UNPAS
Teknik Informatika
Universitas Pasundan

Artificial Immune System Algorithms & Implementation

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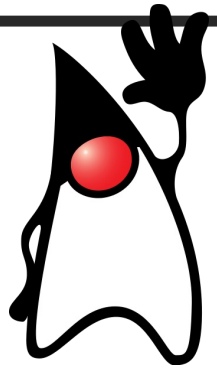
Biodata



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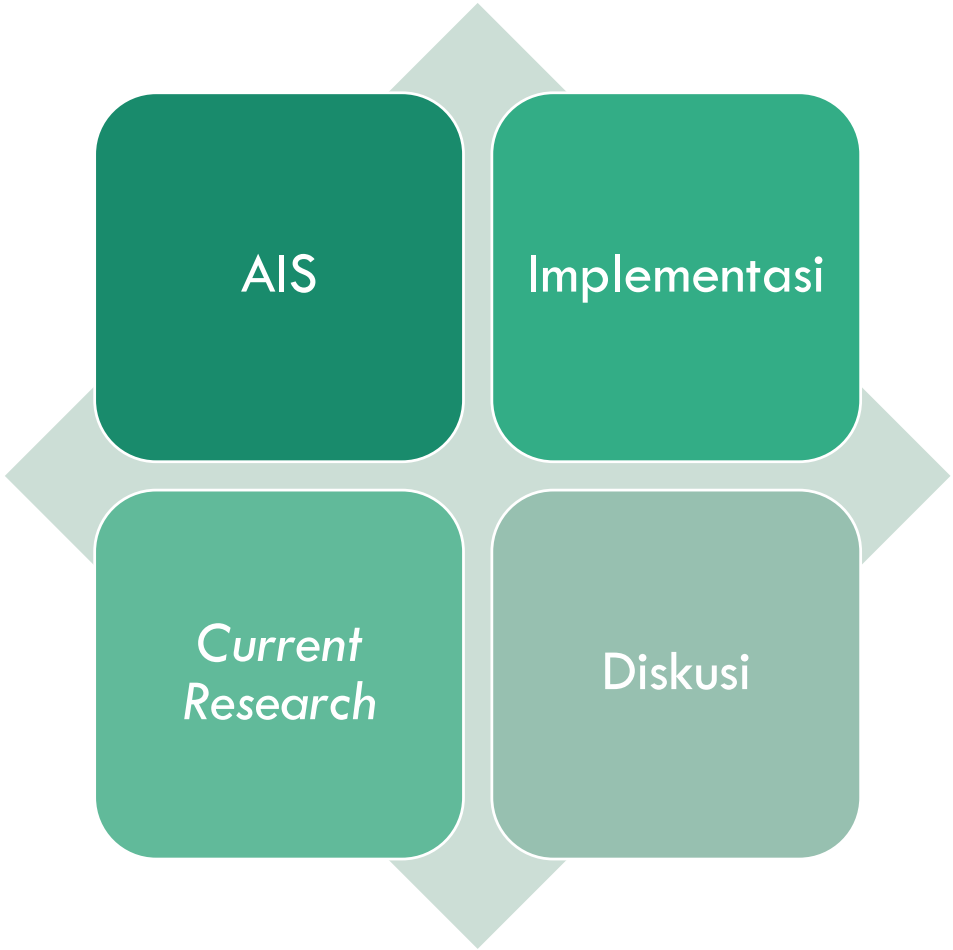
Outline



AIS, Definition

01 Artificial Intelligence

- ✓In artificial intelligence, artificial immune systems (AIS) are a class of computationally intelligent, rule-based machine learning systems inspired by the principles and processes of the vertebrate immune system.

