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VorAIS: A Multi-Objective Voronoi Diagram-based Artificial Immune System

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Context

- Artificial Immune Systems have been derived from existing theories of the functioning of biological immune systems.
- They create a model that is able to discriminate between normal (self) and abnormal (non-self) objects.
- This feature makes AIS specially suited for dealing with problems related to anomaly and intrusion detection.

VorAIS diagram-based Artificial Immune System

VorAIS models the self/non-self using a Voronoi diagram that determines which areas of the problem domain correspond to self or to non-self.

- Various classification metrics, like accuracy, recall, and specificity, must be taken into account.
- Multi-objective approach based on non-dominated sorting of NSGA-II.
- We introduce a mating operator as part of the AIS.

VorAIS components

VorAIS outline

1. Create an initial random population \( \mathcal{P}_0 \) of \( n_{\text{pop}} \) individuals.
2. At iteration \( t \), individuals in \( \mathcal{P}_t \) are mated and mutated.
3. An offspring population, \( \mathcal{P}_{\text{off}} \), with \( n_{\text{off}} \) individuals is created.
4. From \( \mathcal{P}_t \cup \mathcal{P}_{\text{off}} \) the best \( n_{\text{pop}} \) individuals are selected using non-dominated sorting (with crowding distance).

Hyperparameters tuned by grid search (see PPSN paper).

Preliminary study on test problems

- Influence of the mating operator (+m) and the use of the classification metrics (a, r and s, respectively), on two-dimensional problems.

NSL KDD’99 anomaly detection problem

- Compare VorAIS with other AISs in a computer network anomaly detection benchmark problem.
- NSL-KDD’99 has 41—38 numeric and 3 categorical—features and one class attribute describing the nature of the events.

Final remarks

- We have obtained a performance comparable with the state of the art but adequate classification performance is not enough.
- It is necessary to create a compact representation of the ‘normal’ data.
- We developed custom objective functions that rely on volume-based approaches.