



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



UNIVERSIDAD SANTO TOMAS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm Applied to Object Recognition in Mobile Robots

Jose Guillermo Guarnizo¹ and Luis Fernando Nino²

¹ Faculty of Electronic Engineering. Universidad Santo Tomas

`jose.guarnizo@usantotomas.edu.co`

² Intelligent Systems Research Laboratory (LISI). Universidad Nacional de Colombia

`lfninov@unal.edu.co`



Vigencia por seis años

Index

- *Introduction.*
- *Previous Works.*
- *Clonal Selection Algorithm.*
- *Stage Conditions.*
- *Object Recognition Based on Immune Model.*
- *Simulation and Results.*
- *Conclusions and Future Works.*



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA

Institución de Educación Superior sujeta a la inspección y vigilancia del Ministerio de Educación Nacional SNIES 1704.



Res. MEN No. 0456 del 29 de enero de 2016
Vigencia por seis años

Introduction

- The application of object recognition for mobile robots has increased:
 - ✓ Navigation.
 - ✓ Object detection.
 - ✓ Buildings.
- Low-cost sensors have led to use lasers or sonar sensors to obtain characteristics from the object to be recognized.
- In mobile robots, recognition systems need ability to adaptation, robustness, and invariance to rotation and translation.
- Bio-inspired techniques such as Artificial Immune Systems are used for pattern recognition.



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA

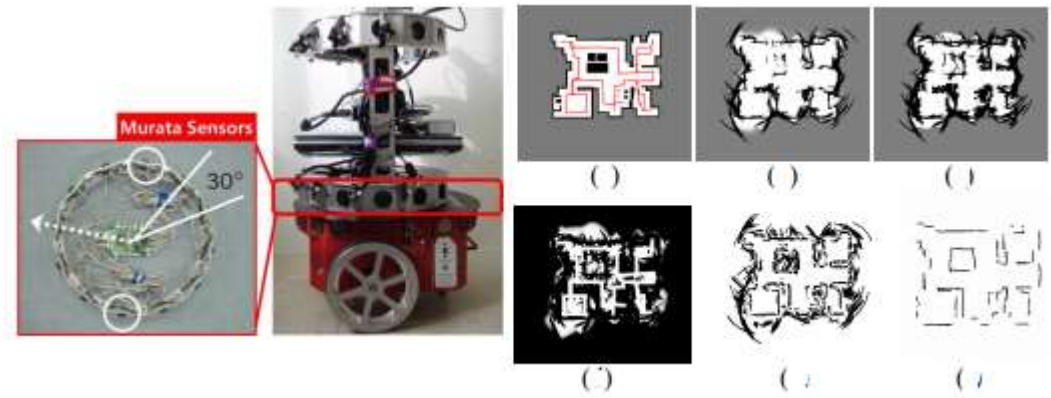
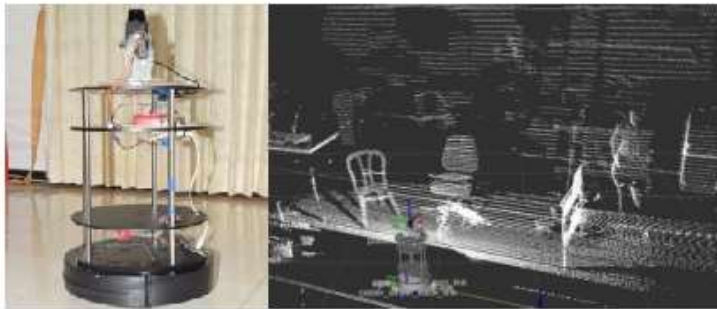
Institución de Educación Superior sujeta a la inspección y vigilancia del Ministerio de Educación Nacional SNIES 1704.



Vigencia por seis años

Previous Works

Low cost sensors such as laser or sonar sensors.



[1]. Low-cost recognition and classification system based on LIDAR.

[2]. Grid map building model based on sonar.