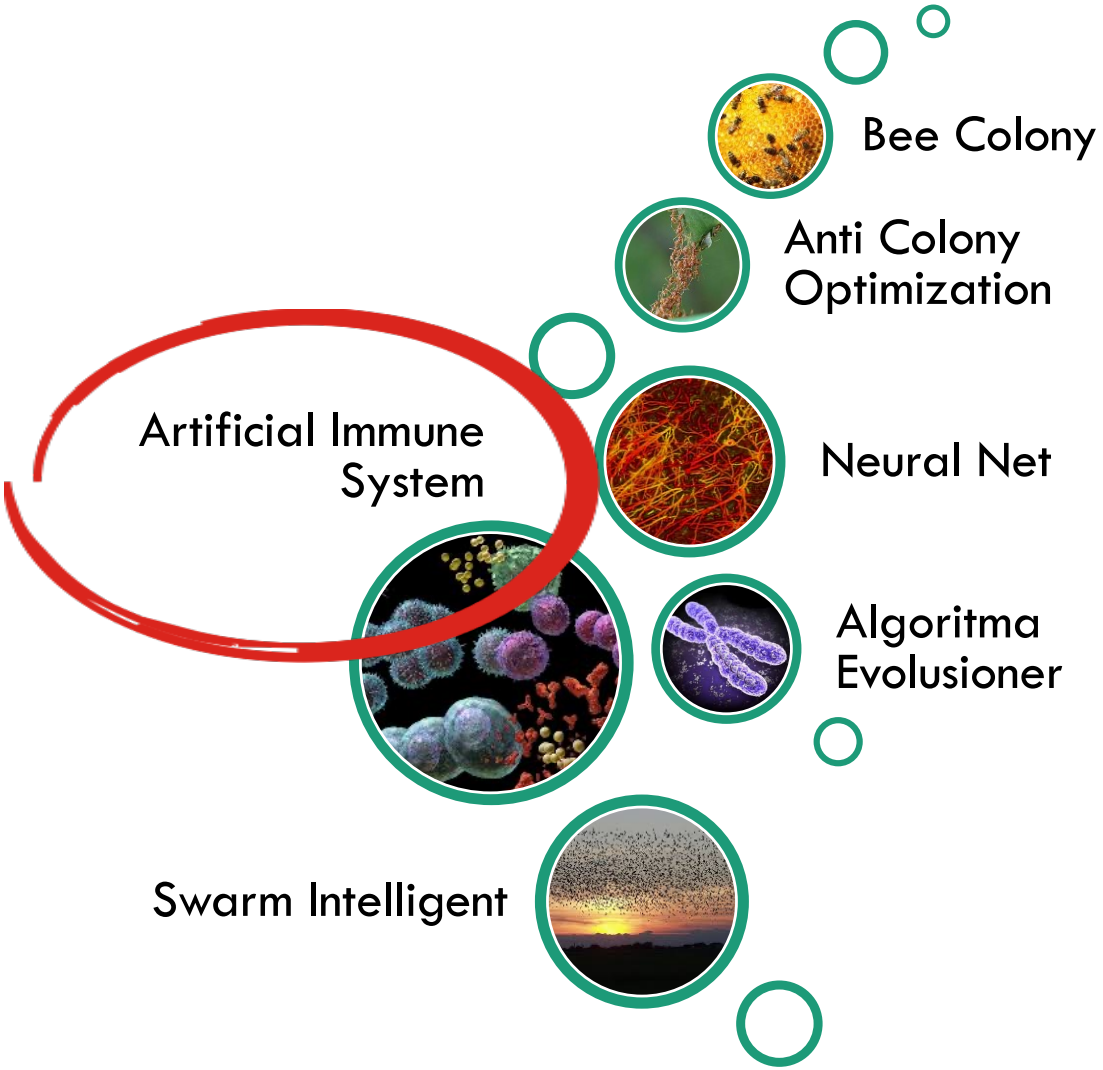
02 Sub-field

- ✓AIS is a sub-field of biologically-inspired computing, and natural computation, with interests in machine learning and belonging to the broader field of artificial intelligence.

03 Applied to problem solving

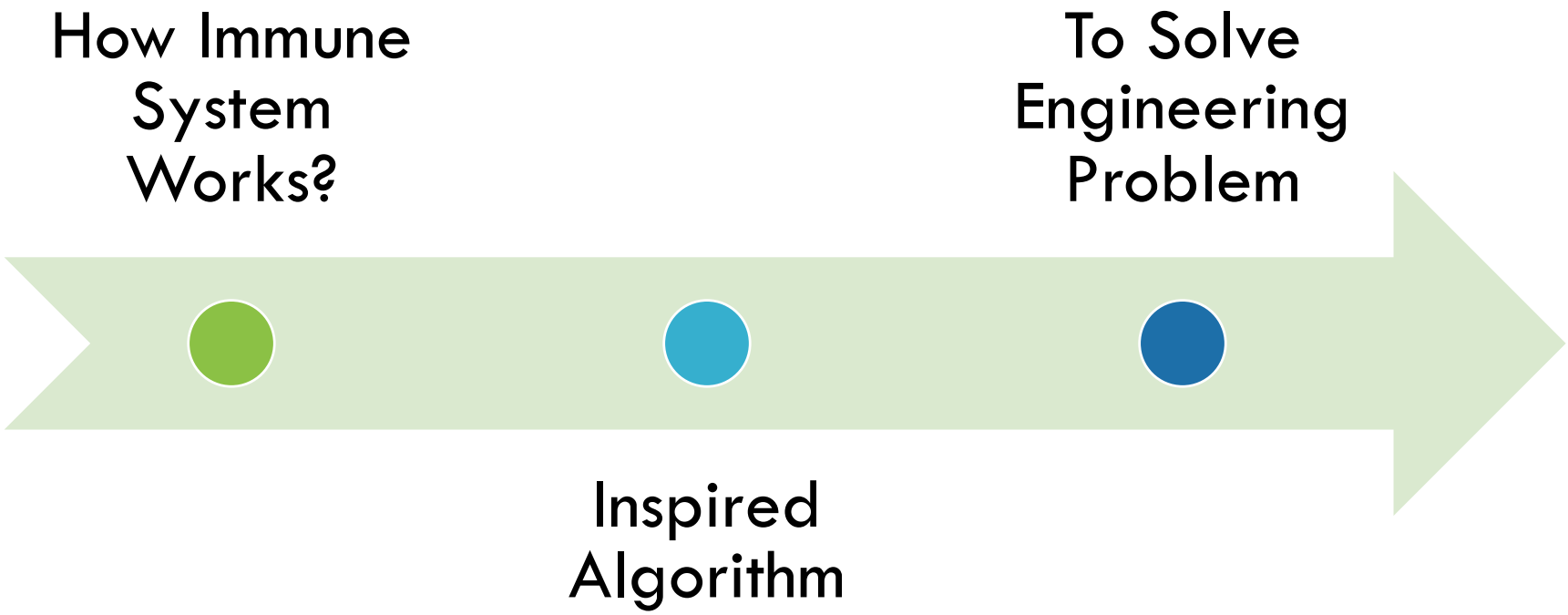
- ✓Artificial immune systems (AIS) are adaptive systems, inspired by theoretical immunology and observed immune functions, principles and models, which are applied to problem solving.

Bio-Inspired Computing



Ayi Purbasari

Artificial Immune System



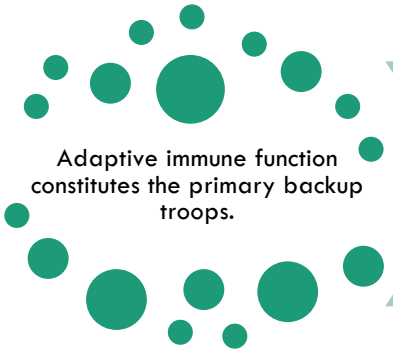
How Immune System Works

Immune function can be divided into two major components:

The innate immune system; it targets everything perceived to be a foreign threat.

The adaptive immune system; It targets specific threats that it recalls from past memory.

