

An Artificial Immune System Model for Multi Agents Resource Sharing in Distributed Environments

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ABSTRACT

Natural Immune system plays a vital role in the survival of the all living being. It provides a mechanism to defend itself from external predates making it consistent systems, capable of adapting itself for survival incase of changes. The human immune system has motivated scientists and engineers for finding powerful information processing algorithms that has solved complex engineering tasks. This paper explores one of the various possibilities for solving problem in a Multiagent scenario wherein multiple robots are deployed to achieve a goal collectively. The final goal is dependent on the performance of individual robot and its survival without having to lose its energy beyond a predetermined threshold value by deploying an evolutionary computational technique otherwise called the artificial immune system that imitates the biological immune system.

Keywords

Multi-Agents, Artificial Immune System, Autonomous Robots, Distributed Environment, Self-Charging Robots.

1. INTRODUCTION

In recent years there has been considerable interest in exploring and exploiting the potential of biological systems for applications in computer science and engineering. These systems are inspired by various aspects of the immune systems of mammals. Artificial immune system imitates the natural immune system that has sophisticated methodologies and capabilities to build computational algorithms that solves engineering problems efficiently [2]. The main goal of the human immune system is to protect the internal components of the human body by fighting against the foreign elements such as the fungi, virus and bacteria [1]. Moreover, research into natural immune systems suggests the existence of learning properties which may be used to advantage in machine learning systems [5].

Similarly, if there is an environment which is divided into sub environment then each sub environment is traversed by a single bot. Every bot is assigned to do a set job in its environment. Considering an environment being divided into n sub environment with m Bots, each working on one environment, the complete environment may be obtained by

summing up all the individual bot and the sub-environment. The objective of this research is to demonstrate the utility of multi-robot deployed using a unique First Come First Serve (FCFS) charging where only a single charger is used by multiple bots in an environment such that none of the bots are allowed to stop functioning by complete discharge of the battery power. To achieve this unique goal a new computational technique called the Artificial Immune System is applied which presumes the discharge of power of the battery as an external attack to malign the operation of the robot in the environment and uses natural immune concepts to make the robot immune to such failure.

2. IMMUNE SYSTEM

The immune system defends the body against harmful diseases and infections. It is capable of recognizing virtually any foreign cell or molecule and eliminating it from the body. To do this, it must perform pattern recognition tasks to distinguish molecules and cells of the body called "self" from foreign ones called "non self". Thus, the problem that the immune system faces is that of distinguishing self from dangerous non self [1]. Antibodies which are also referred to as immunoglobulin are Y-shaped proteins that respond to a specific type of antigen like bacteria, virus or toxin that contain a special section at the tip of the two branches of the Y that is sensitive to a specific antigen and binds to it. When an antibody binds to a toxin it becomes an antitoxin and normally disables the chemical action of the toxin [6]. Based on a study of the human immune system, we have drawn some properties that can serve as design principles of artificial immune based multi agent systems. The properties relevant to the proposed model are discussed below.

Immune memory: It is a result of clonal expansion. Some of the cloned cells differentiate into memory cells and the rest of the clones become plasma cells.

Jerne's idiotopic network deals with the interaction of antibodies. Jerne's network is a network of B cells that communicate the shape of the antigenic epitope amongst them through idiotopes and paratopes [2].

A huge amount of antibodies can bind to an invader and then it signals the complement system [7] that the invader needs to

be removed. Antigens are defective coding on the cell surface that appears soon after the infection of a cell by an infectious agent, but before replication has begun. Epitopes, which are patterns, present on the surface of the antigen are used by the antibody to detect if they constitute a potential threat to the body. When the Paratope of an antibody matches the Epitope of the antigen, a reaction to suppress the antigen is initiated. In case the match is not exact, the antibody undergoes a process called somatic hypermutation [6], a controlled version of mutation, to set it right. The immune system is unique, robust, autonomous and multi-layered. It is augmented with a distributed learning mechanism having lasting memory [7]. This shows the overall functioning of the immune system. The immune system recognizes the antigens and the antigenic patterns are identified. On identification of an antigenic pattern, the B cells communicate the information in parallel to each other by means of paratopes and idiotopes in the network [3].

