Pathogen Dose based Natural Killer Cell

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ABSTRACT

Negative selection algorithm(NSA), which is the most representative classification algorithm among immune heuristic algorithms, has been successfully applied to solve many classification problems. However, there are two obvious problems with NSA. First, NSA establishes specific antibodies for each antigen based on the mechanism of specific antigen matching antibody, which leads to too many and redundant detectors. Second, the detection stage needs to calculate the matching degree of the antigen with all the detectors, and the detection efficiency is low. This paper proposes a new non-specific natural killer cell algorithm (NKA) based on pathogen dose. NKA draws on the mechanism of NK cells constructing phenotype detectors based on pathogen dose. First, NKA defines dose and phenotype detector, and optimizes it based on the memory evolution mechanism of phenotype; then establishes k-d tree for the optimized phenotype, and pathogens only need to match the dose with the nearest phenotype detector. Experimental results show that the method proposed in this paper, NKA, can not only achieve a better performance through fewer detectors, but also has a higher efficiency in the training and detection phase, compared with three NSA-based algorithms.

Motivation

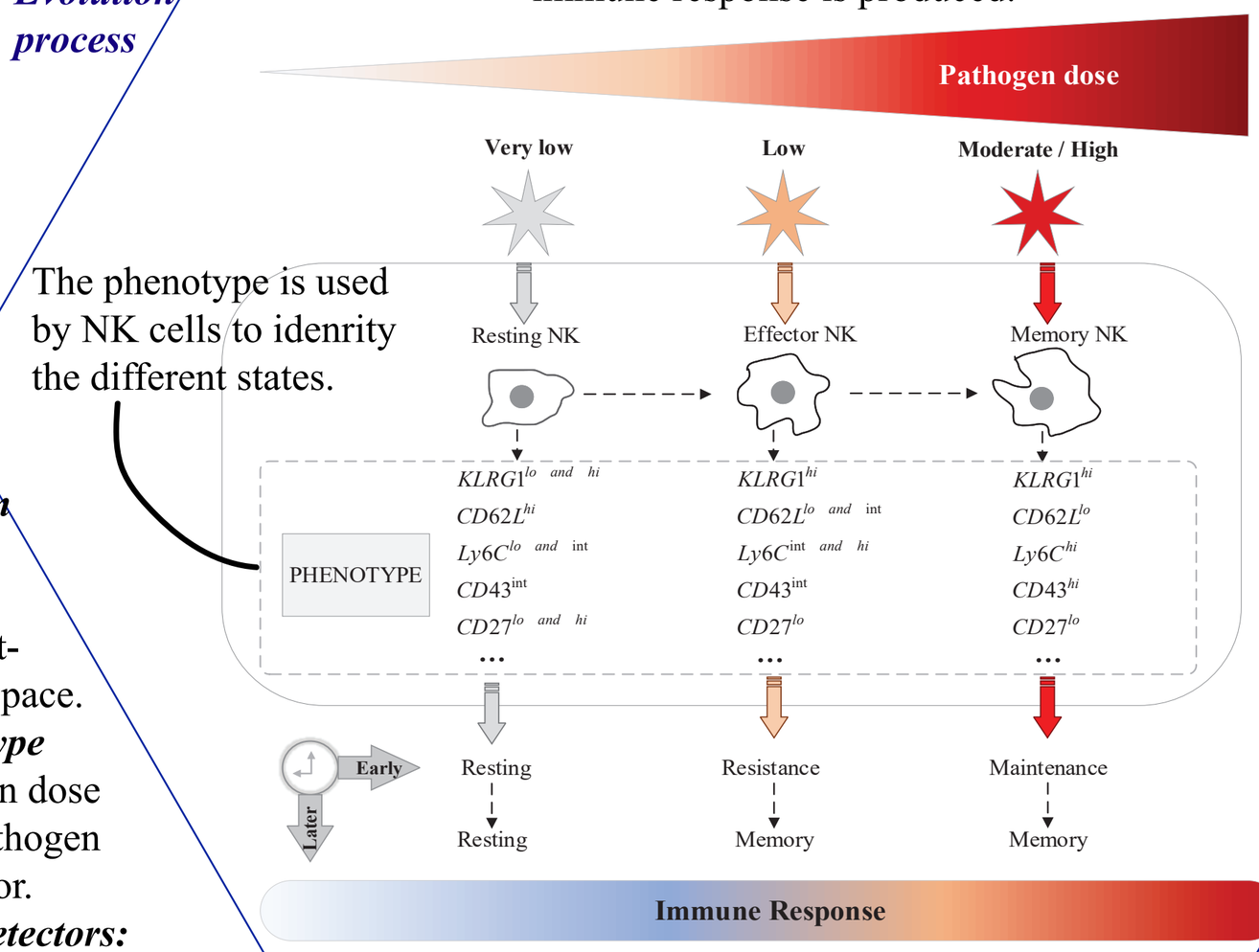
Two problems with distance-based immune model - NSA in nature

