Long-Term Wind Speed Prediction based on Optimized Support Vector Regression

by

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Agenda

- Introduction
  - Wind Speed Problem
  - Related Work
  - Problem Definition
- Proposed WOA-SVR Algorithm
- Experimental Results and Discussion
- Conclusion and Future Works

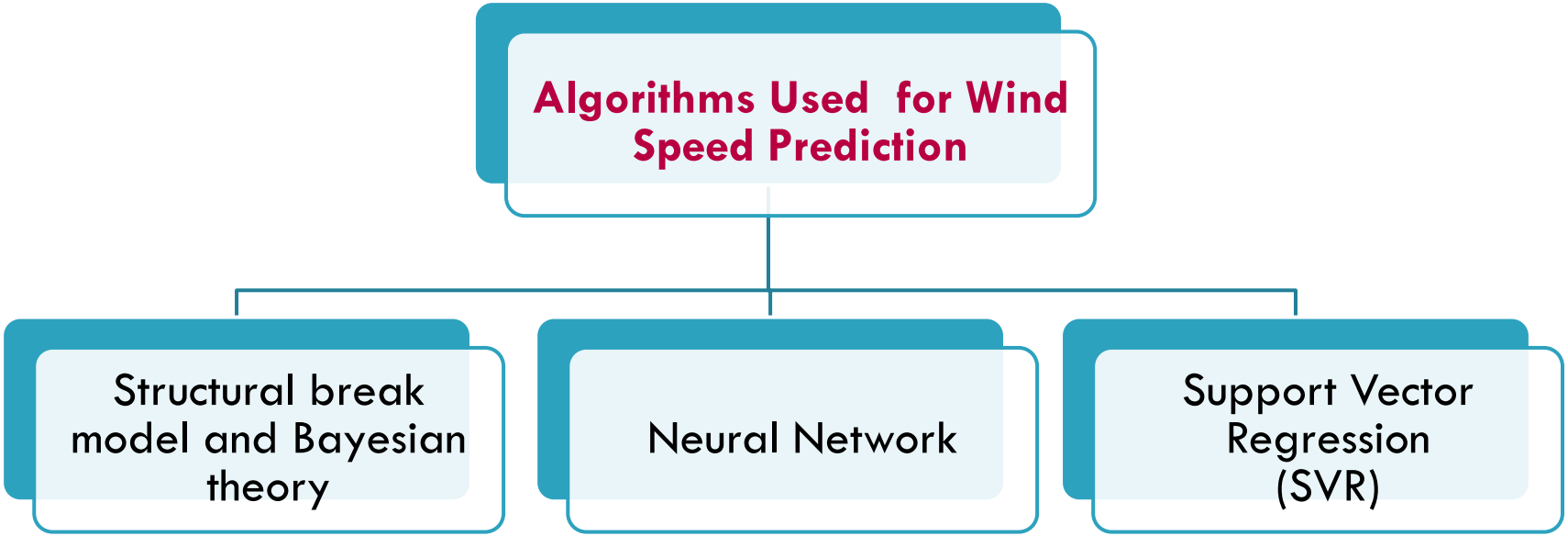
Introduction

Wind energy one of the fastest rising energy resources are wind energy since it is **renewable, plentiful and clean.** One of the most important main sources of **renewable energy** is the energy of the wind. One of the drawbacks for the reliability and precision of the power system is the **fluctuation and nonlinear of wind**

Introduction

- **Wind speed prediction is classified into three categories, named as,**
  - **Short term prediction** could point to forecasting data for a few hours ahead no more.
  - **Medium term prediction** is for a duration ranging from about a few hours to three days
  - **Long-term prediction** point to duration more than three days ahead; yet, there is no ultimate end of the duration

Introduction



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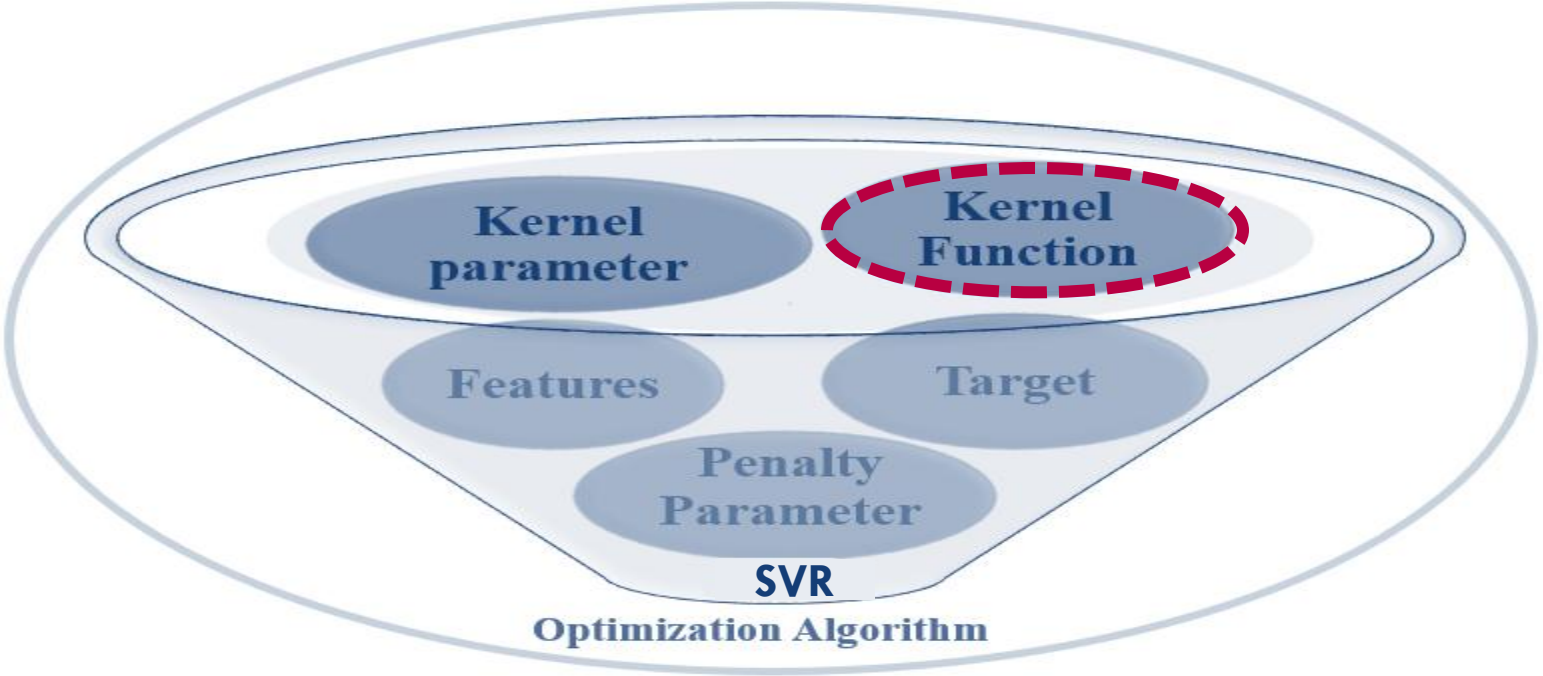

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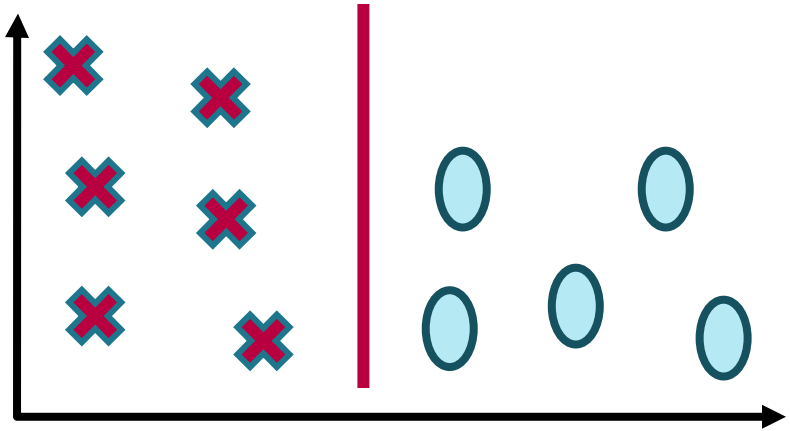
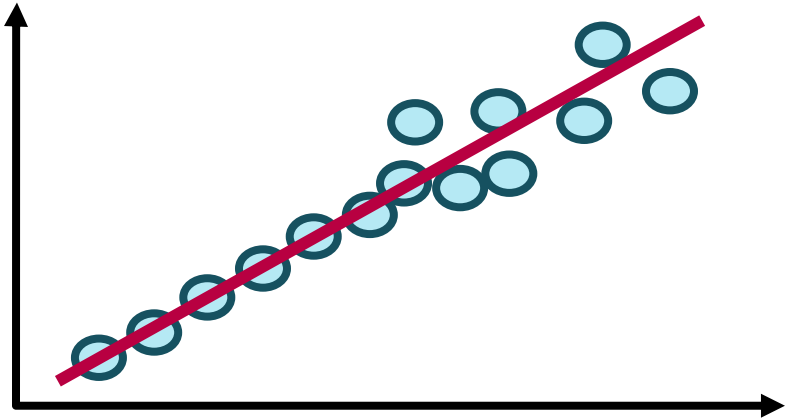
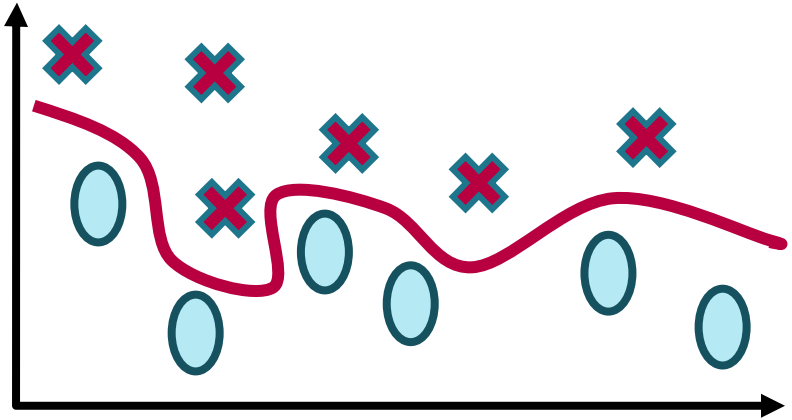


Linear data in 2D
(Discrete Data)

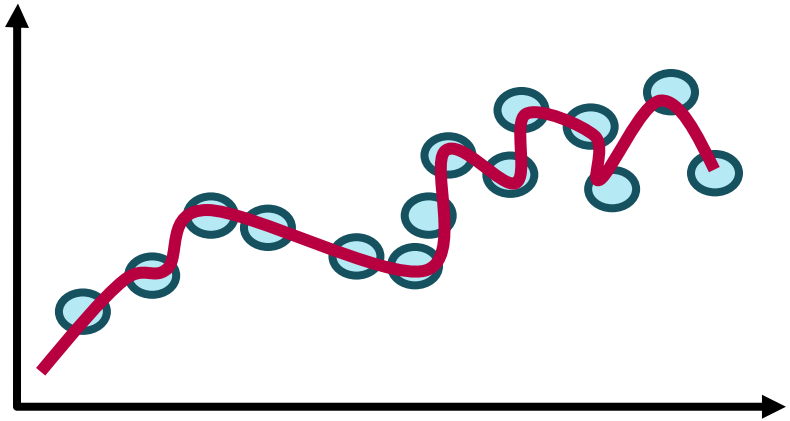


Linear data in 2D
(Continuous Data)

Introduction



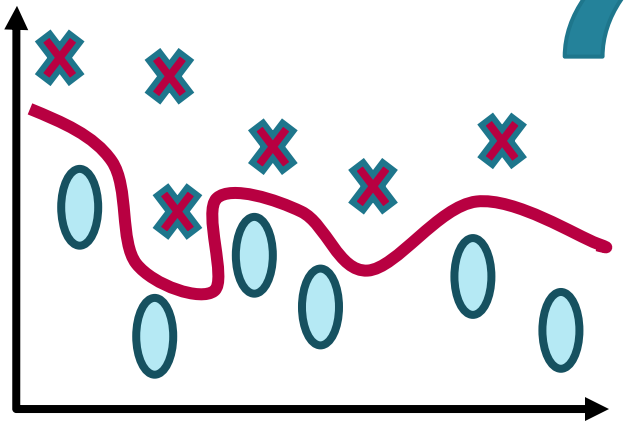
Non-Linear data in 2D
(Discrete Data)



Non-Linear data in 2D
(Continuous Data)

