IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 21, Issue 6 Ser. 3 (Nov. – Dec. 2024), PP 08-16
www.iosrjournals.org

Title

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Date of Submission: 04-12-2024 Date of Acceptance: 14-12-2024

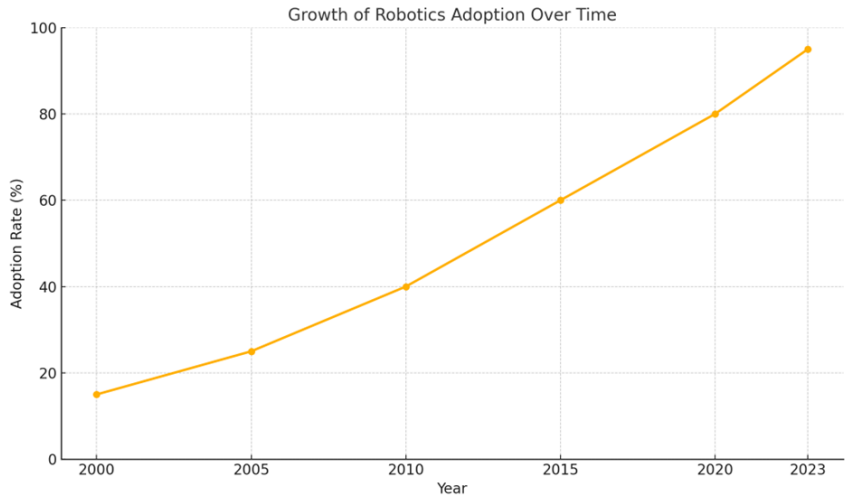
I. Robotics Arm

Robotic arm is a mechanical device which is used to perform tasks with a reduced or no human interaction at all. It can replace the arm of a human being but it is usually more accurate, reliable and can work longer and repeated or risky tasks without getting tired. Industrial robotic arms are common in manufacturing processes especially in assembly lines but their application has spread across other sectors including medical, aerospace and even in prosthetics.

Components of a Robotic Arm

Base/Frame:

The base of the robotic arm is the root part that holds all the other components of the robotic system. It offers support and it also includes the motors or the actuators that are used to move the arm.



Joints:

Robotic arms are mechanical devices which have several axes of motion, which are akin to the joints of the human arm. Each of the joints is a connection between two segments of the arm and can either rotate or move linearly.

Examples of these are revolve, which allow only rotation about a joint axis, and prismatic which allow only translational movement along a joint axis.

Actuators:

Actuators are the “muscles of the robotic arm”. These change energy (electric, hydraulic or a.pneumatic) into movement and control the movement of the arm.

The most popular actuator is the electric motor, although use of pneumatic and hydraulic actuators is made when high forces or accurate movements are required.

End-Effector:

The end effector is the last link of the robotic arm which is use to do the work. The type of end-effector depends on the application and may include tools such as:

Manipulators for receiving objects.

Welding torches for the purpose of bonding metal components.

Instruments used in operations or surgeries.
Tools used in the production of assembling, painting, or packaging.

Sensors:

Sensors give the robotic arm information that it needs in order to tell where it is, how much force it is using, or what the conditions around it are. Common sensors include:
Sensors are to be placed to determine the position and angle of the arm in its different movements.
For measuring the force and torque applied by the end-effector there is the use of force/torque sensors.
Sensors which are used for detecting obstacles nearby the robot.

Control System:

The control system is the powerhouse of the robotic arm. It receives information from the sensors and provides a way of presenting the information to the actuators to move the arm. This system may consist of:
A microcontroller or a robot controller is one type of circuit.
Control and programming software for movements.
Techniques in navigation and control of motions for solving problems.

Power Supply:

A power supply is used to supply the needed energy for the operation of the motor, sensor and controller. In industrial systems, power is usually passed through electrical contacts and, in mobile industrial robotic arms, batteries may be used.

Types of Robotic Arms
Articulated Robotic Arms:

These are in fact arm like structures that have several joints which enable this device to have a good range of movement and flexibility. These are the most popular species of the robotic arms that are employed in manufacturing and assembling processes.
It can vary from 2 to 7 DOF, which means that they can move in many ways.

SCARA (Selective Compliance Assembly Robot Arm):

SCARA robotic arms are characterised by a linear axis that is rigid along the vertical direction but has a high degree of redundancy along the horizontal plane thus making them suitable for use in assembly processes. These are mainly applied in pick and place operations, packaging and even light assembly.

