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Multi-Agent Autonomous Cleaning

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Abstract: In today's world, robots are taking over the world by doing the tasks which used to be done by humans a while ago. Robots are continuously evolving into better and more efficient autonomous agents, makes substantial growth in fields like adaptive artificial intelligence. Our main objective of this people is to create an efficient multi agent autonomous environment for robots for cleaning purposes.

Keywords: Gradient Descent, Centralized controller, autonomous agents, LiDAR

I. INTRODUCTION

Cleaning is a task which seems to be easy when done by humans, but then we shift to autonomous domain it is one of the complex processes out there, it is not as easy as it seems. Cleaning process consist of various factors like amount of dirt present, location of various obstacles, size of the room, availability of resources, time management, allocation of resources, efficient cleaning and many more. Autonomous agents[1] come quite handy when it comes to cleaning purpose. They can be tweaked as per our needs to do better cleaning job than humans. Also, autonomous agents may use artificial intelligence and various neural networks to achieve total autonomous cleaning without any human interference. The basic concept of autonomous agents is to create a self-sustainable, reliable environment which is involves usage of technologies like Artificial Intelligence, Computer Vision etc., and make use of resources efficiently. Autonomous agents are powerful tool. This concept is being used to describe one such process using autonomous agents in this paper.

II. COLLECTION OF DATA

Cleaning process requires a lot of data for processing and implantation of a particular task. When an environment involves multiple autonomous agents, the complexity increases even more. Handling of data becomes utmost important in such cases. Collection is information is the start of any project. In this case, we need data which tells us about the nature of the room, size and dimensions of the room, amount of dirt present, location of dirt, obstacles present in the room, resources available and time available to complete the process. Firstly, the room is mapped by a LiDAR[2] sensor which gives us information about the size, dimensions of the room and also the location of obstacles present in the room. The mapping is done sector wise and a sector containing an obstacle is marked accordingly by the sensor. All these information is sent to a centralized controller.

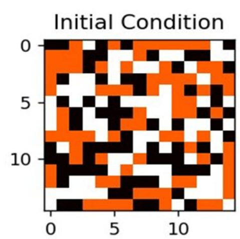

Fig 1. Initial Map

In Figure 1, Orange colour denotes the location of obstacle, black denotes the location of dirt and white denotes clean region.

Coming to the next problem, the amount of dirt present is a vital information which is important of efficient cleaning. Dirt sensor is used to give us the information about the amount of dirt present in the location specified by the centralized controller which in turn received information from LiDAR sensor.

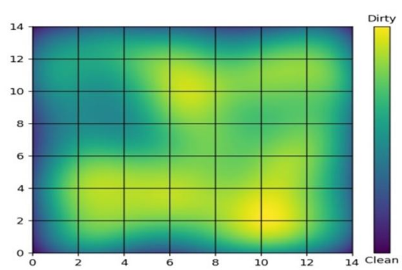

Fig 2. Amount of Dirt

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III. CLEANING PROCESS

Now that we have information regarding the location of dirt, location of obstacle and the amount of dirt present, we can start the cleaning process. First of all, multiple agents are allocated their working sector by the centralized controller and the information is shared with shared with them. The autonomous agents learn the pattern of the dirt present every time they clean the room and store that information in their local memory and as well as specify the same to the centralized controller for better resource allocation, The autonomous agents work on the principle of reinforcement learning, each agent will get a reward for proper efficient cleaning of the toom and a penalty for improper cleaning or giving out false information about the environment. Once the leaning is done, the agent reports back to the controller. Now that its task is completed, centralized controller may allocate the agent to a different sector to assist the agent cleaning that sector. This is can called co-ordinated assistive behaviour. Number of agents can be increased up to a certain point and that the efficiency falls down drastically. The learning pattern for cleaning uses a gradient descent approach[3] to reach the cleaned goal state specified by the centralized controller. The agent learns the cleaning process over time i.e., it comes to know whereabouts of the amount of dirt, frequency of dirt accumulation and the shape and size of obstacles. We can predefine the obstacle's size, shape and location to reduce the complexity of learning. The learning process uses an initial state, goal state, learning rate, number of iterations over which learning is carried out.

IV. PLATFORM

1) *IDE:* PyCharm Community Edition 2021
2) *Language:* Python 3.9
3) *Packages:* NumPy, Matplotlib, seaborn, SciPy, scikit-learn
4) *Algorithm:* Stochastic Gradient Descent

V. RESULTS

The results are divided into two parts, one shows the cleaning process when optimal number of autonomous agents are used in contrast to the cleaning done by large or too smaller number of agents. The results are showed as the desired cleaned region vs actual predicted cleaned region.