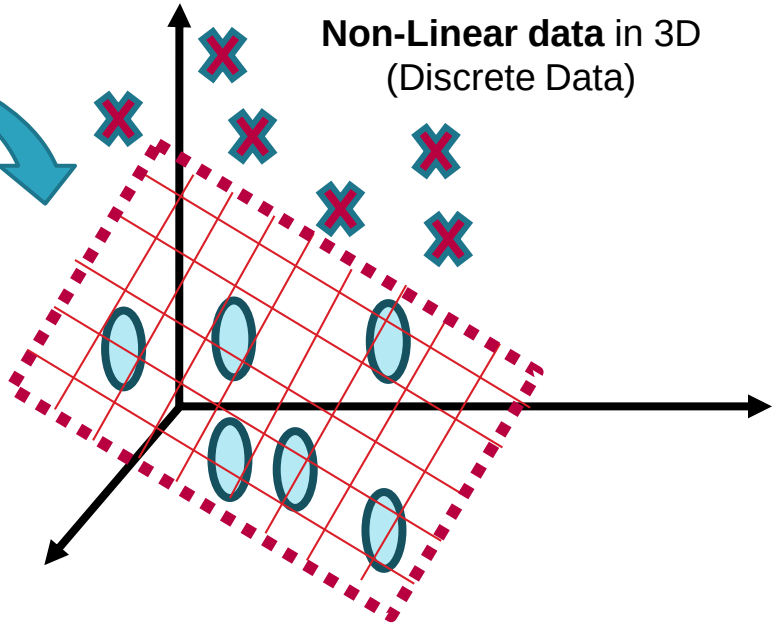
Introduction

Non-Linear data in 2D
(Discrete Data)



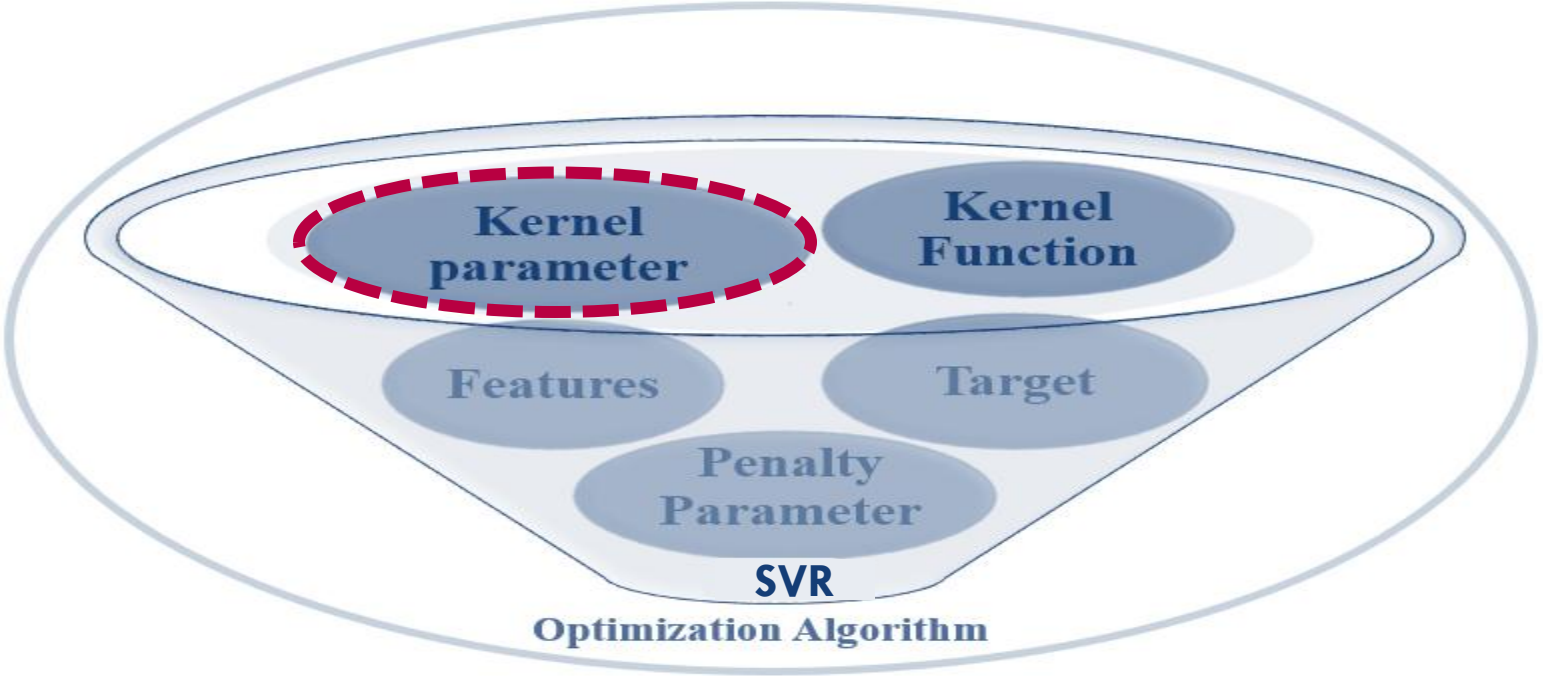
Kernel Function
(i.g RBF)

Non-Linear data in 3D
(Discrete Data)



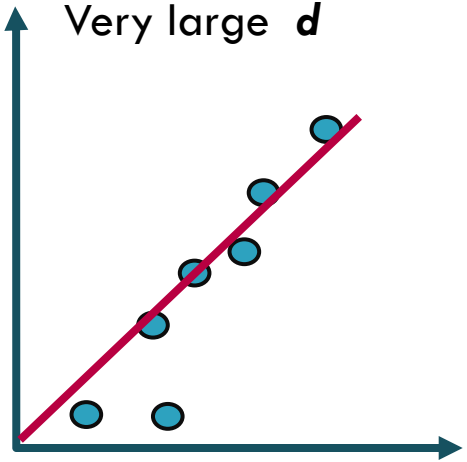
Input space – **Feature space**

Introduction



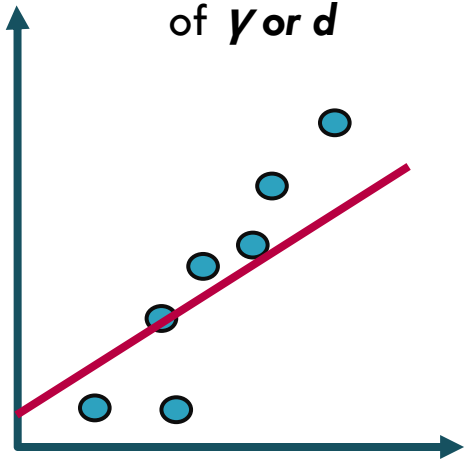
Introduction

Very small ***γ or***
Very large ***d***



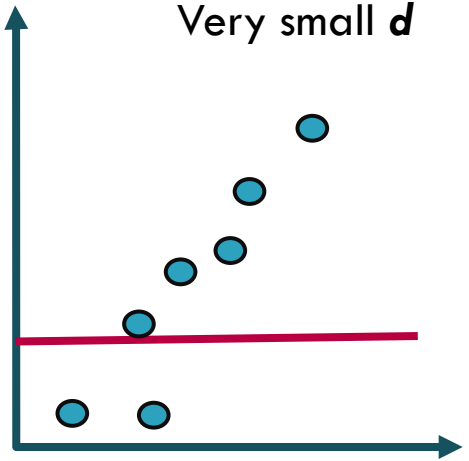
Overfitting

Optimal value
of ***γ or d***



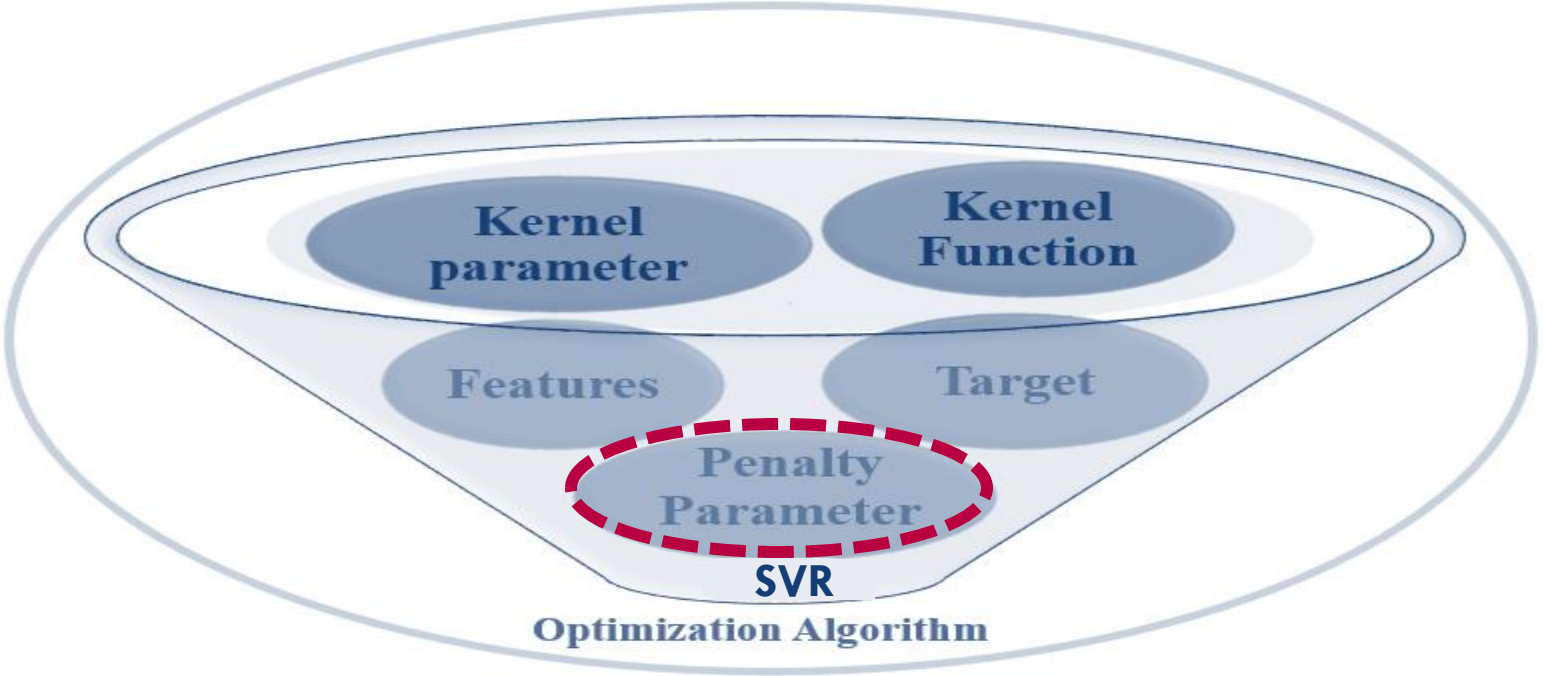
Fit
(Good generalization)

Very large ***γ or***
Very small ***d***



Underfitting

Introduction



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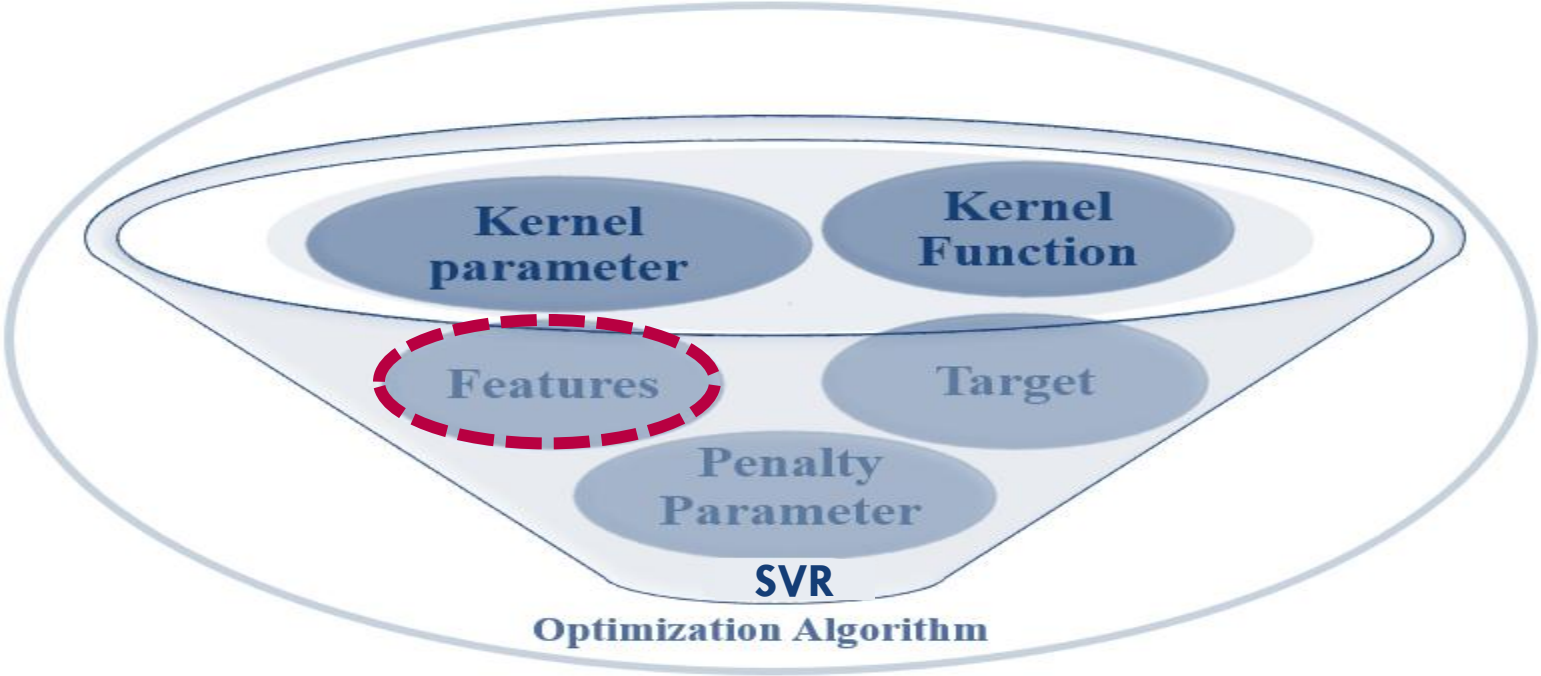