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA

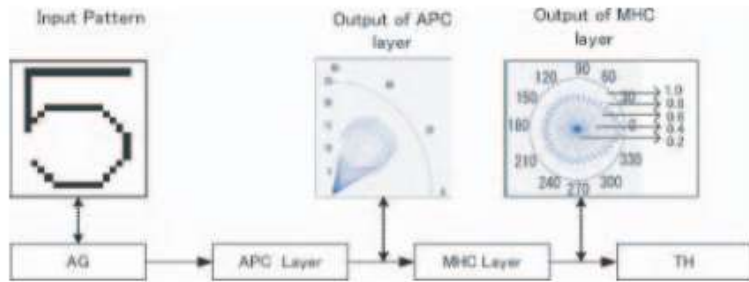
Institución de Educación Superior sujeta a la inspección y vigilancia del Ministerio de Educación Nacional SNIES 1704.



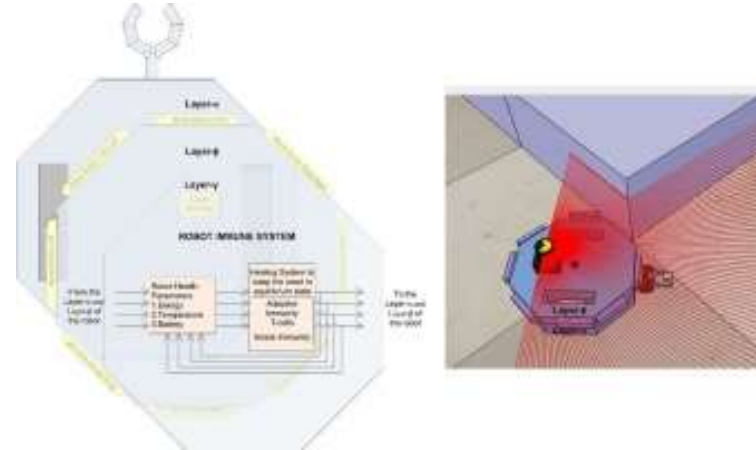
Vigencia por seis años

Previous Works

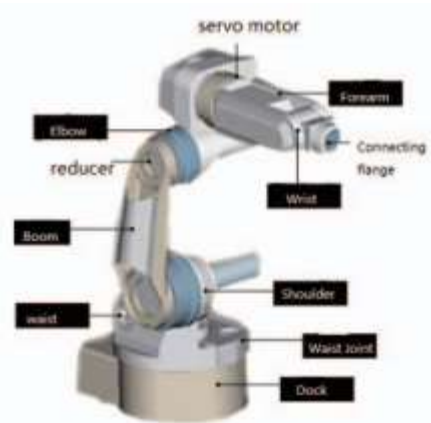
Artificial Immune Systems have been used in different industrial tasks.



[3]. Pattern recognition,



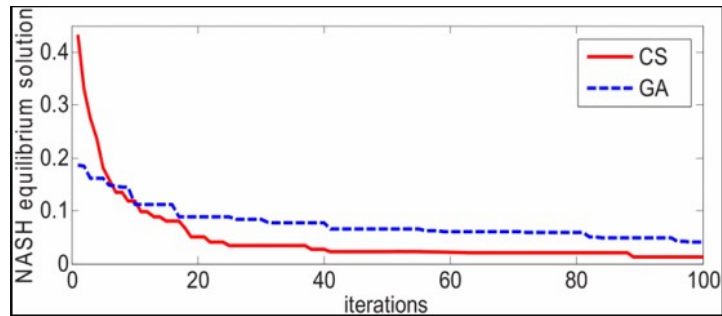
[4]. Cognitive models of behavior.



[5]. Trajectory Planning for Industrial Manipulators.

Previous Works

Clonal selection theory.



