Humans And Robots : A Collaborative Workspace

Final Project Report

SOAS

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1 Introduction

Rapid developments in robotics and artificial intelligence have made it possible for people and robots to interact and work together more frequently. This working connection has a lot of promise in a variety of contexts, from work environments to daily life. The ethical principles that govern these interactions must be looked at as the lines between people and technology become more hazy.

The goal of this project, "Humans and Robots: A Collaborative Workspace," is to investigate the complex interactions between humans and robots in a shared workspace. The "Implementations in Machine Ethics: A Survey" comprehensive survey served as the basis for the investigation and categorization of pertinent research papers, and it served as the project's main source of inspiration. The project involves using the NetLogo platform to construct two different simulations. The first application focuses on the moral principles and decision-making techniques used by intelligent agents or robots operating in the workplace. It aims to comprehend how these artificial beings deal with moral conundrums, apply moral rules, and communicate with their human counterparts. The second implementation looks more broadly at how people and robots interact in a collaborative environment. It tries to examine the many facets of human-robot collaboration, such as trust, cooperation, work distribution, and communication. The study intends to identify potential challenges, assess the efficacy of current ways, and offer modifications for a more seamless and effective collaboration by looking at these interactions.

The project seeks to add to the body of knowledge on human-robot interaction and the incorporation of moral principles in autonomous systems through these two implementations. We can learn important things about the dynamics of collaborative workspaces and improve the design of future human-robot systems by replicating and researching these intricate scenarios. The outcomes of this project could influence the creation of standards, laws, and other frameworks that guarantee the ethical and responsible use of robots across a range of industries. We hope to advance a peaceful and fruitful coexistence between humans and machines by encouraging a deeper knowledge of the ethical implications and interactions in human-robot collaboration.

The "Humans and Robots: A Collaborative Workspace" project, in conclusion, aims to investigate the ethical implications and interactions between people and robots in a shared workspace setting. This project intends to shed light on the complex dynamics of human-robot collaboration and pave the path for more informed and responsible deployment of intelligent technologies in the future by utilizing the NetLogo platform and drawing conclusions from existing research.

2 Theorical Aspect of the Project

The "Humans and Robots: A Collaborative Workspace" project seeks to investigate the interactions and ethical implications between people and robots in a shared workspace. The project's theoretical component is grounded in the comprehension of ethical principles and the requirement to apply them to robots or other intelligent entities when making decisions.

The NetLogo platform, which offers a simulation environment to study and evaluate complex systems, is used to implement the project's model design. The model consists of two main implementations: one analyzing interactions between humans and robots in a more general sense,

and the other concentrating on robots/agents and their ethical principles.
In the initial implementation, the actions and thought processes of intelligent agents or robots operating in the workspace are investigated. Each agent is given a color, with red denoting the employers who are people and blue denoting the robots. The agents roam around the workspace, gather resources, and engage in social interaction. By assessing prejudice and injury among agents, the implementation takes ethical issues into account. Based on the agent's proximity to resources and other agents, as well as the agent's attributes, the concept of discrimination is assessed. The model monitors counts of harm and damage, as well as rates of degradation, pollution, and depletion of resources.
The second application focuses on more extensive interactions in the collaborative workspace between people and robots. It examines a number of topics, including communication, task assignment, trust, cooperation, and potential difficulties that could occur when humans and robots work together. The model mimics both human and robot agents' motions and interactions inside the workplace, enabling the observation of their actions and the evaluation of the efficacy of current strategies.

The model's general structure intends to shed light on the intricate dynamics of human-robot collaboration and the incorporation of moral principles in autonomous systems. The project hopes that by modeling these scenarios, it will help people grasp the ethical consequences, contribute to the creation of rules and regulations, and suggest changes for the responsible and moral use of robots in a variety of fields. The project makes it easier to observe and analyze the types of interactions between people and robots in a collaborative workspace by putting the NetLogo simulations into practice. The outcomes and learnings from the simulations can provide insight on the efficacy of existing strategies and possibly guide the development of reinforcement learning techniques like Q-learning to improve robot behavior and interactions.
In conclusion, the theoretical component of the study focuses on how to comprehend and incorporate moral principles into robot decision-making. The model's use of the NetLogo platform to simulate a collaborative workspace environment enables researchers to look at interactions between people and robots in general as well as issues of bias and injury. The initiative seeks to advance our understanding of human-robot interaction and pave the road for ethical and peaceful cooperation between people and machines.

3 First Implementation : Simulation of a dynamic environment with humans and robots and their ethical values

3.1 Definition of the Ethical Values

As previously stated, our main goal is to investigate and shed light on the ethical principles that all agents, including robots, possess. Our work is focused on identifying and quantifying these ethical standards. It is important to outline the many ethical standards that will be used in this experiment before diving into the technical details. Although there are many ethical principles that may have been used, doing so would have taken more time and involved significant investigation.

- *Harm :* In a dynamic environment where humans and robots need to collaborate with each other, it's very important to mention the notion of "harm". Harm is represented in our case as the negative impact that could a blue agent (robot) do on a red agent (human)

Fig. 1: Representation of Harm in the workspace

in the workspace. The variable "Harm" show then the frequency and number of negative interactions between red and blue agents. It will embody the moral principle of reducing harm or adverse effects on people or groups. To define harm, we relied on these criteria:

- *Distance :* We use the distance between the human and the robot and we can choose the harm threshold. If the distance is inferior to the harm threshold then there is harm.
- *Angle :* The difference in angle between the two agents can indicate the possibility of harm. If a human is on his knees for example to gather an object, he wouldn't see the robot and then be harmed.
- *Size :* The difference in size can help us indicate if there is a possibility of harm as well. If the robot is bigger than the human.
- *Speed :* The speed of the robot can be harming the human if he is in his trajectory. We put a speed limit of course, once it's exceeded then it's a problem.