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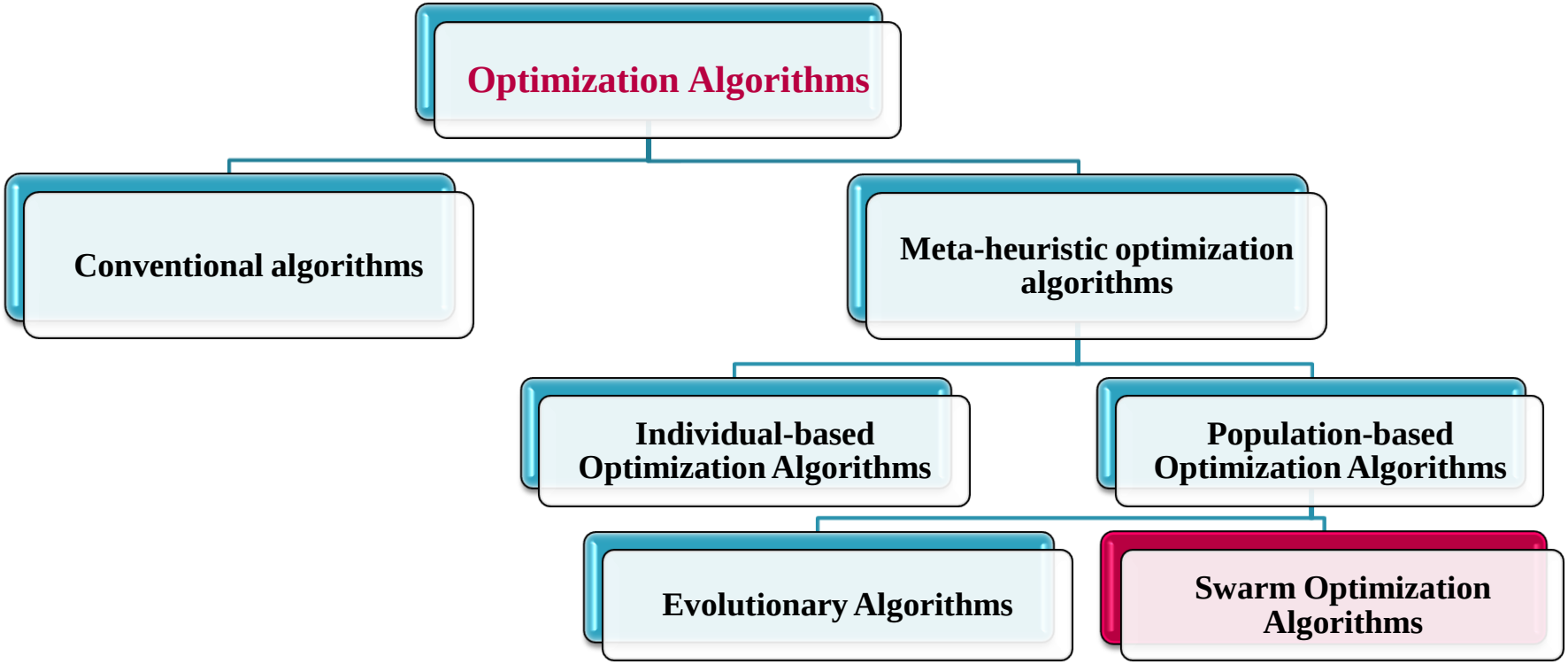

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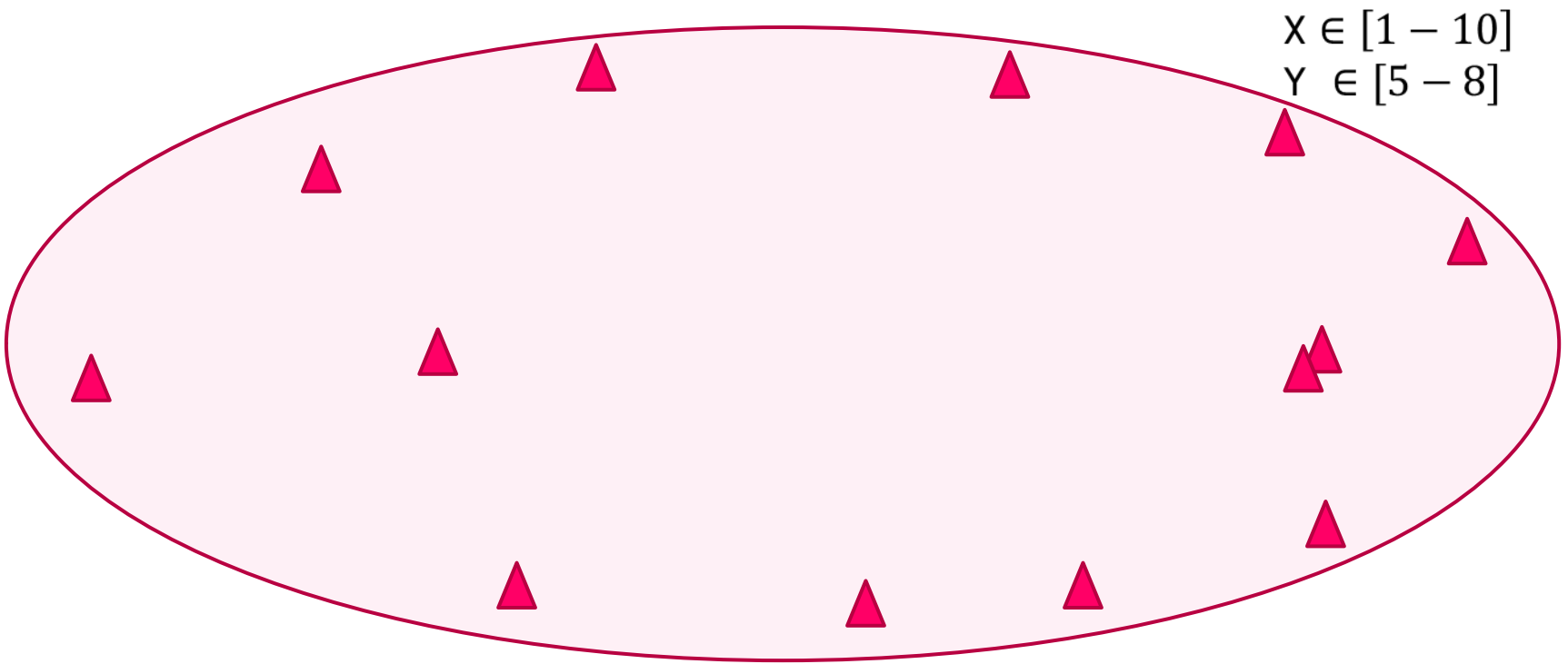

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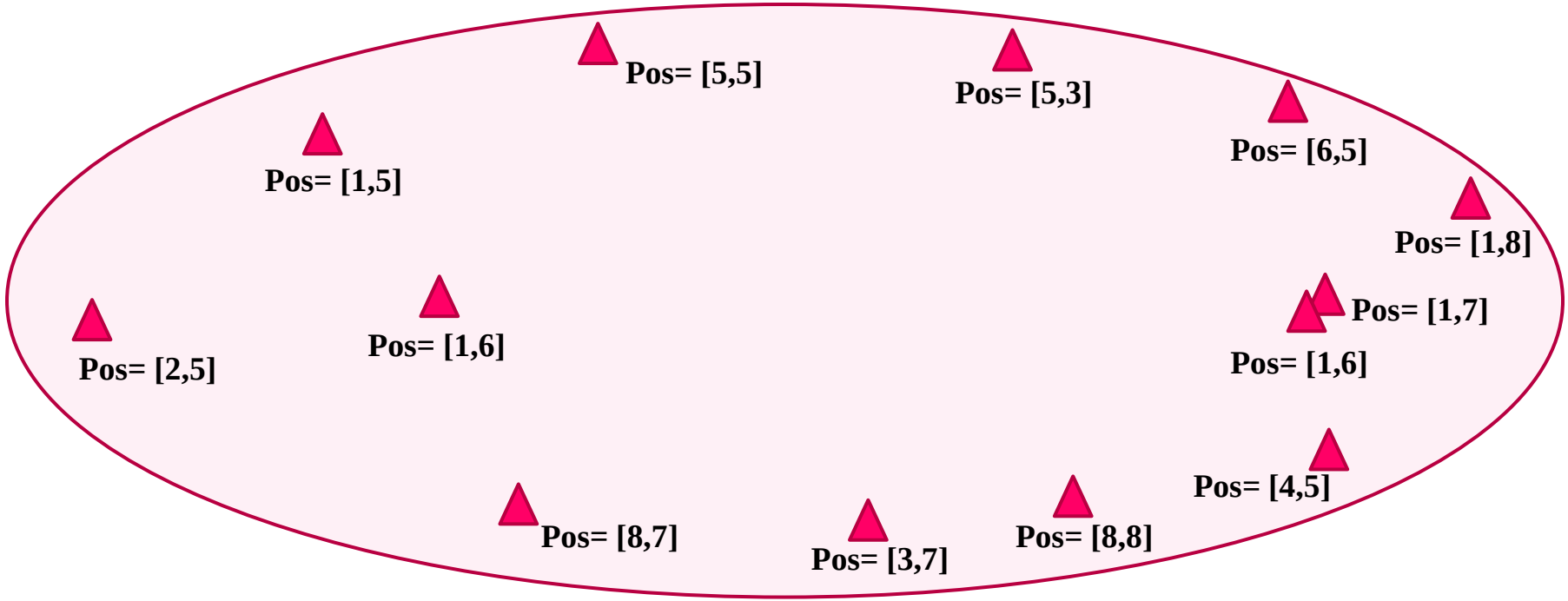

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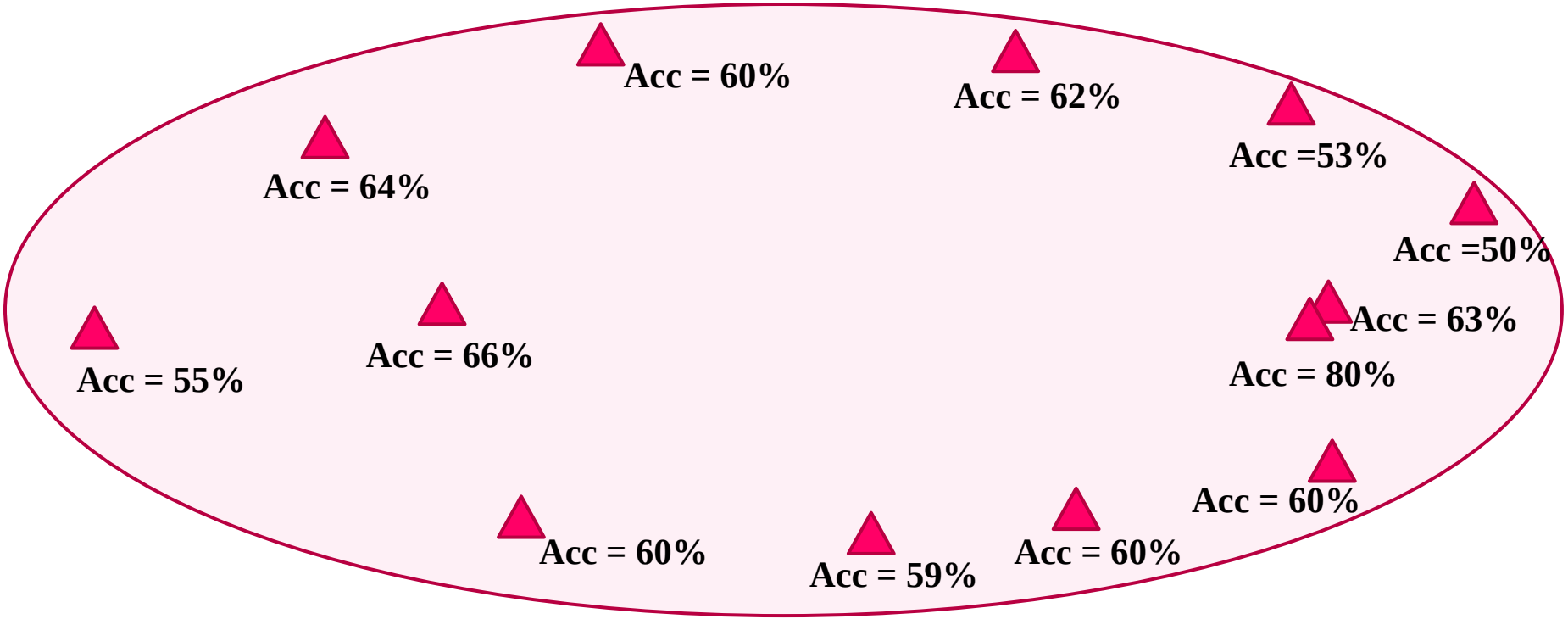

