International Journal of Combinatorial Optimization Problems and Informatics, 11(3), Sep-Dec 2020, 37-48. ISSN: 2007-1558.

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Communication of Mobile Devices with Bioinspired Algorithms

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Abstract. At present, the complexity of the communication problem between mobile devices is a subject of study among the scientific community, since several researchers have been given the task of proposing a better solution using different types of algorithms, in this article we will focus on the search for communication proposals between mobile devices that use bioinspired algorithms. Neural networks, immune system, swarm of bees, termites, flock of birds, fish, inspire some of these algorithms to name just a few. Each of the aforementioned algorithms are inspired by nature, what is intended in this article is to try to understand how these animals communicate with each other to achieve their objectives. Mainly we will focus on the imitation of communication, and examining the work done we will realize which is the most optimal to help us optimize times and improve communication on mobile devices.

Keywords: Mobile devices, Communication of mobile robots, Bioinspired algorithms.

Article Info
Received Dec 12, 2019
Accepted Dec 24,2019

1 Introduction

At present we find different situations talking about problems with which with the experience a solution is given, so different methodologies are given instead of spontaneous acts, using in our daily life certain routine actions carried out which we know as algorithms, these are mainly applied in the computational field. Developing an algorithm consists of having knowledge of the characteristics and elements, in order to be precisely defined. To solve difficulties, there are many possible solutions which some can become one of the most efficient where the capacity of the developer is very important.
Where there are different types of algorithms metaheuristic to name a few:

- López, Salas, & Murillo (2014) [1] describe a deterministic algorithm as the family of algorithms in order to give close solutions without going through the entire search space.
- Tiznado et al. (2011) [2] define one to one stochastic algorithm as an approximation algorithm used as an alternative search method for optimization where the values are unknown.
- López, Salas, & Murillo (2014) [1] define a heuristic algorithm as a limited exploration algorithm in the search space providing solutions in a short time.
- Vélez & Montoya (2007) [3] describe the term of the meta-heuristic algorithm with the definition of some authors where they say that these are approximation algorithms that adopt traditional heuristics with other exploration techniques

Artificial intelligence is a great topic of study in the field of computer science, which focuses on the creation of programs and modules that can be identified as intelligent behaviors, these systems usually have the ability to analyze large-scale data identifying patterns creating predictions automatically, where the agent perceives his environment to perform actions to increase the possibility of fulfilling the desired objective. This term refers to a machine trying to mimic the biological behavior where the machines become more capable.

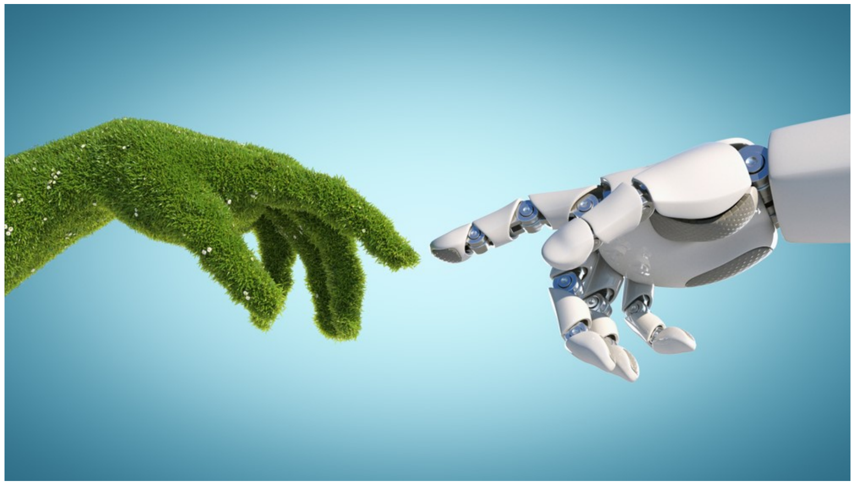

Figure 1. Artificial intelligence Source: by authors and image from [4]

The complexity of the problems has increased over the last few years when we talk about technology, so the search for new techniques to solve them was carried out, which is why nature has been a main source of inspiration since it is capable of providing solutions optimally for issues that are very complicated to solve with traditional methods. In this case, it provides us with a solution in computer optimization, which initiates the appearance of bioinspired algorithms, which adopts the behaviors present in nature, showing remarkable results, these are mainly inspired by genetic algorithms, swarms, and hybrids.