The Adaptive Immune System



Adaptive immune function constitutes the primary backup troops.

Adaptive immunity is comprised of lymphocytes, which are white blood cell (WBC) specialists.

To function, they must have intelligence information and have a specific identification of the target.

The steps:

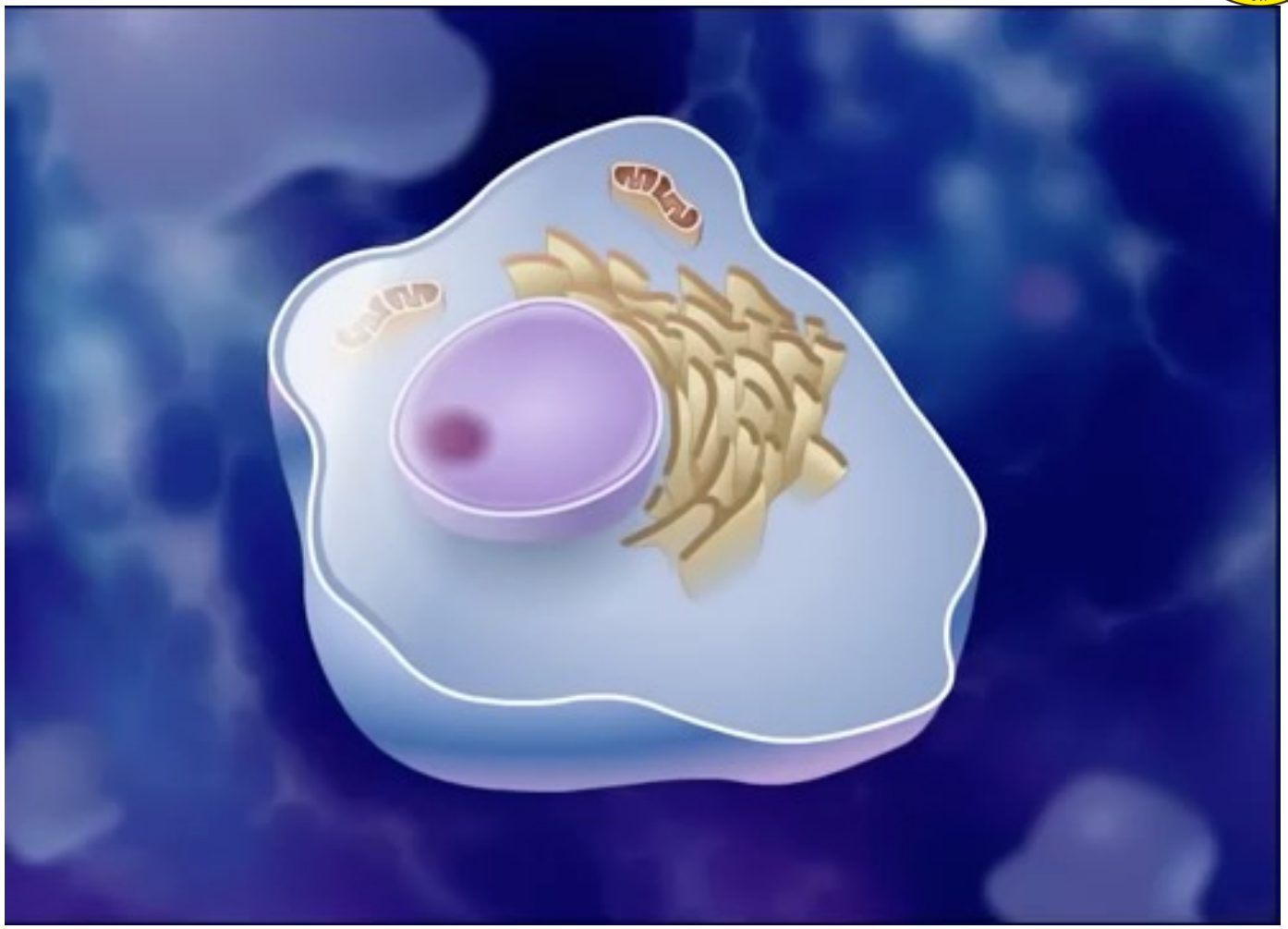
Recognition of target.

If the body recognizes the threat, an attack is immediately formulated.

If the threat is new, it takes more time to educate all the troops, but a plan of attack still goes into motion.

For a new threat that has never been recognized before, mobilizing the troops is typically a several-day affair.