Delta Robots:

Delta robots are parallel robots with three arms on a fixed base structure; the robot often sits on a platform. They are also very light, they can move very fast and are very useful for tasks that need much speed such as packing and sorting.

Cartesian Robots (Linear Robots):

Cartesian robots have three linear axes of motion, similar to the coordinates X, Y and Z, as in a 3D printer. These are easy to use and cheaper but have low mobility than articulated or SCARA arms.

Cylindrical Robots:

These robots have a cylindrical coordinate system with rotary and linear motion meaning they can move about within a cylindrical space. It finds application in areas such as assembly and machine tool manipulation.
Applications of Robotic Arms

Manufacturing and Industry:
Automotive assembly: Robotic arms is the most common type of robots used in automobile industries for welding, painting, assembling, and inspection.

Packaging and Sorting: Robotic arm is widely used for fast and efficient packaging and sorting in food production, pharmaceuticals and E-Commerce industries.

Medical Field:
Surgical robots: Robotic arms help surgeons in minimally invasive surgery for doing precise activities.

Prosthetics: Manicured robotic arms are also used to design sophisticated prosthetic hands so that amputees can be given back their mobility.

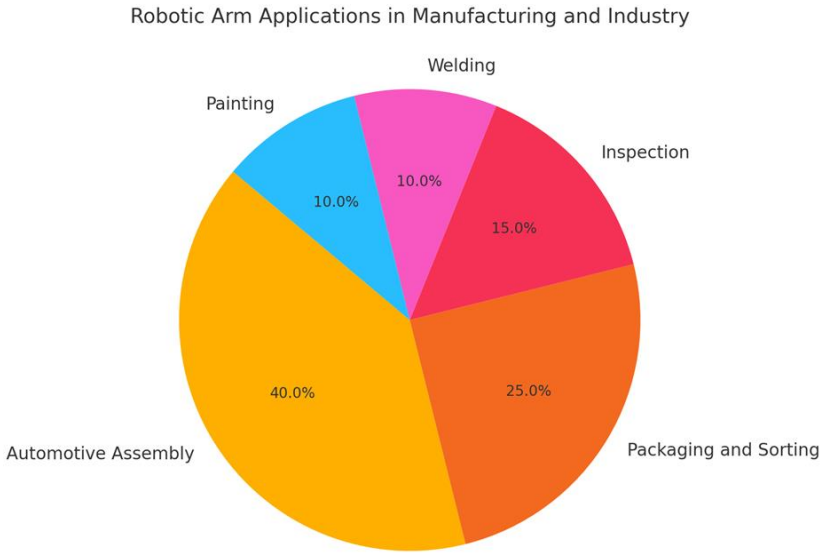
Space Exploration:
Space robots: Robotic arms are common in space missions, for instance, the Canadarm on the Space Shuttle where they are used to deploy and maintain satellites.

Agriculture:
Harvesting: In agricultural robotics, the use of robotic arms include; picking crops, fruits and packaging.

Consumer Applications:
Robotic vacuums: Robotic consumer products, for instance, robotic vacuum cleaners are equipped with robotic arms or similar structures to help them move around a house and clean.

Advantages of Robotic Arms
Precision: Robotic arms can work for hours on end to accomplish a particular task which may be and often is more precise than when done by hand

Speed: They are quicker in many tasks than human beings and therefore increase productivity.



Safety: Robotic arms can do things that are risky for people's lives, for instance dealing with chemicals that are lethal or working in places that are hostile to human beings such as space, underwater or nuclear areas.

Cost-Effectiveness: Even though the cost of buying robotic arms is quite expensive, they end up saving on labor and improving production time.

24/7 Operation: While people require breaks, sleep and time off, robotic arms do not require any of those. Some of the most common types are designed to work for long hours without any form of disruption making them suitable to use in industries that require a lot of work.

Challenges of Robotic Arms
High Initial Investment: It is, however, very expensive for small businesses to buy and set up robotic arms.

Limited Flexibility: Some robotic arm models including those that have few degrees of movement may not be able to perform all operations.

Maintenance: Robotic arms, however, need to be checked up on and repaired periodically so that it can function properly. Eventually, a component or two may fail or become damaged in some way.

Job Displacement: Some jobs may be lost to robotic arms especially for those industries that use low skilled workers.

