Artificial Intelligence Based Robot Technology in Automation Industry

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***Abstract*—Industry 4.0 also known as the fourth revolution is a new era in which industry will deal with technologies like Robotics, Automation, Artificial Intelligence (AI), and many more [1]. We introduce the concept of robots and their practical uses in daily life, highlighting their basic functions. The main text covers the history of robotics, the applicable environment, and the difference between traditional technology and automated robots. It also explains the advancement of machine learning and its impact on robotics. Common techniques used in robotics, such as Support Vector Machine (SVM), K-Nearest Neighbors Algorithm (KNN), and Random Forest, are explained. The text introduces Deep Learning and the context in which it operates. This is followed by a discussion on the advantages and disadvantages of machine learning and deep learning, along with the benefits of combining the two, as well as strategies for avoiding their disadvantages.**

***Keywords*—Machine Learning (ML), Deep Learning (DL), Support Vector Machine (SVM), K-Nearest Neighbors Algorithm (KNN), random forest**

I. Introduction

From everyday life to the military, from toys to the digitalization of weapons, robots have a wide range of applications. Robots are everywhere in our lives. However, due to the obvious lack of independent innovation in China's industrial automation manufacturing industry, with independent intellectual property rights, and fewer independent technology and product brands, there is a big gap between the overall technical level of the industry and the world's advanced level. As a result, China is relatively behind the world level in robotics. China's automated manufacturing industry started late, talent training and knowledge reserve are insufficient, and the shortage of high-end professionals has an inevitable impact on the rapid development of the industry. China's demand for robots is growing yearly and has become an important global market. Industrial robots also reflect a country's level of development because they contain many high-precision parts.

Industrial robots combine advanced technologies in the fields of mechanics, electronics, sensors, wireless communications, voice recognition, image processing, and artificial intelligence, involving various disciplines, and are an important symbol of a country's level of scientific and technological development and the modernization and informatization of the national economy. In mass production, robots can replace the labor force in assembly line production, the efficiency will be much higher than the original, and robots can also work 24 hours. Robots can also replace humans to complete some dangerous work and grow slowly into our lives.

Some of the robots currently in use do not have a high level of industrial precision, which means that some high-precision parts and instruments cannot be manufactured accurately. On construction sites, the situation is extremely complex and cannot be well applied by traditional signal propagation methods, so different schemes should be specified according to the different conditions of each construction site. However, it is extremely cumbersome to develop different plans for different sites, so artificial intelligence and robots can be combined, and they can learn independently and adjust different working states according to different environments. So we need a robot that can learn on its own, adapt to complex environments through algorithms, and improve errors and safety on its own. Long-distance real-time communication is very difficult, and autonomous control of unmanned engineering machines does not require real-time monitoring or intervention, which has broad application prospects for lunar and Mars construction. Today's robots can only control robots through programs, and the programmer's negligence may lead to accidents, and the consequences are unimaginable.

Deep learning is a term that is used frequently today and was developed from machine learning. The speech recognition, sequential data processing, and image processing domains are specifically used with deep learning models like LSTM, RNN, CNN, autoencoder, etc. Additionally, these models are employed to build DL-based detection systems for secure cloud computing [2]. The DL-based security techniques may carry out the same security activities as the ML-based techniques, including (unknown attack detection, new attack detection, etc.). The performance of DL-based security solutions is higher than ML-based security strategies because DL models can analyze very large volumes of traffic and continue to improve performance as data volumes grow. On the other hand, DL-based security solutions are extremely complicated; for example, any neural network, including DNN, CNN, RNN, etc., is built using a variety of hidden layers. Therefore, training for these models requires a lot of time (days/weeks) [2].

In industrial automation, DL and ML can help robots improve their work efficiency and error tolerance. Robots may be equipped with ML and DL to provide better and more accurate results [3]. Robots can correct errors through self-learning. The robot can also optimize the details of the work itself as it works. Self-learning can be made more complete and smoother, and more information can be sought to learn how to optimize.

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II. Technology Evolution and Analysis

A. History and Evolution of Robot Technology

Robotics technology has an interesting history in the automation sector, spanning several decades with breakthroughs and revolutionary advances. Robots have completely changed the way we handle several industrial processes, make items, and carry out monotonous activities. We shall examine the development of robot technology in the automation sector from its inception to the current day in the next sections of this subsection. The origins of robotic automation may be found in the early 1900s when basic mechanical machines that could automate particular jobs began to appear. That being said, the 1950s saw the invention of the contemporary robot. The field's pioneers, George Devol and Joseph Engelberger, unveiled the Unimate, the first industrial robot. This robot represented a turning point in the history of automation when it was employed for material handling duties in a General Motors facility. A new era of robotics was ushered in with the Unimate, whose success paved the way for more advancements.

