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Exploring mobile robotics: Historical applications and future

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Abstract. This paper reviews the history, current research status and future prospects of intelligent mobile robotics. The paper analyzes in detail the automatic navigation of mobile robots and identifies its advantages and disadvantages. Bionic robotics, artificial intelligence, machine learning, and deep learning are further analysed.

Keywords: Mobile Robots, Autonomous Navigation, Bionic Robots, Artificial Intelligence, Machine Learning.

1. Introduction

The word "robot" was first introduced to the real world in 1920 in the Czechoslovak play "Rosen's Omnipotent Robot "[1]. After the influence of computer software and cybernetics in the field of robotics, robots become intelligent and autonomous. An intelligent, dynamic robot is one that operates in a relatively unknown and unpredictable environment. It is also known as an autonomous mobile robot. If a robot has the potential to navigate freely and unhindered, and the intelligence to bypass any obstacles in the movement around it, then any robot will be intelligent or autonomous. Robots are best known by the American Institute of Robotics, which says: "Robots are multifunctional, reprogrammable robotic hands designed to move materials, tools, specialized equipment or parts to perform different tasks by combining motion with variable programming. Mobile robots perform any predefined tasks with AI algorithms. Mobile robots are the first in a long line of software to control robotic behavior in the field of robotic speech or robotic speech, while autonomous robots typically follow sensory (sensing), programming (and performing predefined tasks), and performing tasks like walking, and other tasks in the UK's most logical robotic tasks.

Nils Nilssen and Charles Rosen of the Stanford Research Institute, among others, developed Autonomous mobile robots named Shakey between 1966 and mid-1972. The aim is to study the autonomous reasoning, planning and control of robotic systems in complex environments using artificial intelligence (AI).

Norbert Wiener, an American mathematician, made an important contribution to the development of mobile robots by developing cybernetics [2]. Cybernetics plays an effective role in the development of intelligent robots. Claude Elwood Shannon is an American electrical engineer who developed information theory. His book "Ergonomics" laid the theoretical foundation for artificial intelligence and influenced fields of study such as automated control, pattern recognition, and ergonomics. He invented a very unique device, the mouse. Shannon's mouse was created in 1950. Shannon's mouse is a mechanical mouse that moves through a labyrinth because it is controlled by electrical and mechanical relay circuits. The mouse is believed to be the first manual learning device. In the late 1970s, with the

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development of computer application and sensing technology, mobile robot research appeared a new high tide. Especially in the mid-1980s, the wave of designing and building robots swept the world. A large number of famous international companies have started to develop mobile robotics platforms, mainly as experimental platforms for mobile robotics in university laboratories and research institutes, thus promoting the emergence of many research directions in mobile robotics. Since the 1990s, mobile robots have been studied to a higher degree, which is marked by the development of high-level environmental information sensors and information processing technology, highly adaptive mobile robot control technology, planning technology in the real environment, etc.

The modern robotics industry is building more advanced mobile robots as well as advances and research in electronics, software, artificial intelligence (AI), computers, technology and more. Robotics has also evolved from a simple operation to today's highly automated, intelligent, dehumanized and networked. More than 200 countries in the world now have their own robotics industries. China's robotics industry started late. Autonomous robots are becoming more relevant in today's industrial and commercial environment.

This paper provides excellent comprehensive thoughts on the historical development, function and future research prospects of mobile robots.

2. Mobile Robot Classification

Mobile robots can be divided into indoor mobile robots and outdoor mobile robots from the working environment. From the movement mode: wheeled mobile robot, walking mobile robot, serpentine robot, crawler mobile robot, crawler robot; From the control architecture: functional (horizontal), behavioral (vertical) and hybrid robots; By function and use: medical robot, military robot, disability robot, cleaning robot, etc.. After analyzing these different robots, the characteristics of each robot are pointed out. By Sensor Technology Adopted: Visual Robots; Infrared imaging robot; Ultrasonic ranging robot; GPS robots. Through the analysis of these different robots, the characteristics of each robot are pointed out. According to the sensor technology adopted, it is divided into visual robot, infrared imaging robot, ultrasonic ranging robot and GPS robot. From operational space: land mobile robots, underwater robots, drones, space robots, etc. This article is only about land mobile robots

3. Automated Navigation of Mobile Robots

Different mobile robot applications represent different navigation problems. For intelligent mobile robots, feeling and perceiving the work environment is crucial [3]. Planning pathways, decision-making, and execution of control structures that respond appropriately to this information define how this capability should be integrated to achieve desired results. Therefore, various control structures are put forward, and robust, flexible, reliable and good performance control systems are designed and developed to realize autonomous navigation of mobile robots. Autonomous navigation of mobile robots. Each control structure implies concepts and solutions to address navigation problems. These control structures can be roughly divided into three categories. Negotiable (centralized) navigation. Reactive (behavior-based) navigation and hybrid (deliberative -reactive) navigation. Reconsidered (centralized) navigation architecture models the global work environment through sensory systems or user input .