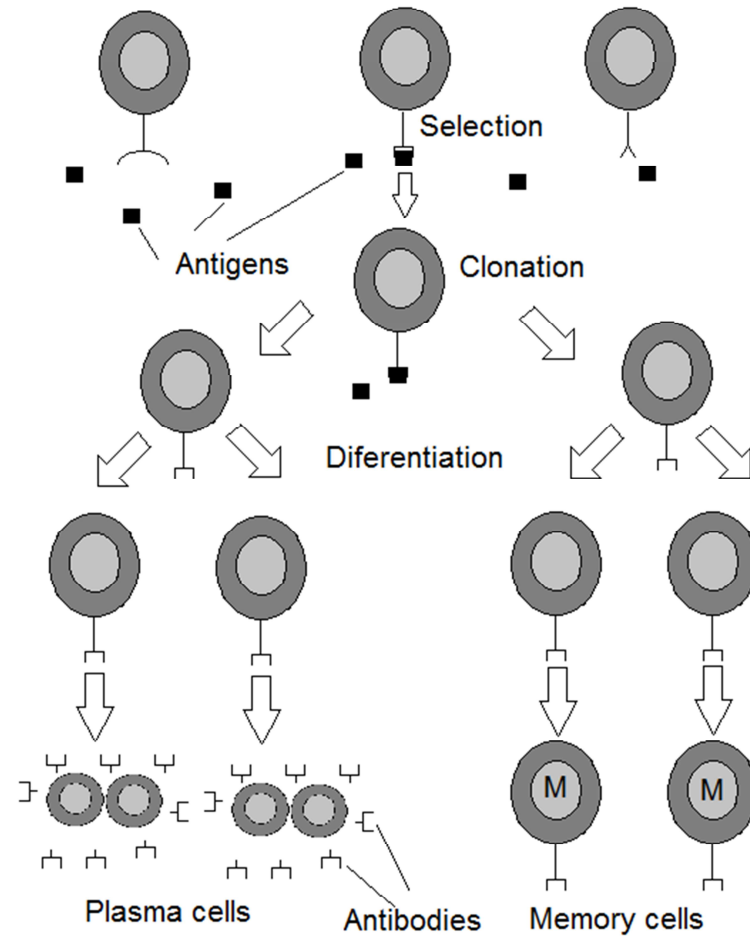
[6]. UAV cooperation.



[7]. Coordination in swarm systems.

[8]. Applications in data mining, medicine or classification.

Clonal Selection Algorithm



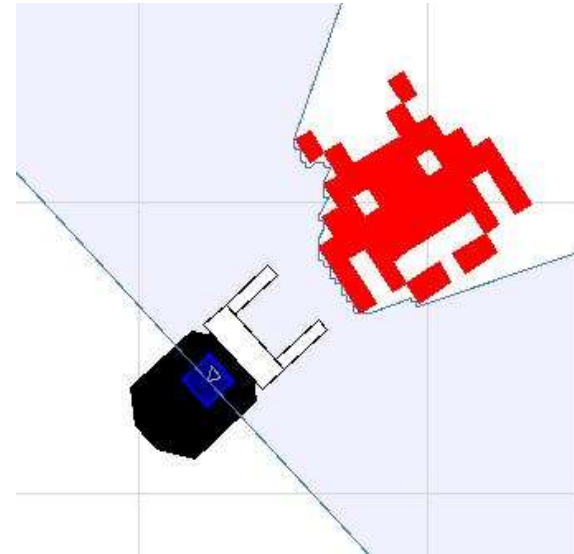
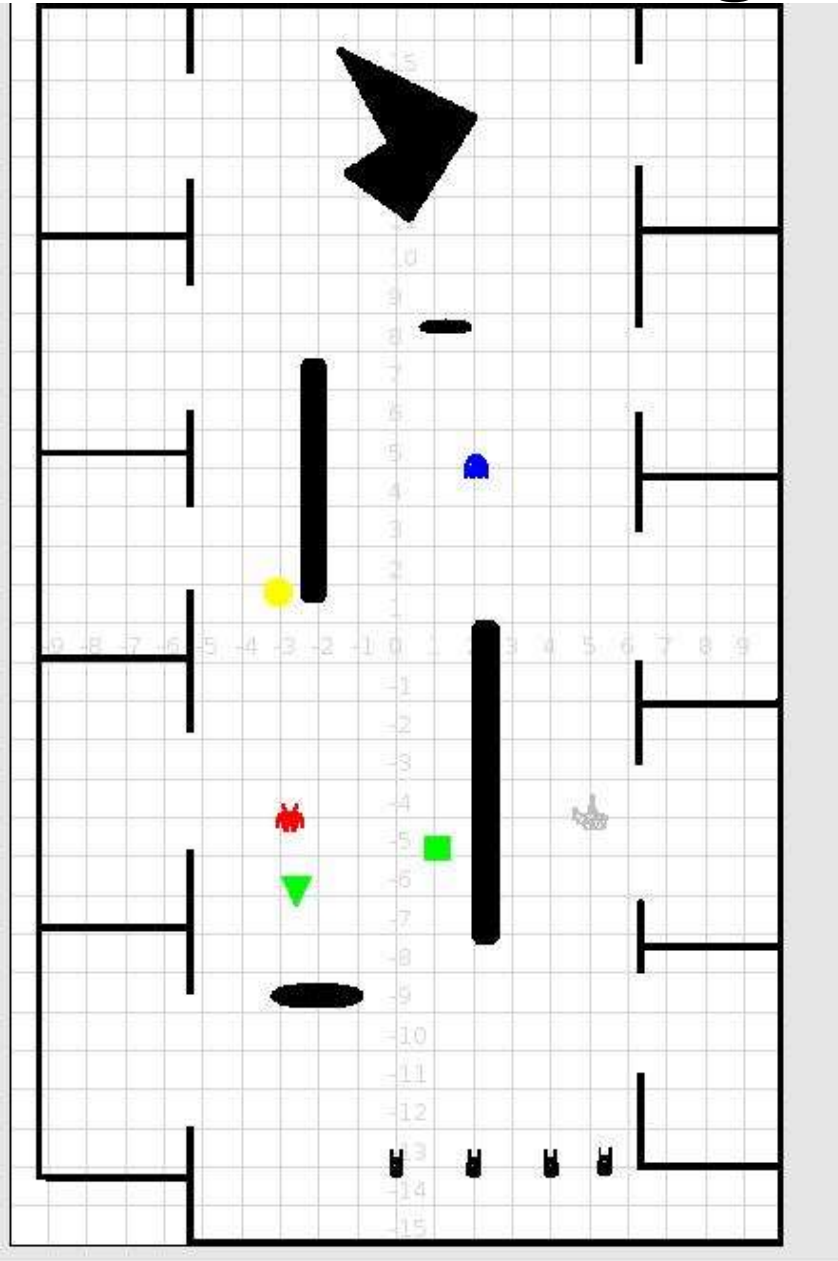
UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA

Institución de Educación Superior sujeta a la inspección y vigilancia del Ministerio de Educación Nacional SNIES 1704.

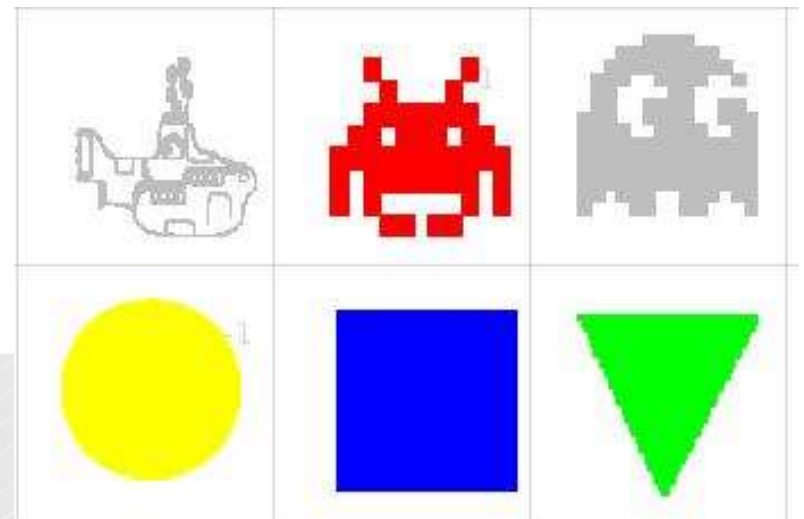


Res. MEN No. 01456 del 28 de enero de 2016
Vigencia por seis años

Stage Conditions



- *Player-Stage*
- *C++*



Clonal Selection Algorithm

Immune Model

- *Robot moves through the environment looking for objects to be classified using laser and color sensors.*
- *Robot should distinguish between self objects and non-self objects.*
- *Black objects are classified as self objects (walls and other robots).*
- *Color objects are classified as non-self objects, activating immune response (objects to be classified).*