In the 1960s, increasingly sophisticated robotic systems with a wider range of functions were created. These early robots were heavy, awkward devices that were mostly employed in the production of automobiles. They offered little flexibility and were programmed via punch cards. But they did set the stage for automation's future.

The 1990s brought further innovation in the field of automation with the introduction of parallel kinematics and the use of lightweight materials in robot design. Parallel kinematic systems allowed for greater precision and speed in robot movements, while lightweight materials made robots more mobile and energy efficient. These developments were particularly important for applications like 3D printing and medical robotics.

The 21st century has witnessed a rapid evolution of robot technology in the automation industry. Robots have become more autonomous and capable of handling complex tasks across various industries, from healthcare to logistics. The integration of AI and ML has allowed robots to learn and adapt, making them valuable assets in industries where flexibility and customization are essential.

One of the most notable advancements in recent years is the rise of collaborative robots or cobots. These robots are designed to work alongside humans, enhancing productivity and safety in various industries. They are equipped with advanced sensors and safety features, ensuring that human-robot collaboration is efficient and secure.

Furthermore, the automation industry has seen the expansion of robot applications into new domains, including household and service robotics. Robots like the Roomba vacuum cleaner and delivery drones have become household names, highlighting the increasing role of automation in our daily lives.

To put it briefly, the automation industry's history with robots has been one of incredible invention and advancement. Automation technology has evolved into a crucial component of contemporary industry, from the days of big, inflexible machinery to the intelligent, cooperative robots of today. Robots are becoming more and more ingrained in our daily lives as technology develops and they get smarter. The future of automation technology will bring even more fascinating possibilities.

1) The working environment of the traditional robot technology

Human digital modeling can be defined as the almost real-time digital reproduction of a real person in a virtual environment. This has been a major obstacle due to the lack of effective human data acquisition techniques [4].

These robots are used in all aspects of automotive manufacturing to improve efficiency, precision, and safety. The following describes the application of traditional robotics in automotive assembly.

Many parts of the car need to be joined by welding to the body, so welding robots are of prominent importance in the production line. Welding robots are commonly used in automotive assembly lines to join metal parts together. These robots can perform repetitive and precise welding tasks, resulting in consistent and high-quality welds. They are often equipped with sensors and cameras to adapt to variations in the parts being welded.

In automotive welding, play requires painting the entire body of the vehicle. Manual painting can lead to inaccurate spraying, resulting in uneven paint color. Paint spraying automated paint-spraying robots are critical to achieving a flawless, even, and consistent body paint finish. They are able to apply the paint precisely with consistent pressure and coverage, ensuring that the car is aesthetically pleasing. These robots can be programmed to follow specific patterns and can switch colors efficiently.

After some of the above basic operations are completed, the corresponding car parts need to be fitted in, which is a physically demanding task to do manually and can lead to defective products that cannot be fitted accurately. Robotic arms are used to assemble various parts of the car, such as doors, seats, and dashboard components. These robots are programmed to perform complex assembly tasks with precision, ensuring that all parts fit together perfectly.

After the final installation, the assembled car needs to be inspected for problems. Robots equipped with sensors and vision systems are used for quality control and inspection tasks. They can identify defects, measure critical dimensions, and ensure that each car meets the required specifications and quality standards.

In addition to automotive assembly, traditional robotics are used in a large number of applications in food processing, revolutionizing the way food is produced and prepared. These robots are an invaluable asset to the food industry as they can perform a variety of tasks with precision, consistency, and efficiency. The following describes the application of conventional robotics in food processing lines.

Robots avoid the need for strong manual labor to cut ingredients evenly and the potential for human injury during the cutting process. Traditional industrial robots are equipped with sharp blades or laser cutting tools for precise cutting and slicing of ingredients such as vegetables, fruits, and meats. These robots allow for even cuts, improving the aesthetics and quality of the final product.

For some novice cooks, the heat can be too hot to handle, resulting in a burnt texture and poor taste. In commercial kitchens and bakeries, robots are used to cook, grill, and bake a variety of foods. They can precisely control temperature, time, and other variables to ensure consistent cooking results.

Inevitably, in traditional manual labor, there is substandard food sold. Vision systems and sensors are integrated with robots to inspect and sort food products for defects such as discolored or misshapen products. Robots can remove substandard products from the line, reducing waste.

Human contact with food in traditional assembly lines can be contaminated with bacteria, leading to unhealthy food. Robots equipped with grippers and conveyor belts can handle food, transferring it between different stages of processing. They can also be used in the sterilization process to ensure food safety by reducing human contact.

AMR can transport food products, packaging materials, etc., significantly improving the efficiency of internal logistics, reducing time, and maximizing space utilization. Furthermore, AMR can alleviate the issues and the safety of the workers who are involved in repetitive tasks, particularly in hazardous conditions [5].