Figure 2. Swarm robots Source: by authors and image from [5]

2 Description of the Problem

Currently, researchers are looking for excellent results when we refer to communication, and the main thing is to have better results taking into account the general purpose, which is required to have a lower consumption of resources such as finding the shortest route, the time, the ability to find the maximum objective function, taking into account biologically inspired algorithms because they have the ability to make decisions autonomously either to implement it on mobile devices or for networks, that is why we will examine the different documents to find which It is the most appropriate algorithm taking into account the different bioinspired algorithms to know which is the best to use and the most used.

3 State of the art

3.1 Mobile devices

Bücken (1996) [6] describe the problem of navigating and mapping, they propose a solution based on grid maps using neural networks, resulting in autonomous operation of a mobile robot with ambient probe sensors.

Goris (2005) [7] propose to carry out a mobile robot capable of being autonomous taking into account aspects such as mechanics, kinematics, dynamics, sensors, location, route planning for the design and creation of this device in order to move freely and execute different tasks.

Sampedro Rea, Jarrín, & Rafael (2014) [8] describe the delineation and elaboration of a mobile unicycle type robot to track trajectories with the help of odometry collecting data to send them to the computer where they will be visualized, communicating the device with the computer through Bluetooth allowing to move without restrictions visualizing the behaviour and trajectory in the LABVIEW software.

Araújo et al. (2014) [9] present a proposal to reduce the construction time of a mobile robot so that the researcher focuses on its main theme by combining the control of these with robotic operating system (ROS) specifically developed to facilitate the use of some tools such as analysis of data and interaction between multiple robots performing simulation tests and created devices.

Orozco-Velázquez et al. (2016) [10] present the design of a mobile robot with the configuration of Ackerman, designed primarily in a computer-aided design tool having several benefits when using it. Environmental impact calculations were made throughout its existence.

3.2 Mobile device communication

Gabriel (1999) [11] according to the results obtained from the experimentation of manipulation of robots by remote control, they identify that this has a difficulty and instability in remote work, which is why they propose the telerobotic method applied to the control of different robots, where they show the advantages of the use of sensory navigation, automatic orientation of shared control cameras and teleoperated genetic navigation in case of communication, showing the pros and cons of using an internet network to participate in the interaction with the devices — proposing a robot man interface.

Valero-Moro, Bonilla-Turmero & Sandoval-Ruiz (2017) [12] present the development of a teleoperated robot station with the purpose of offering an instrument for the robotics microcontroller laboratory, which consists of a platform with a wireless connection of a client connection to a remote connection server, which is based on a design of each of the components, microcontroller programming and implementation, resulting in a set of mobile platforms with wireless communication for manipulation through the server.

Vigueras-Zuñiga (2016) [13] propose a framework to take control of a robot by means of a brain wave classifier obtaining the parameters of movement doing it for free technologies which make it robust.

Rubenstein Michael, Christian Ahler & Radhika Nagpal (2012) [14] perform the Kilobots, are mobile robots to facilitate the implementation of collective work between swarms of large-scale robots which have an infrared communication sending signals which interpret the position of the rest as they move.

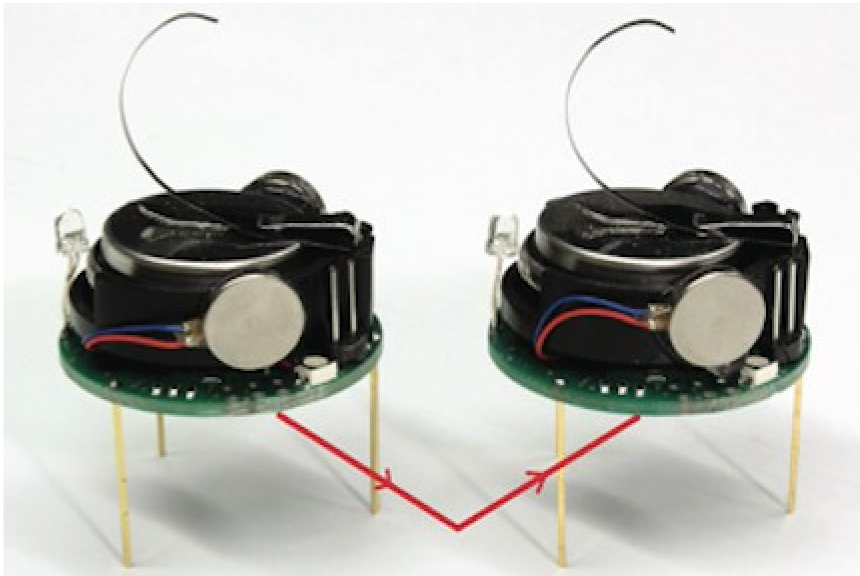

Figure 3. Communication of kilobots Source: by authors and image from [15]