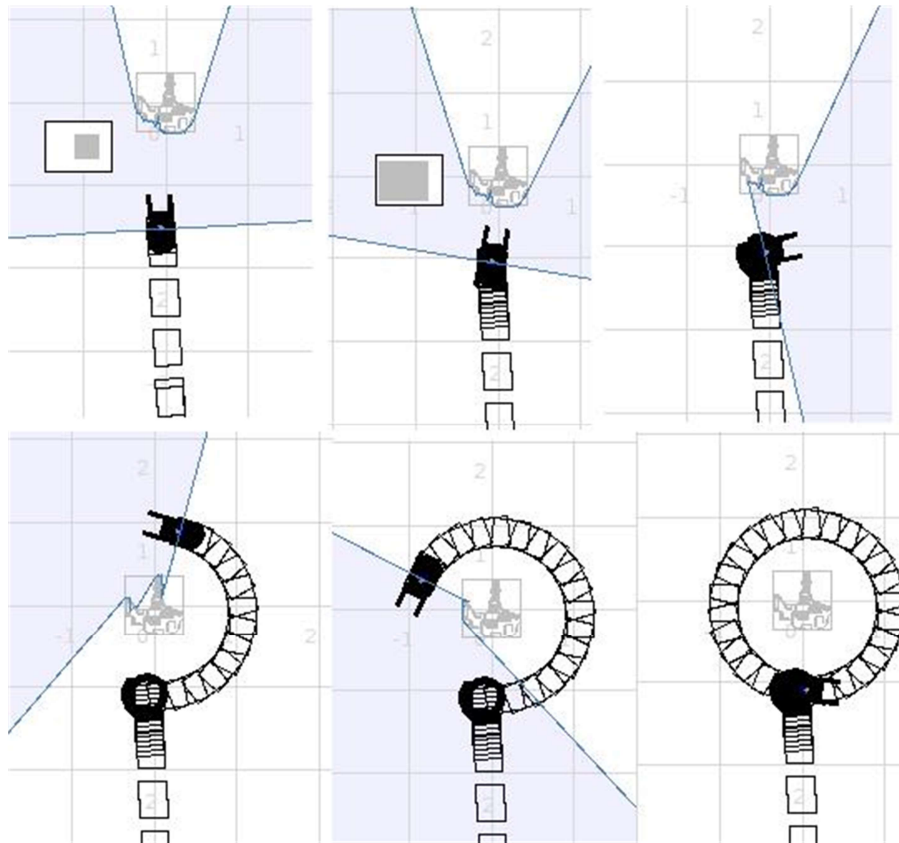
UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm

Immune Model

Obtaining vector of characteristics (non-self objects).



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm

Immune Model

To acquire the antigen of the pathogen (non-self object), Hu invariant moments are used to obtain outline information.

The information on the object is translated to the outline of the object in a plane (x,y), by (1) in the axis X, and (2) in the axis Y:

$$X_c = l * \cos \vartheta - X_r \quad (1)$$

$$Y_c = l * \sin \vartheta - Y_r \quad (2)$$

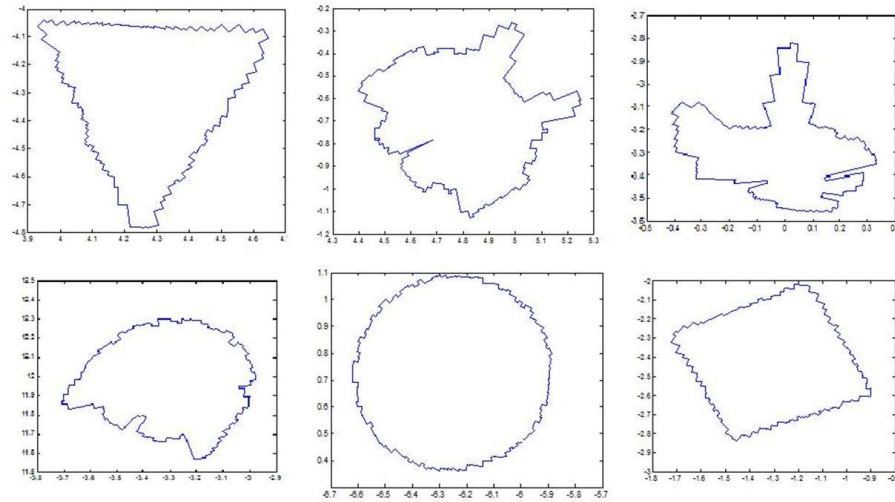
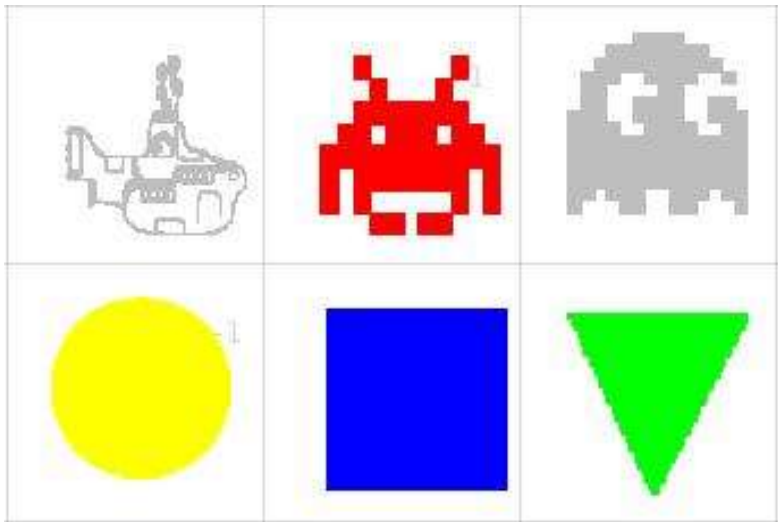


UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm

Immune Model



- *The antigen is the vector that contains the Hu moments on the object,*
- *Each component of this vector corresponds to the epitope.*
- *The antibodies correspond to sets of Hu moments of the different objects previously charged in the robot.*



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm

Immune Model

- *The antigen is compared by a set of the antibodies stored in the robot by (3):
$$Aa = K1|Mp1-Me1| + K2|Mp2-Me2| + \dots + K7|Mp7-Me7| \quad (3)$$*
- *Aa corresponds to error between the antigen and the antibody.*
- *Mpn is the n paratope of Hu moments stored in the robot, Men is the n epitope of the antigen, and Kn is a n scaling factor.*
- *If Aa is lower than the U1 threshold, the object will be considered classified.*
- *If Aa is greater than U1 but lower than U2, the object will be considered indeterminate.*
- *if Aa is greater than U2, the object will be considered unknown.*



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Clonal Selection Algorithm

Immune Model

In case the error is greater than U_2 , the pathogen will be considered unknown and the mechanism of generation of the set of antibodies using clonal selection algorithm is activated.

Immunological metaphor.

Robotic System	Immune Inspiration
Object to Recognize	Pathogen
Hu Invariant Moments	Vector Antigen
Individual Moments	Epitope
Invariant Moments Stored in Robot	Antibodies
Individual Moments Stored in Robot	Paratope
New Object to Recognize	Antibodies Generation
Antibodies Stored in the Robot	Immunology Memory
Color Recognition	Innate Immune System
Outline Recognition	Acquired Immune System

Clonal Selection Algorithm

Clonal Selection Algorithm

1. *A set of antigens is acquired for each pathogen (objects to be recognized).*
2. *For each antigen acquired, one antibody is exactly cloned and created, which corresponds to a non-matured antibody.*
3. *The non-matured antibody is cloned. There are ten clones for each non-matured antibody.*
4. *Each clone is mutated changed each paratope at random $\pm 25\%$ of its value.*
5. *Error between the antibodies non-matured and their own clones mutated is calculated.*
6. *The clones with error lower than 10% are selected as matured antibodies. These clones are included in the immunological memory.*



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Results

Experiment 1

Ten different trajectories were performed for the six elements in order to extract their antigens by measuring the error with the non-matured antibodies acquired previously.

Object	Antibodies activated	Range of errors
Submarine	28 of submarine	From 8 to 42
	16 of triangle	From 18 to 50
Invader	28 of invader	From 8 to 47
	14 of circle	From 30 to 45
Phantom	1 of phantom	40
	36 of phantom	From 8 to 47
	2 of circle	From 46 to 49
Circle	2 of square	From 46 to 48
	20 of circle	From 1 to 10
	26 of invader	From 35 to 50
Square	22 of square	From 8 to 50
	1 of circle	45
Triangle	26 of triangle	From 5 to 46
	4 of submarine	From 30 to 50



Results

Experiment 2

Clonal Selection Algorithm was activated and a set of matured antibodies was selected and included in the immunological memory of the agents.

