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Robotics and Artificial Intelligence

ORIGINAL ARTICLE


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Abstract

The two terms Robotics and Artificial Intelligence are very close to each other. Robotics builds the physical machines (the "body"), while AI provides the intelligence (the "brain") to perceive, learn, and make decisions, enabling robots to perform complex, autonomous tasks beyond simple programming, from self-driving cars to smart assistants, creating intelligent systems that adapt and interact with the world. Together, AI and robotics power advanced automation in logistics, healthcare, and manufacturing, allowing machines to understand human language (NLP), navigate dynamic environments, and improve performance through machine learning[1].

Key Words

NLP, Artificial Intelligence, ML COBOTS, Robotics.

Robotics

Focuses on the engineering, design, and construction of physical robots to automate tasks, emphasizing hardware and mechanical action (e.g., robotic arms, drones).

Evolution & Future

- **History**: The term "robot" was popularized by Karel Èapek in 1920; "robotics" coined by Isaac Asimov in 1941.Leading to George Devol's Unimate (first industrial robot, 1961) and Joseph Engelberger founding Unimation (first robotics company, 1956). Key milestones include early AI efforts (Shakey the robot, 1960s), Stanford Arm (1969), and advancements into AI-driven, specialized robots like Sony's AIBO (1999) and medical systems (Da Vinci). Since 2000, robotics has evolved from specialized industrial machines to sophisticated, AI-powered systems integrated into everyday life, manufacturing, and extreme environments. Key advancements include the rise of consumer and service robots, improved autonomy through AI and sensors, and the introduction of human-robot collaboration (cobots).
- **Trend**: Robotics trends are rapidly evolving with key focuses on AI & Machine Learning for smarter robots, the rise of versatile Humanoid Robots, increased use of Collaborative Robots (Cobots) for human-robot teamwork, A significant development has been the introduction of collaborative robots (cobots), designed to work safely alongside humans in shared workspaces. Equipped with safety features like speed and force monitoring, cobots are lightweight, easy to program (often through hand-guiding), and offer flexibility in manufacturing processes and the growth of Autonomous Mobile Robots

(AMRs) in logistics. Robotics has seen major strides in mobile platforms. This ranges from the widespread success of the consumer-level Roomba robotic vacuum in 2002 to sophisticated autonomous mobile robots (AMRs) used in warehouses and logistics, which navigate using on-board intelligence rather than fixed guides .Other major shifts include Robotics as a Service (RaaS). Robotics as a Service (RaaS) is a business model where companies lease robots and related services (software, maintenance, support) on a subscription or pay-per-use basis, instead of buying them outright, making advanced automation affordable, flexible, and scalable, much like Software as a Service (SaaS). It shifts costs from large capital expenditure (CapEx) to operational expenditure (OpEx) and allows businesses, especially SMEs, to rapidly adopt robotics for tasks in logistics, manufacturing, healthcare, etc., without heavy upfront investment or maintenance burdens. enhanced Cybersecurity, Digital Twins, Soft Robotics, and greater integration of robotics in healthcare, agriculture, and daily life through technologies like computer vision and spatial computing.[3]

- **Impact**: Robotics is transforming industries, driving innovation, and will have a greater societal impact with advances in AI. Robotics profoundly impacts society by boosting productivity, efficiency, and safety across industries like manufacturing, healthcare, and agriculture through task automation, while creating new jobs in design/engineering, but also raising concerns about job displacement, requiring workforce adaptation to higher-skilled roles, and raising ethical questions about human-robot interaction and autonomy.[4]

Applications

- **Manufacturing**: Robots in manufacturing are used for a wide range of applications including material handling, assembly, welding, painting, and quality control. These automated systems enhance production by improving efficiency, accuracy, and safety, and are found in industries like automotive, electronics, food and beverage, and pharmaceuticals. Common tasks include picking and placing parts, machine tending, palletizing, and inspecting products to ensure consistency and reduce defects.[5]
- **Healthcare**: Robotics in healthcare revolutionizes patient care and efficiency through applications like surgical assistance (precision, minimally invasive) Robot-assisted surgery uses robotic arms, controlled by a surgeon at a console, to perform complex, minimally invasive procedures with enhanced 3D vision, precision, and control, leading to smaller incisions, less pain, reduced blood loss, and faster recovery for patients compared to traditional open surgery logistics (delivery of supplies, disinfection), rehabilitation (exoskeletons for recovery), diagnostics (automated lab work, imaging), elderly/patient care (companionship, monitoring, reminders), and pharmacy (automated dispensing). These robots improve accuracy, reduce staff workload for repetitive tasks, speed up recovery, and extend specialized care to remote areas, ultimately enhancing safety and outcomes. .[6]

[7]