How Immune System Works



Artificial Immune System

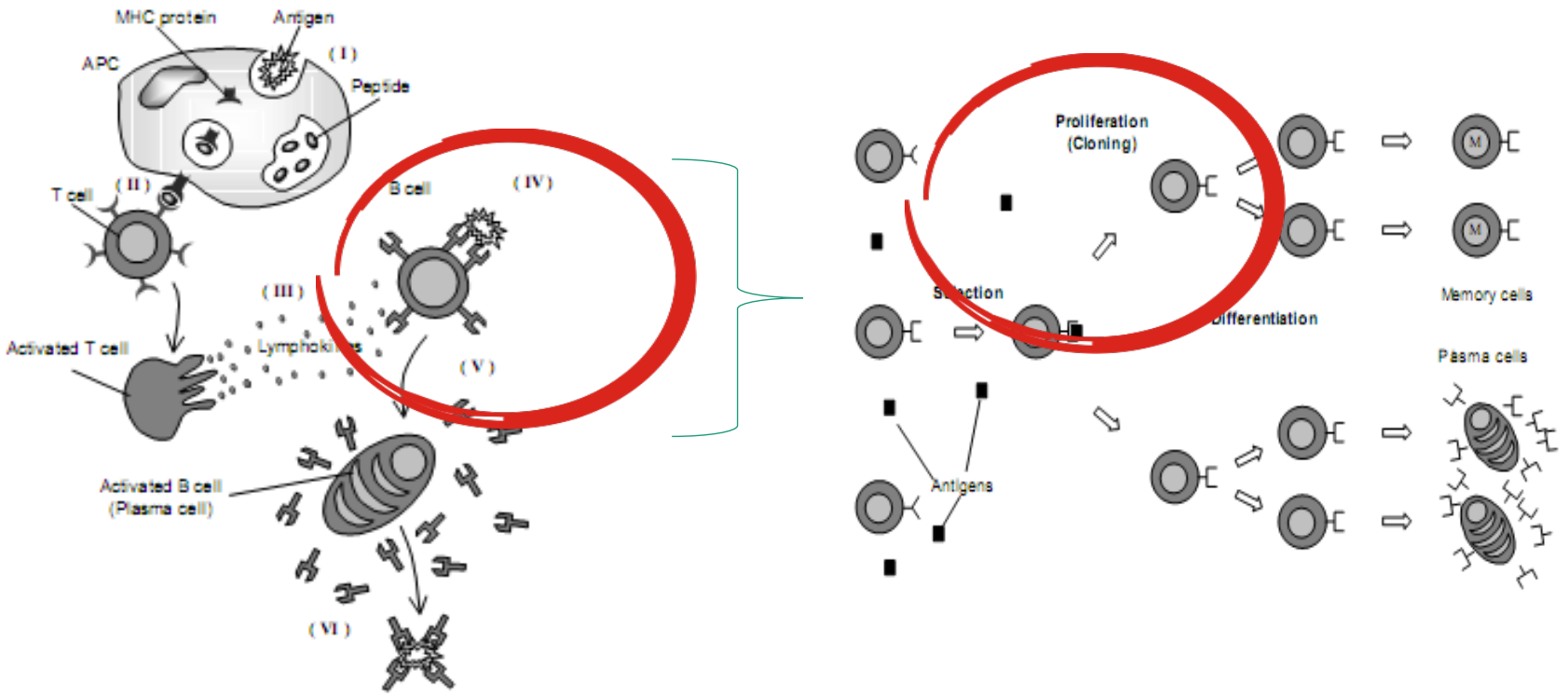
Immune System

- Immune Network Theory (Jerne)
- Clonal Selection Theory (Burnet)
- Negative Selection
- Danger Theory (Matzinger)

Artificial Immune System

- Immune Network Algorithm
- Clonal Selection Algorithm (de Castro & Von Zuben)
- Negative Selection Algorithm
- Dendrit Cell Algorithm

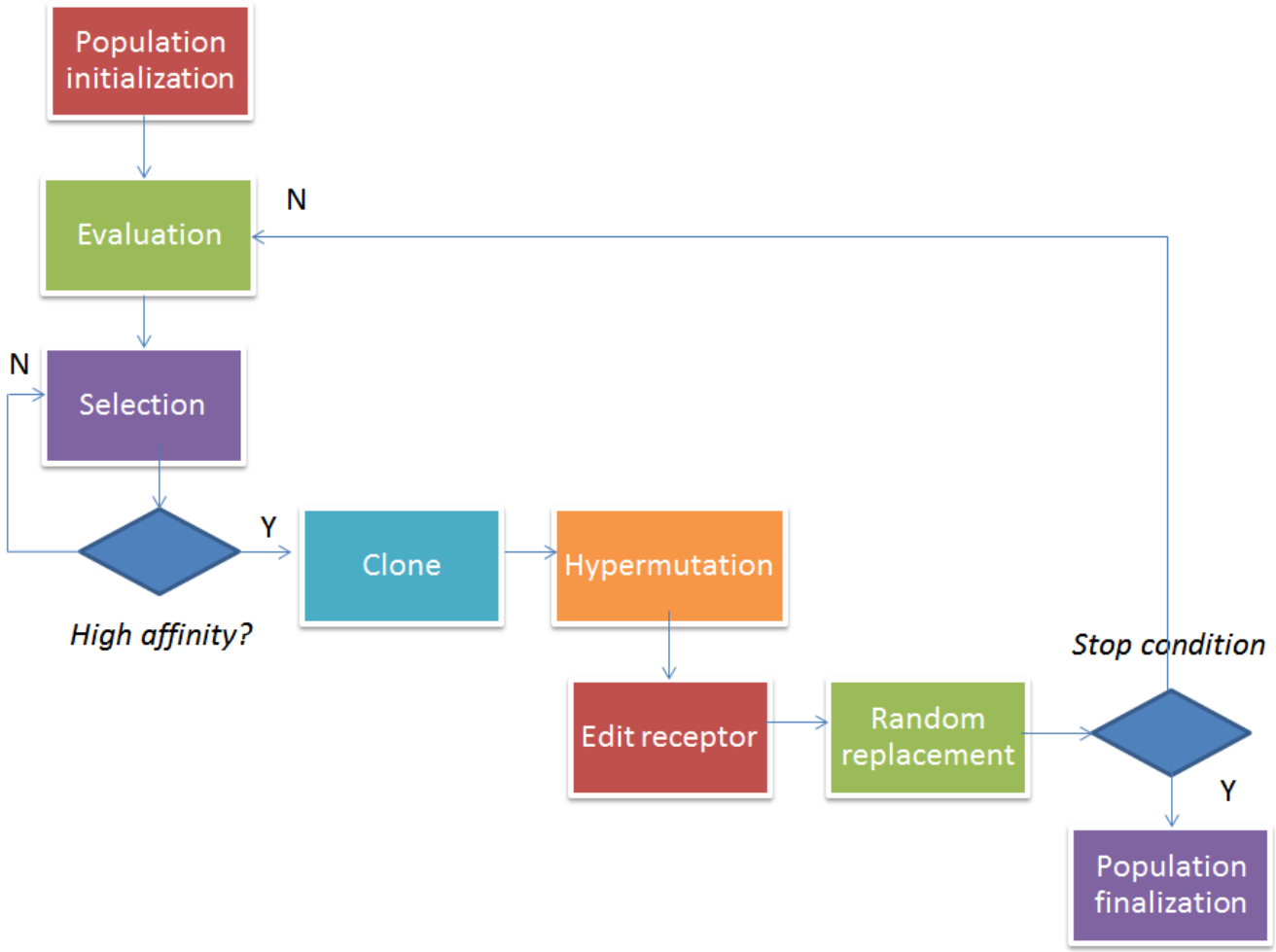
Clonal Selection: Theory (Burnet, 1978)



Immune Response

Clonal Selection Theory

Clonal Selection Algorithm (de Castro & von Zuben, 2000)



Clonal Selection Algorithm (de Castro & von Zuben, 2000)

In artificial immune systems, clonal selection algorithms are a class of algorithms inspired by the clonal selection theory of acquired immunity that explains how B and T lymphocytes improve their response to antigens over time called affinity maturation.