2) Working principle of the traditional robot technology

Traditional robot technology, or industrial robots, operates based on principles and components that enable them to perform various tasks in manufacturing and industrial settings. The working principle of traditional robot technology involves several key elements, such as mechanical structure, actuators, sensors, and control systems. In the rest of this section, we will describe each of these in detail.

Traditional robots have a mechanical structure with multiple joints and links that mimic the human arm's design. These joints and links provide the robot with the ability to move in multiple directions and perform complex motions. The number of joints and the type of joints (e.g., rotational or prismatic) depend on the robot's design and intended tasks.

As for actuators, Robots are equipped with actuators that generate motion. Electric motors, hydraulic, or pneumatic systems are commonly used as actuators. These components drive the robot's joints and links, allowing it to move its arms and end-effector (the tool or device attached to the robot's arm).

Sensors are critical for robots to perceive and interact with their environment. These sensors include cameras, infrared sensors, force/torque sensors, proximity sensors, and more. Sensors provide feedback on the robot's position, orientation, and the objects it interacts with, allowing it to make real-time adjustments.

The control system is the brain of the robot. It comprises hardware and software that manage the robot's movements and tasks. The control system processes sensor data, executes pre-programmed instructions, and can adapt to changing conditions in real-time. It ensures that the robot moves precisely and safely.

In medical surgery, robots are subjected to a lot of demands. These include the small number of instruments available, the issue with large consoles, the constraints on the eye tracking calibration needed, and the procedure-specific limits. The use of conventional laparoscopy, which applies braking mechanisms to each surgical tool, may be impacted by the precise movements of a completely robotic system [6].

B. Machine Learning Robot Technology

In recent years, advances in machine learning, deep learning, and artificial intelligence have completely changed the field of advanced robotics. The fields of advanced robotics are changing as a result of AI, ML, and DL, which are improving robot intelligence, efficiency, and ability to adapt to challenging jobs and surroundings. In advanced robotics, AI, ML, and DL are used in a variety of applications such as natural language processing, autonomous navigation, object recognition and manipulation, and predictive maintenance. Collaborative robots, or cobots, are being developed using these technologies to work alongside humans and adjust to changing jobs and circumstances. In order to give passengers and transportation businesses safety, efficiency, and convenience, advanced transportation systems can make use of AI, ML, and DL [7].

1) Working environment

AI-based robot technology has become integral to the automation industry, transforming manufacturing and logistical processes. In assembly lines, robots equipped with AI can efficiently assemble products with precision, identifying and manipulating objects. Material handling and logistics benefit from AI-driven robots that navigate dynamic environments, optimizing routes and avoiding obstacles for streamlined material flow. Quality control is enhanced through the integration of AI-based vision systems, allowing robots to inspect products for defects using machine learning algorithms. Collaborative robots (cobots) work alongside human counterparts, adapting to human movements and collaborating on tasks such as assembly and inspection. Predictive maintenance is facilitated by AI algorithms, enabling proactive interventions to reduce downtime. Warehousing leverages autonomous vehicles like AGVs and drones, guided by AI for efficient material transport and inventory management. In 3D printing, AI optimizes processes, ensuring real-time adjustments for improved accuracy. Adaptive manufacturing benefits from AI, allowing robots to adjust actions based on real-time feedback. Human-robot collaboration is advanced in tasks requiring a blend of human and robotic skills. Data analytics powered by AI optimize workflows and enhance production performance, while robots equipped with AI sensors conduct detailed inspections and testing for quality assurance. Overall, AI-based robot technology offers diverse solutions, improving efficiency, precision, and adaptability across various automation industry processes.

2) Working principles

Traditional machine learning techniques, such as Support Vector Machines (SVM), random forests, decision trees, and K-nearest neighbors, have the major benefit of using very little input, having good interpretability, and operating quickly[8].

Support Vector Machine

When it comes to Support Vector Machines, we first need to understand the definition of this algorithm:

A support vector machine (often abbreviated as SVM, also known as a support vector network) is a supervised learning model and associated learning algorithm for analyzing data in classification and regression analysis. Given a set of training instances, each labeled as belonging to one or the other of two categories, the SVM training algorithm creates a model that assigns new instances to one of the two categories to create a non-probabilistic binary linear classifier. The SVM model is one in which the instances are represented as points in a space such that the mapping allows instances of the separate categories to be separated by as wide a distinct interval as possible. New instances are then mapped to the same space and predicted to belong to a category based on which side of the interval they fall [9].