1. The algorithm establishes specific antibodies for each antigen based on the specific antigen matching antibody mechanism , which leads to an excessive number of detectors and numerous redundant detectors;
2. The detection phase needs to calculate the antigen and matching degree of all the detectors, the time complexity is high, and the detection efficiency is low.

Resting NK: pathogen dose is very low and no immune respnese is produced.

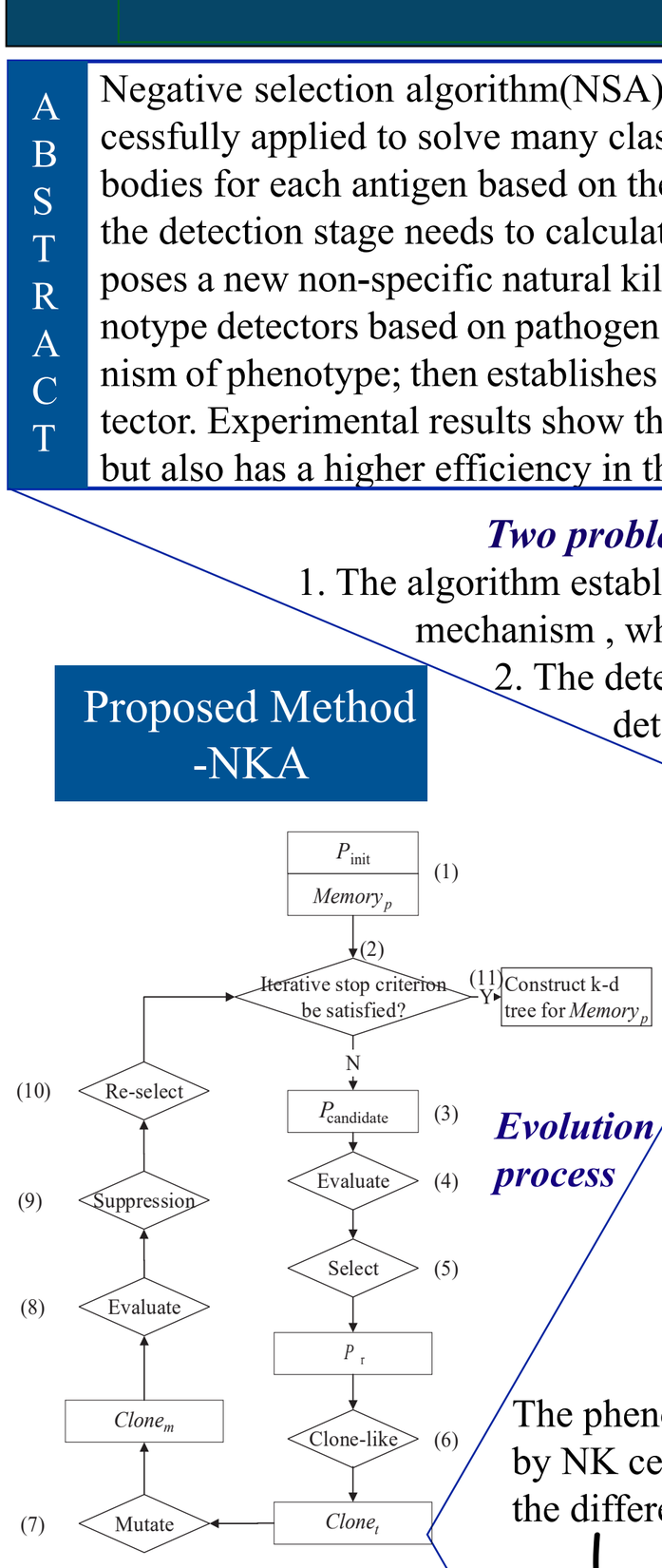
Effector NK: pathogen dose is low and a mild immune response is produced.

