Introduction

This project will have an in depth look at the **use of autonomous agents within a warehouse facility**, aiming to investigate how efficiency and injury risk is affected by using agents instead of manual labour, and compare the results. This is to show what could be changed in supermarkets and other large business warehouses when they become semi-automated removing any unnecessary risk of injury. This can be a crucial decision for businesses to allow for them to maintain maximum sales without the risk of being short staffed due to workplace injury, whilst also trying to maintain the job roles they have.

My main aim for this project is to create a simulation that has automated agents (AA) to go collect the stock from a loading area, assign it to the correct location and then transport it there optimally. Other goals I have are to implement collisions and randomised layouts to fully test the variables of the simulation. From my research and findings, I was able to compare businesses such as Amazon who have already moved to AA alongside supermarkets who haven't, this highlighted a vast difference in work ethic and efficiency, as well as the benefits it has on human workers thus reducing work stress and labour they have to do. The proposed approach I have for this project is to find and compare a range of articles and online sources to assess a varied overview of the topic. Before reading some more in-depth articles on AA in general to help strengthen my knowledge of them as well as personally being at supermarkets and seeing the issues within the warehouses. Once I have finished my research, I created a simulation to run and test the variables changes. The outcome of this project will be to underline the benefits of using autonomous agents within a warehouse compared to the current ways and the recommendation for companies to begin looking into this approach.

Literature Review

The purpose of the literature review is to provide a detailed understanding of what Autonomous agents are and the use within the warehouse operations and the impact on the productivity and safety of using them. By critically evaluating material around the selected topics, it will contextualize the significance of the project.

A thorough approach was conducted for the literature search. Primarily focusing on journals, books, and articles. These were assessed to ensure they were credible authors and sources, which allows for all the theories and case studies to be balanced and fair within the field of autonomous systems in warehousing.

This review has been structured to specifically provide a coherent argument portraying the description of the proposed study. To begin with it will cover the broader role of automation in warehouses and its importance followed by going more in-depth with AA. As well as comparing manual versus automated systems to conclude the review it will highlight the gaps in literature and future options. Overall displaying the importance of the project. Reasons for conducting this project and researching this literature is because the integration of autonomous agents has become increasingly crucial in response to the rapid growth of global e-commerce and the heightened demand for just-in-time logistics. These factors underscore the critical importance of investigating the role of autonomous agents in enhancing productivity and safety in warehousing operations.

Role of automation in warehousing

Automation in warehousing has been a crucial factor for a long time allowing for mass production to be widely more accessible. Due to consumer demand the operations which were heavily run by manual labour were incorporated into automated systems to optimise the efficiency and reduce the operational costs for the labour required.

The major shift towards with automation started from the more complex logistics operations in industries such as retail and manufacturing. A key company to evaluate would be amazon as they have implemented advanced automated solutions to meet the global demands of commerce with flawless management and operating times.

Automation in warehousing can be divided into several important stages:

1. The first key stages are mechanisation, most warehouses began with only the basic mechanical tools such as conveyor belts and lifting vehicles, however this severely relied on human intervention and management.
2. The second integral stage was automation this stage brought about the use of automated systems such as warehouse management systems and automated guide vehicles. Allowing for more efficient sorting and operations.
3. The final stage was intelligent automation, current warehouses of today use autonomous agents to achieve full optimisation. These agents are tasked to work with minimal human intervention using many sensors and algorithms to adapt. “AI-powered systems enable automated inventory tracking and optimization, allowing warehouses to monitor stock levels, locations, and movements in real-time.” (Amoo et al., 2024)

The benefits of automation can offer many advantages which displays the importance of automation in warehousing these key features are increased efficiency, reduced errors, cost

savings and scalability. All these features allow for higher demand to be covered and management of inventory to be more efficient.

Within the real world there are a few key illustrated companies that help show automation importance. The largest and most relevant company that can be compared would likely be amazon as they have adopted the use of kiva robots to manage and improve amazons warehouse operations. These simple robots transport goods across the warehouse and dramatically improve the processing times and space utilization, these major changes have caused their productivity to increase by around 20%. "The integration of Kiva Systems' robots into Amazon's warehousing operations has been nothing short of revolutionary" (Janberg, n.d.). although this online article does not hold compelling arguments it shows the substantial impact the robots had in warehouse management. Although the addition of automation has be revolutionary for the industry there are an array of downsides and cons to it. The first major issue is cost, to setup and begin the process of using autonomous agents is a high start up and running cost as well as the higher technical challenges that may come with the addition of robots. Arguably the largest issue that may arise with the addition of automation is the ethical concerns that may arise within the workplace such as displacement of the workforce and social implications on human reliance. In conclusion the addition of automation in the warehouse industry has been vital to its survival and adaptability due to the demands of today, and by using autonomous agents and intelligent systems its clear to see the transformative impact that is has despite the few down sides that may come along side it.

Critical Evaluation

Within this critical evaluation I intend to discuss and review the literature I have chosen to use within this project and how useful they are towards it as well as if they have convincing arguments, are trustworthy and do they best fit my project.