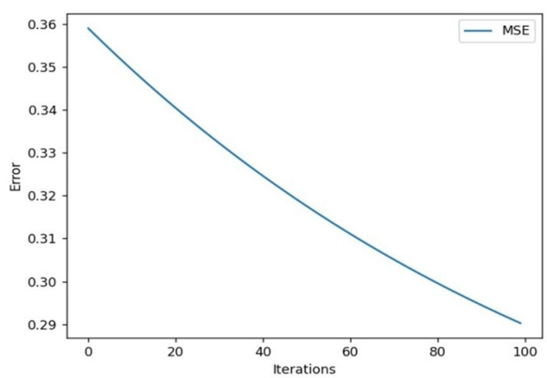

Fig 3. Error vs Iterations of Cleaning

In Figure 3, the graph shows us the decline in the error rate while cleaning the room. After about hundred iterations the room is cleaned efficiently and the cleaning pattern is learnt by the autonomous agents.

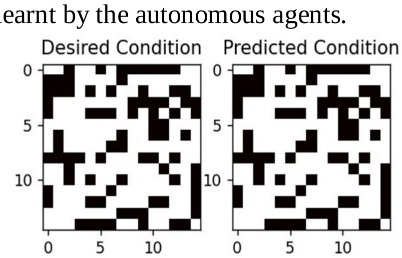

Fig 4. Output of Cleaning Process

From Figure 4, the black sector denotes obstacles while whiter regions are cleaned sectors. We can compare this image to Figure 1 and it is clearly seen that the autonomous agents have learnt how the clean the room with help of the resources available under the control of centralized controller, and cleaned all the dirtier region with total accuracy.

When the number of agents is too many or very few, inefficient cleaning occurs which is shown below.

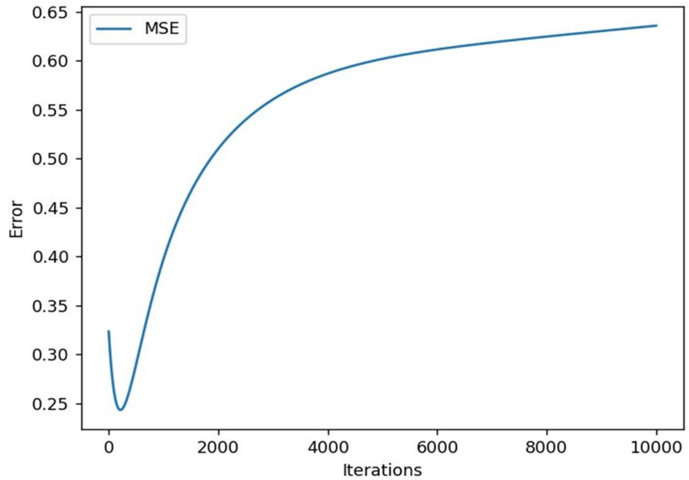

Fig 5. Non-Optimal Cleaning Error

From the above figure, it is clearly seen that as the number of iterations i.e., number of agents doing the cleaning process are increased it leads to a large error and results in very inefficient cleaning.

Usage of non-optimal autonomous agents results in misinformation of various data, inefficient cleaning and vague output and the centralized cannot decide upon resource allocation.

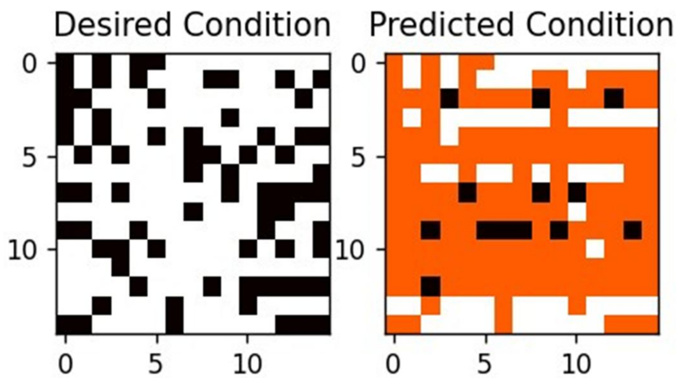

Fig 5. Inefficient Cleaning and misinformation

VI. CONCLUSION

From the above results, we can see that use of multiple autonomous agents in cleaning process is efficient using artificial intelligence and may provide an alternate solution to the traditional cleaning processes.