The application setting of SVM is mainly in classification problems, it is a class of generalized linear classifiers that learn in a supervised manner. Its decision boundary is the maximum margin hyperplane that is solved for the learned samples. SVM is mainly used in classification scenarios such as image classification, text classification, face recognition, spam mailbox detection, and other areas. It is considered by many to be the best-supervised machine learning model that minimizes the empirical error while maximizing the geometric margin, hence it is also known as a maximum margin classifier. The application principle of SVM is to segment the samples by overfitting hyperplanes (which are straight lines in two-dimensional space) to achieve the purpose of classification or prediction. When the linear model approximates the non-linear model, the dimension of the feature space can be increased by methods such as mapping (e.g., adding second or third-order terms to construct polynomial regression in the multivariate linear regression model) so that the purpose of modeling and prediction can be effectively achieved. However, it also brings two problems, one is the huge amount of computation and the other is the generalization ability of the model, which is known as the curse of dimensionality. The support vector machine is an effective way to solve the curse of dimensionality problem. It reduces the amount of computation and improves the generalization ability of the model by using kernel tricks (quickly obtaining the same scalar after mapping the original feature vectors), efficiently scaling the features, and maximizing the distance between the decision boundary and the training instances close to the decision boundary.

In robotics applications, there are not only SVM algorithms but also K-nearest neighbor algorithms, which are common robotics algorithms, they are just slightly different in classification.

K-Nearest Neighbor

K-Nearest Neighbor (KNN) is a type of instance-based or non-generalized learning: the idea is to classify items by calculating the distance between the item to be classified and the k nearest items in the data set, and classifying them according to the proximity of these k distances.

The KNN algorithm is a simple and easy-to-understand classification algorithm for small datasets and is less sensitive to missing and outliers in the data. However, for large datasets, the KNN algorithm can become very slow because it needs to calculate the distance of the item to be classified from all the items in the dataset. In addition, the KNN algorithm also needs to pre-determine an appropriate k-value, which has a significant impact on the results. If the k-value is not chosen correctly, it can lead to inaccurate classification results.

Therefore, the KNN algorithm is suitable for use in environments that require a high level of privacy or want to avoid creating large training datasets. In addition, for some simple problems, KNN can provide fast and effective solutions.

The computational process of the KNN classification algorithm can be understood by reviewing the information:

1. Calculate the distance between the points to be classified and the points of known categories.
2. Sort the points in increasing order of distance.
3. Select the K points with the smallest distance from the point to be classified.
4. Determine the number of occurrences of the category in which the first K points are located.
5. Return the category with the highest number of occurrences of the first K points as the predicted classification of the point to be classified [10].

KNN has many advantages and disadvantages, the advantages are as follows:

1. The algorithm is simple, the theory is mature, and can be used for both classification and regression.
2. It can be used for non-linear classification.
3. There is no obvious training process, but rather the training time complexity is 0 because the data set is loaded into memory at the start of the program and then predicted directly without training.
4. Since the KNN method relies mainly on the limited number of surrounding neighboring samples to determine the class to which it belongs, rather than on the method of discriminating class domains, the KNN method is more suitable than other methods for the set of samples to be classified that have more intersections or overlaps of class domains.
5. The algorithm is more suitable for the automatic classification of class domains with a large sample capacity, while those class domains with a small sample capacity are more prone to misclassification by this algorithm.

The algorithm will inevitably have shortcomings:

1. The need to count the distance between each test point and the training set, when the training set is large, the computational volume is quite large and the time complexity is high, especially when the number of features is relatively large.
2. Requires a large amount of memory and high spatial complexity.
3. Sample imbalance problem (i.e., some categories have a large number of samples while others have a small number of samples), low prediction accuracy for rare categories.
4. It is a 'lazy' learning method, which basically does not learn, resulting in slower prediction than algorithms such as logistic regression.

And KNN algorithm is often applied to the following environments:

1. E-commerce field: according to the user's historical purchase records, recommend relevant products to the user, but also according to the user's evaluation of different products to determine the quality and popularity of the product.
2. Medical area: By comparing the patient's symptoms with the data of known diseases, the KNN algorithm can help doctors quickly and accurately determine the cause of the disease.
3. Financial sector: By comparing a customer's credit history with known fraud data, KNN algorithms can help

banks and other financial institutions assess a customer's credit risk.

Environments with small amounts of data, high privacy requirements, or those that want to avoid creating large training datasets. While KNN algorithms can provide better results in many situations, they may be limited when dealing with large datasets or when efficient prediction is required.

Random Forest

Random forests are part of integrated learning, the core idea is to integrate multiple weak classifiers to achieve the effect of the three ignorant cobblers that are better than Zhu Geliang. Random Forest uses the idea of bagging, the so-called bagging is:

1. Remove n training samples from the training set each time it is put back to form a new training set;
2. Using the new training set, train to obtain M sub-models;
3. For classification problems, use a voting method, where the classification category of the sub-model with the most votes is the final category; for regression problems, use a simple averaging method to obtain the predicted value [11].

