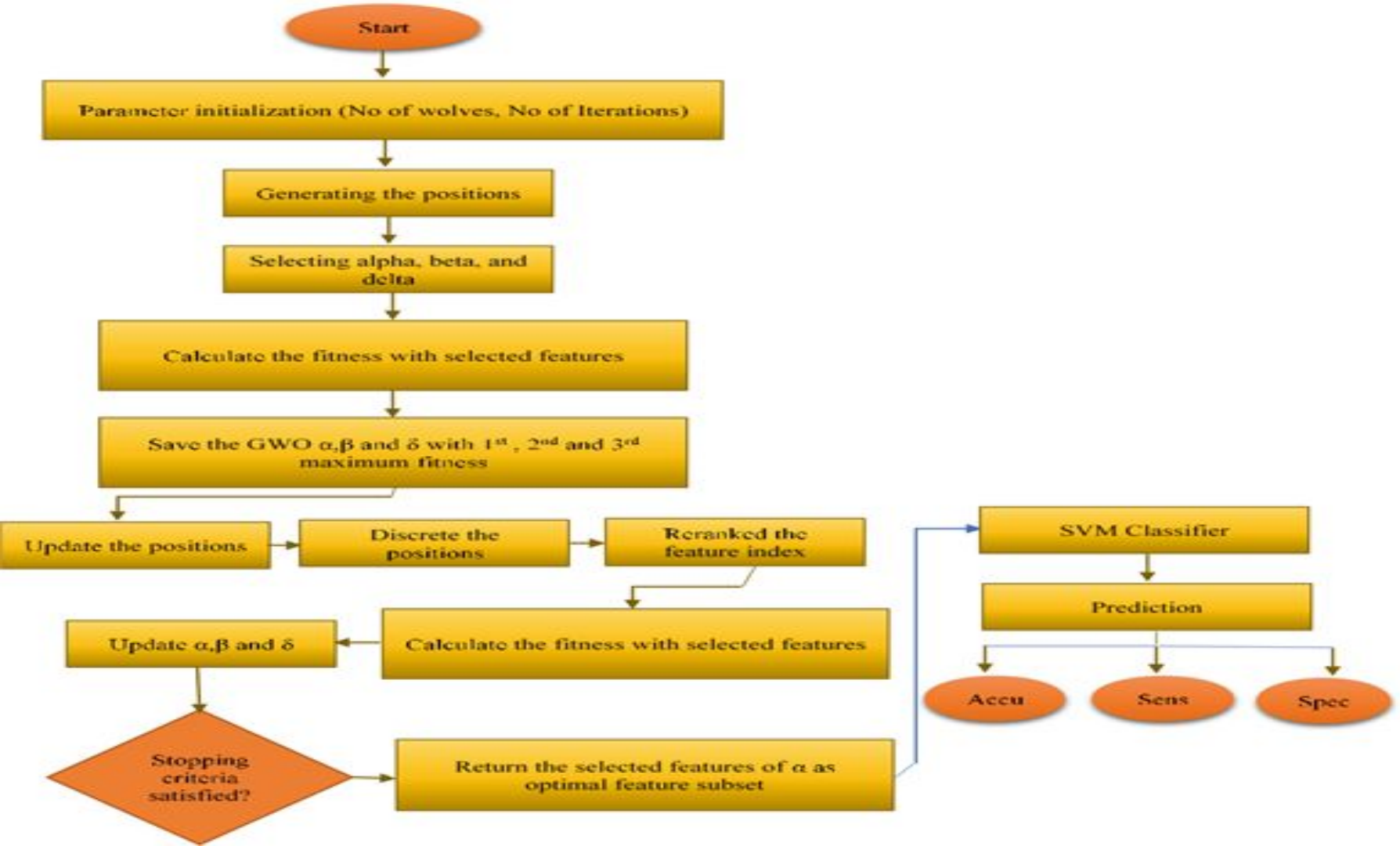
Attacking prey (exploitation)

- The grey wolf finish the hunt by attacking the prey when it stop moving.
- The vector A is a random value in interval [-2a, 2a], where a is decreased from 2 to 0 over the course of iterations.
- When |A| < 1, the wolves attack towards the prey, which represents an exploitation process.

Algorithm

Algorithm 1 Grey wolf optimizer algorithm

Set the initial values of the population size n, parameter a, coefficient vectors $\boldsymbol{A}$, $\boldsymbol{C}$ and the maximum number of iterations Max_{itr}.
Set $t := 0$. {Counter initialization}.
for $(i = 1 : i \leq n)$ **do**
    Generate an initial population $\boldsymbol{X_i}(t)$ randomly.
    Evaluate the fitness function of each search agent (solution) $f(\boldsymbol{X_i})$.
end for
Assign the values of the first, second and the third best solution $\boldsymbol{X_\alpha}$, $\boldsymbol{X_\beta}$ and $\boldsymbol{X_\delta}$, respectively.
repeat
    for $(i = 1 : i \leq n)$ **do**
        Update each search agent in the population as shown in Equation 12.
        Decrease the parameter a from 2 to 0.
        Update the coefficients $\boldsymbol{A}$ and $\boldsymbol{C}$ as shown in Equations 8, 9, respectively.
        Evaluate the fitness function of each search agent (vector) $f(\boldsymbol{X_i})$.
    end for
    Update the vectors $\boldsymbol{X_\alpha}$, $\boldsymbol{X_\beta}$ and $\boldsymbol{X_\delta}$.
    Set $t = t + 1$. {Iteration counter increasing}.
until $(t < Max_{itr})$. {Termination criteria satisfied}.
Produce the best solution $\boldsymbol{X_\alpha}$.


Start
Parameter initialization (No of wolves, No of Iterations)
Generating the positions
Selecting alpha, beta, and delta
Calculate the fitness with selected features
Save the GWO α,β and δ with 1st , 2nd and 3rd maximum fitness
Update the positions
Discrete the positions
Reranked the feature index
Calculate the fitness with selected features
Update α,β and δ
Stopping criteria satisfied?
Return the selected features of α as optimal feature subset
SVM Classifier
Prediction
Accu
Sens
Spec

Proposed Method:

- Wrapper feature selection based on GWO and SVM
- GWO-SVM has been used for the diagnosis of heart diseases based on 13 features of patient
- It has two phases:
  - Eliminate redundant and irrelevant features
  - SVM is applied on the selected features by GWO
- Accuracy increases in case of GWO-SVM compared to SVM

Results

- A comparison was conducted between the proposed method and other competitive counterparts feature selection methods.

- Experimented results demonstrated that the proposed method performed greatly in terms of accuracy and outperformed the state-of-art methods.

- GWO-SVM: 61.4%
- SVM : 59.8%

Future changes:

- Different classifiers could be used with GWO to further enhance the results.
- Moreover, some other datasets can be applied in the future to further investigating the robustness of the proposed method.

References

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