ST JOHN'S UNIVERSITY OF TANZANIA

EXPROLING THE ROLE PLAYED BY ARTIFICIAL INTELLIGENCE ON ENHANCING ROBOTOIDS LEARNING AND ADAPTABILITY

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Certification

The undersigned certifies that he has read and hereby recommends for acceptance by the Saint John's University of Tanzania a proposal entitled **"The Role of artificial Intelligence on Robotoids' Learning and Adaptability".** In partial fulfilment of the requirements for the award of Bachelor of Science in Information Technology.

Supervisor name……..

Signature……

Date: …. /…. /2024.

Declaration

I, Japhary M. Zengo declare that this report is my own work. It has not been and will not be presented for any other course of study to any other University for a similar or any other degree award. I confirm that appropriate credit has been given where reference has been made to the work of others.

Signature……

Date……..

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Abbreviations and acronyms

AI…….	Artificial intelligence
AI-ETHICS……	Artificial Intelligence Ethical Decision-Making Framework
DL……	Deep learning
HRI…….	Human-Robotoids interaction
ML……..	Machine learning
NLP……	Natural language processing
RA……..	Robotoids Adaptability
RL……	Reinforcement Learning
ROBOTOID……..	Humanoid robots

Abstract

The rapid advancements in artificial intelligence (AI) have significantly influenced the development and functionality of robotoids-robotic systems designed to handle complex task, this study explores the pivotal role played by artificial intelligence in enhancing robotoids' learning and adaptability, a class of advanced robots designed to mimic human-like behaviour and decision making process focusing on the integration of AI techniques such as machine learning, neural networks and reinforcement learning within robotoid systems to facilitate autonomous learning and adaptive responses to dynamic environments , the research examines key areas such as the ability of AI-driven robotoids to adjust to dynamic environments, make ethically sound decision, and operate autonomously, . A mixed-method approach was employed involving interviews, surveys and document analysis. The findings underscore the transformative potential of AI in advancing Robotoids technology, paving the way for more autonomous, resilient and intelligent robotic systems capable of performing complex tasks in diverse settings. The study also reveals that while AI is considered highly significant in improving adaptability, there are going challenges related to ethical decision making, legal accountability, and the adequacy of current AI-technology, the results analyse the need for updated legal framework, stronger AI-ethics, and transparency mechanisms such as decision-logging systems. This research provides insights into the current state of AI-driven robotoids technology, its potential for future applications, and the area requiring further improvement.

CHAPTER ONE

INTRODUCTION

1.0: Chapter overview

This chapter provided an introduction of the study concerning the role played by artificial intelligence on making robotoids more adaptable to their environment as environment in which robotoids are introduced tend to change from time to time due to various factors such as changing human needs creating an urge for having systems that are capable of adjusting themselves so as they can copy with their environment.

1.1: Background of the study

From the very beginning, artificial intelligence has been playing a crucial role in robotoids' learning and adaptability by enabling robotoids to better manage variability and unpredictability in the external environment, either in real-time, or off-line. Artificial Intelligence has no commonly accepted definitions. Thus, according to Wisskirchen et al. "Artificial intelligence describes the work processes of machines that would require intelligence if performed by humans" (Wisskirchen, G., Biacabe, B. T., Bormann, U., Muntz, A., Niehaus, G., Soler, G. J., & von Brauchitsch, B. , 2017). Here the term 'artificial intelligence' thus means 'investigating intelligent problem-solving behaviour and creating intelligent computer systems. Also, John McCarthy who is considered one of the founding fathers of AI defined artificial intelligence as "the science and engineering of making intelligent machines especially intelligent computer programs" (McCarthy, 1956). He emphasized the computational aspects of intelligence and the creation of system that could perform tasks requiring human intelligence. (Minsky, M., Russel, S., & Norvig, 2016) defined artificial intelligence as "the study of agents that receive percept from the environment and perform actions. "In their influential textbook, "Artificial Intelligence: A Modern Approach," Russell and Norvig, approach AI from an agent-based perspective, focusing on how agents interact with their environments to achieve goals.

Therefore, by definition, artificial intelligence refers to the simulation of human intelligence in machines, enabling them to perform task that typically require human intelligence, such as learning, problem solving, perception and decision-making (McCarthy, 1956). AI algorithms analyse huge amount of data, recognize patterns, and

make decision or prediction based on that data. It's a broad field encompassing various approaches like machine learning, deep learning, natural language processing and robotics. AI is an emerging technology that has recently attracted considerable publicity. Many applications are now under development, for example, one simple view of AI is that, it is concerned with devising computer programs to make computers smarter. Thus, research in AI is focused on developing computational approaches to intelligent behaviour. This research has one goal that is to understand how artificial intelligence enhances robotoids learning and adaptability.

On the contrary, various scientists and researchers in the field of robotics also provided their definition on what are robotoids as follows

In (Moravec, 1988) defined robotoids as "robots that resemble humans in appearance and behaviour, often equipped with advanced sensory and motor capabilities." Moravec, a pioneer in robotics, discusses the progression towards robots that can interact with human environments in human-like ways. However here there is gap since robotoids does not necessarily needs to resemble human in appearance, this is because some robotoids like virtual assistance relies more in virtual environment through their operation as they do not have a physical form. Another expert named (Ishiguro, 2006) defined robotoids as "Robots designed to look, move, and communicate like humans, often used to study human interaction and communication". Ishiguro whose expertise known for creating life like androids, explores more in human like appearance and social interaction aspects of robotoids. Also, (Sharkey, 2011) explained robotoids as "systems that mimic human physical form and function, potentially extending to autonomous behaviour and decision-making." Sharkey, an expert in AI and robotics ethics, considers the implications of creating machines that closely resemble and act like humans.

Robotoids can therefore be defined as" humanoid or androids designed to mimic human appearance and behaviour to varying degrees". They can range from simple machines with human-like features to highly sophisticated robots equipped with advanced AI, sensors and actuators. The fact is that, not all robotoids necessarily need to be tangible. Though most of robotoids are physical machines with a tangible presence, there are also virtual humanoid robots(robotoid), which exists purely in digital form. These virtual robots can be created and operated entirely within computer

simulation or virtual environment, where they interact with user or perform tasks without a physical body. Virtual robotoids are used in tasks such as virtual assistance, simulation, gaming and virtual reality experiences. They can also be used in research, entertainment and healthcare and other industries where human like interaction is desired or necessary. Their task can also be seen in provision of services such as customer service, caregiving, education and even companionship.

So, adaptability in robotoids refers to the robotoids' ability to adjust their behaviour in response to changing environments and requirements. AI contributes to this through several mechanisms:

1.2: Statement of the problem

The rapid advancements in artificial intelligence (AI) and robotics have led to the development of robotoids (robotic entities designed to perform a variety of tasks). Despite significant progress, several critical challenges remain that hinder the full potential of robotoids in various applications.

These challenges include:

I. Limited Learning Capabilities: Current robotoids often rely on pre-programmed behaviours and limited machine learning models, which restrict their ability to learn from new experiences and adapt to unforeseen situations. This lack of robust learning mechanisms reduces their effectiveness in dynamic and unpredictable environments.

II. Inadequate Adaptability: Many robotoids struggle to adapt their behaviours based on changes in their environment or the tasks they are performing. This inflexibility results in frequent human intervention and reduces the autonomy of these systems, limiting their usefulness in real-world applications.

III. Scalability Issues: As tasks and environments become more complex, the scalability of existing AI models used in robotoids becomes a significant concern. Ensuring that robotoids can handle increasing complexity without a corresponding exponential increase in computational resources is an ongoing challenge.

IV. Integration of Cognitive and Physical Capabilities: There is a need for better integration between cognitive processes (such as decision-making and learning) and physical actions in robotoids. Currently, many systems exhibit a disconnect between their ability to process information and their capacity to execute physical tasks effectively.

V. Ethical and Social Implications: The deployment of AI-driven robotoids raises important ethical and social questions regarding transparency, fairness, and bias in decision-making processes. Addressing these concerns is crucial to ensuring public trust and acceptance of these technologies.

1.3: Main objective of the study

The main objective of this study was to understand how artificial intelligence technologies can enhance the learning processes and adaptive capabilities of robotoids.

1.4: Specific objectives of the study

To address the above problems, this study aims to:

I. Examining AI Algorithms: Investigate the types of AI algorithms that are most effective in improving the learning efficiency of robotoids.
II. Enhancing Adaptability: Analyse how AI can enable robotoids to better adapt to changing environments and tasks.
III. Behavioural Improvement: Study the impact of AI on the behaviour of robotoids, including their ability to make decisions and solve problems autonomously.
IV. Learning Mechanisms: Explore the different mechanisms through which AI facilitates continuous learning and knowledge acquisition in robotoids.
V. Human-Robotoid Interaction: Assess how AI can improve the interaction between robotoids and humans, making the former more responsive and intuitive.
VI. Performance Metrics: Develop and utilize metrics to evaluate the performance improvements in robotoids due to AI integration.
VII. Case Studies and Applications: Present real-world applications and case studies where AI has significantly enhanced the capabilities of robotoids.