VII. FUTURE SCOPE

The autonomous agents have opened a whole new domain of artificial intelligence. Such agents have unexplored and wide scope of applications. These systems can be used everywhere and the application can also be altered to cater to the needs of consumers

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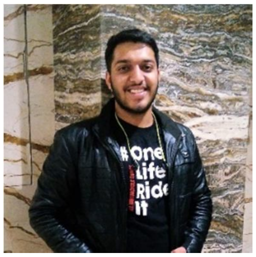

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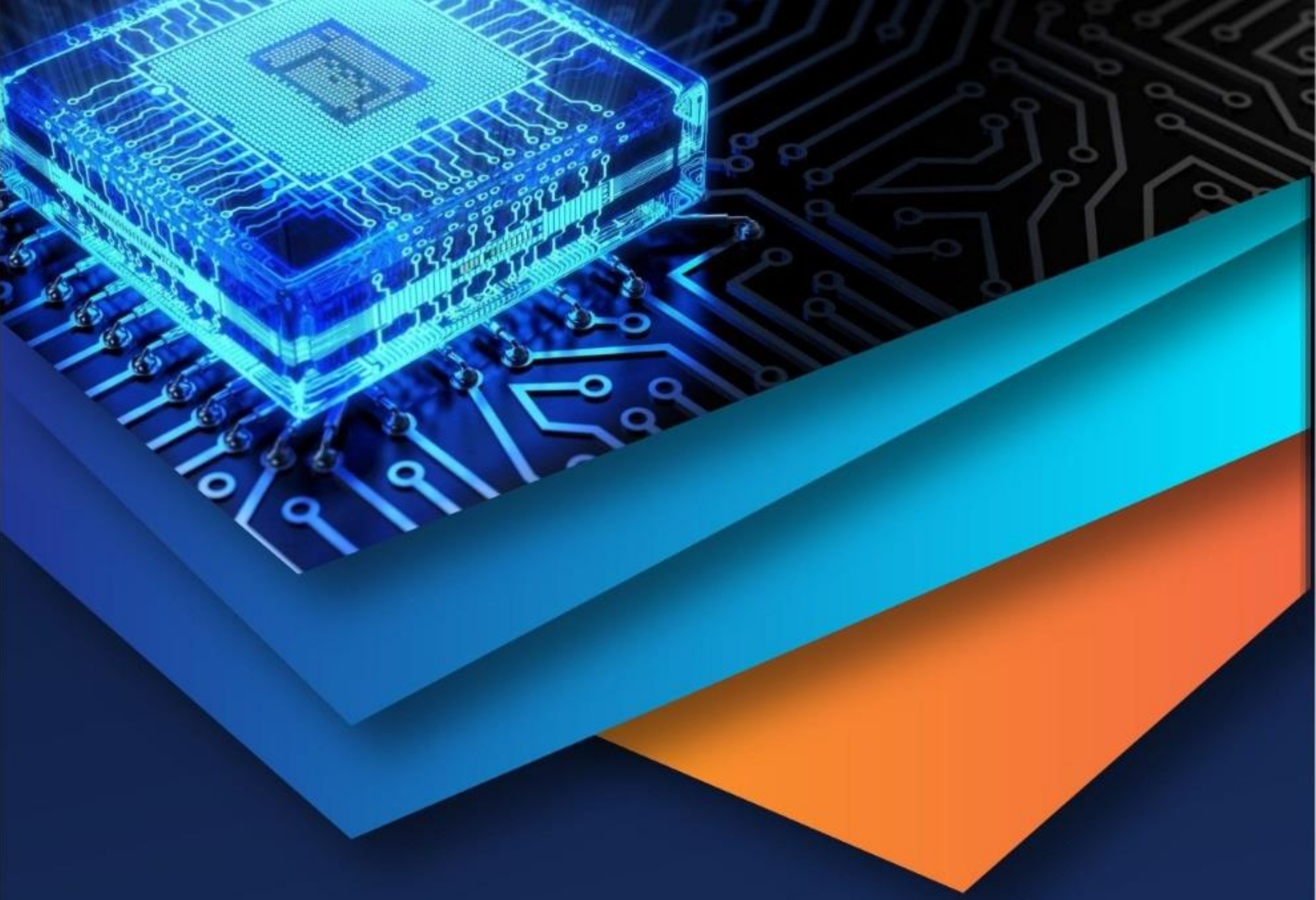

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