Random forest is a very powerful machine learning algorithm that belongs to the class of integrated learning methods that learn by constructing and combining multiple decision trees.

The algorithm itself works like this: the Random Forest algorithm first takes a random portion of samples from the dataset, and then when training for each tree, a random portion of features from the original features are selected for training. At decision time, each tree makes independent predictions about the sample, and then the one with the most votes wins.

This algorithm is suitable for a number of environments. First, because of its random nature, Random Forest works well with a wide variety of data sets, especially those with noise or outliers. Secondly, due to its integrated nature, Random Forests are usually able to achieve better predictive performance than a single decision tree model. Finally, Random Forest is also suitable for dealing with large datasets because it can parallelize the training process. The Random Forest algorithm is suitable for dealing with a variety of environments, especially data sets with noise or outliers. Its randomized and integrated nature gives it good performance when dealing with complex datasets.

However, for those with particularly large feature spaces, Random Forest may overfit. In this case, other methods such as decision tree gradient boosting (e.g., XGBoost, LightGBM, etc.) can be considered for processing.

Lenz had experimented on ML/DL, by presenting a system for detecting robotic grasps from RGB-D data using a deep learning approach. Their method has several advantages over current state-of-the-art methods. First, using deep learning allows us to avoid hand-engineering features, learning them instead. Second, the results show that deep learning methods significantly outperform even well-designed hand-engineered features from previous work [12].

In summary, the Random Forest algorithm is a very versatile machine learning algorithm that can be used in a variety of different environments.

This paper found the algorithm for random forests as follows. Simply, non-parametric CART models can be applied to regression (e.g., estimating the likelihood that an individual has prostate cancer) or classification (e.g., assessing a person's risk of prostate cancer based on age, PSA, and other variables). A decision tree is a common term used to describe the output of a CART model. Clinical literature has long used these kinds of trees to help with diagnosis and treatment selection. The CART algorithm determines the best decision threshold mathematically for a variable by means of recursive partitioning, which involves evaluating the possible values of various thresholds for every predictor and using the best one until additional splitting ceases to enhance discrimination. The tree is "grown" in this manner [13].

C. How Deep Learning Robotics Works

Many use cases, including speech recognition, image processing, natural language processing, sentiment analysis, recommendation systems, and more, have seen success with the use of Deep Learning (DL), and major corporations like Google, Facebook, Amazon, IBM, and others have established their own DL research teams [14].

A neural network is a computational model consisting of a large number of directly interconnected nodes (or neurons). Each node (except the input node) represents a particular output function (or operation, if you prefer), called the excitation function; each connection between two nodes represents the proportion of the signal that is transmitted (i.e. the proportion of the node's "memory" that is considered to have been passed on), called the weight; the output of the network varies according to the excitation function and the weight, and is an approximation of a function or an approximate description of a mapping relationship. The output of the network varies according to the excitation function and weights and is an approximation of a function or an approximate description of a mapping relationship.

Neural networks can be classified as either feedforward or feedback neural networks. Feed-forward neural networks are networks in which the inputs to the current layer depend only on the outputs of the nodes in the previous layer, regardless of the state of the outputs of the previous network, while feedback neural networks access the outputs of the input layer after a time-shifting step in which the inputs do not depend only on the outputs of the nodes in the previous layer.

There are many types of neural networks such as Multilayer Perceptron-MLP, Convolutional Neural Networks-CNN, Long Short Term Memory-LSTM, Generative Adversarial Networks-GAN, Graph Neural Networks-GNN.

1. The Multilayer Perceptron (MLP) is a feed-forward artificial neural network model that maps multiple sets of inputs to a single set of outputs. The MLP can be viewed as a directed graph consisting of multiple layers of nodes, each fully connected to the next layer. Each node is a neuron with a non-linear activation function, except for the input nodes.

2. Convolutional Neural Network (CNN) is a class of feed-forward neural networks that incorporate convolutional computation and have a deep structure. It has representation learning and translation-invariant classification capabilities and is often used to process data with a lattice structure, such as images and speech signals. Convolutional neural networks have excelled in many application areas and are one of the

most representative deep learning algorithms.

3. Long Short-Term Memory (LSTM) is a recurrent neural network with long-term memory capability. It solves the vanishing gradient problem over backpropagation through time in traditional RNN (Recurrent Neural Network) by introducing units with forgetting and remembering functions.

4. Long Short-Term Memory (LSTM) is a recurrent neural network with long-term memory capability. It solves the problem of weight disappearance in backpropagation over time in traditional RNNs by introducing units with forgettable and memory functions.