Navigation is the most basic and important of mobile robots. Deep reinforcement learning plays an important role in the navigation of mobile robots because of its ability to experience and represent learning. Available for indoor navigation, social navigation, local obstacle avoidance and multi-robot navigation. Most of the existing research focuses on augmented reality, but its application is limited by high cost and lack of real-time. Therefore, how to reduce the cost and improve the performance becomes the focus of people's attention. Autopilot solutions are now based on machine learning and artificial vision to sense the environment and speed up decision-making to build tasks.

3.1. Mapping

Mapping is the process of making predetermined environmental maps that allow robots to perform tasks more precisely. In this paper, by analyzing the traditional method, a method of extracting and utilizing

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unknown environmental information based on mapping technology is proposed. Based on this, an application example is given. Experiments show that this algorithm is simple, practical and easy to be programmed. Maps allow mobile bots to recognize changes in a preset environment when navigating, when maps or online are generated. It is also possible to treat the known environment as a whole. Many factors need to be considered in this process: for example, location (i.e., whether to move or not); Barriers; Road width, etc. These are all key factors affecting the performance of the system. Changes in the environment can be due to the existence of new or predefined routes that cannot be used, changes in certain environmental conditions, or other changes

3.2. Positioning

Positioning is the most basic part of mobile robot navigation, which determines the position of robot relative to global coordinates in two-dimensional working environment. Because of the complexity of the robot environment, the types of sensors it is equipped with and the number of sensors, the location methods are also diverse. The main methods are: inertial positioning, landmarks positioning and sound positioning. Land mobile platform has become one of the most commonly used mobile carriers due to its low cost, ease of operation and good mobility, so it is of great significance to study the localization of land mobile platform. This paper introduces three positioning methods based on land mobile platform. Inertial positioning is to install a photoelectric encoder on the wheels of a mobile robot and to roughly locate the attitude by recording the rotation of the wheels. (2) Although this method is simple, due to the wheels skidding on the ground, the cumulative error increases with the increase of the path, and the positioning error accumulates gradually, resulting in a larger error. Yamauchi uses speculative navigation in dynamic environments and locates robots using a grid of evidence. This method matches the evidence grates established at different times and uses a climbing algorithm to search for possible translational and rotational spaces to eliminate the accumulation of errors in the inferred navigation method. Landmark Location In a mobile robot environment, artificial landmarks with known coordinates, such as ultrasonic transmitters, laser reflectors, and so on, are positioned by detecting landmarks.

3.3. SLAM

SLAM technology is of great significance for mobile robot to perceive environment and navigate autonomously in unfamiliar environment [4]. An adaptive Kalman filter based on multi-information fusion is proposed to improve positioning accuracy and reduce errors. This method uses a variety of measurements to estimate unknown parameters. A global optimal value is obtained by using fuzzy C-mean clustering algorithm as the initial weight matrix. Then the particle swarm optimization (PSO) algorithm combined with K-means algorithm is used to determine the final weight vector. Use this weighting matrix for the positioning process. The simulation results show that it is effective. In addition, the performance, advantages and disadvantages of Kalman filter in various situations are analyzed. Finally, the existing problems in this research field and the future directions to be solved are pointed out. The work done in this paper can provide reference basis for practical application. The traditional SLAM algorithm is divided into laser SLAM and visual SLAM according to the processing sensor.

3.4. Pathway planning

Regardless of which navigation method is used, intelligent mobile robots focus on path planning, location, and obstacle avoidance [5].The path planning of autonomous mobile robot in navigation is one of the basic problems. According to a certain performance index, find an optimal or approximate optimal contactless path between the starting state and the target state. According to the robot's cognition of environmental information, there are two kinds of problems: global path planning, which is completely cognizant of environmental information, and local path planning, which is completely unknown or partially unknown. The robot's working environment is detected online by sensors to obtain information such as location, shape and size of obstacles.