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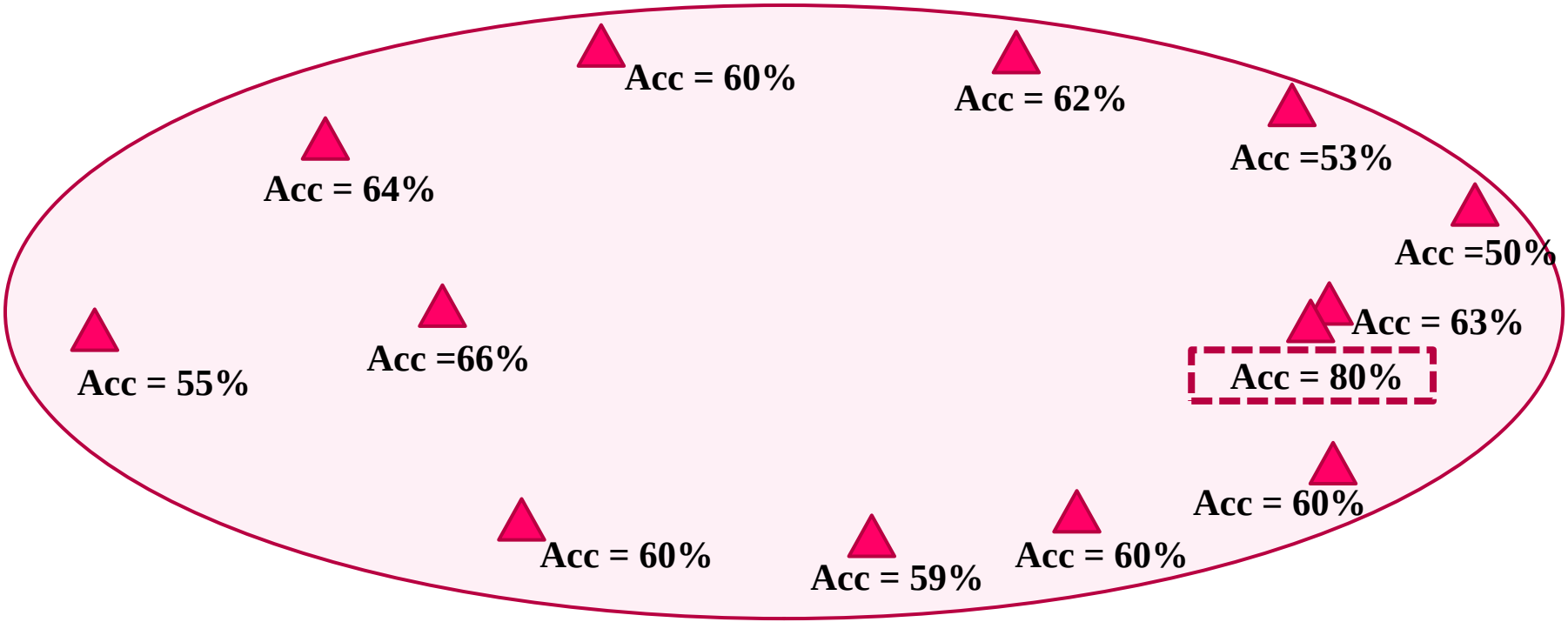

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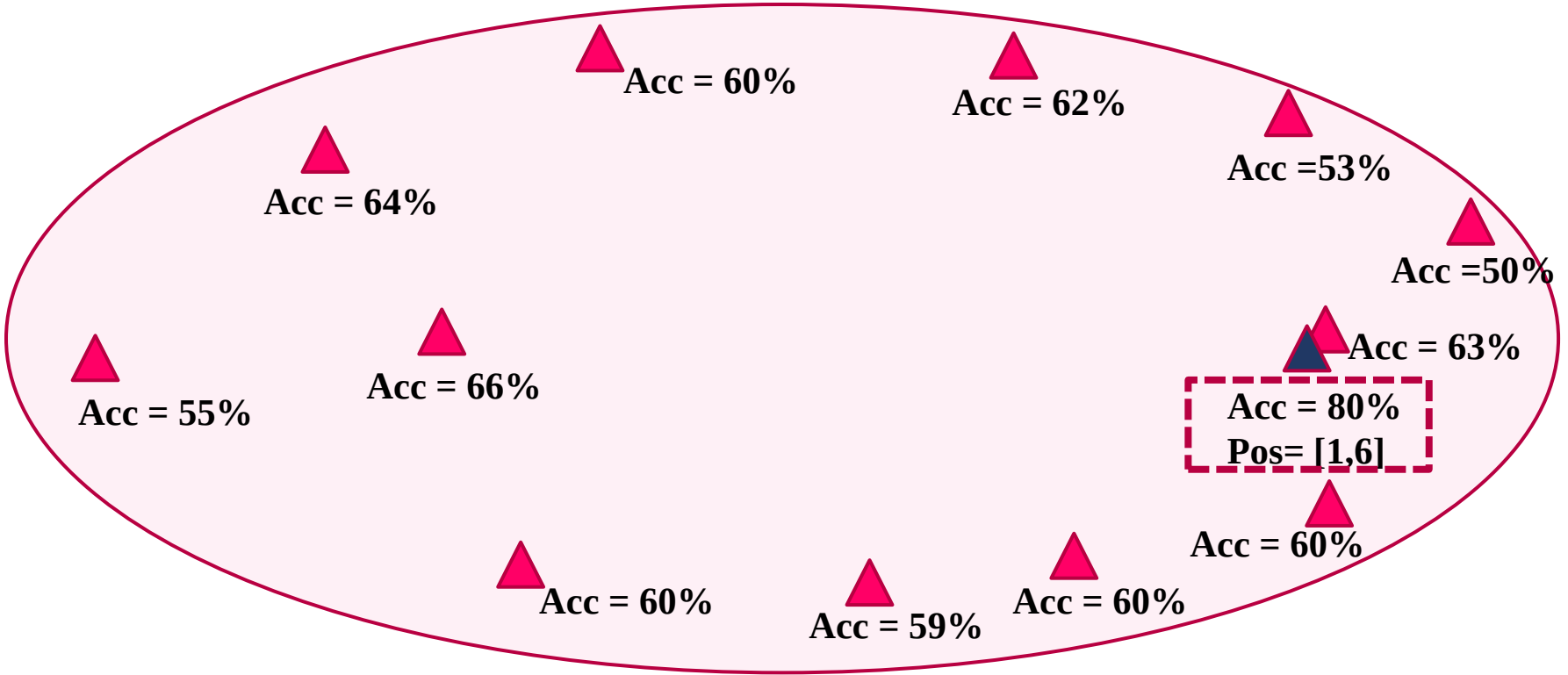

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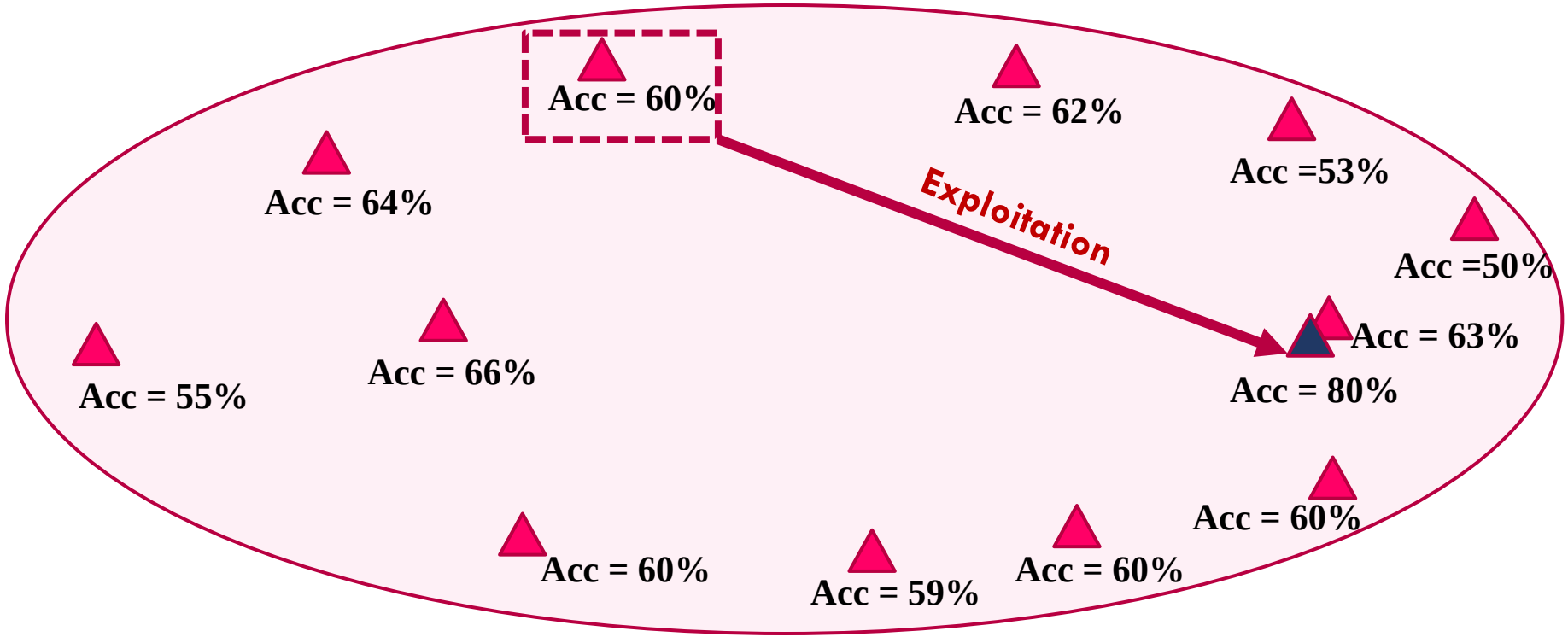

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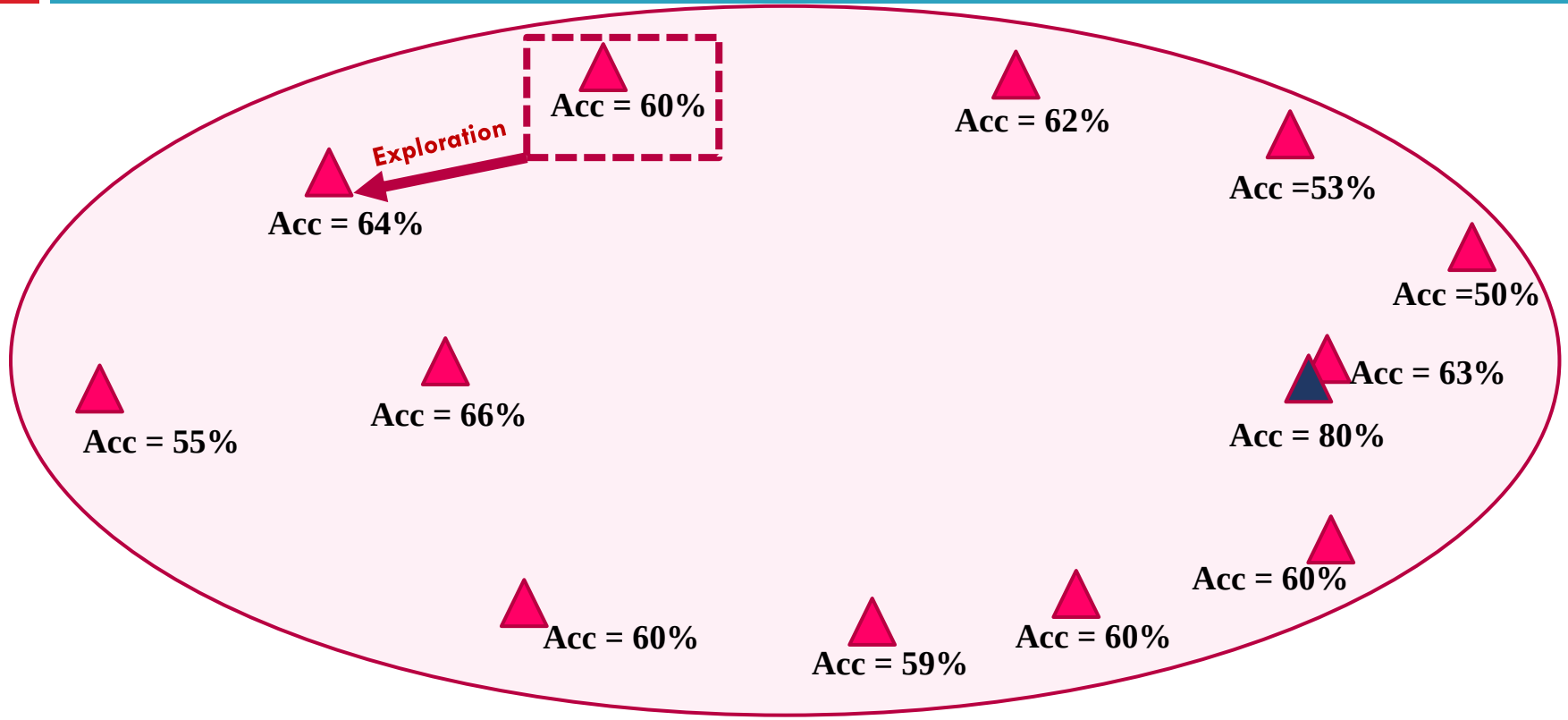