Memory NK: pathogen dose is moderate or high and a violent immune response is produced.



The phenotype is used by NK cells to idenrity the different states.

Proposed Method -NKA



Evolution process

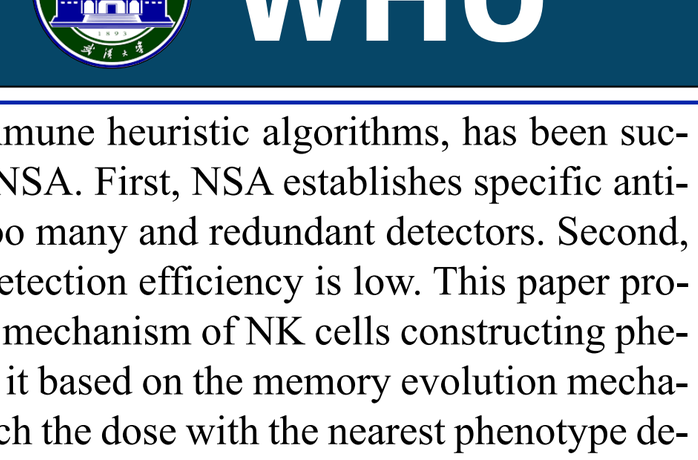
1. Definition of the pathogen feature space: map the input data to n-dimensional real-valued vectors to characterize the pathogen's feature space.

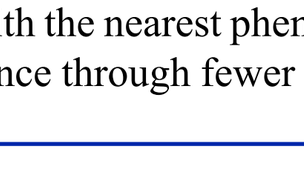
2. Generation of the phenotype detectors: define the pathogen dose and clusters the abnormal pathogen dose as the phenotype detector.

3. Evolution of phenotype detectors: achieve the purpose of optimizing the detector through the cloning, tolerance, and extintion operations of the phenotype detector, and then the k-d tree is established for the optimized phenotype detectors.

4. Detection: use dose matching with the nearest phenotype detector to check whether testing sample is normal or abnormal.

Experiments





The detectors distribution of algorithms on Breast Cancer dataset

Conclusion

Aiming at the problem that distance-based NSA cannot establish an effective detector in normal and abnormal mixed areas, a natural killer algorithm (NKA) based on patho gen dose is proposed in this paper. A theoretical analysis and experimen tal results show that NKA has a better accuracy, detector generation quality, training and testing complexity compared to three versions of distance-based NSA. Hence, it is suitable to use NKA for classification tasks in both low-dimensional and high-dimensional space. Future work will mainly focus on more in-depth theoretical analysis and applying NKA to more different situations to explore more possibili ties of this method.

Biological mechanism of NK

The phenotype is used by NK cells to idenrity the different states.

Features and inspirations

Two notable features of the pathogen dose based NKA

1. The establishment of the phenotype detector of natural killer cells is not specific to a certain pathogen, but non-specifically to the dose of all pathogens with certain characteristics in a certain dangerous zone. The dangerous zone is inspired by the Danger Theory which was proposed by Polly Matzinger. And NKA establishes different NK cell phenotypes based on the characteristic dose of pathogens;
2. When classifying the pathogen, NKA only needs to compare with the core pathogen in the nearest dangerous zone.