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Review on Advanced Automation Using Artificial Intelligence, Machine Learning and Deep Learning

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Abstract:
Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) have revolutionized the field of automation and advanced robotics in recent years. AI, ML, and Deep Learning are transforming the field of automation, making robots more intelligent, efficient, and adaptable to complex tasks and environments. Some of the applications of AI, ML, and Deep Learning include autonomous navigation, object recognition and manipulation, natural language processing, and predictive maintenance. These technologies are also being used in the development of collaborative robots (cobots) that can work alongside humans and adapt to changing environments and tasks. Also, the AI, ML, and Deep Learning are playing a critical role in the advancement of manufacturing assembly robots, enabling them to work more efficiently, safely, and intelligently. Furthermore, they have a wide range of applications in aviation management, helping airlines to improve efficiency, reduce costs, and improve customer satisfaction. The seminar presents an overview of current developments in AI, ML, and Deep Learning in automation and robotics systems and discusses various related applications

Keyword : Artificial intelligence Machine learning Deep learning Automation Advanced

1. INTRODUCTION

1.1 Technologies in the field of Automation and Robotics enhancement

Artificial intelligence (AI), machine learning (ML), and Deep Learning (DL) are all important technologies in the field of robotics and automation [1]. The term artificial intelligence (AI) describes a machine's capacity to carry out operations that ordinarily require human intellect, such as speech recognition, understanding of natural language, and decision-making. Robots can detect and interact with their surroundings, make judgments, and carry out difficult tasks with the aid of AI. [2]. A branch of AI known as "machine learning" uses algorithms to give robots the ability to learn from data and get better over time [3]. It's possible to program robots to carry out certain jobs in robotics, such as grasping, object identification, and path planning. Artificial neural networks are used in deep learning, a type of Machine Learning (ML), to help computers learn from massive volumes of data [4]. Deep Learning has been particularly useful in robotics for tasks such as image and speech recognition, natural language processing, and object detection. Together, these technologies have enabled the development of robots that can perform a wide range of tasks, from simple pick-and-place operations to complex manipulation and navigation in unstructured environments [5]. The application of AI, ML, and Deep Learning in robotics has the potential to transform the field, enabling robots to become more intelligent, autonomous, and effective in a wide range of applications. Robotics is a rapidly evolving field, and the use of AI, ML, and Deep Learning is likely to continue to play a key role in shaping the future of automation [6].

In advanced robotic systems, AI is used to create robots that can perceive, reason, and act autonomously in complex environments. Machine Learning is used to enable robots to learn from their experiences and improve their performance over time. Deep Learning is used to solve specific problems that are difficult to solve with traditional Machine Learning techniques, such as image and speech recognition. By combining these technologies, advanced robotics systems can be designed to perform complex tasks that were once thought impossible. The relationship between them are inclusive in terms of analysis and modification of advanced robotic systems. These are just a few examples of how AI, ML, and Deep Learning are used in robotics. Here are some examples of how they are used in different robotic systems for automation as,

1. Object Detection and Recognition: Object detection and recognition are critical tasks in robotics that have become possible thanks to deep learning. By training neural networks with massive amounts of labeled data, robots can identify and classify objects in their environment with high accuracy [7].
2. Predictive Maintenance: Predictive maintenance is a maintenance approach that uses AI and ML to detect potential issues before they occur. By analyzing data from sensors and other sources, predictive maintenance algorithms can predict when a robot's

components may fail, allowing for proactive repairs or replacements [8].