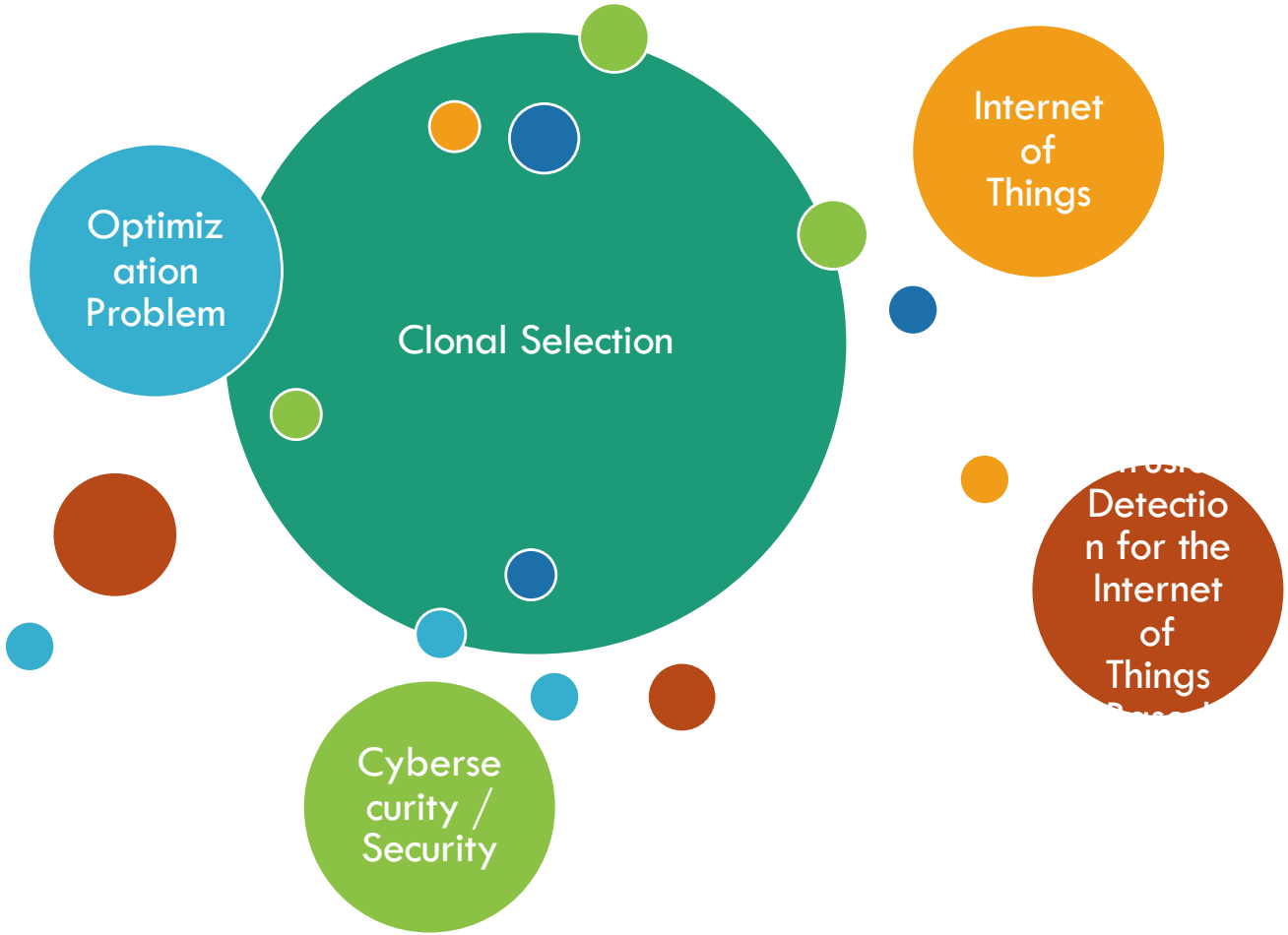
These algorithms focus on the Darwinian attributes of the theory where selection is inspired by the affinity of antigen-antibody interactions, reproduction is inspired by cell division, and variation is inspired by somatic hypermutation.

Clonal selection algorithms are most commonly applied to optimization and pattern recognition domains, some of which resemble parallel hill climbing and the genetic algorithm without the recombination operator.