Alphabot 2 is a mobile robot which is compatible with Arduino and raspberry which has an ultrasonic sensor to avoid obstacles, infrared sensor to follow lines and communication via Bluetooth or Wi-Fi.

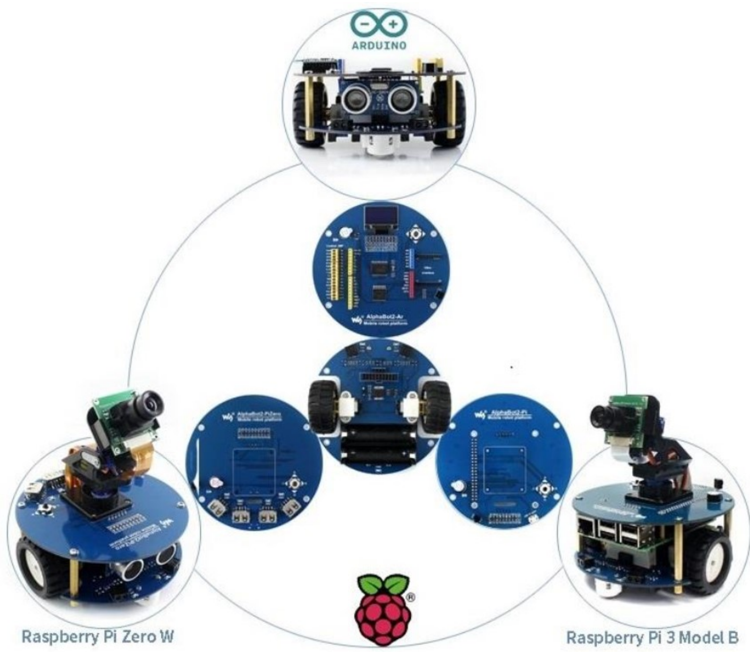

Figure 4. Alphabot 2 Source: by authors and image from [16]

3.3 Bioinspired Algorithms

Mohamad, Omatu, Deris, & Yoshioka (1975) [17] propose the algorithm of a particle swarm to improve optimization to select a subset of genes to catalogue cancer, modifying the rules using the algorithm so that you choose the subset from the data.

Eigen (1979) [18] introduces for the first time the combination of nature and the organization of systems, inspiration is introduced in biological systems considering imitating their behaviour of them.

Kennedy & Spears (1998) [19] use a problem generator to test the operation of algorithms bioinspired by time series. They are obtaining as a result the identification of the pros and cons of the different algorithms.

Hofmeyr & Forrest (2000) [20] propose an immune system algorithm that incorporates natural behaviour having a tolerance of error, dynamic learning, adaptation and self-control, applying it in the detection of intruders in the network, to detect intruders.

Kim & Bentley (2001) [21] describe the use of the immune system algorithm to detect intruders in a network, having machine learning in order to mix both general and specific detectors to learn antigen models.

Kadrovach & Lamont (2002) [22] analyze swarm behaviour such as bird band, fish bank and insect swarm to implement in networks for sensor platforms which are usable for search and surveillance activities, examining simulation behaviour, comparing behaviour swarm, testing various parameters indicated in the methodology.

Figure 5. Biological inspiration Source: by authors and image from [23]

4 Communication by bioinspired algorithms

Petrou and Chan (2011) [24] propose a bee algorithm to assign tasks to robots. These are intended to have the ability to autonomously choose their tasks taking into account their qualities and distance from the objective.

Schmickl & Crailsheim (2008) [25] present a robot communication strategy through large-scale swarm, with the purpose of communicating with each other without any central server. The proposed bioinspired strategy is through the tropholactic behaviour that consists of the mouth-to-mouth feeding of insects.