- **Agriculture**: Robotics in agriculture automates repetitive tasks like seeding, weeding, spraying, harvesting, sorting, and packing, enhancing precision and efficiency across the entire farm, from crop monitoring with drones and soil analysis to livestock management (milking, feeding) and precision fertilization, significantly reducing labor, minimizing resource waste, and boosting overall yield quality and sustainability through AI and sensors. [8]
- **Logistics**: Robotics in logistics involves using automated machines to perform tasks such as picking, sorting, and transporting goods, which increases efficiency, speed, and accuracy in warehouses and throughout the supply chain. Key applications include warehouse robots like Autonomous Mobile Robots (AMRs) and Automated Guided Vehicles (AGVs) for internal movement, as well as drones for last-mile delivery. These technologies streamline operations, reduce errors, and allow companies to handle increased demand more effectively.[9].
- **Exploration**: Robotics revolutionizes exploration by enabling missions in extreme environments like deep space (Mars rovers, deep-sea submersibles) and hazardous terrestrial zones (disaster sites). Key applications include autonomous mapping (Perseverance rover), sample collection, satellite maintenance (Canadarm), environmental monitoring, and paving the way for human colonization through construction and data gathering (Artemis program). Robots explore, analyze, and build, pushing boundaries beyond human reach, from asteroid mining to discovering new species. [10]

  [11]

- **Artificial Intelligence (AI):** Concentrates on enabling machines to mimic human cognitive functions like learning, reasoning, perception, and problem-solving, often through algorithms and data. AI gives robots the ability to sense, interpret, decide, and learn, transforming them from mere tools into intelligent agents that can handle unpredictable situations.

How They Work Together (The AI-Robotics Loop)

1. **Sensing:** Robots use sensors (cameras, microphones) to gather data from the environment in sophisticated, human-like ways.
2. **Perception (AI):** AI algorithms interpret this data to understand objects, speech, and context. Key algorithms and techniques for AI perception include:

Visual Perception (Computer Vision)

These algorithms allow AI systems to "see" and interpret images and videos:

- **Convolutional Neural Networks (CNNs):** A foundational deep learning algorithm specifically designed for processing grid-like data such as images, highly effective for image recognition and classification.
- **Generative Adversarial Networks (GANs):** Used for generating realistic visual content and understanding image features.

- **Region-based Convolutional Neural Networks (R-CNN, Faster R-CNN):** Models used specifically for object detection tasks, identifying and localizing multiple objects within an image.
- **YOLO (You Only Look Once):** A popular real-time object detection algorithm known for its speed and accuracy.
- **SIFT (Scale-Invariant Feature Transform) and SURF (Speeded Up Robust Features):** Traditional computer vision algorithms used to detect and describe local features in images, robust to changes in scale and rotation.
- **Edge Detection Algorithms:** Techniques (e.g., Canny, Sobel) used to identify object boundaries within an image, crucial for scene understanding.

Auditory and Language Perception (NLP)

These algorithms enable AI to perceive and understand spoken language and sound:

- **Recurrent Neural Networks (RNNs) and Long Short-Term Memory (LSTM):** Neural network architectures capable of processing sequences of data, like speech and text.
- **Transformer Models (e.g., BERT, GPT, ERNIE):** Advanced models that use attention mechanisms to understand context and relationships in text, vital for language perception and processing.
- **Word2vec and GloVe:** Models used to create word embeddings, which are numerical representations of words that capture their semantic relationships.

Other Types of Perception

- **Simultaneous Localization and Mapping (SLAM):** A set of algorithms used in robotics and autonomous systems to build a map of an environment while simultaneously keeping track of their own location within that map (used for proprioception and spatial awareness).
- **Perceptron:** The foundational building block of neural networks, a linear classifier used for simple pattern recognition tasks.
- **K-Nearest Neighbor (KNN):** A simple, non-parametric algorithm used in classification and regression, sometimes applied to facial detection with deep learning

2. **Decision-Making (AI):** The AI decides the best action based on its understanding and goals.
3. **Execution (Robotics):** The robot's physical body (motors, actuators) carries out the decision.
4. **Learning (AI):** Feedback from outcomes improves the AI for future tasks (Machine Learning).

Main Applications

- **Autonomous Vehicles:** AI vision and decision-making guide robots (cars) through complex traffic. AI in autonomous vehicles (AVs) uses Machine Learning (ML), Deep Learning, and neural networks to process sensor data (cameras, LiDAR, radar) for perception (seeing pedestrians, signs), prediction (what they'll do), path planning (navigating), and decision-making (steering, braking).
- **Humanoid Robots:** Combining AI for human-like interaction with physical forms for assistance.
- **Collaborative Robots (Cobots):** AI helps cobots safely work alongside humans, responding to gestures and speech.
- **Warehousing:** AI optimizes robot routes for efficient package sorting and delivery. Robotics and AI are revolutionizing warehousing by creating smart, automated systems for tasks like picking, packing, inventory management, and transport, using machine learning, computer vision, and autonomous mobile robots (AMRs) to learn, adapt, and optimize operations for massive efficiency gains, reduced errors, and improved fulfillment speed, tackling complex logistics demands. These technologies enable predictive

maintenance, optimized routing for humans and robots, and real-time decision-making, moving beyond simple automation to truly intelligent warehouse management.

- **Healthcare:** AI-powered robots assist in surgery, logistics, and patient interaction.

Conclusion

The integration of AI and robotics is creating "Physical AI," leading to machines that are safer, more adaptable, and capable of complex, real-time interaction with the physical world, driving innovation across nearly every industry. This is most popular and widely used Scientific term becoming wider and more accurate day by day.

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