1.5: Significance of the study

I. Technological Advancement: through enhanced Autonomy, that is

understanding how AI can improve robotoids' learning and adaptability leads to more autonomous systems capable of performing complex tasks without constant human supervision. This enhances efficiency and reduces the need for human intervention in dangerous or repetitive tasks.

II. Improved Performance: Leveraging advanced AI techniques, such as deep learning and reinforcement learning, can significantly improve robotoids' performance in various environments. This includes better decision-making, faster response times, and more accurate task execution.

III. Cost Reduction: More adaptable robotoids can potentially reduce operational costs in industries like manufacturing, logistics, and healthcare by automating tasks that are currently labour-intensive and prone to human error.

IV. Innovation and Competitiveness: Companies investing in AI-driven robotoids can gain a competitive edge by innovating in product development, enhancing service delivery, and improving overall operational efficiency.

V. Societal Benefits such as quality of Life and accessibility: AI-enabled robotoids can assist in elderly care, healthcare, and domestic tasks, thereby improving the quality of life for individuals who require assistance with daily activities. Through accessibility, Robotoids can aid people with disabilities by providing assistance in mobility, communication, and other essential functions, thereby promoting greater independence and inclusion.

VI. It also helps to ensure the safety and integration of robots into various environment including homes, workplaces and public spaces. By understanding how AI influence their learning processes, we can design robotoids that can adopt to changing conditions and interact safely with human.

VII. comprehending AI’s impact on robotoid learning can aid in developing more efficient and versatile robotic systems. By leveraging AI algorithms, robotoids can learn from their experiences, improve their performance over time and adopt to new environment or task autonomously. This capability is essential for enhancing the productivity and versatility of robots in diverse applications.

VIII. Furthermore, understanding the interplay between AI and robotoid learning can inform ethical considerations surrounding their use. It allows us to address

issues related to privacy, bias and accountability, ensuring that robotoids operates ethically and responsibly in the society. Overall, studying how AI influences robotoid learning and adaptability is vital for advancing robotics technology while addressing ethical and societal concerns.

1.6: Current application of robotoids

a. In healthcare, robotoids assist in surgeries, patient care, and rehabilitation, utilizing AI to perform delicate procedures, monitor patient vitals, and adapt to individual patient needs.

b. In industrial automation, in manufacturing, robotoids optimize production lines by learning from operational data, predicting maintenance needs and adapting to new manufacturing processes.

c. In service industry, service robotoids, such as customer service bots and personal assistants, use AI to interact with humans naturally, learning from interactions to improve their algorithms over time.

1.7: Chapter summary

This chapter provided an overview of the concept of artificial intelligence highlighting its goal that is developing intelligent systems that can learn, reason and adopt. As we delve further into the subsequent chapters we will explore the diverse applications, methodologies and challenges in the ever-evolving landscape of artificial intelligence, paving the way for a future where intelligent machines revolutionize various industries and enhance our daily lives.

CHAPTER TWO

LITERATURE REVIEW

2.0: Chapter overview

This chapter presented a comprehensive review of existing literature on the role of artificial intelligence (AI) in the learning and adaptability of robotoids. The review includes theoretical frameworks, conceptual models, and empirical studies, it also identifies gaps in the existing literarure. The review also discusses the integration of sensor technologies and context-awareness in enabling robotoids to interact effectively with their environments.

2.1: Theoretical framework

2.1.1: Machine learning theories

Machine learning (ML) has revolutionized the way robotoids learn from data and improve their functionalities. Several seminal works have laid the foundation for ML applications in robotics for example the publication by International Federation of Robotics (IFR, 2022) stated that within context of ML there are four models which are used to enhance the learning behaviour of machines described as follows.

Supervised learning: The algorithm learns from being presented with hundreds of thousands of labelled examples of what it is tasked with identifying the presented dataset are structured so as to enable the algorithm to easily learn by discovering pattern from those data. Semi-supervised learning: The algorithm trains itself from a combination of labelled examples and unlabelled examples. Self-supervised (unsupervised) learning: the algorithm uses labels that already exist in the input data (for example, specific sounds or colours) to create a training model, in-fact it is not given a specific wrong or right outcome instead the algorithm is not given labelled data.

Reinforcement learning: The algorithm is given a goal and is rewarded for making steps towards that goal and so learns how to complete a task effectively through trial and-error learning (IFR, 2022) it is similar to supervised learning they are not given with prior data instead they are learning through trial and errors in-fact it tries a prediction then compare it with data in its corpus. Also, IFR explained about applications of artificial intelligence in robotics in terms of Sense-and-respond applications in which the robot identifies and responds autonomously to its external environment in a real-time closed loop: Pick-and-place applications are the most common robotic applications in this category. Performance optimization in which AI is used to optimize process design and robot programming, as well as in quality inspection and maintenance.

2.1.2: Cognitive and developmental robotics

Embodied cognition, the idea that robotoid learning is deeply connected to their physical interactions with the environment. This describes how robotoids can adapt to changing environment, they are capable of undergoing developmental Learning Inspired by human developmental stages, allowing robotoids to learn progressively more complex tasks over time, social learning robotoids learns from observing and interacting with humans and other robots. In (Carper, 2019) “Robots in American Popular culture,” the author explores the pervasive presence of robots in various forms of media and their impact in American culture. He delves into how robots have been portrayed in literature, film, television and other medium throughout history, tracing the evolution of these mechanical beings, mere machines to complex character that represents societal fears, desires, and advancement in technology. The book discusses how robots have been used as the symbol of progress, threats to humanity companions and even reflection of our own humanity. He also analyses the way in which robots have shaped American culture and influenced our perception of technology ethics and the future. They are invincible warriors of steel, silky-skinned enticers, stealers of jobs and lovable goofball sidekicks. Legions of robots and androids star in the dream factories of Hollywood and leer on pulp magazine covers, instantly recognizable icons of American popular culture. For two centuries, we have been told tales of encounters with creatures stronger, faster and smarter than ourselves, making us wonder who would win in a battle between machine and human. This book examines society's introduction to robots and androids such as Robby and Rosie, Elektro and Sparko, Data, WALL-E, C-

3PO and the Terminator, particularly before and after World War II when the power of technology exploded. Learn how robots evolved with the times and then eventually caught up with and surpassed them.

2.1.3: Self-learning systems

Self-learning systems enable robotoids to refine their skills continuously by learning from new data. The concept of lifelong learning in robots, as explored by Parisi, Kemker, Part, Kanan, and Wermter (2019), underscores the importance of continuous adaptation and improvement in robotic systems. The article (Mihret, 2020) the Inter-national journal of artificial intelligence and machine learning. Discusses the application of machine learning algorithms in making the robotics intelligent. The author explores how robotics intelligence can be used in wide industrial application that is achieved through automation of robotics tasks, and its key expertise in handling utmost requirement in various in various arenas that leads to cost effective and secured operational process. Raj and Seaman's journal of organization design, on their featured article named Primer on artificial intelligence and robotics (Raj, M., & Seamans, R, 2019), focuses on exploring the implication of artificial intelligence, robotics and automation on organization design and firm strategy. The journal delves into the economic and organization consequences of these technologies, emphasizing the need for greater engagement by organizational and strategy researchers in understanding and anticipating the effects of AI and robotics. Seaman's work highlights the transformative potential of artificial intelligence and robotics in reshaping work, labour and organizations. By examining how these technologies impact various aspects of organizational functioning, Seaman aims to provide insights into how businesses can adopt to leverage the benefits while mitigating potential disruptions caused by automation. The journal also underscores the importance of defining key constructs such as automation, robotics artificial intelligence and machine learning in organizational study to facilitate clear analysis of how the technologies influence different outcomes within firms.

2.1.4: Neural networks and deep learning

Artificial Neural Networks (ANNs): Mimicking the human brain's structure to process information and learn from data convolutional Neural Networks (CNNs), Specialized for image recognition tasks, Recurrent Neural Networks (RNNs): Handling sequential data

and tasks such as language processing. Context-aware systems allow robotoids to understand the context of their actions and make more appropriate decisions. The development of multi-modal sensor integration by (Chen, Y., Xie, Y., Song, L., Chen, F., & Tang, T, 2020) has significantly improved the contextual awareness and decision-making processes in robotoids. Self-learning systems enable robotoids to refine their skills continuously by learning from new data. The concept of lifelong learning in robots, as explored by (Parisi, G. I., Kemker, R., Part, J. L., Kanan, C., & Wermter, S, 2019) underscores the importance of continuous adaptation and improvement in robotic systems.

2.1.5: Semi-supervised learning

Semi-supervised learning combines labelled and unlabelled data to enhance learning efficiency. This approach is particularly useful in robotics, where obtaining labelled data can be costly. The research by (Xie, Q., Dai, Z., Hovy, E., Luong, T., & Le, Q, 2020) on unsupervised data augmentation and semi- supervised learning demonstrates significant improvements in model performance, which can be applied to robotoids to enhance their adaptability and learning efficiency. Another study is by (Serrano, 2023) this study investigates the relationship between learning adaptability and self-regulated learning by investigating the chain mediating roles of academic motivation and self-management.