Future of Robotic Arms

Owing to technological developments in the area of artificial intelligence, machine learning and robotics, the future of robotic arm is bright. Future trends include:

Collaborative Robots (Cobots): These are robotic arms which are intended to operate in the same space as people. Cobots are designed with safety features which allow them to work together with people, and complete different tasks which require close human contact.

AI-Powered Control Systems: New generation control systems are being developed, including artificial intelligence and machine learning to enhance the efficiency, flexibility and self-governing of robotic arms.

Wearable Robotics: Exoskeletons and wearable robotic arms help humans to enhance their own strength or to help people with disabilities.

Increased Precision and Dexterity: Robotic arms will become more and more advanced and accurate to be able to do very detailed and nuanced work including electronics manufacturing and surgery.

Sensors Integration for Robotics Arm

With regard to a robotics arm, sensor integration is the act of adding different types of sensors into the system with a view of offering feedback information in real time, increasing the reliability of the robot arm and also the reliability of the system. These sensors enable the robotic arm to feel, and thus act within its environment and carry out various tasks such as positioning, grasping and manipulation. Below is an overview of key sensors integrated into robotic arms:

1. Different Sensors Found in Robotic Arms

a. Proximity Sensors:

Function: Used in identification of the existence or lack of existence of objects around the robotic arm to avoid collision and promote safety.
Example: Examples of the sensor technologies include ultrasonic sensors, capacitive proximity sensors.

b. Force/Torque Sensors:

Function: Calculates the force and torque that is applied at the end effector or the joints of the robotic arm. This enables the arm to make some changes with the movements that it makes depending on the pressure or force being used.
Example: Strain gauges, piezoelectric sensors.

c. Encoders:

Function: Measures the angular displacement of jointed structures of the robotic arm and controls the movement of the joints.
Example: Among them are rotary encoders, linear encoders.

d. Vision Sensors (Cameras):

Function: Helps the robotic arm to have vision and thus identify objects in the surrounding for the purpose of grasping them.
Example: RGB, depth, stereo vision cameras.
Use Case: This paper focuses on the object recognition for grasping positioning and assembly tasks.

e. Accelerometers and Gyroscopes:

Function: Control the linear acceleration and angular velocity of the robotic arm and help in balancing and stabilizing the arm during the movements.
Example: Microelectromechanical system accelerometers, microelectromechanical system gyroscopes.

f. Temperature Sensors:

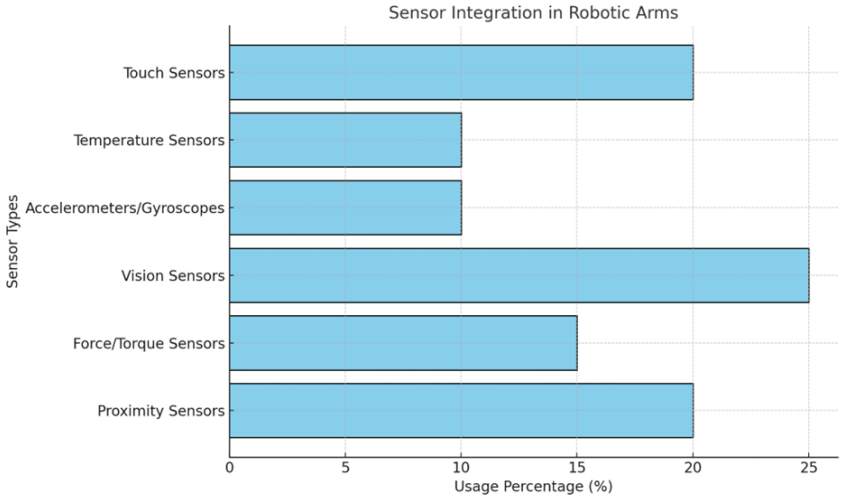
Function: Keeps an eye on temperature of critical parts of the robotic arm to avoid overheating and thus safe usage.

Example: The two most common temperature sensors; Thermocouples, RTDs (Resistance Temperature Detectors).

g. Vision-Based Sensors (LIDAR, RGBD):
Function: Offers a feature of creating a 3D model of the surrounding and also helps the robotic arm to move and manipulate objects in the environment more effectively.
Example: RGBD (Color + Depth) sensors, LIDAR (Light Detection and Ranging).

h. Position Sensors:
Function: Measures the position of the robotic arm or some of its segments in order to keep the correct concept of movement with respect to the space.
Example: Potentiometers, Linear Variable Differential Transformer (LVDT).

i.Touch Sensors:



Function: Senses touch or force at certain locations, for instance on the tip of the robotic arm such as the gripper, for a tender and precise manipulation of objects.
Example: Capacitive sensors, Resistive touch Sensors.