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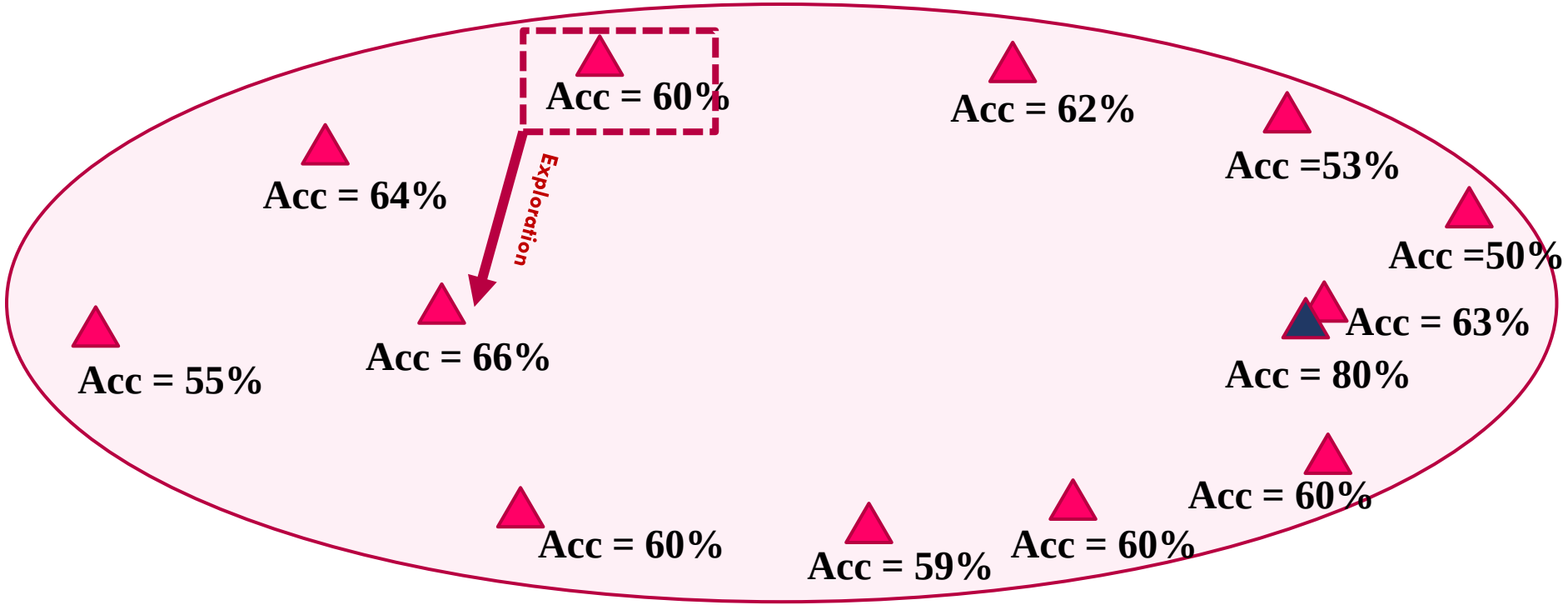

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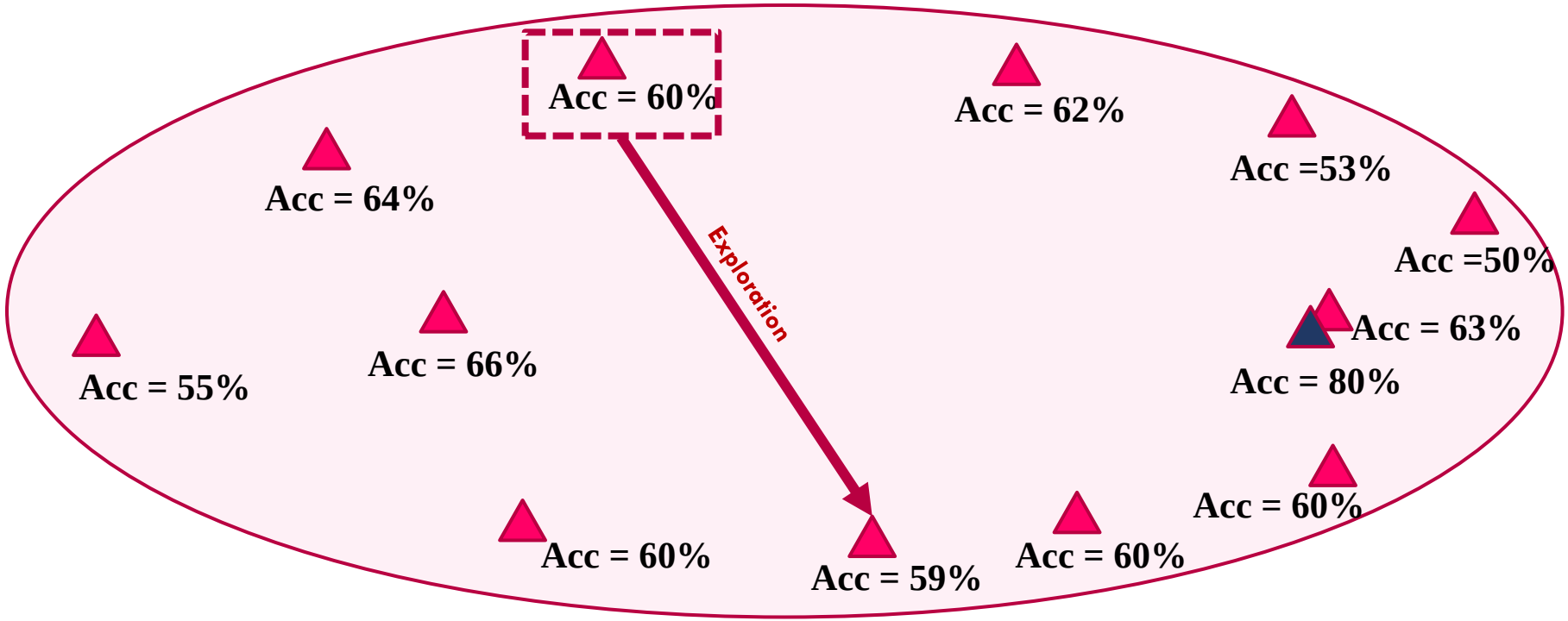

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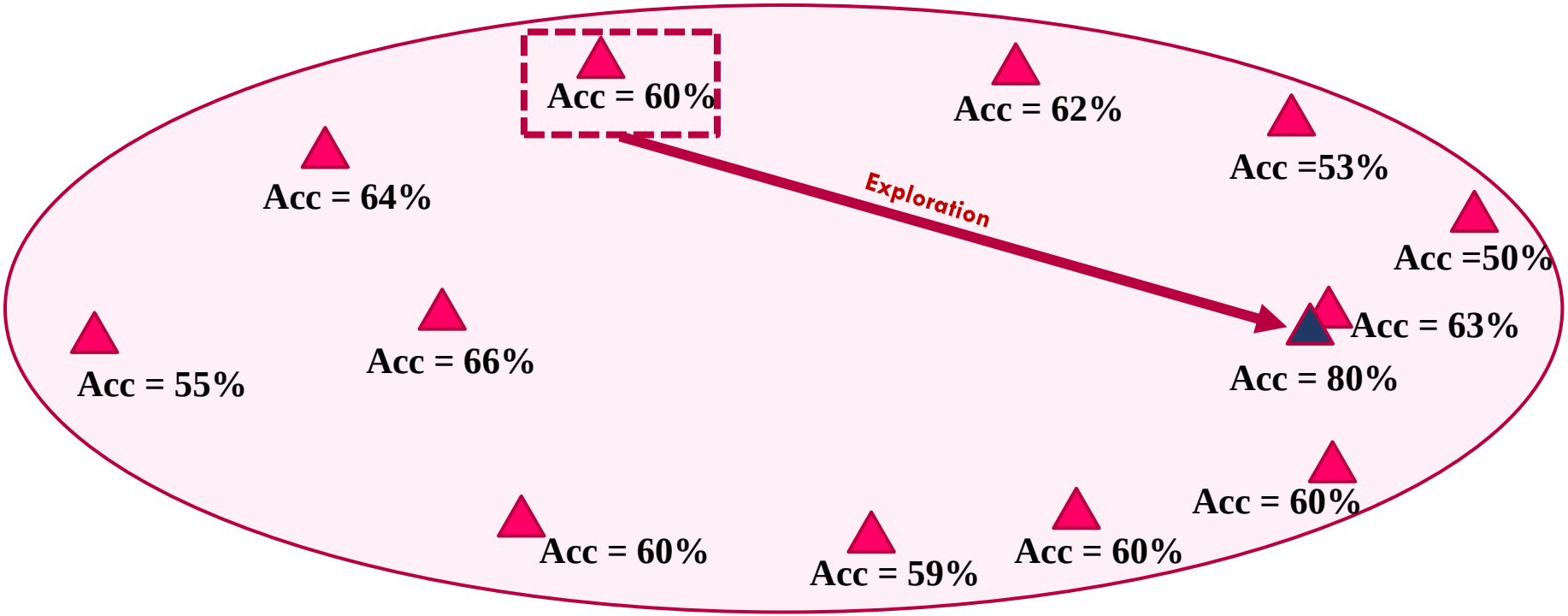

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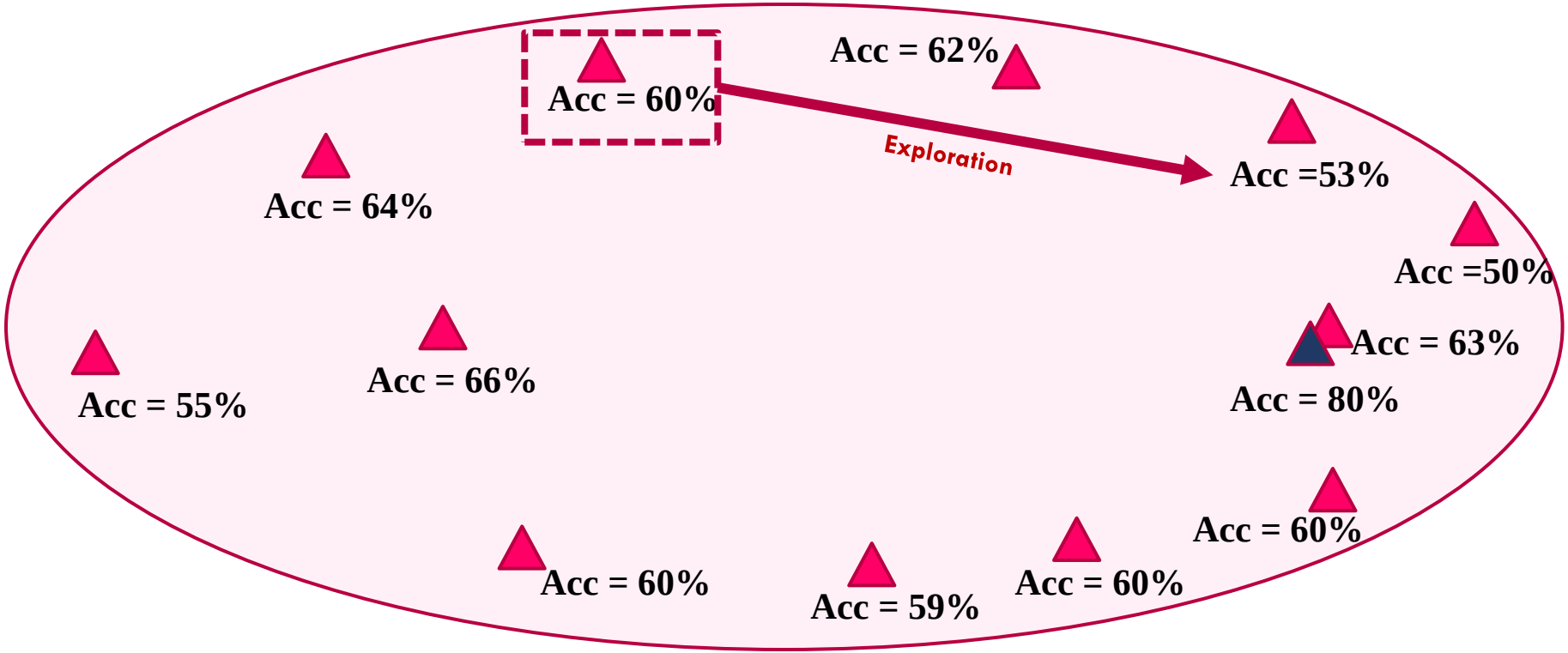
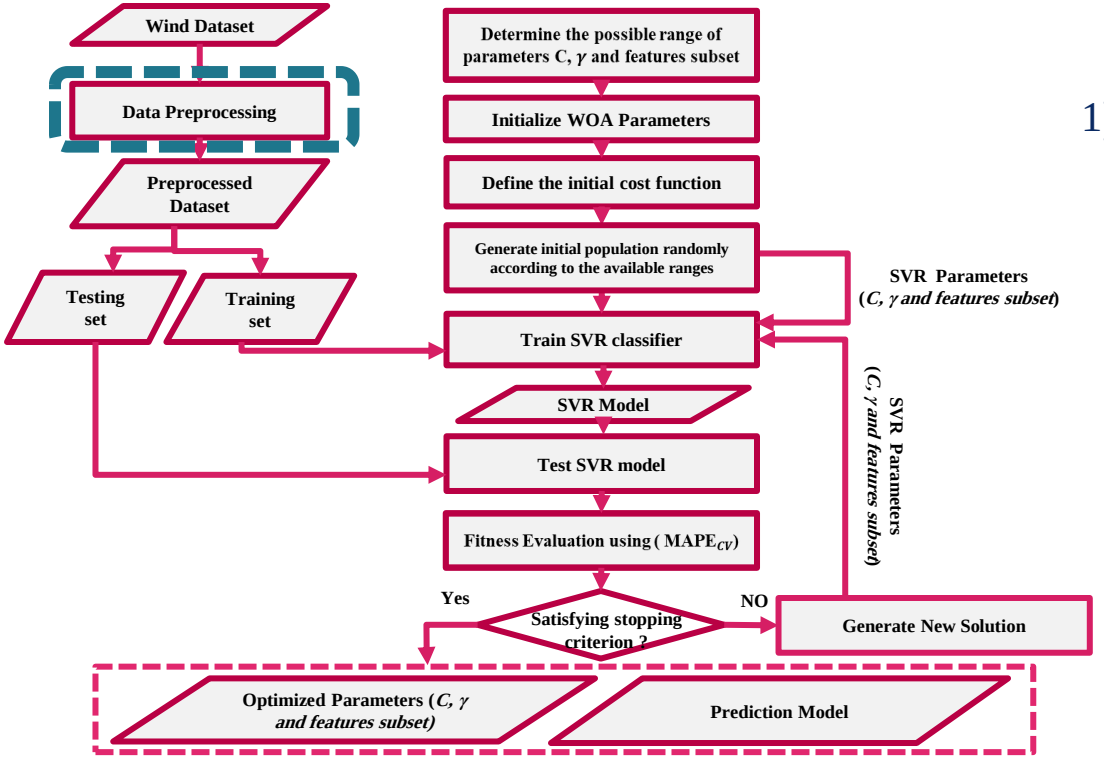