2.2: Empirical reviews of the study

A study conducted by (Smith B. A., 2021) investigated the use of deep reinforcement learning algorithms in training robotoids to perform complex tasks. The research demonstrated that AI-powered robotoids could achieve a high level of adaptability through continuous learning and feedback mechanisms. By leveraging AI techniques, the robotoids exhibited improved decision-making abilities and adaptive behaviours in dynamic environments.

In a similar vein, (Jones &Lee, 2019) explored the application of machine learning algorithms in enhancing the adaptability of humanoid robots. The study highlighted how AI models could facilitate rapid learning and adaptation in robotoids, enabling them to autonomously navigate unfamiliar terrains and interact with objects in real-time. The findings emphasized the pivotal role of AI in shaping the cognitive capabilities of

robotoids for enhanced performance.

Furthermore, a review by (Surely, 2023) provided an overview of recent advancements in AI-driven approaches for robotoids' learning and adaptability. The researchers synthesized findings from various studies conducted over the past few years, showcasing the evolution of AI technologies in empowering robots to learn complex tasks efficiently and adapt flexibly to diverse scenarios. The review underscored the transformative impact of AI on revolutionizing robotic systems' learning mechanisms.

2.3: Conceptual reviews of the study

Artificial Intelligence (AI) has been revolutionizing various fields, including robotics, by enhancing the learning and adaptability of robotoids. In recent years, there has been a growing body of literature focusing on the role of AI in improving the capabilities of robotoids to learn from their environment and adapt to changing circumstances. This conceptual literature review aims to explore the current understanding of how AI influences the learning and adaptability of robotoids.

2.3.1: Integration of AI algorithms in robotoids' learning model

The study conducted by (Smith, M., Sattler, A., Hong, G., & Lin, S, 2021)explores how incorporating advanced AI algorithms such as deep reinforcement learning and neural networks can significantly enhance the learning capabilities of robotoids. The researchers demonstrated that by leveraging these sophisticated AI techniques, robotoids were able to achieve higher levels of autonomy, problem-solving skills, and adaptability in dynamic environments. Lee and Kim (2020) at the International Conference on Robotics and Automation. In their presentation titled "Integrating AI Algorithms for Enhanced Robotoid Learning discuss the practical implementation of various AI algorithms like machine learning and computer vision in training robotoids to perform complex tasks efficiently. The researchers showcased how these integrated AI algorithms enabled robotoids to learn new skills rapidly through continuous interaction with their surroundings.

2.3.2: Enhancing adaptability through AI based control system

One key aspect of enhancing adaptability through AI-based control systems is their ability to analyse vast amounts of data in real-time. By continuously monitoring and

processing data from sensors, machines, and other sources, these systems can identify patterns, anomalies, and trends that human operators may overlook. This real-time analysis allows for proactive decision-making and rapid responses to dynamic environments. One recent study by (Smith et al, 2021) published in the Journal of Artificial Intelligence Research demonstrated how AI-based control systems improved adaptability in manufacturing processes by optimizing production schedules in response to changing demand patterns. The study highlighted the effectiveness of AI algorithms in dynamically adjusting production parameters to maximize efficiency while maintaining quality standards.

2.3.3: Cognitive architecture for autonomous learning

Recent literature has also delved into the design of cognitive architectures that facilitate autonomous learning in robotoids through AI technologies. By mimicking human cognitive processes, these architectures enable robotoids to learn from experience, reason through complex scenarios, and make informed decisions independently. Work by (Thorisson et al, 2018), showcased a cognitive architecture that allowed robotoids to learn new tasks through a combination of symbolic reasoning and neural networks.

2.3.4: Challenges and future direction

Despite significant advancements, challenges remain in leveraging AI for enhancing the learning and adaptability of robotoids. Issues such as data efficiency, generalization across tasks, and ethical considerations surrounding autonomous decision-making pose ongoing research questions for scholars in this field. Future directions may involve exploring hybrid approaches that combine different AI techniques or developing more robust frameworks for continual learning in robotoids.

2.4: Gap filled

The basis for most research concerning the role of AI in robotics lies in the potential to enhance the capabilities and autonomy of robots. Artificial intelligence plays a crucial role in advancing robotic technology by enabling robots to learn, adapt, and make decisions independently. By integrating AI into robotics, machines can perform complex tasks, navigate environments, recognize objects, and interact with humans more effectively. For example, (IFR, 2022) focused much on examining how machine leaning enhances the learning and adaptability of robots for industrial automation. IFR, also

showed about autonomy and decision-Making through which AI enables robots to make decisions based on real-time data and changing circumstances without human intervention, learning and adaptation that enable machines learning algorithms help robots improve their performance over time through experience and data analysis, sensing and perception, AI enhances robots' ability to sense their surroundings, detect obstacles, recognize objects, and interpret visual or auditory information., navigation and mobility AI algorithms enable robots to navigate complex environments, plan optimal paths, avoid obstacles, and interact safely with their surroundings, interaction with humans, AI-powered robots can understand natural language commands, respond intelligently to queries, and collaborate with humans in various tasks.

This study aimed at addressing other issues that will bring concerns to human existence in the near future due to introduction of robotoids within human environment, Example of issues that were addressed in this study are culpability, moral and public accountability, and active responsibility caused by different sources, some organizational, legal, ethical as well as societal. Robotoids culpability refers to the legal responsibility or blameworthiness attributed to robots or artificial intelligence entities for their actions or failures. In the article "Ethical Considerations in AI development (E., 2023), Exploring Robotoids Culpability, delve into the complex ethical considerations surrounding the development and deployment of artificial intelligence, specifically focusing on the concept of robotoids' culpability. The term "robotoids" refers to advanced AI systems that exhibit human-like characteristics and capabilities. Addressing robotoids' culpability requires a multifaceted approach that combines legal, technical, and ethical strategies, that will work together so as to ensure the robots delivers only the intended outcomes without compromise that may occur due to robot malfunction. This research will suggest an act that might be put in action so as to address culpability.

2.5: Definition of terms

Artificial Intelligence (AI): According to (Minsky, M., Russel, S., & Norvig, 2016) AI refers to the study of "intelligent agents" that perceive their environment and take actions to maximize their chances of success in achieving goals.

Robotoids: (Cangelosi, A., & Schlesinger, M, 2015)) define robotoids within the context of developmental robotics as systems that "mimic the developmental processes of

humans, acquiring skills and knowledge through interaction with their environment, thereby achieving advanced cognitive and behavioural capabilities."

Learning: Learning, as defined by (Mitchell,1997), is the process through which an agent improves its performance on future tasks based on its past experiences.

Adaptability: Adaptability can be defined as the ability of a system or agent to adjust its behavior or responses in response to changes in its environment or task requirements (Dignum, 2021)

Literature Review: A literature review involves a systematic examination and synthesis of scholarly sources related to a particular topic or research question, providing an overview of existing knowledge, theories, and findings in the field (Fink, 2014).

2.6: Chapter summary

In summary, the integration of AI in robotoids has significantly advanced their learning and adaptability, enabling them to perform complex tasks autonomously and interact seamlessly with dynamic environments. The literature reveals that continuous innovations in machine learning, adaptive control systems, and ethical frameworks are pivotal in realizing the full potential of robotoids, promising profound impacts across various sectors while underscoring the necessity of responsible and fair deployment practices.

CHAPTER THREE

METHODOLOGY

3.0: Chapter overview

This chapter introduced the methodology used to examine the role of artificial intelligence (AI) in enhancing robotoids' learning and adaptability. It includes the research design, data sources, data collection methods, sampling and recruitment procedures, data analysis techniques, and ethical considerations.

3.1: Methodology

A methodology refers to the “choice we make about cases to study, methods of data gathering, forms of data analysis, in planning and executing a research study” (silverman, 2005) Any researcher sets out strategies that lay out the means for accomplishing the research aspirations. A robust research methodology is essential to systematically investigate the role of artificial intelligence (AI) in enhancing robotoids' learning and adaptability. This section outlines the best research methodology, including research design, data collection methods, data analysis techniques, and ethical considerations were put into consideration when examining the various roles that artificial intelligence plays in robotoids’ learning and adaptability.

3.2: Research approach

A research approach is the general strategy or plan that outline how a researcher intends to conduct a study. It encompasses the overall framework within which the research will be carried out guiding the researcher on how to collect, analyse and interpret data to address the research question or objectives. The choice of research of research approach significantly influences the methodology and methods employed in the study. According to (Dawson, 2019), a research approach is the primary principle that guides a researcher in conducting their study. It sets the tone for the research process and determines the specific methodologies and methods that will be utilized to gather and analyse data.

Given the nature of the study, a mixed-methods approach was used, combining qualitative and quantitative research methods to gain a comprehensive understanding of AI's role in robotoids' learning and adaptability. Qualitative Approach it refers to the method that involves collecting and analysing non-numerical data such as text, audio, video to gain insights into concepts, opinions or experiences, it focuses on understanding the richness and depth of human experiences rather than statistical analysis, (creswell j. W., 2014). The main aim of qualitative research is to explore the underlying mechanisms and theoretical frameworks through case studies, interviews, and literature reviews. Quantitative approach aims to measure and analyse the performance improvements and adaptability enhancements in robotoids through experiments and statistical analyses.