2. Sensors in Robotics Arm Systems.
The integration of sensors in a robotic arm involves several key components and processes:

a. Sensor Fusion:
Definition: Sensor fusion is a technique whereby data from two or more sensors is integrated in order to produce a more accurate and consistent measurement. For instance, integrating the data from force sensors, accelerometers, and vision cameras can assist the robotic arm to make right decisions when it is in contact with objects.
Techniques: To integrate sensor data, and enhance the arm's performance, Kalman filters, particle filters, and machine learning techniques are applied.

b. Real-Time Feedback:
Process: Sensors feed real time information to the controller of the robotic arm to enable it change its actions in relation to the information received. For instance, if an object is seen by a vision sensor in the path of the arm, the arm may move or cease its operation.

c. Communication Protocols:
Example: ROS, CAN Bus and Modbus are some of the most used communication protocols to allow data flow between sensors, the robotic arm controller and the rest of the robotic system components.

d. Calibration:
Definition: The sensors must be set right in order to help in the collection of data and transmission. For instance, the encoders require tuning to identify particular angular displacement of the joints, the vision sensors require tuning to recognize particular features of the objects in changing light conditions.

3. Advantages of Applying Sensor Integration in Robotics Arms

Precision and Accuracy: Sensors help the robotic arm make very accurate movements because position, force, and orientation are continually measured. This is important in activities like; assembly, welding, and surgery.

Autonomy: Since sensors are fitted into the robotic arms, these robots can operate freely in the environment, and make decisions on their own without human intervention. For instance, sensors make it possible for an arm to avoid objects in its path or modify the pressure with which it holds objects that are easily damaged.

Safety: Sensors offer feedback on the arm's movements and the surrounding, thus minimizing injuries and making sure that the arm does not harm people or other equipment.

Adaptability: The integrated sensors give the robotic arm the ability to change its working environment or operation. For example, a vision sensor enables the arm to pick and hold different objects of different shapes and sizes.

Increased Efficiency: The movement of the robotic arm can be controlled with such great accuracy as to enable it to conserve energy as it works to accomplish its tasks.

4. The Main Problems of Sensor Integration

Data Overload: To integrate many sensors, the data may be large and require processing, which may cause performance constraints. This is where effective sensor fusion and data filtering is a key to dealing with this.

Calibration and Accuracy: Some important issues include: how to assure that all sensors will deliver correct and consistent data regardless of the environment in which they are placed – e.g., when exposed to temperature variations or vibrations.

Cost and Complexity: Some of the high-precision sensors like vision cameras and force sensors are costly. Also, using more than one sensor can complicate the system even further.

Trends for Robotics Process

The future of Robotics Process Automation (RPA) depends on technological trends, market requirements and changing business scenarios. Here are the key trends that are likely to influence RPA.

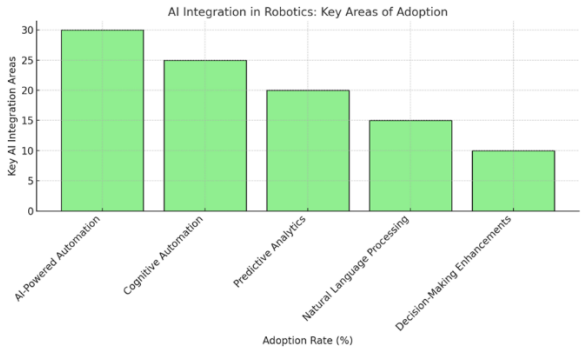
1. The integration with Artificial Intelligence (AI)

AI-Powered Automation: RPA systems of the future will advance in their usage of AI technologies including, machine learning (ML) and natural language processing (NLP). This will allow bots to take on more sophisticated tasks that need a decision making power, for example, analyzing unstructured data, learning from their interactions and becoming better at the task at hand.

Cognitive Automation: Cognitive RPA will enable systems to replicate human type of decision-making and cognitive functions. This is expected to transform sectors such as health, finance and customer services where the context, emotion or sentiment plays a crucial role.

2. Hyper Automation

End-to-End Automation: Hyper Automation is one level higher than RPA as automation encompasses not just limited to repetitive tasks but also business processes with activities, workflows and decisions. This is because RPA is combined with Artificial Intelligence, Machine Learning, Business Process Management, and Analytics.