Introduction

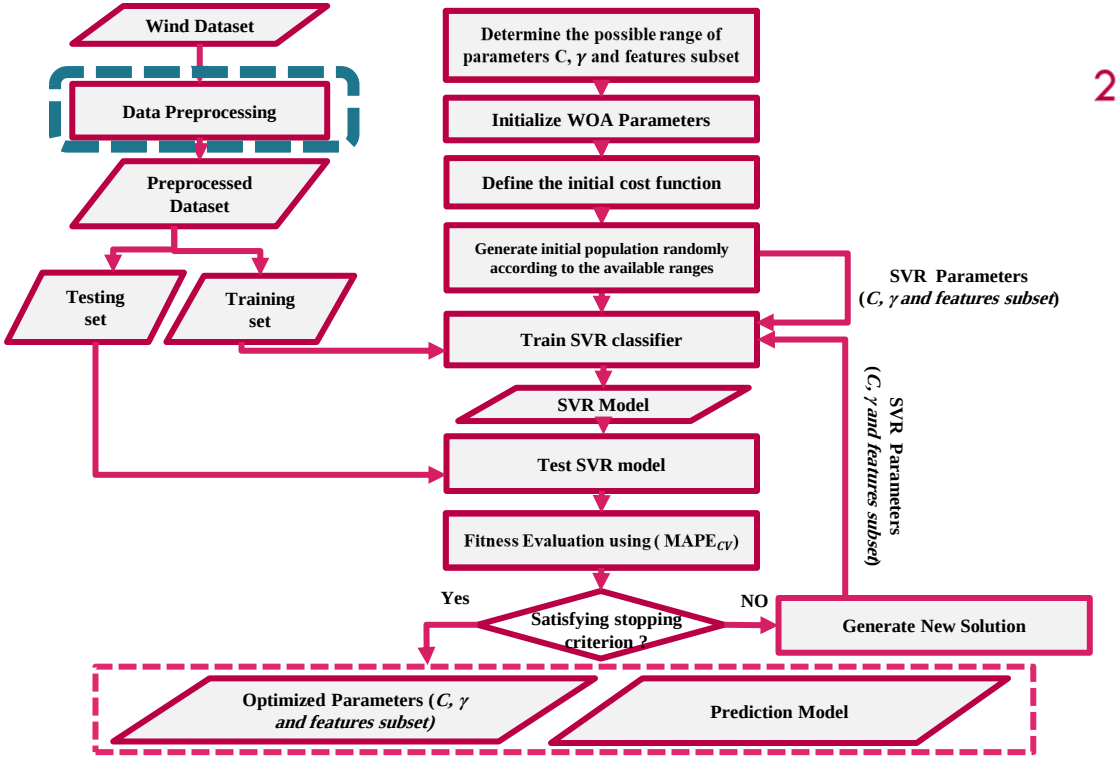
- Using Whale Optimization Algorithm(WOA) to
  - Optimize Kernel function parameter
  - Optimize Penalty parameter
  - Feature selection
- Comparing our results with Traditional SVR and PSO

Proposed WOA-SVR Algorithm



1) In the collected data set, there are some problems such as **missing values**. To overcome this problem, linear interpretation is used to fill these gaps and solve this problem.

Proposed WOA-SVR Algorithm

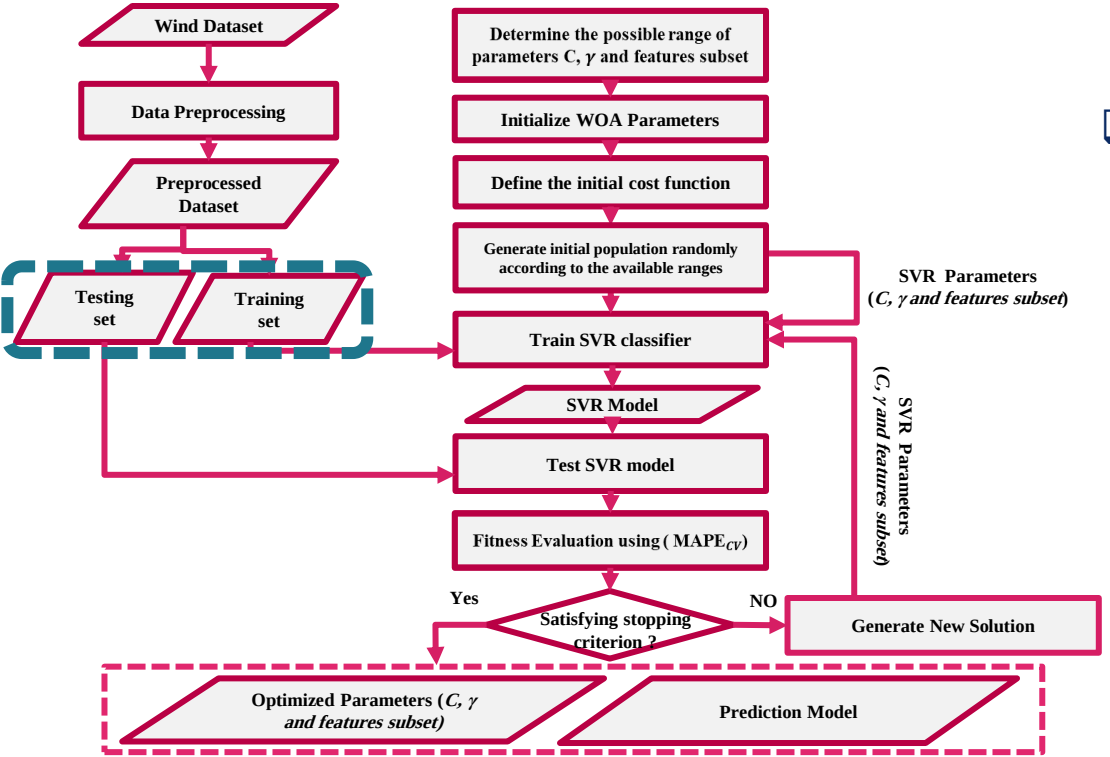


2) Data scaling (Data normalization)

Generally, every feature could be linearly scaled to the range [-1, 1] or [0, 1]. Selecting the target range depends on the nature of the data. Consider

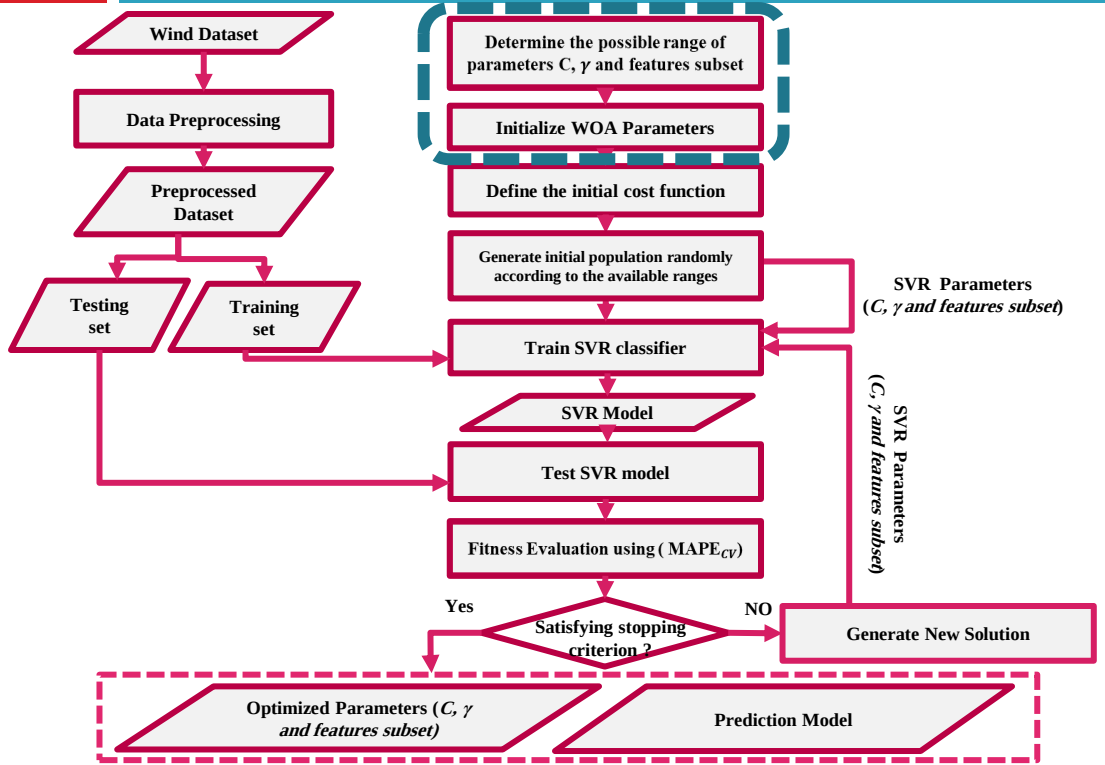
$$x_i^{scale} = \frac{x_i - x^{min}}{x^{max} - x^{min}}$$

Proposed WOA-SVR Algorithm



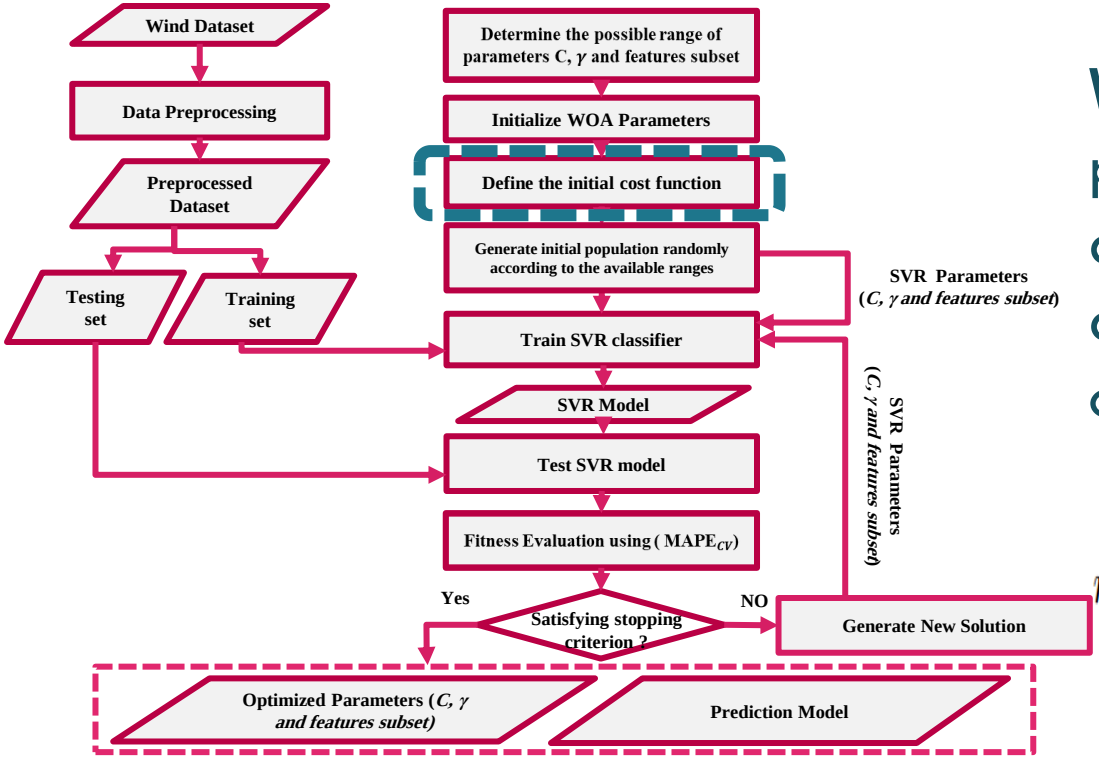
- The dataset is divided into two subsets namely **training** and **testing** datasets using **k-fold cross validation** algorithm(K=3)