Fig. 2: Representation of Discrimination in the worskpace

- *Discrimination:* The discrimination occurs when two blue agents want to use the resources but instead the first blue agent is abusing the use and wouldn't let the second agent use it properly. So we can say that there is discrimination regarding the use of the resource. It was very hard to quantify it and detect it in the environment. The variable capture the number of discriminatory actions taken by blue agents as well as whether discrimination actually happens. It will strive to lessen instances of unfair treatment based on certain characteristics and reflect the ethical values of fairness, equality, and non-discrimination. For instance, we use these criteria to define if there is discrimination or not :
  - *Distance between the agents:* The distance between the two agents is an indicator that probably the two agents want to use the resource.

- *Distance between the agent and resource:* The distance between the agent and the resource shows how the agent discriminates against the use of the resource and not letting the other one use it.

Fig. 3: Representation of Damage in the worskpace

- *Damage:* Damage means whether or not there is damage to the environment, it was very important to include the environmental aspect and ecological aspects. A robot is not a human and therefore he has no obligation and he is not aware if he is abusing the use of resources or not. An error may occur and he could repeat the same action requested by the human over and over again (like making coffee over and over again). The variable control whether environmental damage happens and keeps track of total damage counts. It will support acts that reduce harm and preserve resources and is related to the ethical values of sustainability and environmental stewardship. To define if there is damage or not, we could use the following criteria :
  - *Distance:* The distance here is the distance between the agent and the resource. We are using a damage threshold, if the agent is too close to the resource, then it's damaged.
  - *Resource Depletion:* Resource depletion means the percentage of use of the resource we have. We overall can define the number of resources and their capacity. So if the Resource Depletion ¿ 50, then we know for sure that half of the resources available in the environment are being used and then we have damage.
  - *Degradation:* Degradation is actually defined using the Resource Depletion variable. More than damage, we are actually having a degradation of the environment and then making it an unhealthy place. If we detect degradation, then we are for sure damaging the environment. We use a Degradation threshold.
  - *Pollution:* Pollution in this case is using degradation to define the severity of the pollution in the environment. When the value is more than the pollution threshold already defined, then we have damage.
  - *Ecological Disruption:* All of the variables defined earlier help us to define the ecological disruption value, if it exceeds a value given to it, then we have it. Therefore damage exists.
- *Resource Depletion:* The rate at which resources are being drained in the environment is calculated by this variable. And we calculate it using the max resources and the actual resource available in the environment or within the patches. It emphasizes the appropriate use of resources, which is consistent with the ethical values of resource conservation and sustainability.

- *Degradation:* The variable keeps track of both the rate of environmental deterioration and its overall tally over time. It emphasizes the significance of preserving and enhancing the health of natural systems and connects to the ethical principle of environmental stewardship.
- *Pollution:* The variables depict the amount of pollution present in the environment as well as its accumulative total over time. It relates to the moral imperative of reducing pollution and its damaging consequences on the environment and other living things. As mentioned before, we define it using the degradation. We could define other criteria but for now, we only use the degradation.
- *Death:* This variable keeps track of how many blue agents perish under certain circumstances, or under the accidents of blue-blue agents. It has to do with the moral principle of protecting life and averting unnecessary suffering or death.

The process of defining unique ethical principles is crucial because it enables us to see and comprehend how these values interact intricately in the workplace. By understanding these relationships, we hope to raise ethically responsible agents that put their own welfare first, respect moral principles while dealing with people, and benefit the environment in which they function.

3.2 Technical Implementation

3.2.1 Defining the variables

The NetLogo platform is used in the technical execution of the workspace simulation. To capture and mimic the dynamics of the workspace, the simulation model also incorporates numerous global variables, patches-own characteristics, and turtles-own attributes. The following list of essential implementation elements is provided:
Before explaining the architecture of our simulation, we must define the global variables we are using and the attributes for both the turtle and the patch.
First, we have defined the following global variables and we'll be using them later on. Global Variables:

- *harm:* A boolean variable representing whether harm has occurred between blue and red agents.
- *harmcount:* A counter to keep track of the number of harm occurrences.
- *decayrate:* A parameter indicating the rate of decay for discriminations.
- *discrimination:* A boolean variable indicating whether discrimination has occurred during robot actions.
- *damage:* A boolean variable representing whether damage has occurred in the environment.
- *degradationcount:* A counter to track the cumulative degradation count.
- *bluedeathscount:* A counter to record the number of deaths among blue agents.
- *global-damage-counts:* A variable to store the count of patches with damaged resources.

- *global-harm-count:* A global variable to keep track of the total harm count.
- *numBlueTurtles:* The number of blue turtles in the simulation.
- *pollutioncount:* A counter to track the cumulative pollution count.
- *min-resources:* The minimum level of resources.
- *global-damage:* A boolean variable representing the occurrence of damage globally.