Purnamadjaja & Russell (2005) [26] implement an algorithm inspired by the swarm behaviour of bees in robots with the purpose of communicating these. Doing this through pheromones with the devices they use, this medium is efficient for the coordination of dynamism, the behaviour to be imitated by these living beings is the necrophoric behaviour which aims to implement an example of communication with pheromones in a physical system , the proposed activity to be able to test it in locating and rescuing the robot.

Marqués, Nunes, & de Almeida (2006) [27] proposed and analyzed different algorithms for swarm optimization of particles with the purpose of looking for odours. These were tested in different environmental conditions and the results of effectiveness in their implementation are shown.

Tsai & Lin (2011) [28] propose improvements for the fish bank optimization algorithm such as the implementation of the particle swarm optimization formulation, also imitating fish communication and creating formulas for the main parameters.

Muraleedharan & Osadciw (2003) [29] propose the algorithm optimization by a colony of ants to take the shortest route to send messages, taking into account the information of the sensors since the energy, memory is finite, this communication is intended to be done by means of wiring and wirelessly.

Zeng et al. (2016) [30] propose a programming strategy through the birds swarm optimization algorithm to find a more effective solution for the operation of a micro-network to solve the multi-objective optimization model. With this, it is tried to imitate the behaviour of the feeding of birds, surveillance and the flight since with this it shows a great capacity of search and robustness.

Tsai & Lin (2011) [31] study the behaviour of the fish swarm algorithm with respect to optimization during the process. Where the results are focused on two categories of study, one of them is function optimization and another is learning through neural networks, and this study indicates that according to the evidence the parameters are reduced and the communication behaviour improves the algorithm.

Rubenstein, Cornejo & Nagpal (2014) [32] implement an algorithm with the goal of self-assembly which consists of building complex shapes from multicellular algorithms to complex animal compositions such as large-scale bird flocks with device limitations.

Fujisawa and Imamura (2008) [33] propose to implement an ant colony algorithm through simulation and experimental in a swarm of robots, to communicate via pheromones they put a pheromone path between the dam and the nest, this helps to find the dam by detecting this.

Gasparri, Panzieri & Pascucci (2009) [34] proposed a solution to locate a swarm of robots based on genetic algorithms, in collaboration between them in order to mimic the exchange of sensor information, relative distance and orientation.

Ducatelle, Di Caro and Pinciroli (2011) [3] present a navigation algorithm for even a swarm of robots based on the communication of sending and receiving position information through a wireless network.

Hauert and Winkler (2008) [36] inspiring the communication of ants which are able to place and maintain pheromone paths that lead to the dam and the nest, taking into account the similarity of this communication to many many land users.

Meng, Kazeem & Muller (2007) [37] present a hybrid algorithm consisting of ant colony optimization and particle swarm optimization for swarms of robots where robots can only communicate in a specific range, this consists of a virtual pheromone mechanism to transmit information.

Zou & Luo (2008) [38] propose a strategy for collaborating in swarms of robots based on an ant colony optimization algorithm, modifying to detect the sources of odour that exist in the indoor environment by mimicking the communication behaviour of ants.

Papagianni et al. (2008). [39] They present the efficient operation of the modified particle swarm optimization algorithm for the design of a network, taking into account decisions such as location and link size, the objective of this algorithm is to optimize design cost and delay of sending information.

Zhu & Zhang (2011) [40] propose a particle swarm optimization algorithm to locate the shortest path of a wireless sensor network, in which it can be seen that routing is effectively found, thus achieving a very high precision providing support in the classification.

Liu et al. (2009) [41] propose a fish swarm optimization algorithm with the purpose of looking for the multicast routing tree with a low cost, they observe in the simulation that it has great performance and reliability for the transmission of information in real-time with better speed.

Gao et al. (2012) [42] present a particle swarm optimization algorithm with a wireless sensor network algorithm to identify the location of the nodes, noting that it improved the accuracy in placing with better accuracy compared to the DV-Hop algorithm without modifications and with a communication load.

Kelm & Heiferling (2010) [43] present the patent for a swarm autonomous routing algorithm, through communication nodes to communicate one point to another, focusing on a mobile network, each node contains a table of pheromone values for neighbours, these are dynamic and these are updated passively and actively.