Proposed WOA-SVR Algorithm



Parameter	Value
Maximum number of iteration(Generation)	10
Number of search agents size(Population)	20
Dimension	17
b in WOA	3
Lowe bound of C	1
Upper bound of C	1000
Lowe bound of γ	1
Upper bound of γ	100
Lowe bound of feature	1
Upper bound of feature	15

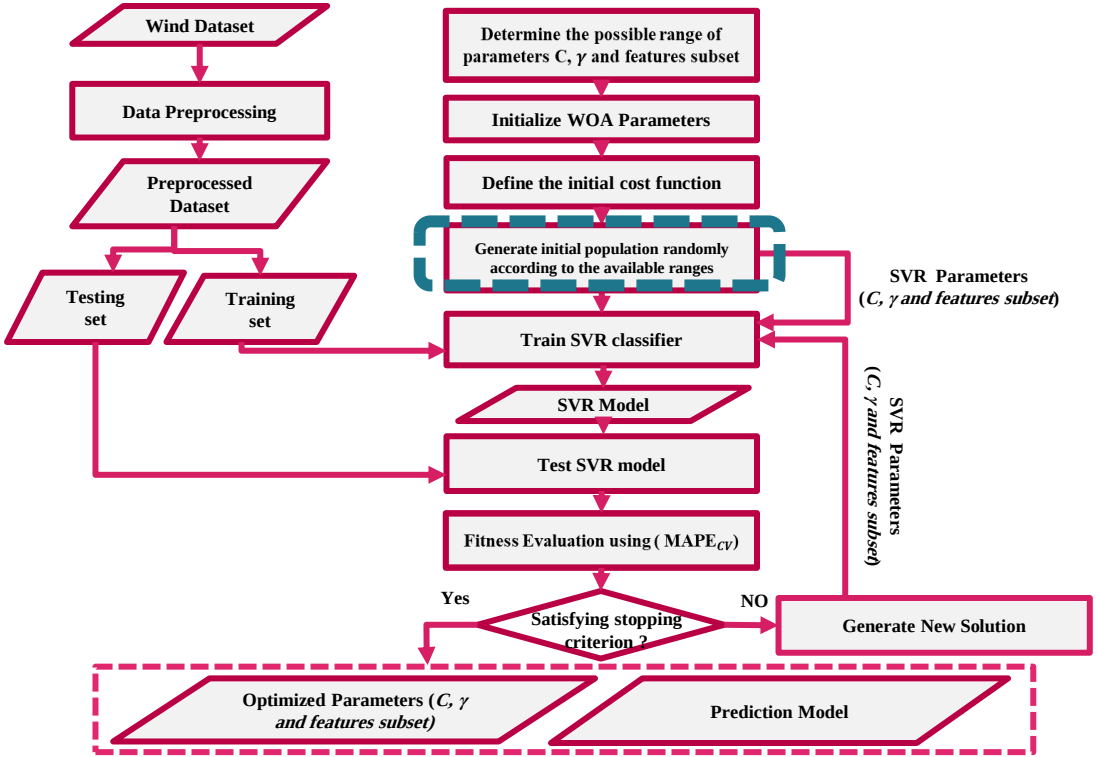
Proposed WOA-SVR Algorithm



WOA use mean abstract percent error (**MAPE**) to determine the goodness or quality of each search agent or solution

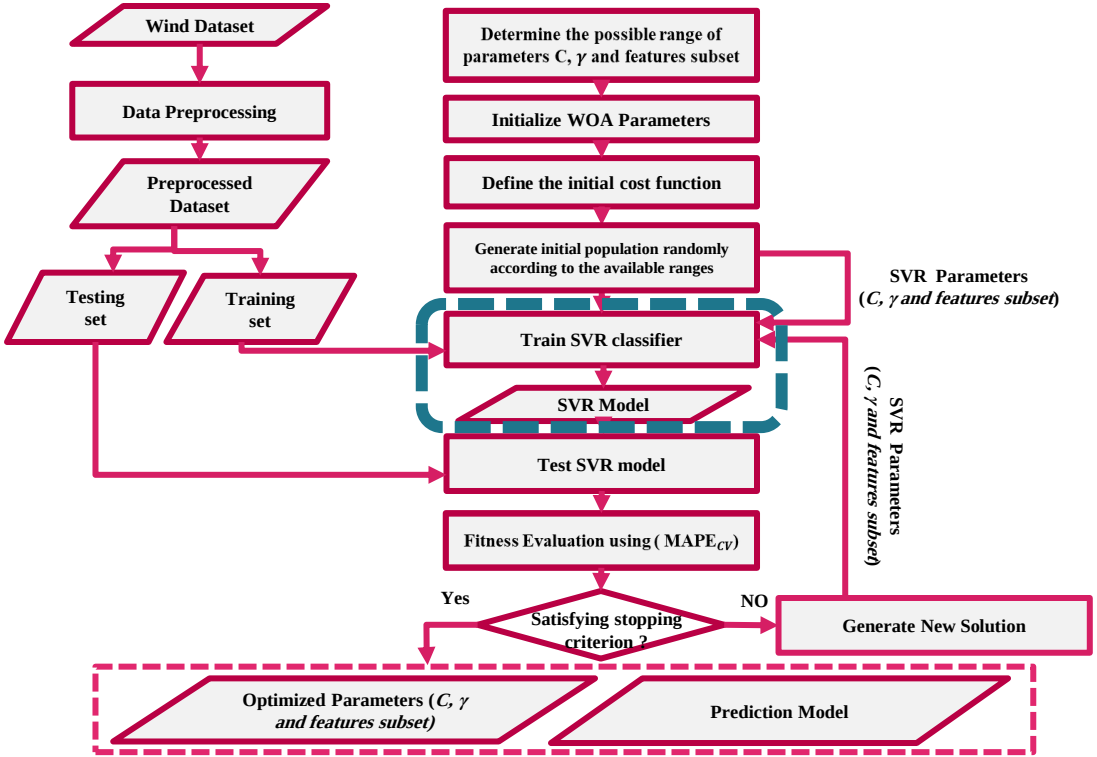
$$min f = MAPE_{CV} = \frac{1}{l}\sum_{1=1}^{l}\left|\frac{Act_i - Pred_i}{Act_i}\right| \times 100 \quad (17)$$

Proposed WOA-SVR Algorithm



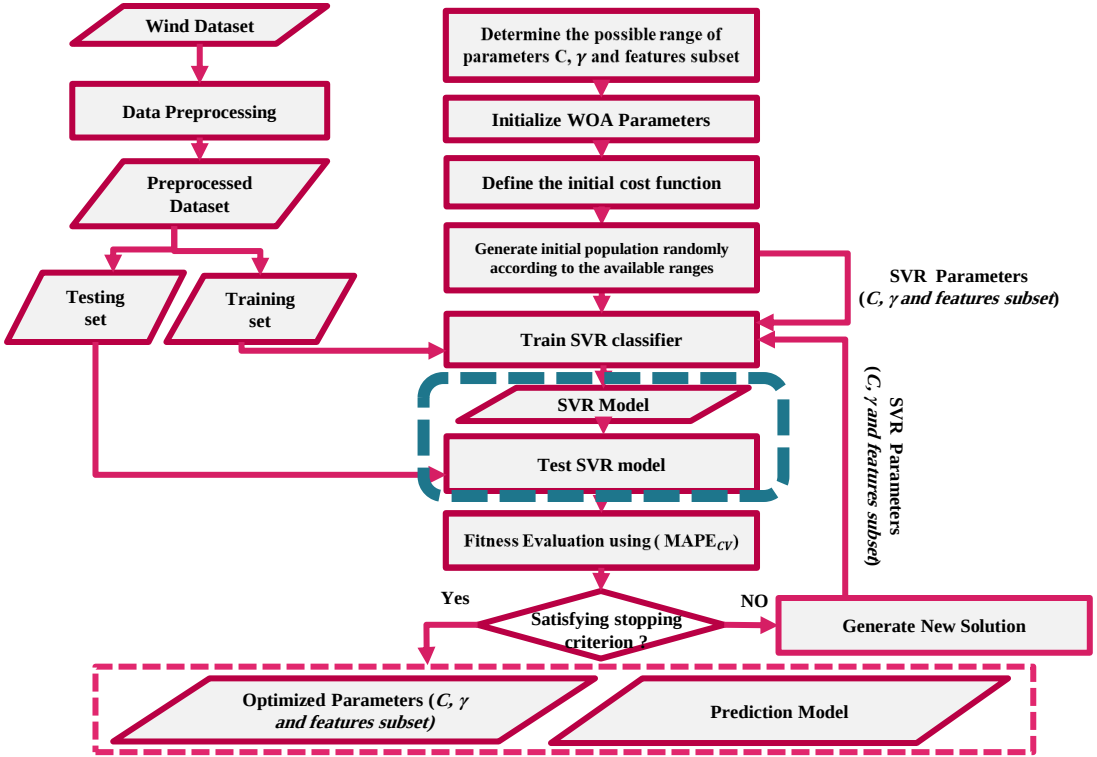
WOA Generate initial population randomly according to the available ranges

Proposed WOA-SVR Algorithm



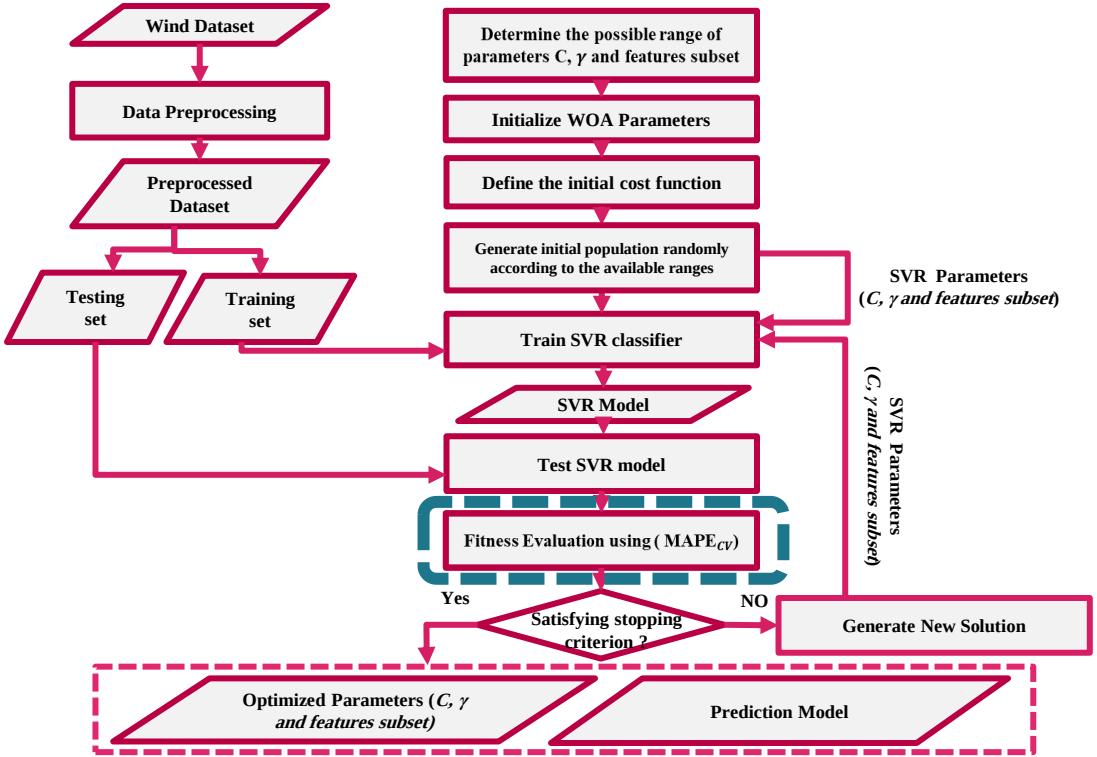
Train SVR using training dataset and selected parameters