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The path planning of mobile robot is to determine the collision-free path from origin to target point. Optimal performance criteria for a collision-free path (such as distance, time, or energy) from the point of origin to the target point. Again, distance is the most commonly used criterion of energy. There are two kinds of path planning algorithms in the available environment: offline path planning algorithm and online path planning algorithm. The offline path plans the obstacle and the robot trajectory in an environment where there is complete static obstacle and robot trajectory information. Obstacle movement is known in advance, also known as global path planning. This method is also known as offline path planning because the environment is incomplete (for example, an unknown object) or the robot cannot perceive the information directly. The advantage of offline path planning is that the system has high reliability. This method is called path planning under static obstacles. And can use the real-time map technology to realize the dynamic situation of the task [6]. Online path planning methods are also commonly called local path planning methods. When complete information about the environment is complete, the mobile robot gets information from sensors, and when it moves around the environment, the environment gets information. This is called online or local path planning. plan. Essentially, online path planning starts off offline but switches to online mode when it detects new changes in an obstacle. Switch to online mode when you notice a new change in the obstacle situation.

4. Bionic robots

Bionics applies biological principles to the research and design of engineering systems, especially to the growing robotics science. The research scope of contemporary robot has been developed from fixed point operation in structural environment to aerospace, interstellar exploration, military reconnaissance attack, underwater underground pipeline and so on. Development of autonomous operations in non-structural environments such as disease detection and treatment, emergency response and disaster relief. Bionics is one of the important contents of robotics research[7]. With the improvement of science and technology, robots are developing in the direction of intelligence. Intelligent robots can perform many complex and heavy tasks in place of humans and have broad development prospects. Robots of the future will serve known and unknown environments that humans cannot or will not be able to meet. Robots are expected to adapt not only to previously structured and known environments, but also to unstructured and unknown environments that will develop in the future. In addition to traditional design methods, people are targeting the biological world, trying to take inspiration from a rich variety of plants and animals and apply their movement mechanisms and behaviors to the study of robot movement mechanisms and control.

In order to study the mechanism of bio-mimetic robot movement, it is necessary to study the biological movement in depth and apply it flexibly in robot research. In this paper, the experimental and theoretical work on the mechanism of bio-mimetic robot movement in recent years is reviewed, and several methods are briefly introduced. Finally, the development trend is pointed out. With the development of computer technology. Computer simulation technology has been used more and more widely in the field of bionic robots. It can not only make people more aware of the diversity of biological movement laws in nature, but also provide a reliable basis for designing new institutions. Therefore, Computer Assisted Engineering (CAE) has become one of the indispensable methods in scientific research and industrial product design and development. It can not only make people more aware of the diversity of biological movement laws in nature, but also provide a reliable basis for designing new institutions. Therefore, Computer Assisted Engineering (CAE) has become one of the indispensable methods in scientific research and industrial product design and development. In this paper, the role of computer simulation in bio-mimetic robot research will be expounded from several aspects. At the same time, its shortcomings are also pointed out. In this paper, the main simulation software and its characteristics are discussed in detail, and some typical simulation examples are given. These examples show that it is feasible and effective to use computer simulation technology to simulate real systems. It has certain reference value. Prospect the future development prospect. In this paper, the research progress of computer simulation in this field is discussed in detail, and some reference points are also summarized. By means of simulation, the relationship between joint angle, angular velocity and torque

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under different gait of bio-mimetic robot is discussed in this paper, and some new understanding is obtained. It also raises questions that need to be addressed. By means of simulation, the relationship between joint angle, angular velocity and torque under different gait of bio-mimetic robot is discussed in this paper, and some new understanding is obtained. It also raises questions that need to be addressed. These findings will help us further understand the mechanism of bio-mimetic robots' movements. To make it work better for humanity. The research on the behavior of bio-mimetic robots is still in its infancy, but the results have laid a good foundation for further study and shown a broad prospect.