Yangyang et al. (2004) [44] propose an adaptation of the bioinspired algorithm for swarming particle swarms to perform an appropriate algorithm for the location estimation problem based on the most relevant factors in order to have an optimal Pareto set using the proposed algorithm.

Shan, Jiang & Li (2006) [45] propose a fish swarm optimization algorithm for a routing problem in computer communication networks, it is intended to modify it with improvements such as the taboo table and a parameter that increases the optimal capacity along with the search for neighbourhoods.

Doerr, Sicker & Grunwald (2008). [46] propose a swarm algorithm with the purpose of finding and managing cognitive radio network control channels, it is able to independently find the variables adapting in the presence of a changing spectrum, implementing devices and simulations to compare with the theoretical results.

Li, Cao, Zhao & Liu (2015) [47] propose a new swarm optimization algorithm called shuffled frog modified algorithm observing the results it can be deduced that it works well considering that it improves the efficiency of the receiver coupling significantly improving the communication performance.

Chao et al. (2013) [48] present a proximity mechanism with recognition of applications for communication between devices derived from a firefly algorithm with which they can discover proximity by having a synchronization to discover neighbours and services at the same time contemplating physical communication but this algorithm is not the most appropriate because in most of the topology the properties of the nodes cannot detect all of their surroundings, so they also propose a firefly expansion tree algorithm to solve the problem.

Dressler (2005) [49] demonstrate the possibility of modifying by means of biological applications of cells for computer networks, with autonomous networks combining the swarm intelligence methodology which proves a better efficiency of self-organization in the networks and with a scalable behaviour.

Wang, Cao, Li, Lee, & Sherratt (2015) [50] implement an ant colony optimization algorithm to find the most suitable mobility path for robots, verifying the simulation results can deduce that the network response regarding performance improves in terms of energy consumption and shelf life compared to other algorithms

Urrea et al. (2009) [51] present various mobile agents to exchange information to know the distribution of the land, they will be able to exchange knowledge in a network by modifying the parameters such as speed and direction with a genetic algorithm, the genetic information of each device is exchanged with others within a range, the data consists of location, speed and direction, seeing the results obtained in simulations to verify the efficiency of the algorithm.

Bastos-Filho et al. (2008) [52] propose a search method in charge of estimating the energy function coefficient and the parameters of the neural network through a particle swarm optimization algorithm, putting into practice in three different communication networks whereby results show an improvement in speed than some others.

Rabah & Wu (2015) [53] study the monitoring of robot swarm formation, so it shows the main communication failures due to noise and disturbances, so they propose applying a particle swarm optimization algorithm to know the leader's trajectory, implementing in simulation.

Ferri et al. (2006). [54] presents the design of a bioinspired algorithm also a multi-agent platform for swarming robots in collaboration to apply it with the purpose of locating a gas source in an indoor environment without airflow, the robots cooperate communicating with each other, with the behaviour of a swarm with the purpose of optimizing the work of discovering the source of gas.

Hamrioui & Lorenz (2017) [55] analyze an algorithm based on the communication of ants to know the shortest route is taking into account efficient communications within wireless networks, based on the work they propose this algorithm to improve the mechanism of route selection exploring the superiorities of a system based on an ant colony.

Kulkarni, Venayagamoorthy & Cheng (2009) [56] present the exploration of the distributed iterative location, where the nodes that are in an insistence serve as a reference to find the rest using a particle swarm optimization algorithm is presenting a comparison of this algorithm with that of bacteria search with regarding location, accuracy and time.

Umarani & Thangaraj (2016) [57] propose a routing solution based on a fish swarm optimization algorithm, which shows that the algorithm with a good search capability with a parameter configuration tolerance is robust, proving to have a better delivery of results than some other algorithms.

Leonov (2016) [58] describes the existence of a new swarm intelligence algorithm that, based on a colony of ants and bees, where they experiment proving to be efficient for simulations of the behaviour of bees and ants in life, to improve routing solutions.

Yang & Yong (2013) [59] describe the design of the swarm optimization algorithm for short-lived fish for the strategy of improving the coverage of wireless sensor networks using nodes, with the feature of detecting events of visual behaviour of swarms, the algorithm can behave independently in case of a divided network, concluding that it significantly improves the coverage of the network with a similar one.

Hui, Chen & Niu (2015) [60] propose a particle swarm optimization algorithm to improve the adaptive quality of the population, where the response of the simulation shows that this increases the convergence rate without increasing complexity, therefore, the performance in Real-time in demanding applications.