Then we can define the attributes particular to the patches (green ones representing the resources in the environment) in general. For each patch, we define a capacity which is the max-resource. And then resource indicate the available resource within the patch.

- *resources:* An attribute indicating the amount of resources available on a patch.
- *degradation:* A measure of the degradation level on a patch based on resource depletion.
- *pollution:* A measure of pollution on a patch caused by degradation.

We can define then the attributes particular to the turtles. In fact, we didn't define the size since it's an already built in attribute particular to NetLogo.

- *attribute:* A string attribute representing the attribute of a turtle ("A" or "B").
- *discrimination:* A counter to track the discrimination made by blue agents.
- *speed:* A measure of the speed attribute for blue agents. The speed is actually distributed randomly within the blue agents with a maximum of 5 for the speed.

3.2.2 Presenting the simulation

To make sure the user can modify the different inputs, we used the "Chooser" and "Slider" within NetLogo. We actually did it for the different variables : Number of Robots, Number of Humans, Max-Resources, harm threshold, discrimination threshold, damage threshold, degradation rate and pollution rate.
For the number of patches, we can define them in the code. For instance, for our case, we have defined a number of patches equal to 40. The max-resources are then distributed randomly within the different patches from 1 to "value we choose". Here is an example of how we implemented these built in Choosers and Sliders.

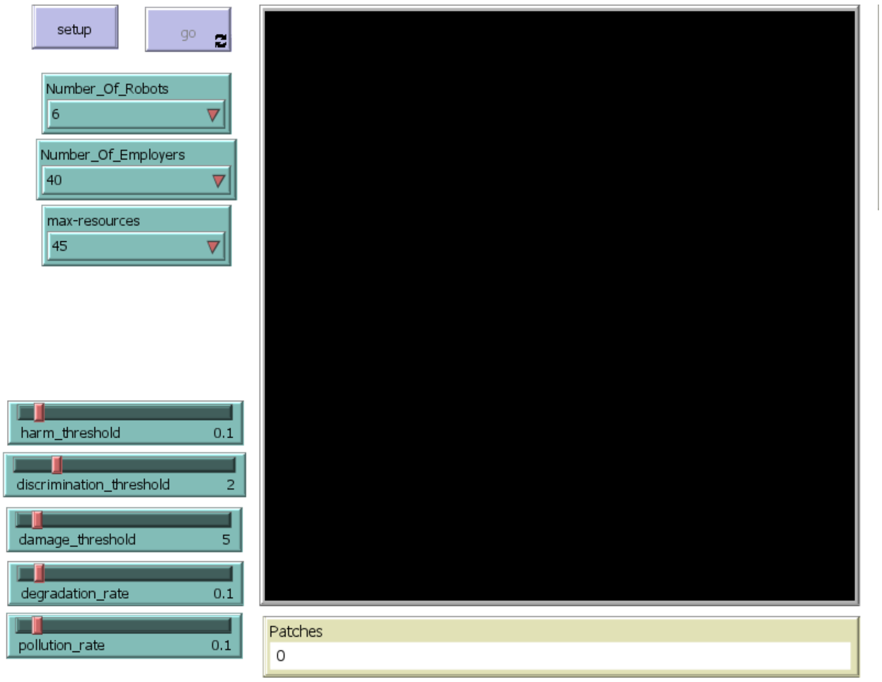


Fig. 4: Representation of the simulation in NetLogo

Technically, we choose the inputs and then click on setup, and after go. Go is defined to be repeated throughout the different ticks. After doing so, we get the following result.
In the simulation, the blue agents symbolize the robots that navigate within the environment. It is evident that there is variation in size and speed among the blue agents, as they are randomly assigned these attributes. On the other hand, the red agents represent humans. In this simulation, we intentionally did not set up specific workstations or desks for the humans. Moreover, both humans and robots are in motion to create a scenario that captures the ethical values in a dynamic environment. The primary focus is on understanding how to foster ethical responsibility in robots within a constantly evolving and resource-rich setting.

The green patches represent the available resources in the environment. Each patch is randomly assigned a certain capacity, with a maximum capacity predefined. When a patch is completely consumed, various outcomes are observed, including damage, resource depletion, degradation, and pollution. In each tick of the simulation, the patches receive random values for resources and other attributes, and vice versa.

By simulating such an environment with mobile humans and robots, along with dynamic resource availability, we aim to explore the challenges and possibilities of cultivating ethical behavior in robots. The interplay between agent movement, resource utilization, and ethical values forms the basis of our investigation.

3.2.3 Discussing the results

Regarding the outcomes, we used graphs to show the distribution and development of different ethical values over the simulation ticks.