Proposed WOA-SVR Algorithm



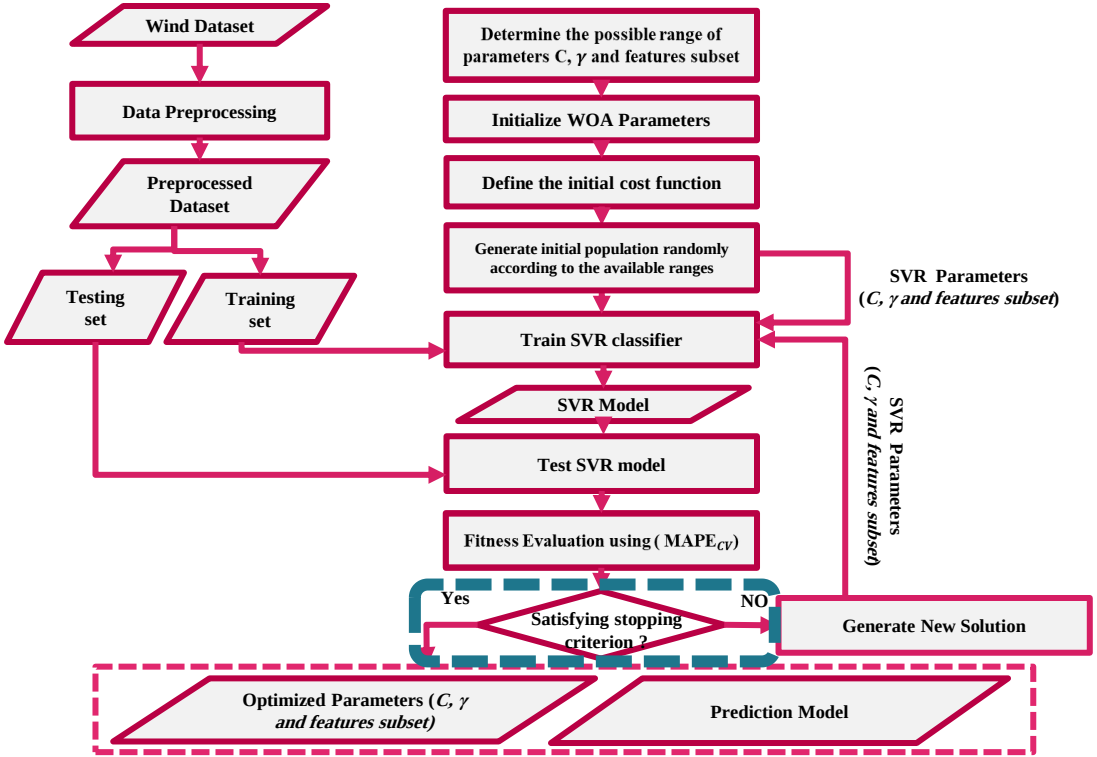
Test SVR model using testing dataset

Proposed WOA-SVR Algorithm



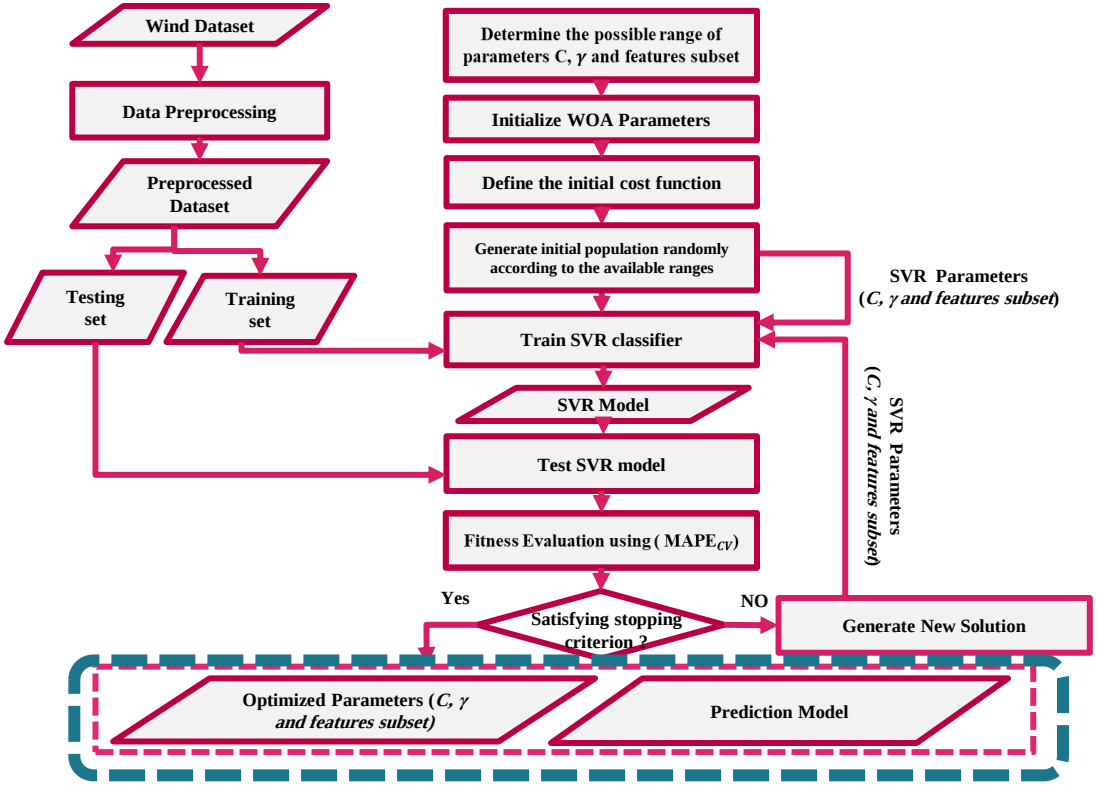
Calculate fitness function for each whale and select the best one to be the optimal solution

Proposed WOA-SVR Algorithm



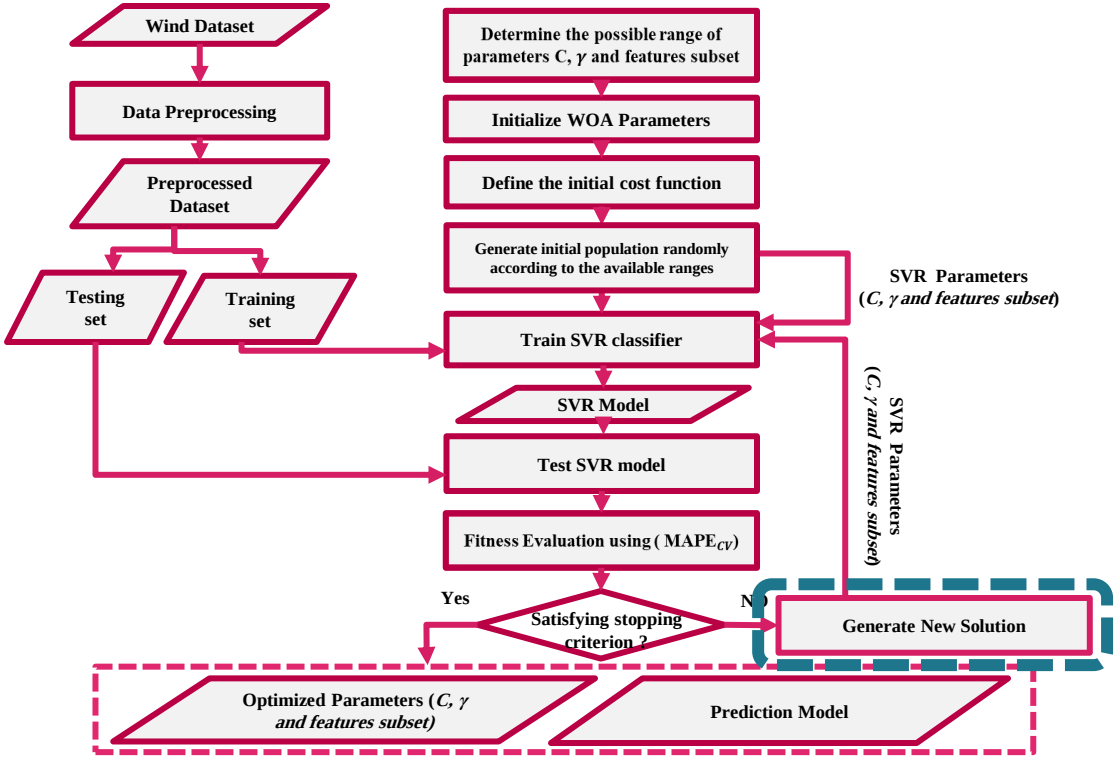
When the termination criteria are satisfied, the operation ends; otherwise, we proceed with the next generation operation. In the proposed algorithms, the WOA is terminated when a maximum number of iterations are reached.

Proposed WOA-SVR Algorithm



Return SVR optimal parameters and prediction Model

Proposed WOA-SVR Algorithm



Each whale proceeds to its next locations.

Experimental results and discussion

Description of Experimental Data

- The used data in this paper is measured on an average daily basis from a meteorological station at Helwan University, Cairo, Egypt, these data were gathered for the year 2016.
- In this paper, sixteen meteorological factors

Experimental results and discussion

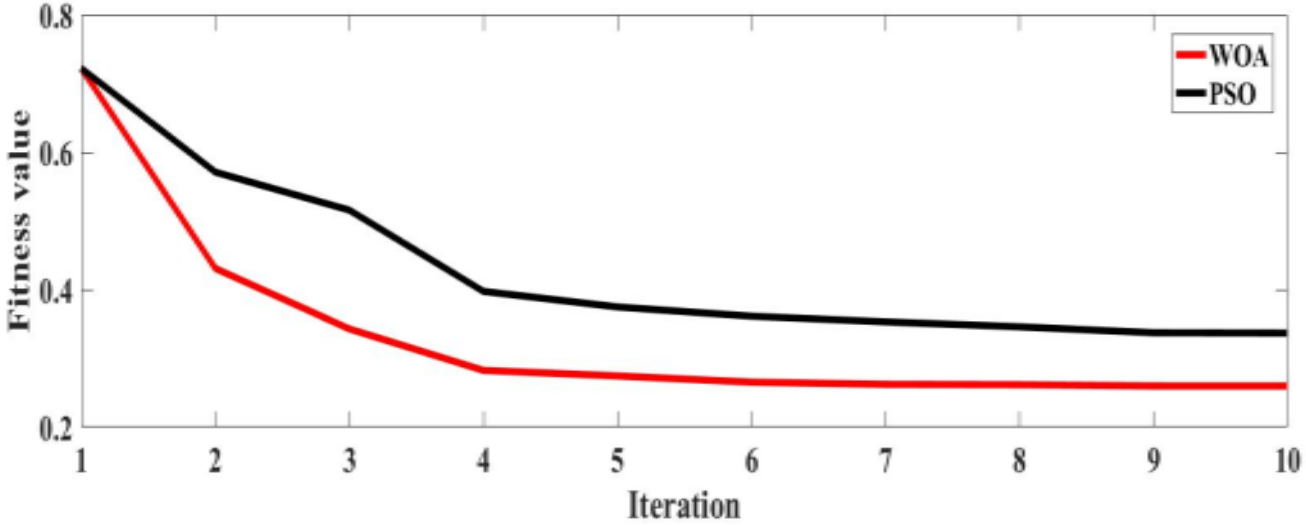
- ***Description of Experimental Data***
  - The time of the study ranges from January 1, 2016, to December 22, 2016, except some missing days. The data set includes 197 wind samples
  - These data are complete and daily average weather data that collected and employed from the Space Weather Monitoring Center (SWMC) in Egypt

Experimental results and discussion

- *Evaluation metrics*
  - *Convergence*
  - *Forecasting Accuracy Measurements*
    - *MAE*
    - *MSE*
    - *MAPE*
    - *RMSE*

Experimental results and discussion

❑ *Comparison of Convergence:*



Experimental results and discussion

❑ *Forecasting Accuracy Measurements*

Meassure	Classifier		
	SVR	WOA-SVR	PSO-SVR
MAPE (%)	0.7010	0.2600	0.3238
MAE	0.5229	0.2243	0.2724
MSE	0.5380	0.2112	0.2488
RMSE	0.7290	0.4282	0.4738




Conclusion

- In this paper, a novel optimization algorithm based on the Whale Optimization Algorithm (WOA) and SVR called WOA-SVR was proposed to optimize the SVR parameters. This algorithm is employed to enhance the performance of SVR in order reduce the regression for wind speed prediction.
- The performance of WOA-SVR algorithms is estimated and compared using wind datasets as real world cases.
- From the experimental results, it can be concluded that WOA-SVR algorithm achieved MAPE, MAE, MSE and RMSE lower than PSO-SVR and traditional SVR.

Future Works

- Multi-kernel learning SVR for wind speed prediction,
- Chaotic swarm optimization for SVR parameters optimization,
- Present a comparative analysis of a swarm optimization algorithms and Kernel functions
- It is an important issue to check the reliability and stability of proposed algorithm, and this can be done by increasing the dataset size.

Questions!?

Thanks and Acknowledgement