3. Gesture and Speech Recognition: Gesture and speech recognition are also important applications of AI and ML in robotics. For example, robots like Pepper can recognize and respond to human gestures and speech, making them useful in a variety of contexts such as customer service or healthcare [9].
4. Robotic Surgery: Robotic surgery is a field where AI and ML are revolutionizing the way operations are performed. By using advanced algorithms, robotic surgeons can assist human surgeons during complex procedures, reducing the risk of complications and improving outcomes. Surgical robots use AI, ML, and Deep Learning to aid surgeons in performing complex operations with greater precision and accuracy [10].
5. Medical applications: Deep Learning techniques are particularly useful in analyzing medical images due to their ability to recognize patterns and features that are not easily identifiable by humans [11]. This can help doctors to identify subtle changes in the images that may indicate the presence of disease [12]. Machine learning models used in drug delivery for infectious disease treatment is shown in the Fig. 1 [13]. Ensemble algorithm, decision trees and random forest, instance based algorithms and artificial neural network are used to enhance drug delivery of infectious diseases.
6. Military robotics: Robotics is used in military operations for tasks such as reconnaissance, surveillance, and bomb disposal. AI and ML algorithms are used to analyze data and make decisions based on the information gathered [14].
7. Agriculture: AI and ML are being used to develop robots that can autonomously navigate and manage crops, increasing efficiency and reducing labor costs. Robotics is used to automate tasks in agriculture, such as planting, harvesting, and spraying. AI and ML algorithms are used to optimize the farming operations, such as predicting weather patterns, optimizing water usage, and monitoring crop health [15].
8. Service robotics: Robotics is used to provide services to humans, such as cleaning, food delivery, and customer service. AI and ML algorithms are used to enable robots to interact with humans and understand their needs and preferences [16].
9. Autonomous driving: AI and ML are used to help cars navigate roads and make driving decisions on their own. For example, self-driving cars use computer vision to detect and recognize objects on the road, and ML algorithms to learn and adapt to new situations and road conditions [17]. For instance, robots like self-driving cars use AI to detect obstacles and predict traffic movements. Meanwhile, ML algorithms use data from sensors, cameras, and GPS to make navigation decisions [18].
10. Robotics manufacturing: Robotics is used to automate tasks in manufacturing plants, such as assembly line tasks, painting, and welding. AI and ML algorithms are used to optimize the robotic operations, such as improving the efficiency and accuracy of movements [2].

1.2 Artificial Intelligence in Automation field

Traditional automation relies on pre-programmed instructions, but AI takes it to a whole new level. Here's how AI is supercharging automation:

- Making it intelligent: AI, particularly machine learning, allows automation to analyze data, learn from it, and adapt its actions. This means AI-powered automation can handle situations that traditional scripts can't, improving efficiency and accuracy.
- Adding perception: AI can endow machines with senses through computer vision. This lets them "see" the world, enabling tasks like robotic quality control or autonomous vehicles.
- Improving decision-making: AI can analyze vast amounts of data to identify patterns and make predictions. This is crucial for areas like predictive maintenance or optimizing logistics in a supply chain.
- Automating complex tasks: AI can handle tasks that require human-like judgment, such as interpreting customer service requests or processing loan applications. This frees up human employees for more strategic work.

Overall, AI is taking automation from simple rule-based tasks to intelligent and adaptable machines that can significantly improve efficiency and accuracy across many industries.

2. Artificial Intelligence and Machine Learning for better deployment of Automation in industries

With more companies recognizing and embracing the potential of Artificial Intelligence (AI) and Machine Learning (ML) to magnify value creation, there is seen a gradual reshaping of the enterprises. Companies that integrate AI and ML with businesses enable swift unprecedented changes to their key processes – product development, production and distribution, quality check, order fulfilment, resource management, marketing, customer relationships and management, and much more.

Artificial Intelligence (AI) includes a broad set of cutting-edge technologies such as Machine Learning (ML), Deep Learning (DL), Optical Character Recognition (OCR), Voice Recognition

and so on, when coupled with Robotics create intelligent automation for organizations across multiple industrial domains.

2.1 Anomaly detection using Machine Learning

Anomaly detection via machine learning can be extensively used to automate the health monitoring of the equipment by detecting anomalies in various attributes like vibrations, sound, temperature, etc. with the help of smart sensor devices. This is useful to identify early wear and tear of the equipment and avoid catastrophic damage. It can catch the smallest flaw that the human eye may miss upon. The data is constantly collected from the sensors and pre-processed using different techniques like data cleaning, integrating, transforming, and reduction for data mining. Techniques can be selected depending on the type of attributes required to extract the features and based on the features various machine learning algorithms can be applied to detect the anomalies.

2.2 Smarter and safer automotive with Deep Learning

For self-driving cars, it is essential to recognize objects/ pedestrians on the road, irrespective whether it is day or night, clear or foggy/cloudy weather. For the success of autonomous cars, automobile companies integrate advanced driver assist systems with thermal imaging. Implementing Deep Learning algorithms on the image data set captured by thermal cameras, it is possible to identify pedestrians in any weather condition and at any time of the day. Depending on the distance of the pedestrians/objects, it can cover a larger part of the image or smaller part of the image. There are few deep learning algorithms like Fast R-CNN or YOLO that can recognize pedestrians/objects from a significant distance by executing following steps:

- Classify the image into classes like pedestrian/ car/ object
- Find the region of the image where particular class falls

This technology enhances automotive industry making autonomous cars safer and efficient on roads ensuring its success.