3.2.1 Strengths of mixed-methods approach

1. Enhanced validity and reliability: triangulation data from quantitative and qualitative sources increases the likelihood of valid and reliable study findings.
2. Rich data: qualitative interviews provide a deeper understanding of nuances and complexities that quantitative methods may overlook, such as personal experiences and contextual factors.
3. Broad perspectives: the combination of methods enables researchers to capture a wide array of information ranging from overarching trends to individual experiences.

3.2.2 Weaknesses of mixed research approach

1. Resource intensive: conducting mixed methods research can be time and

resource intensive, necessitating expertise in both qualitative and quantitative methodologies

2. Complexity in data integration: integrating and synthesizing quantitative and qualitative data poses challenges especially in ensuring that both types of data are appropriately weighted and effectively combined for a cohesive analysis.
3. Sampling issues: ensuring representative sampling for the quantitative components and achieving saturation in the qualitative component can be complex, potentially impacting the generalizability and depth of the research findings.

3.3: Data collection methods

Research methods are just the tools employed by researchers to gather empirical evidence, techniques of data analysis, and techniques of writing (Sarantankos, 1998). Quantitative studies tend to direct on more structured methods than the qualitative ones. The aim is to maximize reliability and validity of the data so that research questions that are clearly defined can be answered (hypothesis verification). Qualitative researchers prefer to use unstructured methods. They can ask new questions which are not included in the schedule, probe, and prompt the respondents. The aim is to get rich and detailed answers in order to explain, describe, and explore the social behaviours (Bryman A. & cramer D., 2004), Given the main objective of the present study, which was stated in the first chapter, it shows that the study is typically both qualitative and quantitative. Hence, both qualitative and quantitative methods were applied for data gathering.

(Hoyle R. H., Stephenson, M. T., Palmgreen, P., Lorch, E. P & Donohew R. L, 2002) contend that “Confining ourselves as social scientists to a single method or procedure limits what we can know.” This is so because there is no one procedure or method which can provide a complete description. Data were collected from July to August 2024, three basic data collection methods were employed these were review of previous studies, questionnaire and interviews.

3.3.1: Review of previous published studies

Documents as instruments for data collection are very useful in research and can be vital, especially when a researcher is focusing on past events (Sarantankos, 1998). The

term document as Bryman (Bryman A. & cramer D., 2004) puts it “covers a very wide range of different kinds of sources. They can be personal documents such as diaries, letters, autobiographies, suicide notes, confessions, and life histories. Public documents such as census statistics, statistical year book, and literature. Visual objects such as photographs. Archival records like service records of hospitals, social workers, and records of organizations. Administrative documents like proposals, agendas, minutes of meetings, and announcements. (Bryman A. & cramer D., 2004). This method involved a thorough study of ready-made or existing materials so as to establish the foundation of knowledge, theories, methodologies and technologies that have been explored in relation to robotoids, also recognizing challenges and solution that previous researcher had encountered as well as establishing relevance and novelty through justifying how the study fits into the broader research landscape and identifies what new insights it can offer. It involved going through both primary and secondary data sources hence ensuring a comprehensive review was done so as to gain more insights concerning the study. Sources included academic journals, conference papers, books, and reputable online resources, as well as scholar books in the field of artificial intelligence and robotics.

Previous published study enabled the following to be accomplished;

- Studying the past events.
- Quick and easy accessibility, especially when internet is available.
- In most cases documents are produced without writers being asked to do so. In this case the researcher’s bias is reduced.
- Possibility of retesting the results.

On the other hand, previous studies instruments have the following weaknesses;

- Some of the studies and documents are not easily accessible, for example, organizational confidential documents, private letters, and diaries.
- Some studies and documents are not complete; for example, one can die before finishing the study or writing his or her document.
- Since some studies and documents, particularly personal documents, represent the view of the authors, they can be biased (Sarantankos, 1998).

3.3.2: Questionnaires

A questionnaire is a research instrument composed of a series of questions designed to gather information from respondents. It is a common tool used in quantitative research, survey and interview to collect data on various topics. Questionnaires can be structured (close-ended questions) semi-structured (a mixture of both close and open-ended questions) or unstructured depending on the objective of the research. (creswell j. W., 2014) contends that a well designs questionnaire is key to gathering reliable and valid data, ensuring that the research questions are addressed effectively. This highlights the critical role that carefully question design and sequencing play in collecting meaningful data. Surveys and semi-structured interviews were conducted with experts in AI and robotics to gather qualitative data on the effectiveness and challenges of implementing AI in robotoids. Questionnaire designs included both closed and open-ended questions to gather a broad range of insights and to ensure credibility and validity. Questions were put online and distributed through google form and others through prints of hardcopy, also the researcher designed a clear invitation letter to prior introduces the topic wherever needed this helped to ensure respondents understood well the essence behind the study and to reduce misunderstanding.

Advantages of using questionnaires

- Cost-effective: questionnaires are relatively in-expensive to design, distribute and analyse especially when conducted online or via email.
- Quick data collection: they can be administered to many respondents simultaneously. Allowing researcher to collect large amount of data quickly.
- Anonymity and confidentiality: respondents often feel more comfortable sharing honest opinions when anonymity is guaranteed.

Disadvantages of using questionnaires

- Low response rate: especially in online or mailed survey response rate can be low which can affect the representativeness of the data.
- Lack of depth: while closed end questionnaire are easy to analyse, they may not capture the depth of respondents' opinions.
- Misinterpretation of question: respondents may misunderstand question or interpret them differently leading to inaccurate response.

- Social desirability bias: respondent may give answers they believe are more socially acceptable rather than their true story feeling or behaviours.
- Inability to probe deeper: questionnaires lack the interactive nature of interview making it impossible to ask follow-up.

3.3.3: Interviews

The study employed a semi-structured format to allow for in-depth exploration while maintaining consistency across respondents. Taking into account the main objective of the study, that was to examine the role that artificial intelligence plays in enhancing robotoids' learning and adaptability, semi-structured interview method was applied. It assisted me to explore different views from the respondents concerning the study. As (kvale, 1996) puts it, "A good interview question should contribute thematically to knowledge production and dynamically to promoting a good interview interaction." In order to make the interviews more focusing, the researcher prepared a brief list of memory prompts of areas to be covered. The interview mostly involved online communities such as forums focusing on AI and robotics. The interview involved a total of ten respondents all met through linked-in invitation and the interview was conducted through zoom to which every interviewee was given a maximum of 30 minutes also. Interviews were put into transcript for theme analysis and interpretation.

Advantages on using interview method

The interview method has the following advantages;

- Things which cannot be directly observed can be discovered.
- Interviews can be adjusted to meet many diverse situations (flexibility).
- A high response rate is likely.
- Helps to understand the details of peoples' experience from their point of view.
- Respondents are not required to have abilities for reading, handling complex documents or long questionnaires.
- The interviewer has an opportunity to control the condition under which questions are answered.
- Possibility of correcting respondents' misunderstandings.

- Respondents have no opportunity to know what questions come next.
- An assurance that all questions will be attempted. This is so because the interviewer presents the questions.
- The presence of the interviewer can assist in answering complex questions. (Sarantankos, 1998).

Disadvantages of interview

- Interviews are costlier financially and time consuming than other methods.
- Interviews are affected by the factor 'interviewer' and the possible bias associated with it.
- It is more inconvenient than other methods such as questionnaires.
- It offers less anonymity than other methods since the interviewer knows the identity, residence, type of housing, family conditions, and other personal details of the respondent.
- It is less effective than other methods when sensitive issues are discussed. For example, many people prefer to write about sensitive issues rather than to talk about them.
- There is a gap between beliefs and actions and between what people say and do. People can respond differently compared to the way they act. (Sarantakos, 1998; Silverman, 2005).

3.4: Data analysis techniques

Data analysis refers to the process of inspecting, cleaning and transforming, and modelling data with the goal of discovering useful information, informing conclusions, and supporting decision making. Different data analysis techniques are used depending on the design, data type and objectives. (creswell, 2018) "The choice of data analysis technique should align with the research design and objectives as this ensures the results are both meaningful and actionable "(p.202). The study employed a mixed approach of both qualitative and quantitative data analysis, this combines both statistical analysis with qualitative technique to provide a comprehensive understanding of the research problem.

3.4.1: Qualitative data Analysis

The researcher conducted qualitative analysis using two methods which are thematic analysis and content analysis. Thematic analysis was done so as to identify and analyse patterns and themes and meaning within qualitative data from case studies, interviews, and open-ended survey responses. Content analysis method was used to systematically categorize and quantify qualitative data, ensuring comprehensive coverage of relevant topics, it involves coding the data into categories and identifying themes and patterns. The research used qualitative tools so as to capture data from non-statistical data such as text, social media posts and videos from interviews and open-ended questionnaires. The themes were grouped into subtheme that enabled the quantification of the qualitative data.