Accelerating Process Transformation: This implies that organizations can automate at scale, and therefore accelerate the rate of process change and minimise the involvement of people in such processes. The attention will now be given to automating processes and not functions or tasks hence improving the efficiency of organizations.

3. RPA as a Service or RPAaaS
Cloud-Based RPA: This paper further notes that as cloud computing progresses, RPA will also be offered as a service. Cloud Based RPA allows flexibility, scalability and the deployment of RPA solutions, where companies of all sizes can easily adopt RPA without having to invest in on-premise infrastructure.

Cost-Effective Scaling: As a service, RPA will cut the costs of initial investments and enable enterprises to adjust the levels of automation when needed. This will make RPA easily implementable across many organizations including the SMEs.

4. The last strategic approach includes Advanced Analytics and Reporting.
Data-Driven Insights: Advanced analytics will be applied to RPA to capture and analyze data from a particular process in the organization. This is certainly going to benefit businesses in terms of understanding the process effectiveness, customer's response and identifying the areas of constraints.

Predictive Analytics: As a subprocess of AI and machine learning, RPA will facilitate the application of predictive analysis, which will help companies prevent problems and improve processes in advance.

5. Low Code and No Code Development in Robotic Process Automation.
Simplifying Automation for Non-Technical Users: The advancement of low-code and no-code platforms will increase the use of RPA to the business users and process owners with no technical background. These platforms provide the ability for users to create and deploy automation processes via visual representations and actions through simple point and click.

Citizen Developers: They will be able to use standardized, point-and-click tools that can help automate processes on their own and minimize the workload that comes with RPA implementations for IT departments.

6. Interaction with People (Human Robot Interaction)
Bots Working Alongside Humans: RPA will not eliminate people, RPA will this time be used to support workers not replace them. The future will encompass more coexistence of humans with robots where the robots will be performing the known routine tasks while human beings will engage in more strategic activities.

Intelligent Assistants: The Virtual assistants using AI will work alongside employees to give real-time information, answer questions and work on routine tasks so that employees are able to focus on more innovative and analytical activities.

7. Improved Security and Compliance Feature.
Robust Security Features: Thus, as RPA is mostly implemented in the essential business functions, its security will be a critical issue in the future. The future RPA solutions will have enhanced security measures such as encryption of the data both at input and output level, user identification and control, and a record of operations performed.

Regulatory Compliance Automation: RPA will help in the introduction of compliance monitoring of the rules and policies of the industry. Due to real-time monitoring, RPA decreases the likelihood of making a mistake, and increases the chances of meeting the GDPR, HIPAA, and financial reporting standards.

8. Process Mining and RPA
Intelligent Process Discovery: Automated Business Process (ABP) will be closely linked with Process Mining (PM) that assists businesses to map the processes that are going to be automated. With process mining tools, the areas that require improvement and the bottlenecks will be revealed thus RPA can be implemented in the best areas.

Continuous Improvement: When implemented, RPA bots will utilize data from process mining to iteratively enhance their performance based on alterations in process or environment.

9. The term used for this is Intelligent Document Processing (IDP).
Automating Document Handling: Through incorporation of AI, RPA will be in a position to perform a variety of document processing activities including invoices, contracts, and even compliance checks. IDP will use OCR, NLP and AI to capture, understand and extract trapped data within documents and automate the process.

Reducing Manual Interventions: The integration of IDP with RPA will greatly minimize the role of manual data entry, enhance data quality and efficiency of document handling.

10. Compliance with the Internet of Things (IoT)
IoT-Driven Automation: RPA will connect to IoT gadgets to design an improved and more sensitive automation network. With the integration of IoT sensors and devices with RPA, organizations are in a position to automate tasks that have input from physical things.

Predictive Maintenance: Applications of IoT integrated RPA are in the PdM in manufacturing, logistics, and healthcare sectors where RPA bots can initiate maintenance processes through real-time information from the sensors installed in the machines or equipment.

11. Expansion to New Industries
Industry-Specific RPA Solutions: Even today, RPA is considered most effective in banking, finance, and healthcare sectors, but in the future, it will expand to new areas, including legal, education, retail, and supply chain. They will create industry specific bots which will address the needs of specific industries, for specific tasks.