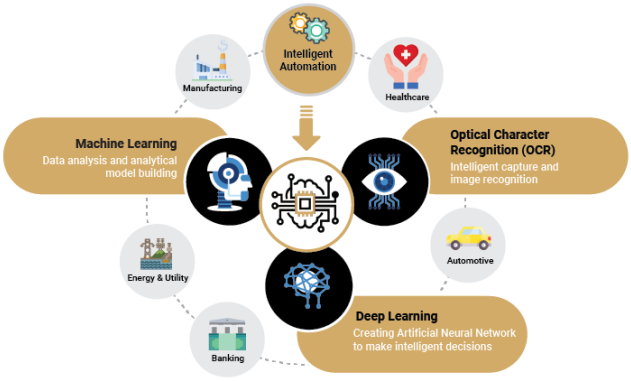

Fig. 1. Intelligent Automation

2.3 Automated quality control for manufacturing using automated visual inspection based on OCR

Traditionally, Quality Control (QC) in manufacturing plants was performed by human experts. But with the help of Deep learning algorithms which run on automated visual inspection systems has automated the QC process by identifying good and bad manufactured products based on the images fed to the algorithm during training. It can identify manufacturing defects repetitively, with consistency and without any exhaustion. This is useful especially in hazardous manufacturing environments involving fire, chemicals, etc. where human access is not safe. OCR is another technology which underneath uses deep learning to recognize the characters. It is of great use in the manufacturing to automate processes which are subject to human errors due to fatigue or casual behavior. These activities include verifications of lot code, batch code, expiry date, etc. Various CNN architectures like LeNet, Alexnet, etc. can be used for this automation and it can also be customized to achieve the desired accuracy.

3. Applications of AI ML and Deep Learning in advanced industrial automation

AI, ML, and Deep Learning are supercharging automation in manufacturing, leading to smarter, faster, and more efficient production. AI and ML can be used to analyze production data and optimize production planning. AI and ML can be used to perform quality control checks on manufactured products. AI algorithms can identify defects in products and alert the production team to make necessary adjustments in real-time. This helps manufacturers to identify and eliminate bottlenecks, reduce waste, and increase productivity [34]. Here's how these technologies are transforming the assembly line:

1. Quality Control: AI, ML, and Deep Learning algorithms can be used to monitor the manufacturing process in real-time and identify defects or anomalies in the products being produced. This can help improve the quality of the products and reduce the need for human intervention in the quality control process.
2. Predictive Maintenance: When industrial equipment is predicted to fail, maintenance may be carried out before a breakdown happens thanks to the usage of AI and ML. By doing so, downtime may be decreased and overall productivity can rise.
3. Autonomous Robots: Advanced manufacturing robots can be equipped with AI and ML algorithms that enable them to operate autonomously. This can be particularly useful in situations where human intervention is not practical or safe, such as in hazardous environments or in situations where precision is critical.
4. Assembly robots: AI, ML, and Deep Learning

technologies are enabling robots during assembly process to work smarter, faster, and more efficiently than ever before, and are helping manufacturers to improve quality, reduce costs, and increase productivity. AI can be used to control and optimize robotic assembly processes. It can enable robots to adapt to changing conditions, work collaboratively with human operators, and learn from past experiences to improve future performance. Also, AI can be used to improve the safety of assembly robots by monitoring their movements and identifying potential hazards. This can help to prevent accidents and reduce the risk of injury to workers. Moreover, AI can be used to optimize the workflow of assembly robots, by analyzing data on the production process and identifying areas where efficiency can be improved.

5. Process Optimization: AI, ML, and Deep Learning can be employed to determine the most effective way to make a product in order to improve the manufacturing process. This can save waste and boost overall effectiveness.
6. Supply Chain Optimization: AI and ML can be used to optimize the supply chain by predicting demand and ensuring that the right materials are available at the right time. This can help reduce inventory costs and improve overall efficiency.