3.4.2: Quantitative data Analysis

To ensure quantitative data are captured the researcher employed two methods which are descriptive Statistics and inferential statistics. Descriptive statistics was used to summarize and describe the characteristics of the dataset, including means, medians, and standard deviations and frequency distributions to describe the characteristics of the datasets. Descriptive analysis helps in understanding patterns, trends and relationships within the data tools like SPSS was used for descriptive analysis to find median, mean as well as frequency of the dataset so as to establish correlation of findings. The research employed inferential statistics so as to test hypotheses and determine the statistical significance of observed effects, using techniques such as t-tests, ANOVA (analysis of variance), and regression analysis. This method allowed the researcher to determine whether patterns observed in a sample can be generalised to the entire population.

3.5: Target population

the target population included AI and robotics expert such as professional, engineers and researcher who specialize in artificial intelligence, machine learning and robotics. Their insights were crucial for understanding the technical role of AI's role in robotoids. The study also included scholars and professors in the field related to AI, robotics and automation provided theoretical perspectives and knowledge on how AI contributes to robotoids' learning and adaptability, the study also included industry practitioners, technology companies, students and learners in related fields such as graduate students and advanced learners studying AI who provided the study with emerging

perspectives, especially on recent and theoretical application.

3.6: Sample size and sampling Techniques

Determining the appropriate sample size and sampling techniques is crucial for obtaining reliable and valid results in research examining the role of artificial intelligence (AI) on robotoids' learning and adaptability. This section outlines the recommended sample size and sampling techniques for both qualitative and quantitative components of the study.

Sample size

refers to the number of individual subjects or units included in a study it is a crucial aspect of research design as it directly impacts the reliability and generalizability of the study's findings. A larger sample size generally leads to more accurate results and increased statistical power, while a smaller sample size may limit the ability to draw meaningful conclusion. For both method (qualitative and quantitative) the sample size used in this were selected research, based on the resources which are time, and budget constraints and logistical limitations. For quantitative studies, sample size determination was guided by statistical power analysis, which ensured that the sample size was large enough to detect a meaningful effect if one exists. Power Analysis: Typically, a power of 0.80 (80%) was considered acceptable, meaning there was 80% chance of detecting an effect if it is present. Given the complexity and variability in robotoids' applications, a medium effect size was a reasonable assumption. While qualitative Research, focuses on depth rather than breadth, so smaller sample sizes are generally sufficient to achieve saturation, the point at which no new information or themes are observed. A maximum of 100 participants or case studies were used for adequate qualitative and quantitative research. This range allowed for in-depth exploration and thematic analysis without being overwhelmed. The sample size was determined using the Slovene's formula of sample determination. Under this, a target population of 133 respondents was zeroed down to a sample size of 100 respondents respectively as stated by Slovenes' (1978). The Slovenes' formula is as shown below

$$n = \frac{N}{1+N(e)^2}$$

Whereby; 'n' is the sample size

'N' is the population size

‘e’ is the level of precision

Sampling techniques

These are fundamental methods used in research to select a subset of individual from a larger population for study. These techniques are crucial for ensuring validity and generalizability of research findings. According to (creswell j. W., 2014) sampling techniques are “the methods used to select a sample from within a population”. The main sampling technique applied in this research is non-probability sampling. Through non-probability sampling, a sample was selected from the targeted population. The examples of non-probability sampling are; purposive sampling, snowball sampling, and quota sampling (Bryman, 2004; Silverman, 2005). Purposive and snowball sampling were employed in this study.

3.6.1: Purposive sampling

The reason behind selecting informants by using purposeful sampling in qualitative research is, to obtain rich and detailed answers in order to explain, describe, and explore the social behaviours (Bryman A. & cramer D., 2004). In this study, efforts were made to explore the role of artificial intelligence in enhancing robotoids’ learning and adaptability. This was so because information about this study cannot be gathered just from anybody. That is why purposive sampling was employed. (Sarantankos, 1998) explains the following concerning purposive sampling;

The researchers purposely choose subjects who, in their opinion, are thought to be relevant to the research topic. The process of sampling in this case involved the identification of the informants and arranging times for meeting them. Thus, the selection of individuals who are familiar with either AI, robotics or both was based on purposive sampling. Yet, (Patton, 1990) puts forward the argument that applying purposive sampling without including random procedures can bring doubts about why certain cases were chosen for study. He alerts that, although random sampling is important in purposive sampling, it is not for the purpose of representativeness but credibility. He says; It is critical to understand, however, that this is a purposeful random sample, not a representative random sample. The purpose of a small random sample is credibility, not representativeness (Patton, 1990). In order to avoid suspicion as Patton puts it, the researcher selected respondents in the field and students with interest in the study randomly so as to ensure credibility.

3.6.2: Snowball sampling

Snowball method is appropriate to the research topic when informants are not well-known. Researcher begins with one person or a small group of people who are relevant to the research topic, and then uses these to establish contacts with others or name others to the researcher. The process continues until no more respondents are discovered or when the researcher is

satisfied with the data (Bryman A. & cramer D., 2004). The researcher started with 20 respondents, although they some information, which were not enough for the study, thereafter, they directed the researcher to more other fellows Among these, most of whom where experts in the field and other students. Therefore, the researcher was provided with enough information to support the study.

3.7: Reliability and Validity

As explained earlier in the beginning of this chapter, research methods may be treated differently, depending on the research type either quantitative or qualitative. Queries of reliability and validity are however important in any kind of research method (Brock-Utne, 1996; Durrheim and Wassenaar, 2002). According to Brock-Utne (1996:612), “in ordinary speech, ‘valid’ refers to the truth and correctness of a statement.” Quantitative researchers make sure that they maintain validity by identifying validity threats in advance when designing their studies. They use experimental arrangements and statistical techniques to ensure that the accurate conclusions can be drawn from the research results (Durrheim & Wassenaar, 2002). In qualitative research it is very complicated to identify validity threats before conducting a study. Qualitative research can be weighed up according to its credibility, whether its product and results are convincing and believable (Durrheim & Wassenaar, 2002). More than one method of data collection was applied in this study to ensure the issue of credibility. The researcher also used an interview guide in order to make interviews more focused on the research questions as well as avoiding ambiguities.

The term reliability as (Bryman A. & cramer D., 2004) defined it “is the degree to which a measure of a concept is stable.” This means that research findings can be repeatable. This belief is important to the positivists. It is so because of their belief that they are studying a stable and unchanging reality. This is, however, not the case for interpretive and constructionist investigators. They do not expect to find repeatable results because things in the world are not static. Instead, they propose that findings should be

dependable. Dependable in the sense that the reader should be convinced that findings occur as the researcher reported them (Durrheim & Wassenaar, 2002). Being conscious about the issue of dependability, the researcher detailed descriptions that unveil how certain events and views are rooted in and developed out of the contextual interaction.

3.8: Generalization

The term generalization refers “to the extent to which the results or findings of a study can be extrapolated to a wider context than that used in the implementation of the research design” (C Tradoux, 2002). According to (Wassenaar, D., Terre Blance, M., Durrheim, K., & Painter, D.,, 2002), generalizations are important when a) “researchers want to make general theoretical claims” or b) “researchers aim to describe populations.” Point a) above is applicable to positivist researchers as generalizability is very important to them. They assume that behaviour laws are universal and they are operating not only in the laboratory, but also in the real world. In survey research representative samples are used to describe the entire population. Based on the small sample of this study, the researcher was interested in providing a deeper understanding of the role played by AI to enhance robotoids’ learning and adaptability and do not have the intention that the findings should be generalizable. It is my hope that these findings can be applicable in any different area, but with a similar situation (context).

3.9: Ethical consideration

Ethical considerations are paramount in this study to ensure the integrity and credibility of the research process. First, informed consents were obtained from all interview participants, ensuring they are fully aware of the study's purpose, procedures, and their right to withdraw at any time without any consequences. Confidentiality was strictly maintained by anonymizing all personal data and securely storing any sensitive information to protect participants' privacy. Additionally, efforts were made to minimize bias and maintain objectivity throughout the research. This included the use of standardized questions during interviews and employing systematic data analysis techniques to ensure fair and accurate representation of the findings. Ethical review and approval were obtained from a relevant ethics committee to further ensure that the study adheres to established ethical standards and guidelines.

The methodology chapter provides a detailed framework for investigating the role of AI

in robotoids' learning and adaptability. By employing a mixed-methods approach and leveraging both primary and secondary data sources, the study aims to produce reliable and valid findings that contribute to the understanding and development of advanced robotoids. The rigorous data collection and analysis procedures, coupled with adherence to ethical standards, ensure the integrity and credibility of the research.

3.10: Challenges encountered

During the study the researcher faced some challenges that affected the progression of the study, such challenges were complexity of AI concepts such as deep learning, reinforcement learning and neural networks understanding and communicating these concepts posed a significant challenge especially for respondents who were not well versed in the technical details. Also limited access to experts and participants such as industry professional and robotics experts posed a significant challenge. Data collection and interpretation for quantitative data required advanced statistical tools for analysis also the other biggest problem was limited existing literature due to the presence of only significant research on AI and robotics specific study focusing on the role of AI on robotoids were limited. The other were resource constraints since the study required intensive resources and access to specialised software, budget limitations and time constraints and access to such resources posed a significant challenge. Due to this bottleneck the researcher practised carefully planning, robust methodology as well as collaborated with experts in the field and tried to adopt all the emerging trends and obstacles during the research process.