3. ARTIFICIAL IMMUNE SYSTEM

The immune system is highly complicated and appears to be precisely tuned to the problem of detecting and eliminating infections. It is believed that it also provides a compelling example of a distributed information-processing system, one which we can study for the purpose of designing better artificial adaptive systems [3], [4]. AIS uses the concepts of natural Immune System to improve the computational techniques and in this paper an attempt is made to provide mechanisms to prevent failure in a multi-robot environment. Every autonomous robot works on limited power and it is drained as the robot works on its course. Using the AIS concept the loss of energy or power from the robot is viewed as an antigen and immune concepts are incorporated to ensure that such antigen do not disrupt the normal functioning of any of the robots.

When more than one bot work autonomously in an environment, it is made sure that none of the bot is allowed to lose its power completely making it non functional. If any one of the bot has weak battery strength that is below the threshold value and is waiting in a long queue to recharge itself, then it may stop functioning completely by it is allowed to be recharged. In order to avoid such eventualities and making one of the robot invalid this simulation allows such robots with critical threshold values to jump the queue to charge immediately ignoring the normal rules of the queue. If such critical cases are not encountered the robots follows the normal characteristics of a queue, thereby ensuring that no robots are allowed to be invalid and completes the assigned task. This suggested technique makes a multi-robot or multi-agent scenario more robust and consistent ensuring the completion of a desired goal.

4. ENVIRONMENT DESCRIPTION

Every bot traverses its environment to do a set job. Considering an Environment(E) being divided into n sub

environments $g(E_n)$ where n is the no of the environment ($n = 1, 2, 3, 4, \dots, n$). The work done by each of the bot is $w(E_n)$. So by summing up the work done by a bot on a sub environment gives the work done on an environment.

$$W(E) = w(E_1)g(E_1) + w(E_2)g(E_2) + w(E_3)g(E_3) + w(E_4)g(E_4) + \dots + w(E_n)g(E_n)$$

4.1 Working Description

The algorithm followed is normal FCFS. When there are lot of variables waiting in a queue then an algorithm is followed in which the first variable to have entered the waiting queue will be the first one to come out of the queue. Whenever the battery is running low then the bot stores its present position and moves towards its docking point. On reaching its docking point the bot check s for the charger. If the charger is empty it moves to the charger otherwise it enters in the queue while waiting for its turn to avail the charger .in this case it follows FCFS. In case the bot is running very low and is towards the rear of the queue then it is made to jump to the top of the queue, hence being the first to avail the charger in the queue. This way the bots are saved from complete failure due to the lack of battery charge. After the charging is complete the bot moves back the position where it had encountered its low power problem. It then resumes its previous work that it was doing.

4.1.1 Simulation Workspace

There are four Autonomous Bot working in different sub environment. Each bot starts from any random position & battery strength. Once the bot reaches the red mark it moves back to the green mark in a straight line. There is only one charger shared by all the four bot. Each bot has a unique docking (waiting) station in case the charger is in use.

The following are the battery strength indicator

High	Average	Medium	Low	Very low
				
Green	Yellow	Orange	Red	Pink

The environment considering ($n=4$) where n is the no of bots and which is also the no of sub environments is described from Fig 1 through Fig 11.

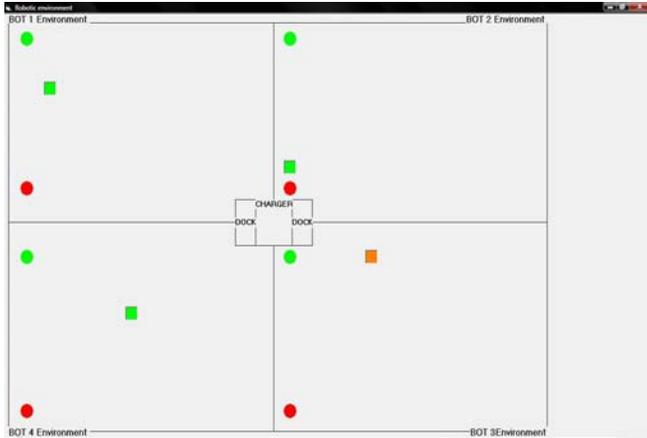


Fig 1. All the bot start from any random position with any random battery strength.