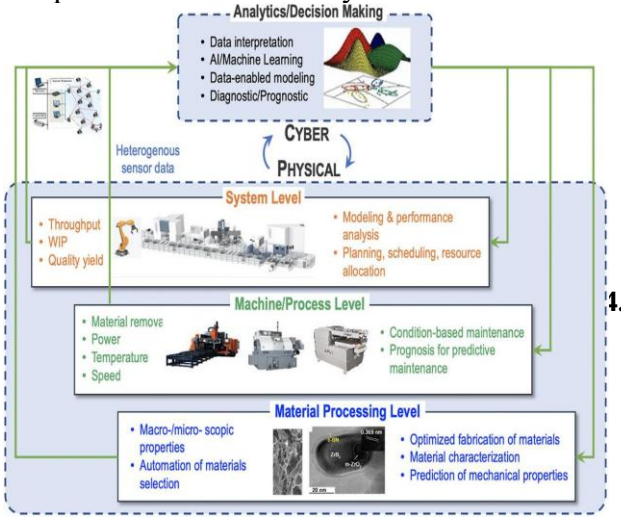

Fig. 2. Application of AI in DL in advanced manufacturing process and robots [5].

7. Collaborative Robots: AI and ML can be used to enable robots to work alongside human workers in a collaborative environment. This can help improve productivity and safety by allowing robots to perform repetitive or dangerous tasks while humans focus on more complex tasks.

AI, ML, and Deep Learning have a wide range of applications in advanced manufacturing, including in robotics and Automated Guided Vehicles (AGVs). The technologies are essential for optimizing the performance of advanced manufacturing robots and AGVs, allowing them to work more efficiently, accurately, and safely in a variety of settings. Some examples of these applications include:

1. Object detection and recognition: AI and ML algorithms can be used to identify and recognize different objects in a manufacturing environment. This can be useful for robots and AGVs to navigate and interact with their surrounding.
2. Real-time decision making: AI algorithms can enable robots and AGVs to make real-time decisions based on
3. sensor data, allowing them to adapt to changing conditions in a manufacturing environment.
4. Path optimization: AI algorithms can be used to optimize the path that a robot or AGV takes through a manufacturing facility, reducing travel time and increasing efficiency.

Application of AI in Deep Learning in advanced manufacturing process and robots is shown in the Fig. 2 [5]. This flowchart explains a crucial idea from the viewpoint of system requirements when assessing the applicability of any AI technology to guarantee that overall objectives are satisfied and sub-optimization is avoided.

Overall, by increasing productivity, cutting costs, and raising product quality, the employment of AI, ML, and Deep Learning in advanced industrial automation has the potential to completely transform the manufacturing sector.

4. Challenges of AI, ML and Deep Learning in automation and robotics applications

4.1 Challenges of AI, ML and Deep Learning algorithms

While these technologies offer many benefits, they also pose significant challenges. One of the biggest challenges is the need for large amounts of high-quality data to train AI and ML algorithms. However, data collection, labeling, and annotation can be expensive and time-consuming, and the data may be noisy or biased, which can affect the accuracy and reliability of the models. This can be particularly challenging in robotics, where data can be difficult to obtain and may be subject to noise and uncertainty. In addition, robotics applications often require real-time processing, which can be computationally expensive and may require specialized hardware. Furthermore, in order to analyze

massive volumes of data, build models, and make predictions in real-time, AI/ML/ Deep Learning systems need a lot of processing power. This can be difficult in robotics applications since robots are constrained by energy and computing power limitations.

The applications often require instruments to operate in dynamic and changing environments which need adaptability in operations. AI/ML/ Deep Learning models must be designed to adapt to new situations and learn from experience, which can be challenging. Another challenge is the need for equipments to be able to operate safely and effectively in a wide range of environments. As they become more autonomous and are handled by humans, ensuring their safety becomes a critical challenge. AI/ML/ Deep Learning algorithms must be designed to prevent accidents, detect and respond to potential hazards, and avoid collisions with humans and other objects. This requires the development of robust AI and ML algorithms that can handle unpredictable situations and adapt to changing conditions. It also requires the development of sensors and other hardware that can provide accurate and reliable data about the euipments surroundings. In addition, there are ethical and societal challenges associated with the use of AI in automation. For example, there are concerns about the impact of automation on jobs and the potential for AI systems to be biased or to perpetuate existing inequalities. There are also concerns about the potential to be used for harmful purposes, such as military applications or surveillance.

Overall, while AI, ML, and Deep Learning offer many opportunities in automation and robotics, there are also significant challenges that must be addressed in order to realize their full potential. Researchers and engineers in this field must work to develop robust algorithms, hardware, and ethical frameworks that can support the safe and effective use of these technologies.