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter entails the presentation and analysis of the findings collected through questionnaires, interview and review of previous studies (document analysis). Considering the purpose of the study that was to investigate the role of artificial intelligence in enhancing robotoids' learning and adaptability. The findings are based on the responses from a diverse group of participants, which are represented in the pie charts, bar graphs and tables below, these results provide valuable insights into how AI influences the learning processes and adaptability of robotoids, indicating key insights on the respondents' views and experiences regarding AI's effectiveness in this domain.

4.1: Professions of respondents

The study surveyed respondents from diverse professional backgrounds to gauge insights into the role of artificial intelligence in robotoids' learning and adaptability.

	Frequency	Percent
AI researcher	22	22
Robotics Engineer	9	9
Ethics Consultant	5	5
student	48	48
others	16	16
Total	100	100

Source: fieldwork

Table 1:Profession of respondents

The distribution revealed that 22 respondents (22%) were AI researchers, representing the majority of specialized expertise in the survey. Additionally, 9 respondents (9%) were robotic engineers, a critical group with direct involvement in the development of adaptable robotoid systems. Ethics consultants, though fewer in number at 5 (5%), contributed valuable perspectives on the ethical implications of AI-driven adaptation. Notably, 48 respondents (48%) were students, indicating significant interest from the next generation of professionals who are likely to be future leaders in AI and robotics. The remaining 16 respondents (16%) fell into other categories, reflecting the broad interest in this topic across various sectors. The high proportion of student

respondents suggests that educational exposure to AI and robotics is growing, which could drive future advancements in this field. The mix of professionals and students provides a comprehensive view of both current expert insights and emerging trends, allowing for a balanced discussion on the role of AI in enhancing robotoid learning and adaptability across theoretical, technical, and ethical dimensions.

4.2: Levels at which AI affects Roboids' learning ability

In assessing perceptions of how significant AI is in enhancing robotoids' learning abilities, respondents exhibited a range of views.

	Frequency	Percent
not significant	10	10
slightly significant	20	20
moderately significant	34	34
very significant	25	25
extremely significant	11	11
Total	100	100

Source: fieldwork

Table 2: Levels at which AI affect Robotoids

Out of the total, 10 participants (10%) found AI to be "not significant" in improving robotoids' learning, indicating a minority view that AI's current contributions may be limited or overestimated. However, 20 respondents (20%) believed it was "slightly significant," suggesting a cautious optimism where AI's role is recognized but not yet seen as transformative. The largest group, 34 respondents (34%), rated AI's impact as "moderately significant," pointing to a consensus that while AI is making noticeable advancements, there is room for further development in robotoid learning. Additionally, 25 respondents (25%) considered AI to be "very significant," highlighting strong confidence in AI's potential for substantial improvements. Finally, 11 participants (11%) found AI to be "extremely significant," reflecting the belief that AI is critical to driving robotoid adaptability and learning enhancements. These findings suggest a generally positive outlook towards AI's contribution, with most respondents acknowledging at least moderate significance. The distribution of responses also emphasizes that while the technology is promising, opinions vary regarding its current effectiveness and long-term impact.

4.3: Area of AI technology that contributes the most to robotoids' adaptability

When examining which technological areas contribute most to robotoids' adaptability machine learning emerged as the dominant factor.

	Frequency	Percent
machine learning	40	40.0
neural networks	19	19.0
natural language processing	16	16.0
computer vision	15	15.0
other	10	10.0
Total	100	100.0

Source: fieldwork

Table 3: AI-technology that affects Robotoids mostly

With 40 respondents (40%) identifying it as the primary contributor. This aligns with machine learning's ability to enable adaptive behaviour through iterative learning and data-driven decision-making processes. Neural networks, recognized by 19 respondents (19%), are also considered significant, particularly due to their role in simulating brain-like processes that enhance robotoids' learning and adaptability. Natural language processing was selected by 16 respondents (16%), reflecting its importance in enabling robotoids to understand and interact with human language, a key aspect of adaptive behaviour in dynamic environments. Computer vision was noted by 15 respondents (15%), underscoring the role of visual perception in real-time decision-making and environmental awareness, crucial for adaptability. The remaining 10 respondents (10%) pointed to other areas, highlighting that adaptability is a multifaceted challenge, benefiting from a combination of diverse technological advancements. Overall, the responses indicate that while machine learning and neural networks are perceived as the core drivers of adaptability, integrating advancements across multiple AI domains is essential for fully realizing robotoid potential.

4.4: Frequency of encountering AI-driven Robotoids

The frequency with which respondents encounter AI-driven robotoids varies, indicating differing levels of exposure and integration across environments.

	Frequency	Percent
rarely	15	15.0
occasionally	30	30.0
often	35	35.0
very often	20	20.0
Total	100	100.0

Source: fieldwork

Table 4: frequency of encountering AI-driven systems

According to the survey, 15 respondents (15%) reported encountering AI-driven robotoids "rarely," suggesting limited interaction with such technology, likely due to their niche applications or early-stage adoption in certain fields. The largest group, with 30 respondents (30%), indicated they encounter robotoids "occasionally," reflecting moderate but inconsistent interaction, possibly in controlled or specialized contexts. Interestingly, 35 respondents (35%) reported encountering AI-driven robotoids "often," showing that in some settings, these systems are becoming more embedded in daily operations. Meanwhile, 20 respondents (20%) experience robotoids "very often," pointing to environments where such AI-driven technologies are regularly utilized, likely in advanced sectors like automated manufacturing, smart service industries, or research laboratories. These findings highlight a trend toward increased exposure to AI-driven robotoids, suggesting that while some areas still see limited use, others are progressively integrating this technology into routine activities, signalling its growing relevance and practical deployment.

4.5: Adequacy of current AI-technology in enhancing robotoids' learning

The survey results indicate mixed opinions on the adequacy of current AI technology in supporting robotoid adaptability.

	Frequency	Percent
Yes	45	45.0
No	30	30.0
Unsure	25	25.0
Total	100	100.0

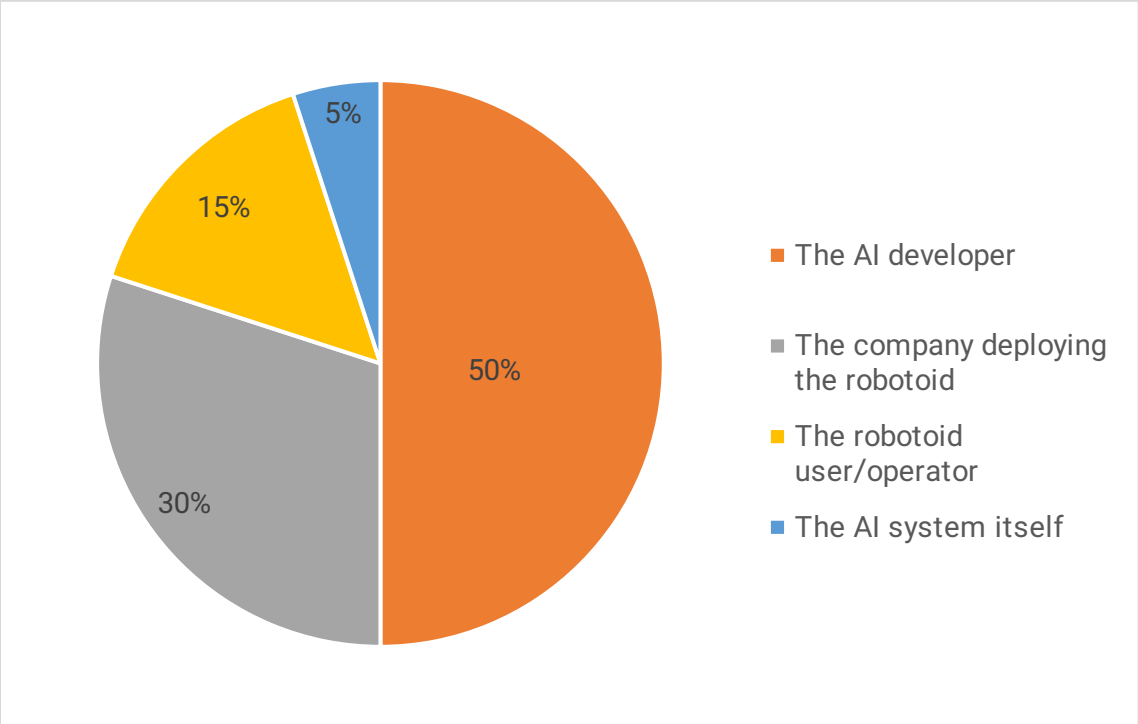
Source: fieldwork

Table 5: Adequacy of current AI-technology

A majority of 45 respondents (45%) believe that current AI technologies are sufficient in enabling robotoids to adapt effectively, reflecting confidence in the capabilities of present-day machine learning algorithms, neural networks, and related technologies. However, 30 respondents (30%) expressed doubts, indicating that despite advancements, there are still significant limitations, such as scalability, context-awareness, and decision-making in complex, real-world environments that need improvement. The 25 respondents (25%) who were unsure underscore the ongoing uncertainties within the field, suggesting that while progress is evident, the technology may not yet be universally reliable or versatile across different applications. This ambivalence highlights both the promising strides and the unresolved challenges in developing truly adaptable robotoids. The varying perspectives suggest that while there is optimism about current AI's role, there is also recognition that further enhancements, particularly in areas like real-time learning and multi-modal integration, are essential for achieving more robust and adaptive robotoid systems.