The main components of LSTM include Forget Gate, Input Gate, and Output Gate, which are responsible for deciding whether the current input is accepted, whether it is remembered for a long period of time, and whether the inputs in memory are output at the current time. LSTMs have the function of memory and are therefore often used in data and scenarios with time series characteristics.

5. Generative Adversarial Networks (GAN) is a deep learning model that consists of two networks: a generator and a discriminator. The generator is responsible for learning the distribution of real data and generating new data samples, while the discriminator is responsible for discriminating between real and generated data. During the training process, the generator and the discriminator perform adversarial optimization and eventually reach a dynamic equilibrium that makes the generated data samples very similar to the real data.

GAN has made breakthroughs in many fields, such as unsupervised learning, image generation, and computer vision. It is a kind of structured learning, which can output complex structured data, such as sequences, matrices, etc. The emergence of GAN has greatly facilitated the research of unsupervised learning, and picture generation, and has been expanded from the initial picture generation to various fields of computer vision, such as image segmentation, video prediction, and style migration.

6. Graph Neural Network (GNN) is a general term for algorithms that use neural networks to learn graph-structured data. It can extract and discover features and patterns in graph-structured data to meet the needs of graph-learning tasks such as clustering, classification, prediction, segmentation, and generation.

7. The history of GNN can be traced back to 2005, when Gori et al. first proposed the concept of GNN, using RNN to process undirected graphs, directed graphs, labeled graphs, cyclic graphs, etc. Bruna et al. proposed to apply CNN to graphs, and through a clever transformation of convolutional operators, they proposed a Graph Convolutional Network (GCN), which was derived from GNN. GCN) and derived many variants. In addition to Graph Convolutional Neural Networks, the main algorithms of GNN include Graph Self-Encoders, Graph Generative Networks, Graph Recurrent Networks, and Graph Attention Networks.

Graph Neural Networks have a wide range of applications, including but not limited to tasks such as image classification, video processing, speech recognition, and natural language understanding. Data in these tasks is typically represented in Euclidean space. A central assumption of existing machine learning algorithms is that individual instances are independent of each other.

ML/DL is used in many fields and the systems are varied and there are different systems in different fields.

III. ML/DL Robotics: Advantages, Limitations, Generalization, and Societal Impact

A. The Advantages of Using ML/DL-based Robot Technology over the Traditional One

The main advantage of machine learning and deep learning robotics over traditional robotics is their ability to adapt and learn.

1. Machine learning and deep learning technologies enable robots to adapt to different environments and tasks. By learning from large amounts of data, robots can automatically adapt their behavior and strategies to changing environments. This makes robots more flexible and reliable in responding to unknown or uncertain situations.

2. The use of ML and DL can improve accuracy in specific cases. These techniques require the identification of patterns and relationships by learning large amounts of data to make accurate predictions of outcomes. In the medical field, the use of ML DL can help doctors diagnose diseases and develop treatment plans more accurately. By analyzing large amounts of medical images and data, these technologies can learn the characteristics and manifestations of different diseases and thus provide more accurate advice when making a diagnosis. In addition, these technologies can predict disease trends and treatment effects based on information such as a patient’s medical history, symptoms, and signs, helping doctors develop better treatment plans.

3. In the field of logistics, the use of ML and DL can help optimize distribution routes, improve transport efficiency, reduce transport costs, and so on. For example, using deep learning algorithms to analyze and learn from historical transport data can predict future transport demand and route congestion, helping logistics companies to develop more reasonable distribution plans. In addition, in construction sites, the use of technologies such as machine vision and deep learning can monitor and manage the construction process and safety, improving construction quality and safety.

4. ML and DL algorithms are highly flexible and scalable and can be applied to a wide variety of different domains and problems. Whether objects are shifted, added, or removed, the algorithm parameters and model structure can be adapted to new situations by adjusting them. Their flexibility and scalability allow them to adapt to a variety of different environmental changes and quickly adapt to new situations. For example, in logistics, when the transport demand changes, using ML and DL can help logistics companies quickly re-optimize the distribution routes and adjust the transport plan to the new demand situation. In the construction site, when the construction plan or construction materials change, using ML and DL can quickly monitor and manage the construction process to ensure construction quality and safety.

In conclusion, the advantages of machine learning and deep learning techniques lie in their adaptive ability, learning ability, efficiency, generalization ability, and robustness, which make robots more efficient, accurate, and reliable in dealing with complex and dynamic tasks.

Robotics might undergo a revolution as a result of the application of AI, ML, and DL, which could lead to new heights in productivity, safety, and efficiency [15].

B. The Limitations of Using ML/DL-based Robot Technology

While machine learning and deep learning robotics have many advantages, they also have some limitations.