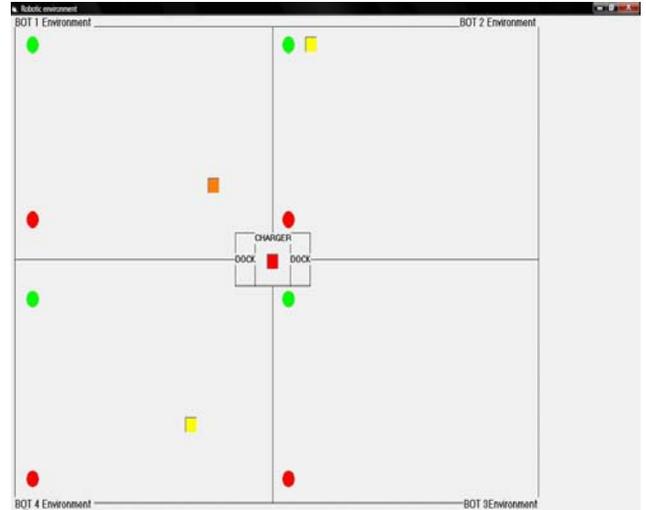


Fig 4. Bot 4 moves to the charger as the charger is not in use and no other bot is there in the docking station.

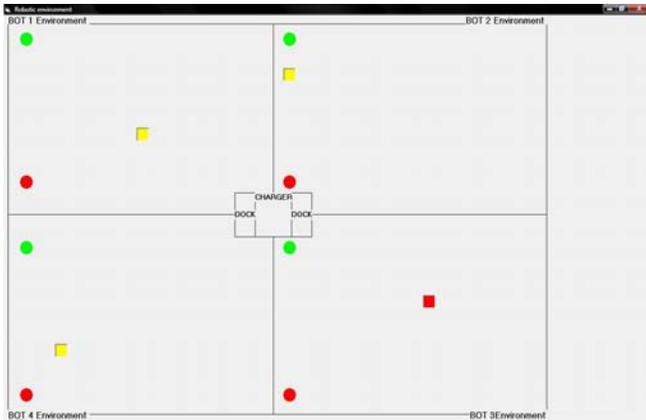


Fig 2. All the bot is working while Bot3 is on low battery.

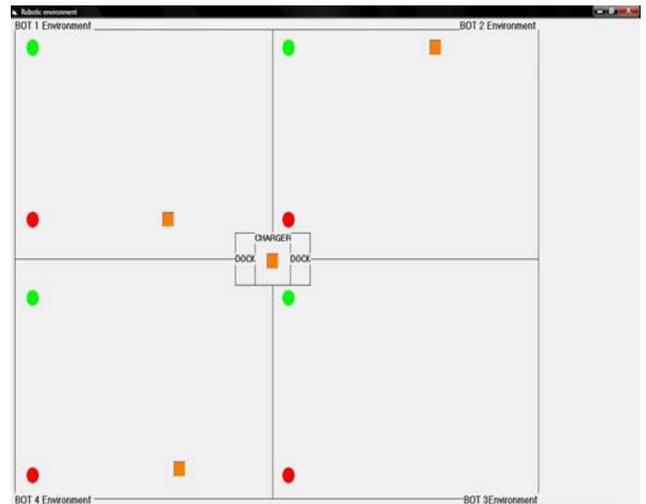


Fig 5. Bot 4 starts charging its battery.

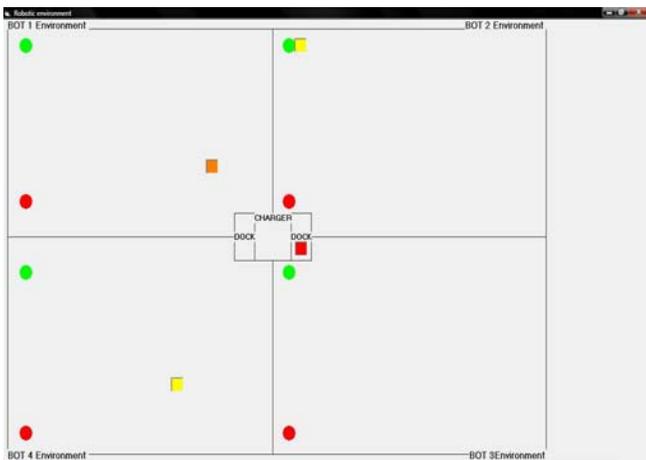


Fig 3. Bot 3 reaches its docking station and checks for the charger's availability.

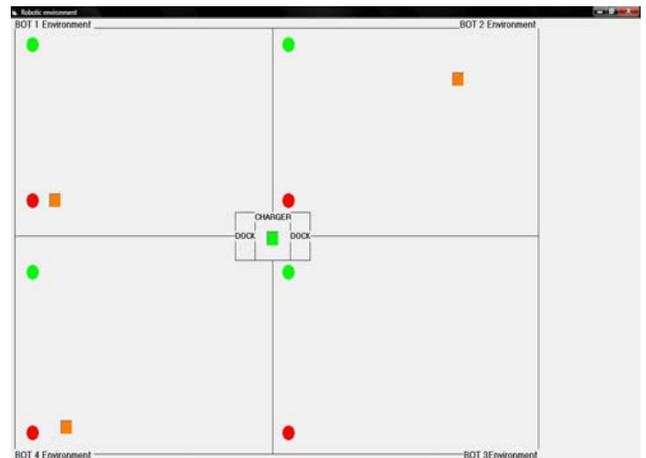


Fig 6. The bot eventually gets charged starts moving to its position.