5. Artificial intelligence

Artificial intelligence (AI) is the technology that manifests human intelligence in ordinary computer programs[8]. Artificial intelligence can be divided into two definitions of "artificial" and "intelligent." "Artificial" mainly refers to the imitation of what exists in nature, has a certain structure and is able to move according to human requirements; "Intelligence" refers to the ability to understand the world and transform it. There is a connection and a difference. "Artificial" means something designed by humans and made and produced by humans. Artificial intelligence research usually involves studying human intelligence itself. "Artificial" usually refers to machines as a means to an end. And "intelligence" generally refers to the thought patterns and response mechanisms that the human brain controls as it performs complex tasks. And "intelligence" is made up of human brain function and its associated behavioral patterns. Because of its unique advantages and great potential, it has aroused great interest since its birth. After more than half a century of continuous exploration and development, artificial intelligence has made significant achievements [9]. It is now in the practical phase. With the development of computers. Artificial intelligence has reached into all areas of social life. It has become a major symbol in the development of contemporary science and culture. Intelligence involving animals or other artificial systems is also commonly considered to be AI-related research. Artificial intelligence is now being used more widely in computing [10]. It is also applied in robot, economic and political decision-making, control system and simulation system.

6. Machine learning and deep learning

Machine learning, as a subcategory of computer science, has evolved from pattern recognition research to today. At present, machine learning has become an emerging discipline with breakthroughs in many fields [11]. With the maturation of machine learning theory and technology, its applications are expanding to cover all aspects of economics, management and medicine. Machine learning is also thought to be a recognize area of AI research, giving computers the ability to learn through data. To achieve this goal, machine learning explores the development of models that can predict and learn from existing datasets. and predictive learning of available datasets. The model runs on algorithms that enable data-driven prediction and does not follow a defined code. So machine learning is often used in a range of problems where designing precise algorithms is not very practical. From this perspective, machine learning can replace expertise in human information processing. Therefore, it may become a new research hot spot in the field of artificial intelligence in the future. The main purpose of this paper is to apply machine learning to the modeling and analysis of complex systems and thus to solve practical problems such as decision support systems. To do this, the machine provides an algorithmic tool data-set for processing data sets and providing predictions. In fact, machine learning tends to mimic human abilities, and most of the time human abilities work well. In determining a satisfactory solution, adopt theoretical or empirical considerations.

The interdisciplinary field of optimization and machine learning has recently attracted the attention of leading scientists. Machine learning has benefited from optimization, which in turn promotes optimization. Machine learning is now recognized as a substitute for human expertise in information processing. Machine learning has also been shown to have the ability to simplify optimization functions. Optimization, on the other hand, is a source of great power that automatically improves decision-making. However, optimization in real-life applications, including robotics, has not yet had the opportunity to reach its full potential. In some cases, people take advantage of uncertainties to reduce

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losses and risks. Therefore, uncertainty is inevitable for optimization problems. That makes people think about how to deal with that uncertainty to get better results. Even in this case, however, machine learning in this case has shown the ability to model all or part of an optimization function based on existing optimization functions. Ability to model optimization functions based on a reliable dataset.

Intelligent robot is an inevitable trend [12]. Deep learning plays a decisive role in this process. It completely changes the face of traditional robot image and speech recognition technology, solves the basic problems of robot location and navigation, completes the construction of working environment map and so on. It is one of the most powerful robot vision and hearing technologies. This paper mainly introduces the computer vision system based on depth neural network (CNN) and the intelligent car based on this model. Experiments show that this method can achieve high accuracy and high efficiency. With the development of network technology, the CNN model has been widely used in other fields. The application of deep learning to robotics has also greatly improved the accuracy of robotics.

Traditional robotics only requires robots to be able to perform simple, repetitive tasks. Under these conditions, robots do not need to know the information about their working environment, as the actions they perform are not directly related to their surroundings. But when robots are asked to be more intelligent, it is important for them to realize their familiar environment.

7. Future Research Outlook

Agribusiness, warehouses, military operations, medical institutions, and logic companies are all looking for new and modern ways to improve operational efficiency, safety, accuracy, and speed [13]. Therefore, the future all needs the support of self-driving cars. In the long run, too much research is needed to create more analytical systems and achieve higher levels of autonomy. In recent years, the field of artificial intelligence has made great progress. With the development of deep learning technology, its application field is becoming more and more extensive. In the field of artificial intelligence, AI is used to solve specific application problems, such as traffic planning and management, medical diagnostics, etc. Artificial intelligence (AI) has become the fastest growing, most influential, and most promising technology. The next 10 years will bring a lot of innovative people in and making decisions. Intelligent robots will become more ultra-modern in ways that are smarter and closer to humans. However, several existing automation solutions still have many drawbacks, such as inadequate understanding of complex scenarios and lack of appropriate algorithms. Because of the diversity and complexity of the environments, sensors and methods involved, the positioning and navigation of autonomous vehicles in random environments is an issue. Although other similar studies have been carried out through literature surveys, future research is needed in various directions. Future autonomous robotic systems will create objects that perform tasks using a variety of collaborations. Of these, ML and DL are the two intelligent models that are currently considered the most likely alternatives to traditional machine learning algorithms. MLC can effectively solve the problem of data sparseness. DL can better handle Multi-valued classification tasks. Isomeric collaboration and combination potential can greatly facilitate a wide range of applications. Combining ML and DL with mobile robotics can improve the application range and accuracy of robotics.