Machine learning and deep learning techniques require large amounts of data for training and learning. However, in some cases, there may be a lack of sufficient data to support the learning process, which can lead to inaccurate or unreliable models. And machine learning and deep learning techniques require significant computational resources and time to train models. Since deep learning models are often large, they require high-performance computers or GPUs for training, which makes the training process costly and time-consuming.

The performance of machine learning and deep learning models often relies on preset parameters. Finding the optimal parameter values may require manual tuning or the use of trial-and-error methods, which undoubtedly adds to the time and cost.

Although deep learning techniques have better robustness, they are still vulnerable to a number of attacks and disturbances. This makes it still challenging for robots to cope with uncertain and dangerous environments.

While machine learning and deep learning robotics have many advantages, they also have some limitations such as problems with data requirements, computational resources, interpretability, dependence on predefined parameters, and robustness. These limitations need to be fully considered when applying these techniques and appropriate measures need to be taken to address them.

Because complicated data models are involved, training a model comes at a hefty cost. Additionally, DL raises the cost for customers by requiring hundreds of computers and pricey GPUs [16].

C. How to Generalize the ML/DL-based Robot Technology in Automation

It is not necessarily the case that the higher the accuracy, the better it is, and it needs to be judged in the context of specific application scenarios. In industrial scenarios, in addition to accuracy, factors such as real-time and stability also need to be considered. If you just pursue high accuracy and ignore other factors, it may lead to unstable system operation or failure to meet the actual demand.

When the industrial scene produces changes, if the movement of objects, changes in temperature, changes in air pressure, etc. have an impact on the characteristics of the collected data, then the previously learned network parameters may no longer be applicable and the model needs to be retrained. Therefore, in order to improve the generality of the model, it is necessary to collect various types of data as much as possible, including different scenes, different times, different working conditions, etc.

In addition, some techniques can be used to improve the generalization ability of the model, such as data augmentation, migration learning, domain adaptation, etc. Data enhancement is to generate more training data by adding noise or transforming data to improve the generalization ability of the model; migration learning is to apply the knowledge learned from one task to another task to accelerate the learning process and improve the generalization ability. Techniques may be used without large data sets because of artificial neural networks, which reduce the prediction error rate [17].

Some automation techniques can also be used to assist in model design and optimization, such as automated feature engineering, automated model selection, and automated hyperparameter optimization. These techniques can help us quickly find the optimal model and parameter configurations, thus improving the generalization ability and performance of the model.

D. Impact of Using ML/DL-based Robot Technology for the Society

The application of machine learning and deep learning techniques in various neighbourhoods has already had a profound impact on society.

1. Deep learning technology can be used for medical diagnosis and treatment. This technology can help doctors to analyze medical images and data, and can also assist them in tumor detection, disease detection, disease prediction, and so on. It can also greatly improve the accuracy of diagnosis.

2. Machine learning and deep learning technology can be used in financial risk control, investment decision-making, and other fields. By analyzing financial data and market trends, it can assist investors in making investment decisions on stocks, bonds, etc. to improve returns and reduce risks. Deep learning technology can also be used in anti-fraud, anti-money laundering, and other financial security neighborhoods.

3. In the industrial sector, a real-time IoT system with cameras and controls might save a significant amount of human resources. Because the system anticipates errors and prevents them, it may save a substantial amount of resources by identifying odd conduct, sounding an alert, and taking the necessary action in response. There are two main differences between traditional solutions and machine learning (ML) solutions: 1) ML solutions increase the accuracy of predictions, and 2) ML solutions greatly increase the automation of factory management. [18]

Although the application of machine learning and deep learning brings a lot of convenience, there are also many negative effects.

1. The wide application of machine learning and deep learning may lead to the reduction of some traditional jobs, resulting in the unemployment of many grassroots employees and making it difficult for more people to find employment. The development of the automation industry will be the repetitive industries that are replaced by machines.

2. Machine learning and deep learning require a large amount of data support, and so much data may contain a large amount of users' private information. If effective protection measures are not taken, it may result in data leakage and may be abused by wrongdoers.

3. The application of machine learning and deep learning may lead to the problem of uncontrolled technology. Because the algorithms of machine learning and deep learning have a certain degree of complexity, we may not be able to fully understand and master these algorithmic behaviors and results, which leads to the possibility of unforeseen dangers.

The application of machine learning and deep learning technologies has already had a profound impact on society, and they are changing our lives, improving productivity and quality of life. At the same time with the advancement of technology comes the potential hazards of machine learning and deep learning.

IV. Conclusion

In industrial automation, the indispensable intelligent system is ML/DL, because ML/DL is an important part of AI. AI in a new area needs to understand to make appropriate instructions, and ML/DL can help AI quickly understand so that it can make decisions. ML/DL also cannot fully adapt to all environments; we need to give ML/DL different environments and also give ML/DL a lot of data support to better learn to adapt to a specific environment.