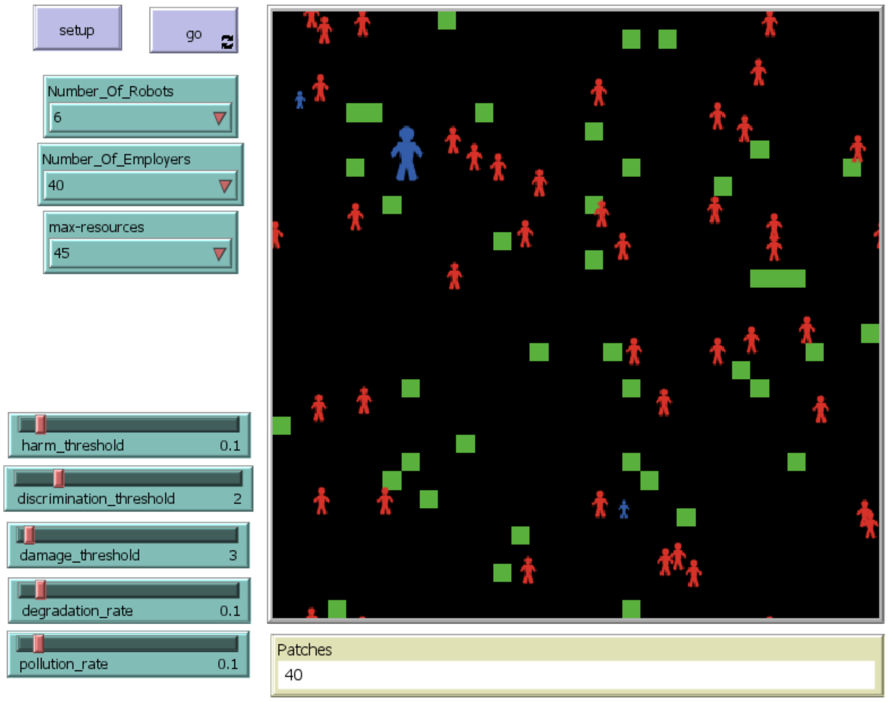


Fig. 5: Representation of the simulation in NetLogo

It's significant to note that the majority of the graphs displayed cumulative values linked to the various ethical criteria. As a result, rather than showing a sinusoidal signal, the results shown tend to show an increasing trend. This cumulative depiction enables us to see how the ethical ideals have grown and developed over time as a whole, giving us insights into how they have affected the simulation as a whole.
Here is some results we got using the different input we presented earlier :

- *Number of robots is:* 6
- *Number of employees is:* 40
- *Maximum of resources is:* 45
- *Harm Threshold is:* 0.1
- *Discrimination Threshold is:* 2
- *Damage Threshold is:* 45
- *Degradation Threshold is:* 0.1
- *Pollution Threshold is:* 0.1
- *Resource Depletion is:* 50

Upon examining the harm graph, it becomes evident that there is a significant increase in the number of harm possibilities after 10,000 ticks. This observation aligns with our expectations,

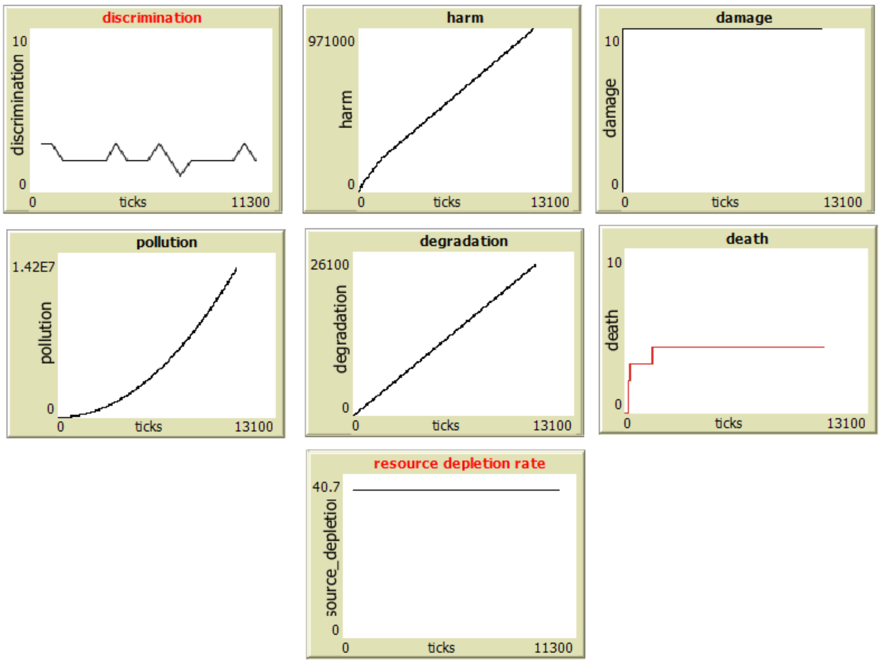


Fig. 6: Representation of the simulation after the go

as the concept of harm is determined by multiple factors, including distance, size difference, angle difference, and speed. Considering that we employ the "OR" operator to evaluate these conditions, it is highly likely that at least one of these conditions is satisfied, resulting in the detection of harm instances.

In analyzing the pollution and degradation graphs, it becomes evident that the number of pollution and degradation instances is substantial. This observation is to be expected, considering that we represent the cumulative count of pollution and degradation across all ticks. As a result, it is natural to observe a significant number and a ascending trend in the graph, given the continuous accumulation of pollution and degradation over time.

The damage graph and the resource depletion rate graph exhibit a pattern where the values start from 0, reach a certain level, and then remain relatively constant. This behavior is consistent across various experiments conducted with different input values. The stability of these values over time can be attributed to the availability of resources in the environment. It is possible that the resources are gradually depleted, leading to damage being incurred, and subsequently, the values of damage and resource depletion rate reach a plateau. Although there may be some minor fluctuations, they might not be prominently reflected in the graph. To provide a comprehensive representation of the obtained results, I will present the detailed findings in the Command Center.

As mentioned before, we can see that there is a slight variation when it comes to the rate, but it's not taken into account since it's a slight variation.