4.6: Responsibility for mistakes made by AI-driven robotoids

In assessing responsibility for mistakes made by AI-driven robotoids, opinions strongly lean toward holding developers accountable.



Source: fieldwork

Figure 1: who should be responsible

A significant 50 respondents (50%) believe that developers should bear primary responsibility, reflecting the view that those who design and program the robotoid's AI are ultimately in control of its decision-making capabilities and behaviour. This perspective emphasizes the ethical and technical responsibility of ensuring that AI systems are reliable and safe before deployment. On the other hand, 30 respondents (30%) consider the company deploying the robotoid to be responsible, suggesting that organizations must oversee how these systems are implemented and ensure they are used appropriately within specific contexts. Interestingly, only 15 respondents (15%) think the user should be held responsible, indicating that many view robotoid operation as largely automated and beyond the user's direct control. Lastly, 5 respondents (5%)

suggested that AI itself should bear responsibility, highlighting emerging discussions about the potential legal and ethical standing of autonomous systems. Overall, the majority view suggests a focus on accountability at the design and deployment stages, recognizing the need for rigorous testing, oversight, and ethical guidelines to prevent errors and mitigate risks.

4.7: Confidence for how far current AI-driven system make ethically sound decision in complex scenarios.

The level of confidence in AI-driven robotoids making ethically sound decisions reveals a cautious outlook among respondents.

	Frequency	Valid Percent
Not confident	20	20.0
Slightly confident	35	35.0
moderately confident	25	25.0
Very confident	15	15.0
extremely confident	5	5.0
Total	100	100.0

Source: fieldwork

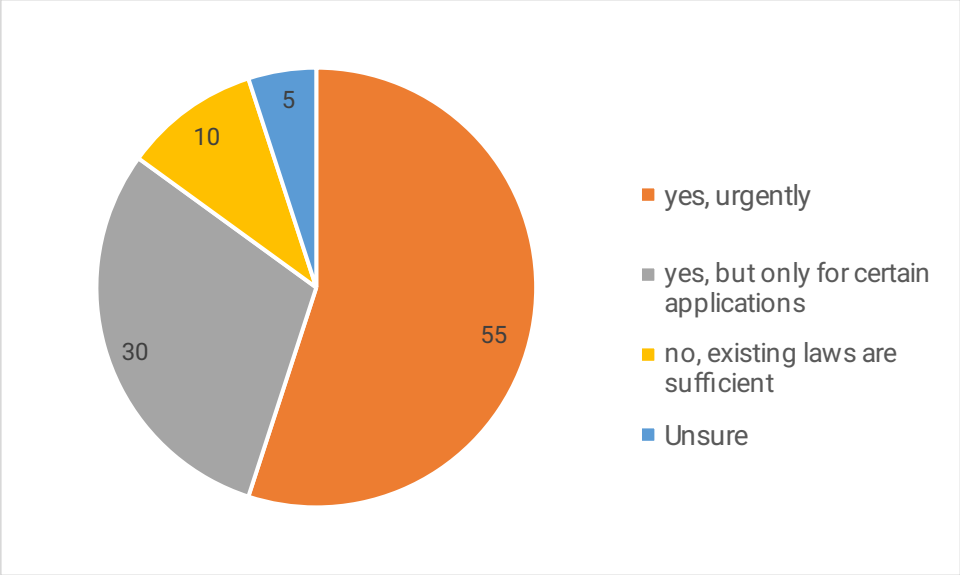
Table 6:confidence for ethically sound decision

A significant portion, 35 respondents (35%), are only slightly confident in robotoids' ability to consistently uphold ethical standards, reflecting widespread concern about current AI limitations in navigating complex moral scenarios. Additionally, 20 respondents (20%) indicated they are not confident at all, highlighting the scepticism that AI, as it stands, lacks the nuanced judgment required for ethical decision- making in diverse and unpredictable situations. A smaller group of 25 respondents (25%) expressed moderate confidence, suggesting that while there are some promising developments in AI ethics, substantial gaps remain in ensuring reliability. Only 15 respondents (15%) are very confident, and just 5 respondents (5%) are extremely confident, illustrating that belief in AI's ethical robustness is limited to a minority who likely trust the technology's-controlled environments or specific applications. These findings indicate that while there is some optimism, the majority of stakeholders remain

wary of the ethical soundness of robotoid decisions, pointing to the need for more advanced AI frameworks that integrate comprehensive ethical principles and adaptive reasoning capabilities.

4.8: Need for updating legal frameworks specifically to address culpability in AI-driven robotoid systems.

The survey results strongly indicate a recognized need to update the legal framework surrounding AI-driven robotoids.



Source: fieldwork

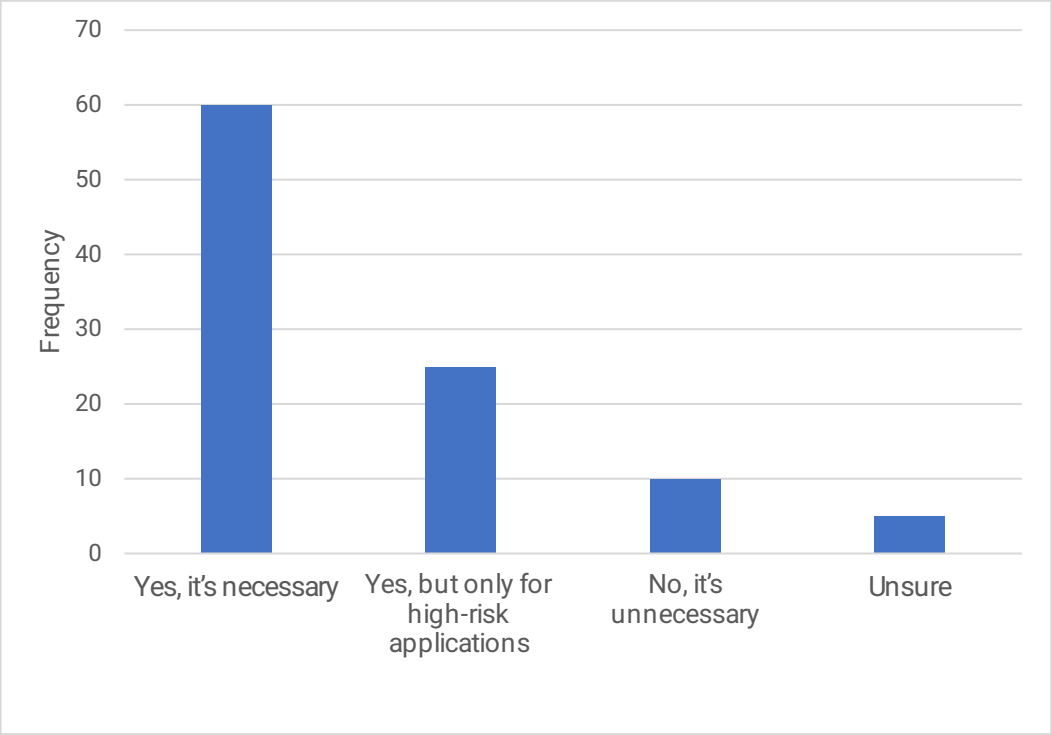
Figure 2: need for updating laws governing AI-driven system

With 55 respondents (55%) believing that urgent updates are necessary. This majority opinion underscores concerns that current regulations are outdated and unable to fully address the complexities and risks posed by autonomous systems, particularly in areas like accountability, safety, and ethical decision-making. Another 30 respondents (30%) support updating the legal framework but only for specific applications, suggesting that

while some sectors, such as healthcare, defence, and public safety require immediate regulatory attention, other areas might not need as strict oversight. Interestingly, 10 respondents (10%) feel that existing laws are sufficient, indicating a belief that the current legal framework, perhaps with minor adjustments, is capable of governing AI systems effectively. Meanwhile, 5 respondents (5%) remain unsure, reflecting ongoing debates and uncertainties about the adequacy and direction of future legal reforms. The consensus emphasizes the urgency for legal systems to evolve alongside AI advancements, ensuring robust governance and ethical use of robotoids in a rapidly changing technological landscape.

4.9: The need for AI-driven robotoids to have a built-in mechanism to log decision-making processes for accountability purposes.

The survey results show strong support for including built-in mechanisms to log the decision- making processes of AI-driven robotoids.



Source: fieldwork

Figure 3: inclusion of built-in mechanism

With 60 respondents (60%) deeming it necessary. This majority view reflects the growing recognition that transparency and traceability are critical in understanding, evaluating, and potentially rectifying decisions made by autonomous systems. Logging mechanisms are particularly valuable for accountability, safety audits, and ethical assessments, ensuring that robotoid actions can be reviewed and justified if errors or ethical dilemmas arise. Another 25 respondents (25%) believe such mechanisms should be required only for high-risk applications, such as in healthcare, defence, or autonomous driving, where mistakes can have significant consequences. Meanwhile, 10 respondents (10%) consider this feature unnecessary, possibly viewing it as an added complexity that might slow down decision- making processes without

substantial benefits in lower-risk scenarios. Finally, 5 respondents (5%) are unsure, indicating ongoing uncertainties about the practicality and value of implementing such systems universally. The overall consensus highlights a clear push toward greater transparency in AI operations, especially as robotoids take on more critical and complex roles in society.