ML/DL can greatly improve productivity. ML/DL can repeat an action on the assembly line, and the error rate is very small. ML/DL reduces labor costs and saves time. ML/DL is also a sign of industrial progress and a sign of a country's technological level, as fewer people work on the production line and the possibility of safety accidents is reduced.

If the ML/DL needs to work in different environments, the hard disks can be stored in different environments. The appropriate hard disks are inserted in the different environments. A large amount of data must be prepared for the ML/DL to learn before it is referenced. If there is too little data, the ML/DL may not work with high accuracy and make decisions that do not match the instructions. When manipulating the ML/DL, it is necessary to transform the content of the operation into the language that corresponds to the ML/DL.

Conflict of Interest

The author has claimed that no conflict of interest exists.

References

[1] R. Goel and P. Gupta, "Robotics and Industry 4.0. a roadmap to Industry 4.0: Smart production, sharp business and sustainable development," pp. 157–169, 2020.

[2] R. Ahmad and I. Alsmadi, "Machine learning approaches to IoT security: A systematic literature review," *Internet of Things*, vol. 14, 100365, 2021.

[3] R. Raj and A. Kos, "A comprehensive study of the mobile robot: history, developments, applications, and future research perspectives," *Applied Sciences*, vol. 12, no. 14, p. 6951, 2022.

[4] S. Baskaran, F. A. Niaki, M. Tomaszewski, J. S. Gill, Y. Chen, Y. Jia and V. Krovi, "Digital human and robot simulation in automotive assembly using Siemens process simulate a feasibility study," *Procedia Manufacturing*, vol. 34, pp. 986–994, 2019.

[5] M. U. Farooq, A. Eizad, and H. K. Bae, "Power solutions for autonomous mobile robots: A survey," *Robotics and Autonomous Systems*, vol. 159, 104285, 2023.

[6] T. Williamson and S. E. Song, "Robotic surgery techniques to improve traditional laparoscopy," *JSLS: Journal of the Society of Laparoscopic & Robotic Surgeons*, vol. 26, no. 2, 2022.

[7] R. F. Madvari, "Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) on Health, Safety and Environment (HSE)," *Archives of Occupational Health*, vol. 6, no. 4, pp. 1321–1322, 2022.

[8] Q. Bai, S. Li, J. Yang, Q. Song, Z. Li, and X. Zhang, "Object detection recognition and robot grasping based on machine learning: A survey," *IEEE Access*, vol. 8, pp. 181855–181879, 2020.

[9] SMON. 2018. If you don't understand SVM after reading this article, come and fight me. *Zhihu Column*. [Online]. Available: https://zhuanlan.zhihu.com/p/49331510

[10] "Detailed Explanation of Random Forest (Understanding Random Forest from Decision Trees)". *Zhihu Column*. 2022. [Online]. Available: https://zhuanlan.zhihu.com/p/471494060

[11] H. Shan. (2020). Introduction to KNN Algorithm. *Zhihu Column*,. [Online]. Available: https://zhuanlan.zhihu.com/p/53084915

[12] I. Lenz, H. Lee, and A. Saxena, "Deep learning for detecting robotic grasps," *The International Journal of Robotics Research*, vol. 34, no. 4–5, pp. 705–724, 2015.

[13] S. J. Rigatti, "Random forest," *Journal of Insurance Medicine*, vol. 47, no. 1, pp. 31–39, 2017.

[14] A. I. Károly, P. Galambos, J. Kuti, and I. J. Rudas, "Deep learning in robotics: Survey on model structures and training strategies," *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, vol. 51, no. 1, 266–279, 2020.

[15] M. Soori, B. Arezoo, and R. Dastres, "Artificial intelligence, machine learning and deep learning in advanced robotics, A review," *Cognitive Robotics*, 2023.

[16] A. J. Moshayedi, A. S. Roy, A. Kolahdooz, and Y. Shuxin, "Deep learning application pros and cons over algorithm deep learning application pros and cons over algorithm," *EAI Endorsed Transactions on AI and Robotics*, vol. 1, no. 1, 2022.

[17] L. E. Alatabani, E. S. Ali, and R. A. Saeed, "Machine learning and deep learning approaches for robotics applications," in *Proc. Artificial Intelligence for Robotics and Autonomous Systems Applications*, *Cham: Springer International Publishing*, 2023, pp. 303–333.

[18] J. Bian, A. Al Arafat, H. Xiong, J. Li, L. Li, H. Chen, and Z. Guo, "Machine learning in real-time internet of things (IoT) systems: A survey," *IEEE Internet of Things Journal*, vol. 9, no. 11, pp. 8364–8386, 2022.

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