Objects	Antibodies cloned activated	Range of errors
Submarine	50 of submarine	From 4 to 30
Invader	100 of invader	From 8 to 30
	5 of circle	From 25 to 30
Phantom	40 of phantom	From 3 to 30
Circle	30 of circle	From 1 to 30
	5 of invader	From 27 to 30
Square	32 to square	From 7 to 30
Triangle	47 of triangle	From 2 to 27
	10 of submarine	From 17 to 29

Results

Experiment 3



- *In two cases, antibodies of the square had affinity values around 70.*
- *These values were greater than U_2 , and the clonal selection algorithm was activated*
- *As for the circle and the invader, affinity values were lower than 20 (lower than U_1); they were classified correctly.*



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA



Results

Experiment 4

Kohonen maps were developed for comparison. For the experiments the six objects considered in experiments 1 and 2 were used.

Objects	Antibodies activated.	Neurons activated.
Submarine	10 of submarine	9 of submarine 1 of triangle
Invader	10 of invader	5 of invader 3 of phantoms 1 of submarine 1 non-classifiable
Phantom	10 of phantom	6 of phantom 2 of square 2 non-classifiable
Circle	10 of circle	10 of circle
Square	10 of square	5 of square 3 of phantom 1 of circle 1 non-classifiable
Triangle	10 of triangle	6 of triangle 2 of submarine 2 non-classifiable



Conclusions and Future Works

- *For the acquired response, a set of antibodies was trained by a proposed Clonal Selection Algorithm.*
- *The antibodies showed robustness in case of noise in the classification.*
- *The noise was modeled as superficial deformation.*
- *The AIS was adaptable to new pathogens and their new antibodies generated were stored in the immunology memory of the robot.*
- *In future works Artificial Immune Systems will be proposed for machine learning applied to 3D object recognition using kinetic and real sense in mobile robots.*

References

1. Llanos Neuta, N., Aponte Vivas, S., Velandia Fajardo, N., Rodriguez Giraldo, O., & Romero Cano, V. (2018). *Low-cost recognition and classification system based on LIDAR sensors. IEEE 2nd Colombian Conference on Robotics and Automation (CCRA). Barranquilla, Colombia.*
2. Lee, S.-J., Lee, K., & Song, J.-B. (2014). *Development of advanced grid map building model based on sonar geometric reliability for indoor mobile robot localization. 11th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI). Kuala Lumpur, Malaysia.*
3. Wang, W., Gao, S., & Tang, Z. (2008). *A Complex Artificial Immune System. 2008 Fourth International Conference on Natural Computation. Jinan, China.*
4. Akram, M., & Raza, A. (2018). *Towards the development of robot immune system: A combined approach involving innate immune cells and T-lymphocytes. Biosystems, 172, 52-67.*
5. He, T., Zhang, Y., Sun, F., & Shi, X. (2016). *Immune optimization based multi-objective six-DOF trajectory planning for industrial robot manipulators. 12th World Congress on Intelligent Control and Automation (WCICA). Guilin, China.*

References

6. Wang, Y., Zhang, W., & Li, Y. (2016). *An efficient clonal selection algorithm to solve dynamic weapon-target assignment game model in UAV cooperative aerial combat*. 35th Chinese Control Conference (CCC). Chengdu, China.
7. Weng, L., Liu, Q., Xia, M., & Song, Y. (2014). *Immune network-based swarm intelligence and its application to unmanned aerial vehicle (UAV) swarm coordination*. *Neurocomputing*, 125, 134-141.
8. Luo, W., & Lin, X. (2017). *Recent advances in clonal selection algorithms and applications*. *IEEE Symposium Series on Computational Intelligence (SSCI)*. Honolulu, HI, USA.



Acknowledgements. This work has been funded by “FODEIN 2019” at Universidad Santo Tomás, Bogotá Colombia, project code: 1936005.

Questions?

jose.Guarnizo@usantotomas.edu.co



UNIVERSIDAD SANTO TOMÁS
PRIMER CLAUSTRO UNIVERSITARIO DE COLOMBIA