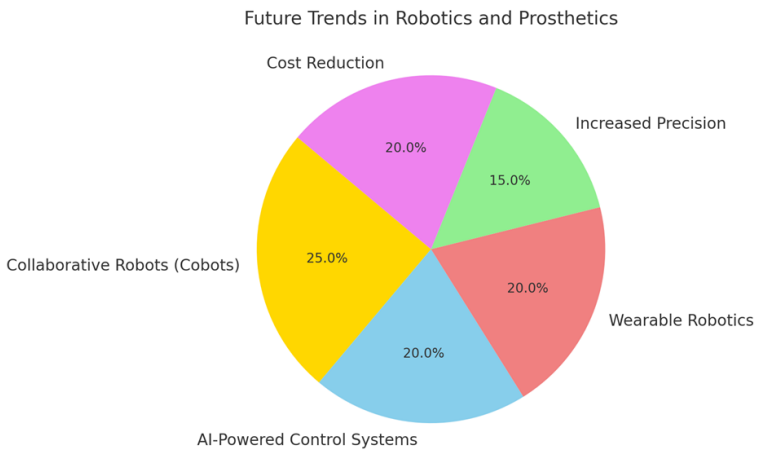
Smarter Customer Service: Customer service will further adopt more chatbots, virtual assistants and RPA as more customer support will be automated across various channels to ensure better and faster support to customers.

12. RPA Governance and Ethics
Automation Governance: Thus, as RPA becomes an inherent part of the business environment it will be vital to tackle the challenges of managing and governance of the automated workflows. This paper predicted that the governance of RPA frameworks will be enhanced to guarantee that the bots are working properly in an ethical, secure and legal manner.

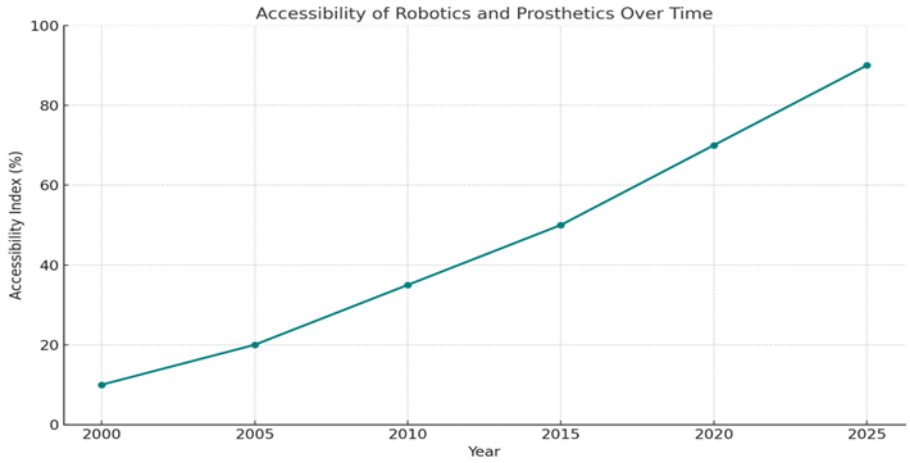
Ethical Concerns: The issues around ethical delivery of automation, such as people displacement, the issue of bias in designing AI tools, will come to the forefront as to how RPA should be conducted in a way that is ethical, and how organizations should ensure that automation is equitable and done in a way that is fair to all.

II. Conclusion

In conclusion, the use of robotics, especially in the area of prosthetics, is revolutionising healthcare by enhancing the quality of life of disabled persons. Starting from the very basic forms of prosthetic limbs which were mainly used to replace a lost limb to the present day sophisticated robotic systems which not only help a person walk, run or even jump but also do so with a lot of ease and precision, the advancement of robotics in the field of prosthetics has been incredible. Therapies that include AI sensors, new materials, and control systems are not only Robotic Prosthetics, but they are an opportunity to give people with limb loss a sense of control over their lives.



However, the combination between robotics and prosthetics is still developing and eliminating new records, which open new horizons. In the future when the technology will become even more developed, it will be possible to offer individualized, effective and also cheaper and more sustainable solutions to a larger number of people across the globe. However, the problems of cost, availability of technology, and legal issues still exist. It is while researchers and engineers are striving to overcome these challenges, the future of robotics and healthcare looks very promising.



Furthermore the research being carried out in robotics for prosthetics shows how technology when used in the right manner and with consideration to the affected people can be a benefit to society. This is not science fiction anymore as this field grows, and as we see, prosthetics become a part of one's body, people will be able to live their lives without restrictions.

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