Han et al. (2014) [61] intend to improve the device-to-device communication by means of a fish swarm optimization algorithm in which the objective is to improve the ability to minimize system interference which has limited resources, maximizing user satisfaction.

Su et al. (2013) [62] propose a solution for device-to-device communication based on cellular networks with the problem of reducing interference in it, implementing the solution of using a particle swarm optimization algorithm to improve system performance with the minimum requirements, the simulation shows that it is superior in performance compared to other schemes.

Ding & Liu (2004) [63] presents a perspective for the collection of information and communication in wireless sensor networks, taking into account the behaviour inspired by the ant colony achieving an improved chain by optimization by an ant colony, resulting in a simulation that the operation, this is much better than others.

Table 1. Comparison Chart.

N	Authors	Trends (used algorithms)
1	Petrou et al.	Ant Colony Algorithm
2	Schmick and Crailsheim	Swarm Algorithm
3	Purnamadjaja & Russell	Bee Colony Algorithm
4	Marques, Nunes & de Almeida	Particle Swarm Algorithm
5	Tsai and Lin	Fish Swarm Algorithm
6	Muraleedharan and Osadciw	Ant Colony Algorithm
7	Zeng et al.	Bird Swarm Algorithm
8	Tsai and Lin	Fish Swarm Algorithm
9	Rubenstein, Cornejo, & Nagpal	Swarm Algorithm
10	Fujisawa et al.	Ant Colony Algorithm
11	Gasparri, Panzieri & Pascucci	Genetic Algorithm
12	Ducatelle et al.	Swarm Algorithm
13	Hauert et al.	Ant Colony Algorithm
14	Meng, Kazeem, & Muller	Ant Colony Algorithm/ Particle Swarm Algorithm

15	Zou & Luo	Ant Colony Algorithm
16	Papagianni et al.	Particle Swarm Algorithm
17	Zhu & Zhang	Particle Swarm Algorithm
18	Liu et al.	Fish Swarm Algorithm
19	Gao et al.	Particle Swarm Algorithm
20	Kelm & Heiferling	Swarm Algorithm
21	Yangyang et al.	Particle Swarm Algorithm
22	Shan, Jiang & Li	Fish Swarm Algorithm
23	Doerr, Sicker & Grunwald	Swarm Algorithm
24	Li et al.	Shuffled Frog Leaping Algorithm
25	Chao et al.	Firefly Swarm Algorithm
26	Dressler	Swarm Algorithm
27	Wang et al.	Ant Colony Algorithm
28	Urrea et al.	Genetic Algorithm
29	Bastos-Filho et al.	Neural Network Algorithm
30	Rabah, & Wu	Particle Swarm Algorithm
31	Ferri et al.	Genetic Algorithm
32	Hamrioui & Lorenz	Ant Colony Algorithm
33	Kulkarni, Venayagamoorthy & Cheng	Particle Swarm Algorithm
34	Umarani & Thangaraj	Fish Swarm Algorithm
35	Leonov	Bee Colony Algorithm / Ant Colony Algorithm
36	Yang & Yong	Fish Swarm Algorithm
37	Hui, Chen & Niu	Particle Swarm Algorithm
38	Han et al.	Fish Swarm Algorithm
39	Su et al.	Particle Swarm Algorithm
40	Ding & Liu	Ant Colony Algorithm

5 Discussion and future research

It is observed that the most used algorithms within the scientific community are swarm algorithms thanks to its great adaptation to solve problems of great difficulty and especially among all the documents analyzed we can see that the algorithm of optimization by ant colony is one of the most used Since this offers better stability in communication between devices or communication networks thanks to the optimization of resources such as energy, or information transfer speed, it is also one of the most used to know the appropriate route to find a solution.

We can also observe that they use an algorithm in large quantities such as swarm particle optimization or fish swarm thanks to the improvements that are obtained with these in terms of performance and without requiring many resources in terms of devices

Figure 6. Ant Colony Source: by authors and image from [51]

Acknowledgements

The authors Eduardo, Martin and Fernando being CONACyT Fellows No. CVU: 929343. The authors thank CONACyT and the National Laboratory for Autonomous Vehicles and Exoskeletons No. 295536 for the support provided.

We thank all the authors for their publications that made this work possible.

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