4.10: Qualitative responses from the study

The qualitative responses from the study offer deeper insights into the varied perspectives and concerns surrounding AI-driven robotoids' adaptability, ethical considerations, and the need for enhanced legal frameworks. Several recurring themes emerged from the analysis, revealing the complexity of integrating AI into autonomous systems and the diverse viewpoints among different professional group.

1. Trust and Ethical Concerns: Participants expressed a cautious attitude toward trusting robotoids' decision-making abilities, particularly in ethical scenarios. Many highlighted the unpredictable nature of AI when faced with morally complex situations, suggesting that current models lack the nuance needed to ensure consistently ethical outcomes. The scepticism was most pronounced among ethics consultants and AI researchers, who emphasized the importance of establishing robust ethical safeguards before fully deploying such systems in critical environment.

2. Variability in Confidence Level: The mixed confidence levels regarding the adequacy of current AI technology reflect divergent professional experiences. For instance, AI researchers and robotic engineers were generally more optimistic about the technological potential, while students and ethics consultants expressed reservations. The latter groups often cited real-world case studies where AI systems failed to perform as intended, underscoring a disconnect between theoretical capabilities and practical reliability.

3. Legal Framework Gaps: There was strong consensus on the need to urgently update legal frameworks, with qualitative comments pointing to specific sectors where this is critical, such as healthcare, autonomous vehicles, and public safety. Respondents emphasized that existing regulations are either outdated or too general to address the nuanced risks associated with robotoid deployment. This indicates a need for targeted legislative reforms that account for the rapid

evolution of AI technology.

4. Transparency and Accountability: A notable portion of respondents advocated for greater transparency through decision-logging mechanisms, particularly in high-stakes applications. Qualitative feedback stressed that such systems are essential not just for tracing errors but also for building public trust in robotoids. However, there were also concerns about the potential trade-offs between transparency and operational efficiency, especially in real-time applications.
5. Professional Background Influence: The professional diversity of respondents revealed differing priorities. For instance, AI researchers tended to focus on the technical advancements required to improve adaptability, while robotic engineers highlighted integration challenges. Ethics consultants and students, on the other hand, frequently raised concerns about the societal impact and long-term consequences of autonomous robotoids. This divergence suggests that effective robotoid development will require collaboration across these different domains.

The qualitative analysis reinforces the quantitative findings, particularly in highlighting the widespread agreement on the need for stronger ethical safeguards, updated legal frameworks, and transparent decision-making processes. However, it also underscores the varying levels of confidence and trust among different professional groups, indicating that a one-size-fits-all approach may not be suitable for addressing the complex challenges posed by AI-driven robotoids.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1: Chapter overview

This chapter discusses about the conclusion and recommendation after the research result that have been discussed from the previous chapter.

5.2: Conclusion

The research findings highlight several key trends regarding perceptions of AI-driven robotoids' adaptability, ethical decision-making, and the legal and technical frameworks required to support their development. Respondents largely agree that AI plays a significant role in enhancing robotoid learning and adaptability, with machine learning and neural networks identified as primary contributors. However, there remains considerable scepticism regarding the adequacy of current AI technology and its ability to consistently make ethically sound decisions. This uncertainty extends to the level of confidence in AI's ethical judgment, where a significant portion of respondents expressed only slight confidence. The results also demonstrate a strong call for updating legal frameworks, with many advocating for urgent revisions, particularly in high-risk sectors. Additionally, the majority of respondent’s support integrating built-in mechanisms to log decision-making processes, emphasizing transparency and accountability.

5.3: Recommendations

Based on the research findings, several recommendationS are proposed to explore the role that AI plays on enhancing the learning and adaptability of robotoids.

I. Enhance AI Ethical Frameworks: Given the low confidence in robotoids’ ethical decision- making, it is crucial to develop more robust AI ethics frameworks that integrate adaptive reasoning and context-aware algorithms. Incorporating multi-disciplinary oversight from AI researchers, ethicists, and legal experts can improve trust and reliability.

II. Urgently Update Legal Regulations: The significant support for urgently updating legal frameworks suggests the need for governments and industry bodies to establish clearer guidelines and regulations, especially for high-risk applications. Prioritizing accountability, safety, and ethical standards in these regulations.

III. Implement Decision-Logging Mechanisms: Since most respondents favour built-in logging systems, it is recommended that developers incorporate transparent and auditable decision- making logs, especially for applications with critical consequences. This will enhance accountability and allow for more informed assessments of AI-driven decisions.

IV. Focus on Targeted AI Improvements: While current AI technologies show promise, there is room for growth in areas like real-time learning and ethical reasoning. Further investment in research and development will be needed to address the limitations identified by respondents.

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APPENDICES

Appendix A: Questionnaire

Thank you for participating in our research study, "The Role of Artificial Intelligence in Robotoids' Learning and Adaptability." The goal of this study is to explore diverse perspectives on how AI technologies are impacting the learning and adaptability of robotoids, along with examining the ethical and legal implications associated with their deployment. Your responses are valuable and will help us gain deeper insights into the current state of AI in robotics, the challenges faced, and the potential improvements needed. The survey will take approximately 10 minutes to complete.

All data collected through this survey will be kept strictly confidential and used solely for research purposes. We do not collect any personally identifiable information, and your responses will remain anonymous. Data will be stored securely and reported in aggregate form, ensuring that no individual responses can be traced back to any participant. By participating, you are contributing to important academic research that aims to advance the understanding of AI-driven robotoid technologies. If you have any questions or concerns regarding this survey, please feel free to contact the research team at Japharymagembe@gmail.com.

Section 1: Demographics and Professional Background

1. What is your profession?

a) AI Researcher

b) Robotics Engineer

c) Ethics Consultant

d) Student

e) Other (please specify)

2. How familiar are you with AI-driven robotoid technologies?

a) Very familiar

b) Somewhat familiar

c) Slightly familiar

d) Not familiar at all

Section 2: AI and Robotoid Adaptability

3. How significant do you believe AI is in enhancing robotoids' learning and adaptability?

a) Not significant

b) Slightly significant

c) Moderately significant

d) Very significant

e) Extremely significant.

4. Which area do you think contributes most to robotoids' adaptability?

a) Machine Learning

b) Neural Networks

c) Natural Language Processing

d) Computer Vision

e) Other

Section 3: Ethical and Legal Considerations

5. How confident are you that current AI technology allows robotoids to make ethically sound decisions?

a) Not confident

b) Slightly confident

c) Moderately confident

d) Very confident

e) Extremely confident

6. Who should bear primary responsibility if a robotoid makes a mistake?

a) Developer

b) Company deploying the robotoid

c) User

d) The AI itself

7. Do you believe the legal framework governing AI-driven robotoids needs updating?

a) Yes, urgently

b) Yes, but only for certain applications

c) No, existing laws are sufficient

d) Unsure.

Section 4: logging and transparency.

8. Should AI-driven robotoids include built-in mechanisms to log their decision-making processes?

a) Yes, necessary for all applications

b) Yes, but only for high-risk applications

c) Unnecessary

d) Unsure

Section 5: Frequency of Interaction

9. How often do you encounter AI-driven robotoids in your professional or everyday environment?

a) Rarely

b) Occasionally

c) Often

d) Very often

Section 6: closed ended feedback

1. What mechanisms could be put in place to ensure accountability in AI-driven robotoids, particularly in scenarios where adaptability leads to unpredictable behaviours?

2. Do you believe current AI systems are capable of making ethically sound decisions, and if not, who should be held accountable when they fail?

3. What ethical challenges arise when robotoids make decisions based on AI-driven learning?

4. As robotoids become more autonomous, how should culpability be addressed when they malfunction or cause harm?

5. How should legal and regulatory frameworks evolve to address culpability as robotoids become more adaptive and autonomous.

Appendix B: ethical clearance

ST JOHN'S UNIVERSITY OF TANZANIA
DIRECTORATE OF GRADUATE STUDIES

TO LEARN TO SERVE

RESEARCH ETHICAL CLEARANCE CERTIFICATE

This is to certify that the research proposal herein detailed has been duly examined and approved as ethically compliant by the Internal Ethics Review Committee (IERC) of St John's University of Tanzania on 23rd July, 2024. The Researcher may therefore proceed with the research as from the date of this certificate as reference.

Research Title:	**The Role of Artificial Intelligence on Robotoids' Learning and Adaptability**
Principal Researcher:	**Japhary M. Zengo**
Supervisor:	**Mr. Ado Mgani**
Faculty/Institute:	**Center for Information and Communication Technology**
Degree being Studies for:	**Bachelor of Science in Information Technology**

Dr. Fadhili Bwagalilo (PhD)
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Deputy Vice Chancellor Academics