A use and inciteful research article that I have analysed is "AI-driven warehouse automation: A comprehensive review of systems" this in depth review of the use of AI within a warehouse helped to create a strong understanding of the current trends and implementation of the automation and AI within the industry, because of this it strongly fits and supports the context of my project allowing for a stronger and more thoroughly backed argument. Despite this however it lacks any data or results that can be compared to and used alongside my tests meaning it falls short of being complete sufficient causing more data to be found elsewhere to back up my claims. This article allowed for me to find current and trending methods and techniques being used in the current warehousing industry so that I can compare my methods too. Within this article there are a few statements such as, "AI revolutionizes order fulfilment processes in warehouses, enabling faster, more accurate, and cost-effective order processing from receipt to delivery (Torchio, 2023)." (janberg, n.d.), that support the ideals of the use of AI but fail to include the downsides of it such as the start up cost and technical changes. Theses are major concerns when companies think about using AA as if they do transition and it does not work out or causes the business to struggle a massive financial deficit appears. As well as the ethical and moral concerns when relating to workers and the potential loss of jobs or work hours making companies wonder if it is worth switching to robots and potentially losing reputation. So, although this article gives thorough insight into the revolutionary addition of AI in the warehousing business it fails to include a majority of costs and difficulties of using the technology to begin with. Furthermore, they do touch upon some challenges that may be faced with the addition but mostly focus on the cyber side of issues such as malware and cyber-

attacks. In conclusion, although this article lacks in a few areas of knowledge it thoroughly supports my project and is a building block of a sturdy foundation for it.

Another set of new articles written by the BBC display a varied selection of information showing the state of warehouse operations before the addition of autonomous agents and robots. The first new articles talk about injury rate within amazons' warehouses in 2021 with the statistics "A union-backed study of safety data found Amazon workers had 5.9 serious injuries per 100 people - almost 80% higher than the rest of the industry." (BBC News, 2021) this showed the dire situations within amazons' warehouses before the introduction of Kiva robots and how important that change was. This heavily supports the need for automation and robots in warehouse to drastically reduce the chance of human injury and stress that they may undergo. The second Article 'Robots to take on more supermarket tasks' demonstrates the changes businesses in the warehouse world where undergoing to accommodate the changes in automation and efficiency. With this article alongside the other one it is clear that even over the last 5 years it has been key for warehouses to begin the shift towards using robots and more automation. Which heavily supports and boosts this projects goals and aims. Despite being a news article and potentially being less dependable than a research post or book it is from a more well known and trusted source so likely has accurate figures and data to support it. So, to conclude it can be shown as a useful and key part of helping to show the past developments and states within this task.

Whilst researching and searching for useful literature I found two particularly important documents that helped change the foundational understanding of autonomous agents and multi agent systems. Giving me the ability to make a more developed and detailed project with support arguments, these are:

The first vital piece of literature that I have decided to use is called "Autonomous Agents and Multi-Agent Systems" this peer reviewed journal is created by the international foundation of AA and multi agent systems. This covers every field and aspect that might be related to AA allowing me to find all necessary pieces of data within it. This journal contains vast knowledge with over eight hundred articles that can be used and referenced. This allows me to find lots of results to use within this project to back my findings and decisions. My main aim from this journal is to find multiple articles that will let me highlight and strength my knowledge of certain techniques and methods towards creating autonomous agents and how to further enhance them. Due to the high volume of work and the vast amount of people who have peer reviewed it I strongly agree with all arguments and statements it suggests showing little weak points within the papers allowing for a strong backing to my project. In summary this journal is by far the most important and integral piece of literature for my project and allows for me to further develop and strengthen my reasonings and methods.

Another strong book written in the early 2000s explores "topics of self-control and personal autonomy" (Mele 2001). This foundational research shows the understanding of autonomous agents and the evolution it held going towards autonomy and self-control this is vital to understand to have a strong background of AA and why they can revolutionise the warehouse world. Upon reading this book its clear that although the understanding of AA is vastly different to the current times it shows that the design and path that it could take was understood and discussed heavily. This high-quality book logically presents and explains the ideals of autonomy and why it is a best path for AA to take. While also counter arguing about why self-control and autonomy can be immoral. A massive counter argument that is proposed is that how can agents be autonomous if humans are not fully autonomous as stated ""agnostic autonomism":

the position is agnostic about whether the falsity of determinism is required for autonomy while asserting that it is more credible that there are autonomous human beings than there are not." (Mele 2001). This book is incredibly useful to me and allows for a greater understanding of past views allowing for a more rounded and unbiased opinion within this project. Ultimately this is a greatly beneficial item of literature and will be used within the project to aid in the comparison of tests between the capabilities of human vs robotic efficiency.

Conclusion

Taking everything into account a vast selection of literature has been chosen and researched to allow for the greatest understanding of autonomous agents and the ways in which to use them. With this knowledge I can now create a thorough and detailed project that can strongly back my proposed idea and allow for the best outcome. As well as allowing for a richer and deeper knowledge base for which I can enhance the way I create the code and project as by understanding how AA works more, I can create a more efficient and neater code that can be easily adapted and improved if able. My overall understanding of autonomous agents and the concept that has been around for decades is greater and by using this collection of literatures I can support my findings and tests with data and references. All these pieces of literature collectively show that there is large potential in the warehouse industry for enhanced autonomy, as well as there being the knowledge to implement and revolutionise the industry creating a more efficient and safer workspace even when compared to the drawbacks.