Clonal Selection: in Engineering Problem

- De Castro & Von Zuben:
  - a binary character recognition task will be used to test its learning and memory acquisition capabilities;
  - a multi-modal optimization task; and
  - a 30 cities instance of the Travelling Salesman Problem (TSP).
- Nowdays:

Clonal Selection: in Engineering Problem



Implementasi AIS

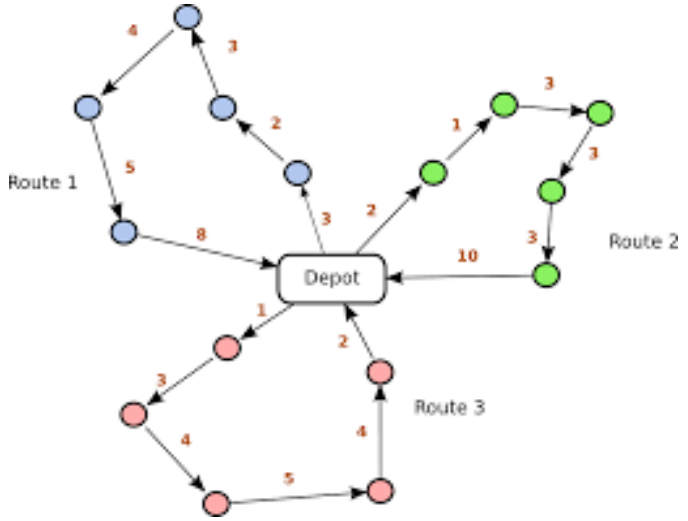
Clonal Selection Algorithm untuk persoalan Optimasi

AIS for VRP

VRP AIS

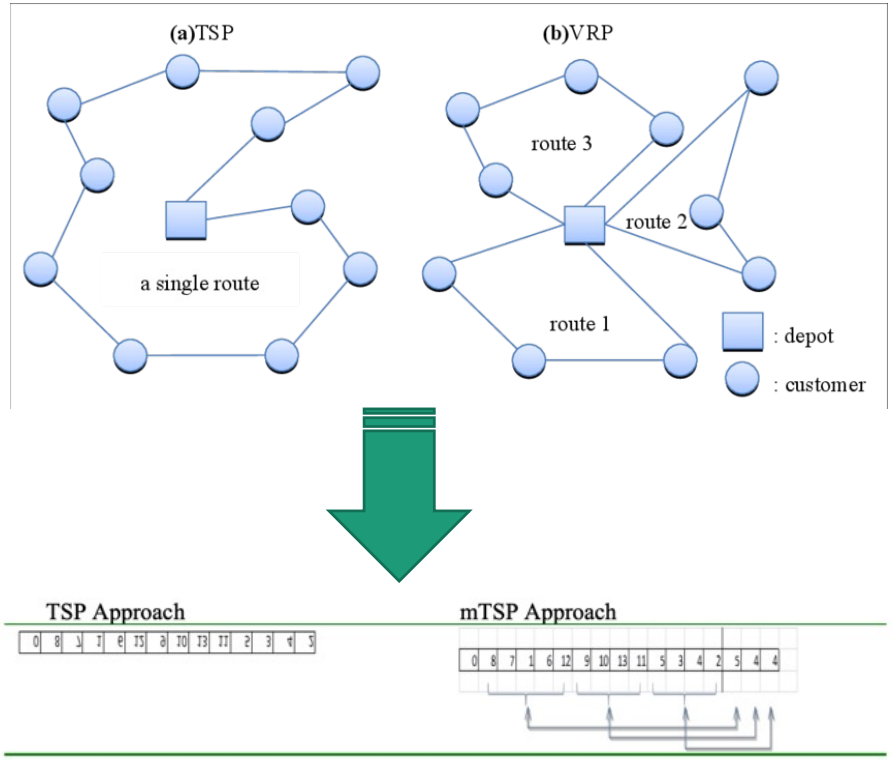
Vehicle Routing Problem

- Vehicle Routing Problem (VRP) is an optimization problem in determining routes with limited vehicle capacity.
- There is an initial depot and a number of n locations with various demands.
- A vehicle departs from the initial depot, visits all locations to fulfill requests from each location.
- The purpose of this problem is to minimize the total distance traveled by the vehicle by arranging the order of places to visit along with when the vehicle will return to fill its capacity again.

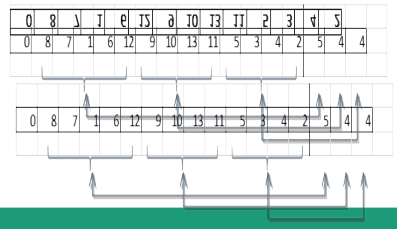


Vehicle Routing Problem

- Basically, VRP can be solved using multi-Traveling Salesperson Problem (mTSP). Where a salesperson must visit the entire city exactly once, and return to his hometown.
- At mTSP, there are m salesperson who each visit a particular city exactly once, and return to the original city.
- MTSP is a complex problem, namely a difficult problem where there is no solution with a polynomial time to solve it and requires a non-polynomial-time algorithm (NP Problem).
- In resolving NP problems, the exact approach cannot handle the problem large.
- The heuristic approach is the choice of solutions, namely a quick approach to get a feasible solution.



Solving VRP with CSA



Stage	Name	Description
1	Initialization	Initially individual population (N) randomly.
2	Evaluation	a) Select Antigen – A single antigen is selected at random without replacement (for the current generation) from the pool of antigens.
		b) Exposure – The system is exposed to the selected antigen. Affinity values are calculated for all antibodies against the antigen. Affinity is a measure of similarity, and is problem dependent. It is common to use Hamming distance.
3	Selection	Selection – A set of n antibodies are selected from the entire antibody pool that have the highest affinity with the antigen.
4	Cloning	Cloning – The set of selected antibodies are then cloned in proportion to their affinity (rank based).
5	Hypermutation	The clones (set of duplicate antigens) are then subjected to an affinity maturation process to better match the antigen in question. Here, the degree of maturation is inversely proportional to their parent's affinity (rank based), meaning that the greater the affinity, the lower the mutation.
6	Editing Receptor	The d individuals in the remaining r antigen pool with the lowest affinity are replaced with new random antibodies.
		Loop, Stage 1-5 until stop condition e.g. number of generation or convergent or optimal.
7	Population Finalization	Population Finalization

Mapping VRP with CSA

Clonal Selection Algorithm Stage	Vehicle Routing Problem
Population initialization	Set of randomly generated combination solutions. There are (n-1)! possibilities that the solutions may be raised. This population is part of the whole combination solutios. The number of solutions is generated by the specified population size.
Affinity evaluation	Evaluation of affinity checks each combination solution that has raised, find the cost required to form the combination solution.
Selection: affinity maturation	Affinity is how close the cost of a combination solution with the optimal/best cost. The combination solutions with higher affinity will be selected.
Cloning	Cloning is process to copy selected combination solutions, number of copies are depends on clone factor:
Hypermutation	Cloned/copied combination solutions will be mutated according to hypermutation probability mutate factor:
Edit receptor/elicitation	After mutate, we will have the best solutions-that will be replacedthe worst combination solutions in the initial population.The number worst combination solutions replaced will be depends on some random size replacement d.
Stop condition	Clonal selection process will be repeated until a stop condition obtained. Stopping criteria could be the number of generations, or numbers of populations are evaluated, or best cost found.