Self-driving cars, drone deliveries, and the intelligent industries that travel with robots are innovations that have had a huge impact on the way factories operate. The use of mobile robots in underground mining could speed up mapping of mines, support workers, create virtual models and improve safety. With the advent of Industry 4.0, robotics and robotics will become one of the key elements of future enterprise production activities. However, the understanding of Industry 4.0 is not clear: Can robots work as effectively as humans? How does it do that? What do robots do? What can it accomplish? What exactly can a "machine swap" do for a business? What consequences could it have? Are robots really going to replace humans? Are robots more reliable than humans? Can robots reduce manufacturing costs? Can robots meet the needs of different customers? Can robots cope with extreme weather? Can robots save employees time? Can robots reduce labor intensity? Can robots be more efficient? Will robots be able to do certain tasks in place of humans? Can robots make workers smarter? Are robots more capable of self-learning? Can robots help people design safer and more efficient

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products or services? Can robots reduce labor costs? Will it provide a better experience for users? AI + Automation "How Will It Change Our Lives?" "What it takes to change a robot and how it can adapt to a complex environment are all topics worth exploring, such as obstacle avoidance, motion planning in tropical conditions, and collaborative multi-robot path planning. Opportunities remain open to mobile robotics researchers.

Intelligent robots are helping the machine economy work, and the Internet of Things will be more fully realized [14]. In addition, advances in artificial intelligence, 5G, cloud-native technology and automation will provide deeper industrial applications. The robotics industry will continue to thrive in the years ahead. The global robotics market is concentrated in developed countries such as Europe and the United States. At present, more than 10 countries around the world have put in place policies to promote the healthy and rapid development of the robotics industry, and some Asian countries, including the European Union and Japan, have spared no effort to introduce supportive policies. Since 2016, the global robotics market has entered a period of high growth. The global robotics market size was estimated at USD 76 billion in 2017. Growth will continue at a high pace in 2018. The global robotics market is expected to decline in 2019. The global robotics market reached $84 billion in 2017 and is expected to grow to around $1 trillion by 2020. China, as the world's largest consumer market for robotics, is also receiving increasing attention. The European Commission estimated global robot sales at $10 billion in 2017 [15]. That number is expected to double by 2022. Among them, consumer electronics, dominated by smartphones, cars and medical devices, are the biggest growth drivers of the global robotics market. The market for autonomous mobile robots is growing very fast in services, software and robotics applications. Countries such as China, India and Brazil are actively promoting the robotics industry. Robots are estimated to be in demand in the global market by between 100 million and 200 million by 2020. The rapid growth of the robotics industry will bring huge business opportunities. With the advent of artificial intelligence, the global robotics market will enter a period of rapid growth. Global robot sales are forecast to reach around 100 million units in 2020. That number could double by 2025. The main factor for market growth is the increasing demand for and adoption of automated products in various end-use settings. This has led to increased development and research by several companies operating in the market. Furthermore, the growth of the mobile robot market has been encouraged by governments across the globe. The central Government provides grants and funding for the manufacture of advanced mobile robots for industrial and defence applications. However, the greatest challenge to the development of this technology is the lack of experts and research. At various research institutions, technologists around the world are busy building the next generation of autonomous systems.

8. Conclusion

Intelligent Mobile Robotics (IMA) is an innovative autonomous vehicle system (AMS) designed to overcome the unprecedented demand for mobile robotic systems in various fields, such as industry, healthcare, fire and military operations. Because of its special properties, it is attracting more and more attention from governments and industry all over the world. Since the 1980s, countries have been investing in intelligent robotics. With the mobilization of intelligent mobile robots, the company's business has grown rapidly, with diverse and flexible applications. So far, a lot of people have been working on it and getting some results. To date, more than 50 countries around the world have conducted related research. Smart mobile robots are also increasingly used in the military, medicine, entertainment and education. So far, more than 200 manufacturers around the world are working on this, and many countries have policies in place to encourage the industry to thrive. A variety of intelligent robots have been developed. The application field of intelligent mobile robot is also becoming more and more extensive. At present, many kinds of intelligent mobile robots have been developed in the world, such as wheeled mobile robots, tracked mobile robots, walking robots and various other types of robots. Among them: Artificial Intelligence (AI), Computer Vision (CVS), Machine Learning (RLM) and others. Novel technologies have developed and mitigated human lifestyles in which environmental hazards and risks and exposures have been minimized. In recent years, there has been a rapid increase