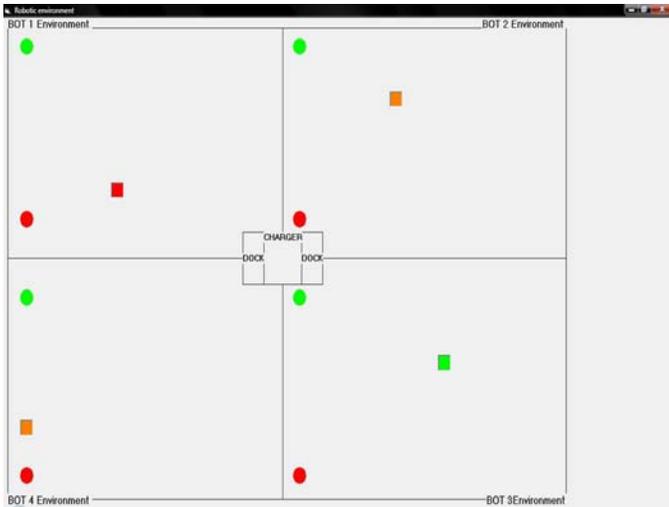


Fig 7. The bot comes back to the the position where it had last left from for charging.

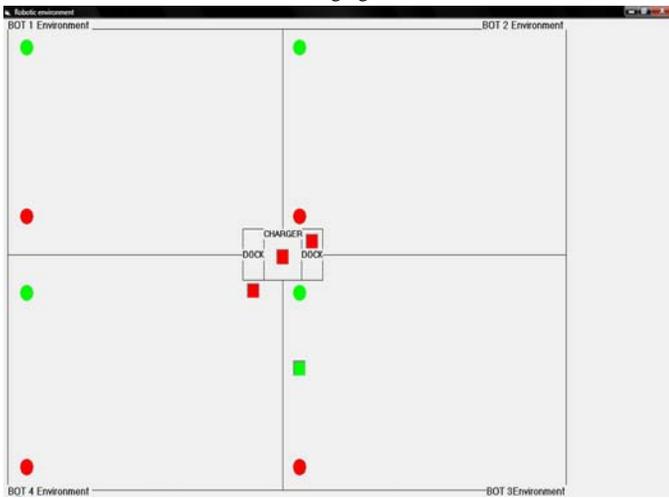


Fig 8. Bot 1 is being charged, Bot 2 is waiting next in the queue for the charger, Bot 4 is just going to reach the dock for charging.