Case Study:
Waste Management In Bandung City

- Bandung City

Waste Management

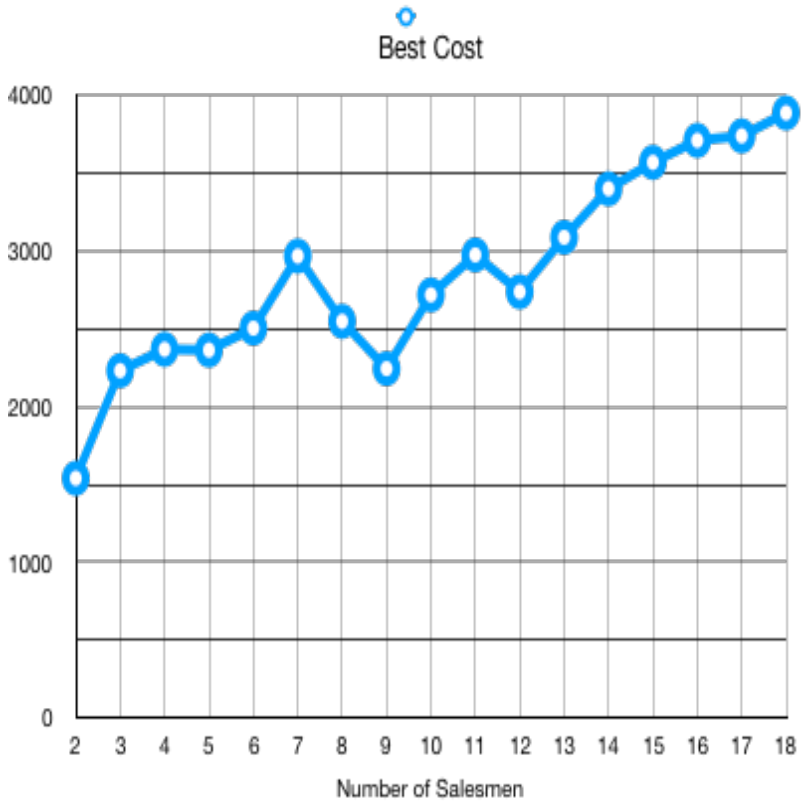
Experiment

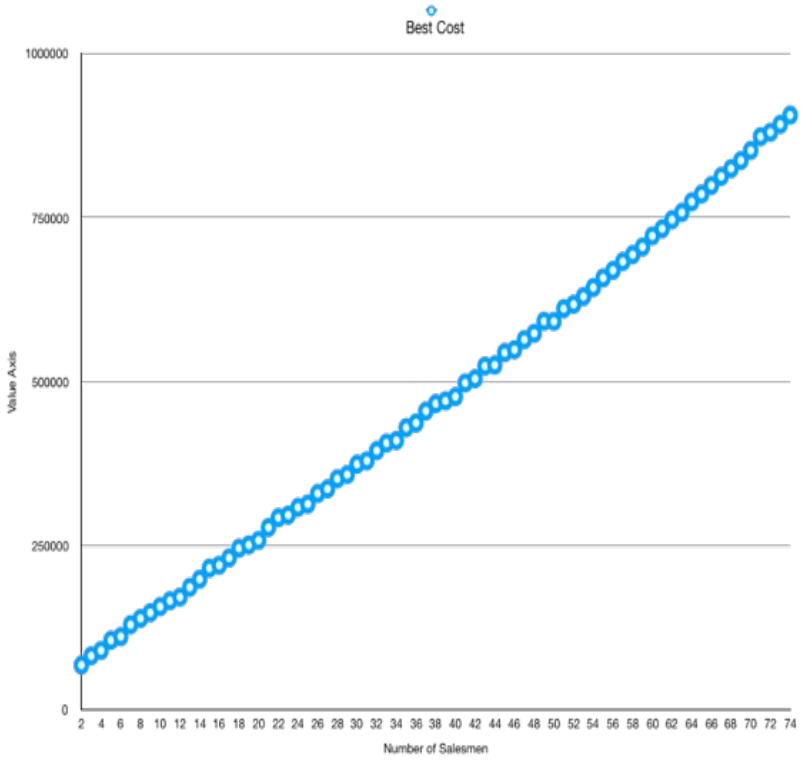
Dataset	**Waste transportation In Northern Bandung, West Java, Indonesia: Bandung36.vrp and Bandung148.vrp**
VRP parameter:	Number of vertices: 36 or 148
	Number of salesmen: between 2- 17 and between 2 - 74
CSA parameters	Number of population (N) = 50; Selection size (n) = 10; The value for the cloning factor (β) = 0.1; Value for mutation factor (rho) 2.5;Size for random replacement (d) = 5
Determination of criteria stops	Number of generations (g) = 1000, 10,000, 100,000