Now let's turn our attention to the discrimination graph, which exhibits a slightly sinusoidal

```
Resource Depletion Rate: 36.722222222222214
Cumulative Degradation: 17849
Cumulative Pollution: 7140448
Discrimination count: 2
Damage count: true
Harm count: 743458
Death count: 4
Degradation count: 18964.444444452594
Resource Depletion Rate: 36.72222222222222
Cumulative Degradation: 18964
Cumulative Pollution: 8060837
Discrimination count: 2
Damage count: true
Harm count: 784458
Death count: 4
Degradation count: 20080.00000001229
Resource Depletion Rate: 36.72222222222221
```

Fig. 7: Representation of the simulation after the go

pattern with fluctuations from one tick to another. Unlike the cumulative values represented in other graphs, the discrimination graph captures the number of discrimination events occurring in the environment. Each value on the graph represents a distinct occurrence of discrimination, indicating instances where blue agents engage in unfair resource utilization and prevent other blue agents from accessing them. For instance, if the value is 3, it signifies that three such discrimination events occurred during the simulation. The sinusoidal nature of the graph reflects the dynamic nature of these discriminatory behaviors and their varying occurrences throughout the simulation.

Lastly, let's discuss the death graph, which showcases changes in the number of deaths from one tick to another. Similar to the discrimination graph, the death graph represents the deaths that occur in each individual tick rather than accumulating them over time. It reveals instances where blue agents cause harm to other blue agents based on the predefined criteria and conditions established in the simulation. The fluctuations in the graph indicate the variability in the occurrence of such harmful interactions between blue agents throughout the simulation.

3.2.4 Conclusions and remarks

In conclusion, exploring the different ethical values and their impact on the environment has been a fascinating experience. We have observed how these values interrelate and depend on one another.

The number of robots, humans, and resources in the environment significantly influences the outcomes we have presented. For instance, we discovered that increasing the number of patches (resources) in the environment leads to a decrease in discrimination. This correlation makes sense since agents have a greater variety of resources to choose from, reducing the likelihood of discrimination in resource usage.

Similarly, reducing the number of humans and resources in the environment has shown a decrease in harm occurrences. With fewer resources available, robots have less incentive to move extensively, thereby reducing the chances of harming humans. However, this reduction in resources can increase the instances of discrimination. Therefore, finding a balance between resource availability and minimizing harm is a challenging task.

To mitigate damage to the environment, reducing the overall resource quantity and increasing the maximum resource capacity can be effective measures. This approach prolongs the time it takes to reach the maximum resource depletion, giving the environment a longer lifespan. However, it should be noted that reducing resources may lead to increased instances of discrimination and deaths, as robots compete for limited resources without being aware of each other's presence.

Pollution and degradation are influenced by each other and also depend on resource depletion. Increasing the maximum resource capacity alone may not solve the problem of environmental damage. A robot that abuses a resource with a maximum capacity of 45 will likely abuse it even if the maximum capacity is increased to 50. Thus, sustainable solutions may require additional criteria, such as imposing usage limits or implementing waiting periods before resource utilization, to promote responsible resource management.

In summary, achieving ethical responsibility in an environment characterized by constant movement and rich resources requires careful considerations of various factors, trade-offs, and potential unintended consequences. I believe, it is crucial to further explore the environmental aspects and analyze robot behavior in more complex simulations. This can be achieved by introducing various types of resources and implementing a learning capacity for robots. By rewarding them with credits and gifts for exhibiting desirable behavior, such as minimizing environmental damage, practicing sustainable resource usage, and avoiding harm to humans, we can incentivize ethical conduct.

4 Second Implementation : Creating an environment to observe the Human-Robot Interactions

As mentioned earlier, this section will delve into the interactions that take place between employees and robots within the workspace. In this experiment, our focus will be on productivity and efficiency, as well as exploring the concepts of coordination and collaboration. Additionally, we aim to examine the implementation of communication protocols and task allocation to better understand their impact. Instead of emphasizing ethical values, our main objective is to assess how these factors contribute to enhancing workplace dynamics.

4.1 Describing the environment

Our motivation behind developing the simulation stemmed from a call center environment. We sought to create an accurate model that captures the intricacies of a call center, recognizing its inherent complexity. By choosing this environment, we aimed to provide a compelling example for observing the interactions between robots and humans in a challenging and multifaceted setting.

What sets our simulation apart is the user's ability to customize the floor plan according to their preferences. Whether it involves two or more floors, the user has the freedom to design the

Fig. 8: Call Center office

layout, including the number of desks and additional facilities like a kitchen, printer, bathroom, and meeting room. The inclusion of these facilities is essential because the robots are expected to assist employees in various tasks, ranging from delivering papers in the meeting room to preparing coffee in the kitchen. As the robots navigate the workspace and engage in different missions, they will interact with other humans along the way, potentially receiving additional tasks.

This simulation's unique aspect lies in empowering the user to design their own workspace, allowing them to observe the interactions that unfold. The dynamics of these interactions may vary as employees transition between different environments, which we will explore later. Furthermore, we have incorporated additional variables to gain a comprehensive understanding of the interactions between employees and robots.