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in interest in the field of robotics engineering. In this paper, we introduce the overview and research prospect of intelligent robots in the past 100 years. In this context, there is a need for sufficient literature to describe the current and future trends in the industry. Therefore, this article mainly makes some introduction to this aspect. This paper focuses on the research and development, working principle and application of autonomous vehicles. It is understood to be the first comprehensive survey of intelligent mobile robots to cover a century of research. But these advances have not gone smoothly, in part because of a lack of understanding and technology for mobile robots. In order to get a better understanding of this problem, some relevant historical data of intelligent mobile robots are reviewed. This article covers the development of smarter and more reliable robots from the time the word "robot" first appeared in the world in 1920 until 2021. This provides excellent starting points for new researchers and a useful footnote blueprint for mature researchers. So we think there will be more of the same in the years to come and publish. This thesis will be of great benefit to researchers in the future because it involves a great deal of literature investigation and a deeper concept of mobile robot theory.

References

[1] Britannica. The Editors of Encyclopedia. “R.U.R.”. Encyclopedia Britannica, 20 November 2014. Available online: https://www.britannica.com/topic/RUR (accessed on 24 August 2022)

[2] R. Raj and A. Kos, “A Comprehensive Study of Mobile Robot: History, Developments, Applications, and Future Research Perspectives,” Applied Sciences, vol. 12, no. 14, p. 6951, Jul. 2022, doi: 10.3390/app12146951.

[3] Nakhaeinia, Danial, et al. "A review of control architectures for autonomous navigation of mobile robots." International Journal of the Physical Sciences 6.2 (2011): 169-174.9

[4] Aulinas, Josep, et al. "The SLAM problem: a survey." Artificial Intelligence Research and Development (2008): 363-371.

[5] Raja, Purushothaman, and Sivagurunathan Pugazhenthi. "Optimal path planning of mobile robots: A review." International journal of physical sciences 7.9 (2012): 1314-1320.

[6] Sariff, N., and Norlida Buniyamin. "An overview of autonomous mobile robot path planning algorithms." 2006 4th student conference on research and development. IEEE, 2006.

[7] Chi, D.C., and Yen, G.C.. "The state of research on bionic robots and their future development." Robotics 23.5 (2001): 5.

[8] Xu Yanfeng, Sun Hanxu. Development and application of artificial intelligence in the field of robotics [J]. Development and innovation of electromechanical products, 2004(1):4.

[9] Vrontis, Demetris, et al. "Artificial intelligence, robotics, advanced technologies and human resource management: a systematic review." The International Journal of Human Resource Management 33.6 (2022): 1237-1266.

[10] Brunette, Emma S., Rory C. Flemmer, and Claire L. Flemmer. "A review of artificial intelligence." 2009 4th International Conference on Autonomous Robots and Agents. Ieee, 2009.

[11] Liu, Chen-Hui. "Artificial intelligence and robotics." Western Leather 38.20 (2016): 1.

[12] Luettel, T.; Himmelsbach, M.; Wuensche, H. Autonomous Ground Vehicles—Concepts and a Path to the Future. Proc. IEEE 2012, 100, 1831–1839. [Google Scholar] [CrossRef]

[13] Kuutti, S.; Bowden, R.; Jin, Y.; Barber, P.; Fallah, S. A Survey of Deep Learning Applications to Autonomous Vehicle Control. IEEE Trans. Intell. Transp. Syst. 2021, 22, 712–733.

[14] Grehl, S.; Mischo, H.; Jung, B. Research Perspective—Mobile Robots in Underground Mining: Using Robots to Accelerate Mine Mapping, Create Virtual Models, Assist Workers, and Increase Safety. AusIMM Bull. 2017, 2, 44–47.

[15] Mosavi, Amir, and Annamaria Varkonyi. "Learning in robotics." International Journal of Computer Applications 157.1 (2017): 8-11.