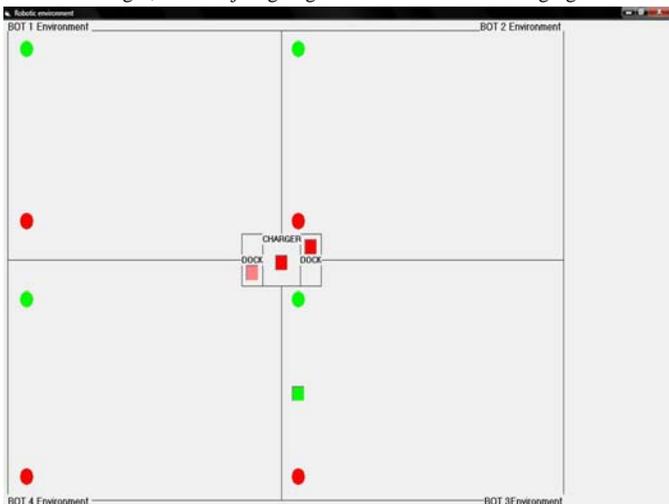


Fig 9. Bot 4 has reached the lowest battery phase

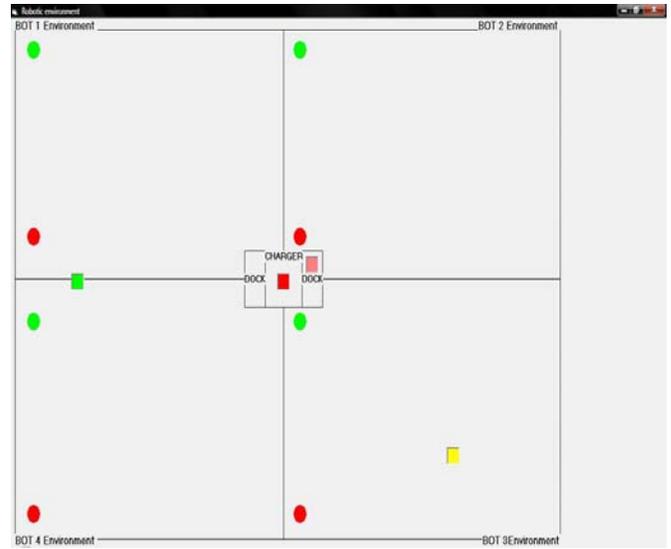


Fig 10. Bot 1 has finished charging, Bot 4 goes for the charger while the Bot 2 waits reaching its lowest battery phase.

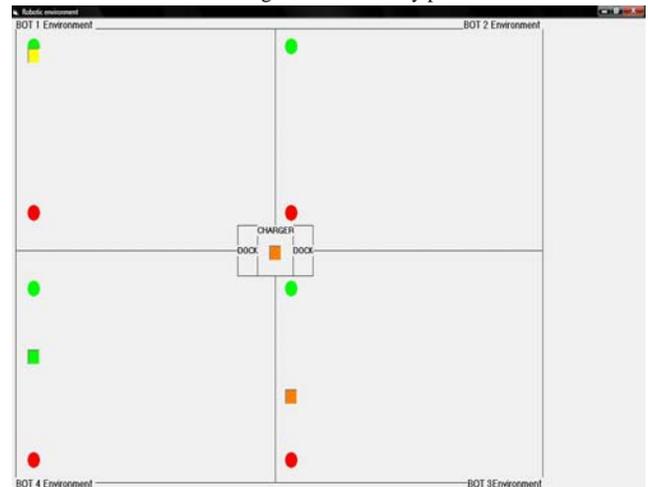


Fig 11. After Bot 4 is finished charging Bot 2 goes for the charger

In Fig 1 It is seen that the bots starts traversing from any random initial point with any random battery strength. The bots keep exploring their environment in a predefined way. Once any one of the bot encounters a weak battery problem it stores its present position and moves to its docking point as shown in Fig 2 and Fig 3. On reaching its docking point it checks for the availability of the charger, if the charger is available then it moves to the charger and starts charging as shown in Fig 4 and Fig 5. Once the bot is charged it moves to its last stored working position as elaborated in Fig 5 and Fig 6.

Considering more then two bots in their docking station and one in the charger, the first bot is considered as the next bot for charging as in FCFS described in Fig 7 and hence according to the Fig 7, bot 2 should be going in next to the charger. However in Fig 8, it is seen that bot 4 battery has

become very weak so it is given a jump in the queue before bot 2 which was considered to go in next. So bot 4 gets the charger before bot 2 as in Fig 9. At last after bot 4 is charged bot 2 is charged as shown in Fig 10.

4.1.2 BotCharging Algorithm

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Start
Loop: a = 1
  For (i = 1 to 4)
    Start bot(i) from any random position with any
    random battery strength
    bot(i).position = bot(i).position + 1 Centimeter
    bot(i).battery strength =
    bot(i).battery strength - 1 Micro charge unit
    if(bot(i).battery strength < 2nd last battery strength)
      Call Charging
    End if
    If bot(i).position = red post
      Move to Green post
    End if
  Exit for
Goto Loop
End

Start sub Charging
  X(i)= bot(i).position
  bot(i).position = bot(i).position + 1
  if (bot(i).position <> bot(i).dock)
    Call Priority FCFS
  End if
End sub

Start sub Priority FCFS
  If (charging.position = empty)
    bot(i).position = charging.position
    charging.position = nonempty
  Else
    Queue(a)=i
    a = a+1
    If bot(i).strength = last battery strength
      const = Queue(a)
      i = a
      For (c =i to 1)
        Queue(c)= Queue(c-1)
        c = c - 1
      Exit for
    End if
  End if
End sub

```

5. CONCLUSION

This research attempts to model a simulation environment based on artificial immune system applicable to intelligent multi agents [3]. An application for the model is simulated. None of the bot is allowed to die by implementing artificial immune system. A unique FCFS is implemented which is re-scheduled if the battery strength of one of the bot goes below the threshold level. The bot whose strength goes down this level is made to jump to the top of the queue, thereby increasing the consistency and efficiency of the complete system.

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