4.2 Challenges of AI, ML, and Deep Learning specifically in automation applications

Data Challenges:

- Data Specificity: Training data for automation tasks needs to be highly specific to the environment and actions the robots will perform. Generic data might not translate well to real-world scenarios, leading to errors and malfunctions.
- Data Labeling: Training data often requires manual labeling for AI models to understand the information. This labeling process can be time-consuming and expensive, especially for complex tasks.
- Data Drift: Real-world conditions can change over time. If training data doesn't reflect these changes (data drift), the robots' performance can degrade.

Technical Challenges:

- Limited Dexterity: While robots are becoming more adept, they may still struggle with tasks requiring fine motor skills or handling delicate objects. This can limit their application in certain automation tasks.
- Generalization: AI models trained for specific tasks might struggle to adapt to slightly different situations or variations in the environment. This can make them less flexible and robust in real-world automation settings.

Integration Challenges:

- Interoperability: Integrating AI-powered automation systems with existing infrastructure can be complex, especially if different technologies or communication protocols are used.
- Scalability: Scaling up AI-powered automation solutions across a large operation can be challenging. It requires robust infrastructure, well-defined processes, and ongoing maintenance.

Performance Challenges:

- Real-time Performance: Some automation tasks require real-time decision making and reactions. Depending on the application, AI models might not be able to process data and respond quickly enough.
- Explainability and Debugging: As with robots, understanding why an AI-powered automation system makes a particular decision can be difficult. This makes troubleshooting and debugging errors more challenging.

Additional Considerations:

- Cost-effectiveness: The initial investment in developing and deploying AI-powered automation systems can be high. The long-term benefits need to justify the upfront costs for businesses to adopt these solutions.
- Human-AI Collaboration: While AI automates tasks, human oversight and collaboration are still crucial for many applications. Training and effective human-machine interfaces are essential for successful implementation.

By acknowledging these challenges and working towards solutions, developers and businesses can ensure AI, ML, and Deep Learning are effectively utilized to enhance automation applications.

5. Advantages of AI, ML and Deep Learning in Automation

AI (Artificial Intelligence), ML (Machine Learning), and DL (Deep Learning) applications have brought about significant advancements in the field of robotic. Some of these advantages of AI, ML and Deep Learning

applications in automation and advanced robotics include:

1. Automation: AI, ML, and Deep Learning can automate many repetitive and mundane tasks in robotics, freeing up human resources to focus on more complex tasks.
2. Enhanced accuracy: These technologies can improve the accuracy and precision of automation systems, reducing errors and improving overall performance.
3. Adaptability: AI-powered automated systems can adapt to changing environments and tasks, making them highly versatile and useful in a range of industries and applications.
4. Predictive Maintenance: Machine learning algorithms can help equipments to predict when maintenance or repairs are required, leading to reduced downtime and cost savings.
5. Improved Decision Making: AI and ML algorithms can analyze large amounts of data and make informed decisions based on that data, allowing robots to make better decisions and take appropriate actions.
6. Improved efficiency: By optimizing processes and reducing waste, AI, ML, and Deep Learning can improve the overall efficiency of industrial automated systems, resulting in cost savings and increased productivity.
7. Better decision-making: AI, ML, and Deep Learning can enable controllers to make better decisions based on data analysis and pattern recognition, leading to improved performance and outcomes.
8. Adaptability: These technologies can enable robots to adapt to changing environments and situations, making them more versatile and capable of handling a wider range of tasks.
9. Increased safety: By automating hazardous or dangerous tasks, AI, ML, and Deep Learning can improve safety in the workplace, reducing the risk of accidents and injuries.
10. Cost Reduction: The implementation of AI and ML applications in advanced robotics can significantly reduce costs associated with labor and maintenance.
11. Improved Decision-making: By using AI and ML algorithms, robots can make informed decisions based on data analysis, resulting in better overall performance.

Overall, the use of AI, ML, and Deep Learning in robotics has the potential to revolutionize the field and unlock new levels of performance, efficiency, and safety.

6. Conclusion

Artificial Intelligence, Machine Learning, and Deep Learning are acting as a powerful turbocharger for automation. This infusion of intelligence is creating a new era in automated systems – versatile, adaptable, and continuously improving. These technologies are transforming automation from pre-programmed, rule-based tasks to a level of intelligence and adaptability that significantly improves efficiency, accuracy, and safety across a wide range of industries. These advancements promise to transform automation across industries, enabling more complex tasks, safer human-robot collaboration, and even autonomous operations in challenging environments. The future of automation is intelligent, collaborative, and constantly evolving, driven by the transformative power of AI.

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