4.2 Technical Implementation

4.2.1 Setting up the environment

As mentioned earlier, the user have the ability to choose his own plan and design it as well using the draw function. As we will see bellow, we have different options to choose from to design our own environment :

Once the various elements of our floorplan have been drawn, it is necessary to export the floorplan to our desktop for future use. This allows us to implement different scenarios by modifying factors such as the number of employees. The floorplan is exported in a TXT format and saved

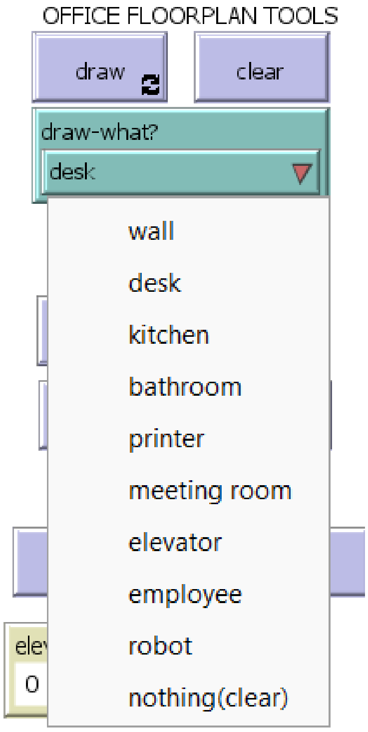


Fig. 9: Representation of the draw function

Fig. 10: Representation of the import/export floorplan function

in our downloads folder. Subsequently, whenever we wish to run the simulation, we simply need to click on the "import floorplan" button.

The file floorplan contain informations about the different elements we included in our environement, their colors, their names and their positions.

As a result, our aim was to create a workspace that resembles a call center, and the following image illustrates the outcome. In the image, employees are depicted next to their brown desks, while robots have their own designated rooms (in our case, the charging room). The robots

```
"export-world data (NetLogo 6.3.0)"
"Robot_Worker_Proximity_1.nlogo"
"05/20/2023 22:05:35:559 +0200"

"RANDOM STATE"
"0 0 -1727483681 398 0.0 false 880759116 -1479930097 1712600544 1094500465 -773803541
705779340 -1527549129 679921489 2139116413 1422639234 394845380 986962145 1996472458 1712512594
2015342057 -1567702544 584317376 -264855743 1031289656 1056265877 -141986033 -247958391 -265280405
1473118828 1031273768 -919031000 2080920508 1092499149 128851789 460280129 830544188 510288240
660197776 1007190959 -519424679 1401647998 -1607550404 -1254322584 100502758 226931606
1786094522 -926958431 157520031 -1730512368 -1658206442 528521038 1311849364 1681924007 55605034
1444784525 1991548118 1368034346 -2085765227 -1909023117 2127694996 -492524862 -1639893432 -666130429
978661496 -696564639 1880758484 -1519259295 820459040 2029698638 1191974255 -346002897 1426574948
1771936847 265598556 577369428 1794228736 -661389394 1675913534 -325684913
```


Fig. 11: Representation of the floorplan file

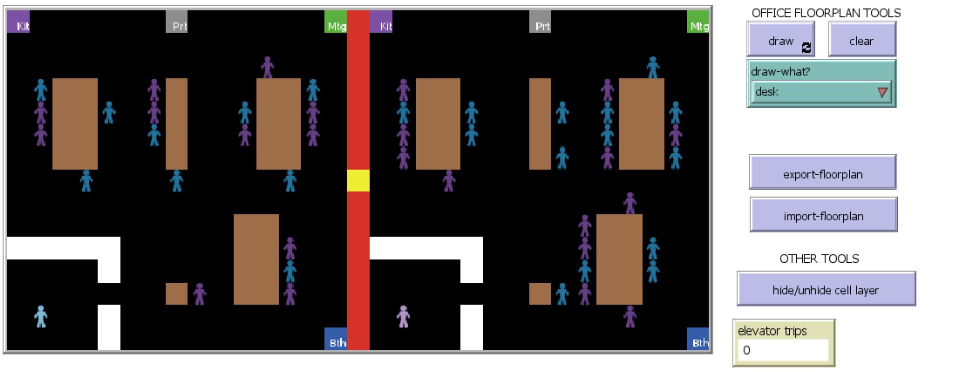


Fig. 12: Representation of the floorplan

remain stationary until they are called upon, using the charging rooms to recharge themselves in the meantime. Additionally, we have a yellow lift and a two-story layout.

On each floor, there is one robot accompanied by a specific number of employees which 46. The user has the flexibility to decide whether they want the employees and robots to navigate between floors. In our case, we would like them to move between floors in order to observe both the interaction between humans and machines, as well as the interaction between machines themselves.

Once the floorplan has been designed, the next step is to set up the office environment by assigning the appropriate roles to employees and robots, as well as identifying other facilities. This ensures that employees are recognized as employees and robots are identified as robots within the simulation. Additionally, the setup process involves configuring the specific attributes and characteristics of the employees. Prior to this step, the employees are merely placeholders without any defined attributes or roles, but the setup phase gives them their intended identities and defines their roles within the simulated environment. For more technical details, the setup employees() function will create employee objects, assigns them random spots on the floorplan, and stores them in a list to initialize the desired amount of employees in the simulation.

In addition to configuring the office layout and setting up employees, we have the ability to define the elevator barrier, determine the percentage of filled desks, and make a decision regarding floor-to-floor movement. These aspects have a significant impact on the overall outcome, and

Fig. 13: Representation of setup office

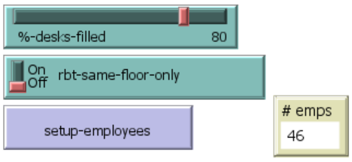


Fig. 14: Representation of setup employees

we will discuss their implications in the conclusion.