Experiment Result

Number of salesmen	Sub-tour Cost	Total Cost
2	1106 434	1540
3	66 1102 1064	2232
4	885 108 113 1263	2369
5	994 254 222 643 251	2364
6	250 377 42 1260 168 408	2505
7	693 42 106 930 222 40 936	2969
8	72 40 780 206 42 1031 156 222	2549
9	860 66 108 222 168 42 72 40 667	2245
10	42 1043 222 293 108 206 156 543 40 66	2719
11	959 72 40 42 206 147 222 156 66 108 958	2976
12	1007 206 156 42 168 66 222 106 40 146 108 472	2739
13	974 42 423 108 72 40 198 206 156 66 106 476 222	3089
14	206 66 474 156 198 106 685 146 40 222 42 72 108 880	3401
15	601 42 250 803 168 222 106 206 40 198 146 72 156 108 453	3571
16	494 108 168 606 40 66 156 106 222 250 42 146 250 206 72 780	3712
17	222 206 278 40 338 1057 66 106 250 108 198 146 288 168 42 72 156	3741
18	892 206 42 146 108 198 338 66 72 156 250 40 106 290 311 278 222 168	3889

Experiment Result (2)



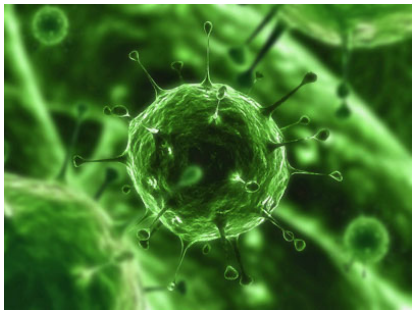


Conlusion AIS for VRP

- A clonal selection based algorithm was proposed for solving the VRP with mTSP approach.
- This algorithm is can show solution for mTSP for Bandung waste transportation dataset.
- Two dataset in experiments show that the best cost (minimal cost) result from 2 salesmen / driver in VRP.
- This is because, the cost represent distance between nodes.
- Actually we need other representation of cost, like capacity of the truck and the time limit as VRP constraint.
- This is will be future research.
- VRP can be solved by mTSP approach using bio-inspired computation like Clonal Selection Algorithm.
- This algorithm has been shown the good performance, but has several limitations since the need to define constraint for the VRP constraints.

Current Research

Immune-inspired Optimization Model untuk Winner Determination Problem pada Spectrum Frequency Combinatorial Auction



Immune Inspired Computation

Spectrum Frequency Combinatorial Auction

Pengelolaan Spektrum Frekuensi Radio [http://postel.go.id]

Machine Learning for Stunting Prediction

Aplikasi iPposyandu

Data - Dataset

Machine Learning

Data bayi & balita

CRISP_DM

- LSTM, Naive Bayes, SVM, Tree
- Clonal Selection

https://play.google.com/store/apps/details?id=id.iposyandu.kader&hl=en&gl=US

Clonal Selection: in Engineering Problem

Clonal Selection: in Engineering Problem

- Optimization Problem. Eg:
  - The use of Clonal Selection Algorithm for the Vehicle Routing Problem with Time Windows
  - A Clone Selection Algorithm for the Open Vehicle Routing Problem - IEEE Conference Publication
  - An improved immune clonal selection algorithm and its applications for VRP - IEEE Conference Publication
  - Clonal selection algorithm for vehicle routing - IEEE Conference Publication

Clonal Selection: in Engineering Problem

- Optimization Problem:
  - Application of Clonal Selection Algorithm in Construction Site Utilization Planning Optimization (Xi Wang, 2016)
    - CSUP is the decision making process for determining the locations of temporary facilities within the boundary of a construction site by identifying spatial, functional relationships between the temporary facilities. Its objective is to identify an optimal layout from a large number of alternative solutions so that a set of predetermined facilities are appropriately located while satisfying site specific constraints.

Clonal Selection: in Engineering Problem

- IoT. Eg:
  - Research on Intrusion Detection for the Internet of Things Based on Clone Selection Principle (Liu, 2012)
  - An Immunity-Based IOT Environment Security Situation Awareness Model (Yunquan, 2017)

Research on Intrusion Detection for the Internet of Things Based on Clone Selection Principle

- The fast development of the Internet of Things (IoT) makes its security problems appear gradually.
- It is urgent to study the intrusion detection technology for IoT security threats, based on the clone selection principle.
- The key elements in the clone selection theory are simulated.
- The clone selection algorithm is realized to be applied in IoT.
- Detection elements for security threats evolve to adapt the real IoT environment.
- The proposed method is expected to improve the detection efficiency of IoT security threats.

Clonal Selection Algorithm and Industry 4.0

- Industry 4.0 - Artifical intelligence
- Computational intelligence
  - Soft Computing
  - Subset of AI, Bezdek (1994)
- CI:
  - Fuzzy logic
  - Neural networks
  - Evolutionary computation
  - Artificial Immune System
    - Clonal Selection Algoritms

Clonal Selection: in Engineering Problem

- Cybersecurity
  - A botnet detection approach based on the clonal selection algorithm (Lysenco, 2018)
    - A new technique for the botnets' detection in the corporate area networks. It is based on the usage of the algorithms of the artificial immune systems. Proposed approach is able to distinguish benign network traffic from malicious one using the clonal selection algorithm taking into account the features of the botnet's presence in the network. An approach present the main improvements of the BotGRABBER system. It is able to detect the IRC, HTTP, DNS and P2P botnets.

Clonal Selection: in Engineering Problem

- Security
  - The Methods of Artificial Intelligence for Malicious Applications Detection in Android OS (Bezobrazov, 2016)
  - Detection of Mobile Malware: An Artificial Immunity Approach (Brown, 2016)
  - Adaptive artificial immune networks for mitigating DoS flooding attacks (Vidal et al, 2017)
  - Applications of artificial immune systems to computer security: A survey (Fernandes, 2017)

Conclusion

- Optimization Algorithms are used in engineering fields
- Clonal Selection Algorithm as an algorithm for optimization problem is used in engineering fields
- Beside optimization problem, CSA is used for Security, esp. in IoT Security
- As part of Computational Intelligence, CSA has potential contribution in industry 4.0 technology

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Thank you