After setting up the parameters, we have the option to initiate the simulation by clicking on "Go." The simulation can run for a specific number of ticks or indefinitely, as both options are available. Additionally, we can adjust the likelihood of meetings taking place on different levels of the office, which affects the probabilities of employees and robots moving between levels. Finally, we can observe the results of our simulation. The results will be represented using graphs and reporters to have a clear idea of what's happening throughout the simulation.

4.2.2 Discussing the results

To explain better the simulation logic, we will explain it further. In fact, it is centered on how tasks are carried out and how robots move to complete them. Employees are given tasks to accomplish, and they have the option of asking a robot to help. The employee dials the robot, which then determines the quickest route to the employee after receiving the call. It moves in the direction of the employee, passing through the office and, if required, switching floors. The robot helps the worker do the assignment after it has arrived.

Therefore, the robot's movement is essential for quickly getting to the workers and aiding task completion. The simulation then and as mentioned before simulates the dynamics of collaboration between humans and robots in achieving goals by coordinating task assignment and robot movement.
Taking in consideration these variables, we get the following results.

- *Probability of moving between floors:* 0.7
- *Percentage of desks that are filled:* 80
- *Elevator Barrier:* 20
- *Moving on the same floor only:* OFF

In Figure 16, it is observed that a significant number of employees have a non-zero value next to them, indicating the amount of time they interacted with the robots. This information allows us to calculate the percentage of employees who either did not encounter or utilize the robots.

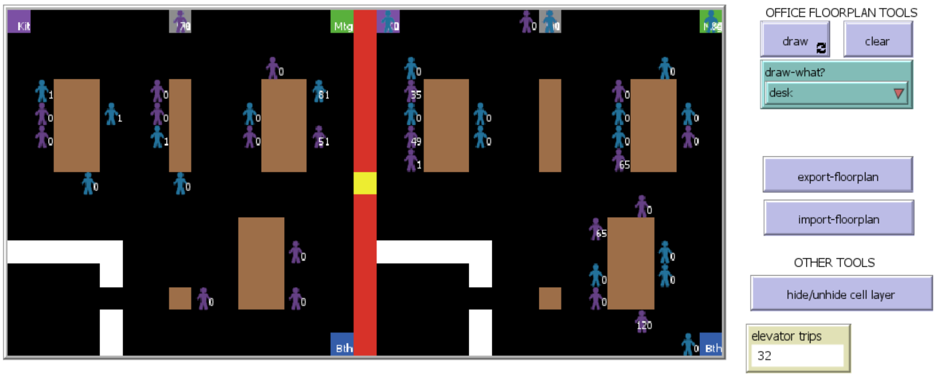


Fig. 15: Representation of floorplan result

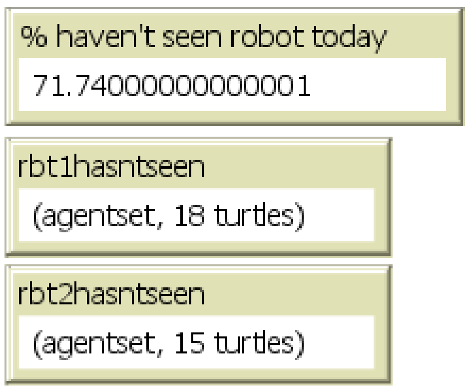


Fig. 16: Representation of results

Fig. 17: Representation of results

In our case, after 4000 ticks, it is found that 71 percent of employees did not have any interaction with the robots or assign any tasks to them, resulting in no encounter. Furthermore, a comparison between robot 1 and robot 2 reveals that robot 2 was utilized more frequently than robot 1.
This discrepancy could potentially be attributed to performance issues or the specific needs of employees on the second floor, which necessitated greater reliance on robot assistance. Various theories can be explored to understand these outcomes. It is important to note that the robots were allowed to move between floors, and graphs were generated to examine their inter-floor movement patterns. Analyzing these graphs may provide insights into the usage discrepancy between robot 1 and robot 2.

The first graph provides an overview of the destinations within the workspace. These destinations can represent both the assigned tasks for the robots and their physical destinations. It is evident that a significant portion of the destinations are the kitchen and the printer area. This suggests that the robots are frequently assigned tasks related to these facilities, which aligns with the employees' workload and requirements.

In the second graph, a comparison between Robot 1 and Robot 2 reveals a notable difference in their movement patterns. Robot 1 appears to primarily remain on the first floor and does not frequently visit the second floor to perform tasks. On the other hand, Robot 2 demonstrates more inter-floor movement, interacting with employees on both floors. This discrepancy in preferences could be attributed to various factors such as performance limitations, insufficient battery charge, or lower speed. Notably, Robot 2's ability to move between floors easily and accomplish tasks more frequently contributes to its higher interaction rate with employees.

Overall, these graphs shed light on the distribution of tasks and the movement patterns of the robots. They provide insights into the preferences and efficiency of each robot, offering potential explanations for their varying levels of interaction with employees in different areas of the workspace.

4.2.3 Conclusions and remarks

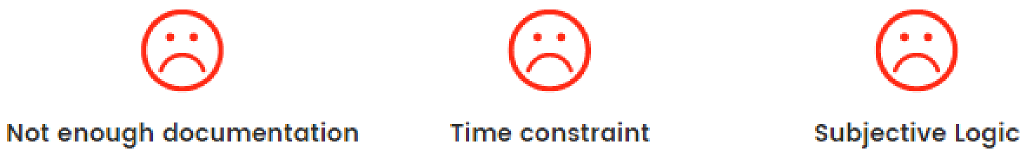
In conclusion, our simulation of worker-robot interactions in the workplace, especially in a call center context, has produced insightful results. We were able to examine the dynamics of task distribution and robot movement by creating the floorplan, setting up the workplace, and configuring the workers and robots.Through the simulation, we discovered that a sizeable portion of employees were unable to use the robots or assign jobs to them. This shows that more research on how to boost robot engagement and usage in the workplace may be necessary. Additionally, we saw that the two robots had different usage styles, with Robot 2 participating more actively in inter-floor travel and task completion than Robot 1. Performance restrictions, charging capacities, or different task needs on each floor could all be contributing factors.

Visual depictions of these patterns could be seen in the graphs showing general destinations and movements for specific robots. The frequency of locations like the printer area and kitchen area suggests the importance of chores using these amenities in the office. Understanding these task distribution patterns and robot motions can guide future resource allocation improvements and work toward maximizing human-robot interaction. Overall, I think this simulation was a useful tool for researching and examining how people interact with robots in complex work environments. It emphasizes the significance of work distribution, robot movement, and their influence on interactions between humans and robots. Still i think we could do more research and investigation on why the employees didn't use the robots, and why the robots are not being used equally when it comes to the tasks allocated.

5 Challenges and Future Work

5.1 Challenges faced in the project

Due to the dearth of thorough documentation and resources on the subject, implementing intelligent agent ethical agents is a difficult task. Since the study of ethical agents is still relatively young and developing, there aren't many set frameworks and instructions for putting them into practice. It is challenging to establish a precise and widely accepted set of rules and principles to direct the creation of such agents due to the absence of standardized documentation.



Additionally, the subjective character of ethical issues themselves adds another layer to the implementation process. Individuals and cultures may hold different ethical standards, which can result in different interpretations and perspectives of what is considered ethical behavior. Given that various developers may prioritize and value ethical aspects differently based on their own viewpoints and opinions, this subjectivity introduces a certain amount of bias into the implementation.

Time restrictions may make it more difficult to develop ethical agents, in addition to the difficulties presented by incomplete documentation and arbitrary interpretations. Research, study, and consideration must go into creating a strong and complete ethical framework. It is a difficult task that requires considerable thought and effort investment to figure out how to measure ethical ideals and include them in intelligent agent systems. Real-world projects, however, frequently have time constraints that can prevent in-depth investigation of ethical issues, leading developers to make concessions and trade-offs.

In conclusion, the implementation of ethical intelligent agents is a difficult and complex task. Significant challenges include the lack of resources and documentation, the subjective nature of ethical questions, and time restraints. It is critical to support continuous research, teamwork, and the creation of standardized policies and frameworks that can offer better guidance for integrating moral agents into intelligent systems in order to advance the subject.

5.2 Opportunities and future work

For the project's continued growth, a deeper knowledge of the nature of interactions between intelligent entities, and the introduction of ethical ideals into the model, a particular focus on the second implementation would be highly advantageous. It might be feasible to learn more about the complexity and subtleties of ethical decision-making within intelligent systems by expanding the research. The use of reinforcement learning strategies, such as Q-learning, is a worthwhile strategy to take into account for improving the implementation. Agents can learn and develop their behavior through trial and error using reinforcement learning algorithms. The robots might use Q-learning to modify and improve their actions and decision-making based on the input and rewards they receive from their surroundings. As a result, an iterative learning process would be possible, enabling the robots to dynamically modify their behavior to conform to ethical principles.

By incorporating reinforcement learning, it would be possible to observe how the robots interact with their environment, make decisions, and assess their impact on ethical values. This would provide valuable insights into the effectiveness of the implemented ethical framework and identify potential areas for improvement. Through iterative experimentation and analysis, the project could contribute to advancing the field of intelligent agent ethics by uncovering new strategies and approaches for promoting ethical behavior in autonomous systems. In fact, a fuller understanding of the difficulties and potential related to the implementation of ethical agents would also be provided by expanding the study to incorporate more intricate scenarios and environments. An extensive investigation of the robots' conduct and their adherence to ethical norms in diverse circumstances might be made possible by taking into account a range of ethical conundrums and decision-making scenarios.

In conclusion, by continuing the project and incorporating reinforcement learning techniques, particularly through the utilization of Q-learning, it would be possible to further develop the implementation, observe the nature of interactions, and explore the integration of ethical values into the model. This would contribute to a deeper understanding of ethical decision-making in intelligent systems and facilitate the refinement and enhancement of the ethical framework within the project.

6 Bibliography

[1] Tolmeijer, S., Kneer, M., Sarasua, C., Christen, M., Bernstein, A., 2021. Implementations in Machine Ethics: A Survey. ACM Comput. Surv. 53, 1–38. https://doi.org/10.1145/3419633

[2] Discrimination against robots: Discussing the ethics of social interactions and who is harmed

[3] Barfield, J.K., 2023. Discrimination against robots: Discussing the ethics of social interactions and who is harmed. Paladyn, Journal of Behavioral Robotics 14. https://doi.org/10.1515/pjbr-2022-0113