



molex

REPORT

The Molex 2024 Robotics Report

How Robotics Will Empower
Human Potential

NOVEMBER 2024

TABLE OF CONTENTS

Introduction03

Foundational Technologies: The Current Landscape of Robotics04

From Assistants to Empathetic Companions: What’s Ahead in Home Robotics07

Industrial Robots: Partners in Innovation and Co-Creation10

Healthcare Robotics: Precise and Patient-Centered Care14

Robots in Education: Personalized Learning Companions18

**Robotics Systems for Defense: Autonomous
Systems in Modern Military Applications21**

Conclusion: Molex and the Future of Robotics24

INTRODUCTION

As robotic systems grow more intuitive, intelligent and interconnected, they'll shift from being helpful tools to becoming indispensable partners in nearly every aspect of our lives. Whether in factories, healthcare settings, classrooms or right at home, robotic systems are already transforming industries. And this is just the beginning.

Imagine a world where robots don't just automate tasks but collaborate with us — anticipating needs and solving problems before they arise. They will push the boundaries of what's possible. Advances in artificial intelligence (AI), machine learning (ML) and sensor technology will accelerate this evolution, integrating robotic systems seamlessly into our daily routines. Beyond efficiency and precision, we'll come to rely on robotic systems for creativity, companionship and new insights that have yet to be conceived.

In the years ahead, robots of all types and capabilities will evolve from specialized roles to become as ubiquitous as smartphones. They'll enhance the way we work, learn, heal and live, tackling both mundane and complex tasks, freeing us to focus on higher-level thinking, innovation and human connection. This isn't just the next step in automation; it's a leap toward a future where robots unlock new potential for humanity.

As we explore the role of robotic systems and devices across various industries, we'll discover how they are poised to reshape the future, taking on more responsibilities, making decisions and augmenting human capabilities in



unprecedented ways. The era of robotics is here and the future ahead will see them becoming embedded into the very fabric of our everyday lives.

This report provides a deep dive into the evolving relationship between humans and machines, grounded in the expertise of experienced engineering teams innovating across multiple industries, ranging from manufacturing and healthcare to defense and home automation. Only through this extensive experience can insights be shared around what designers need to know to make cutting-edge robotic applications a reality across all key applications.

FOUNDATIONAL TECHNOLOGIES: THE CURRENT LANDSCAPE OF ROBOTICS

The future of robotic systems hinges on several key enabling technologies that not only enhance performance but also allow these systems to function autonomously in dynamic environments. While many of these innovations are already familiar to industry experts, they provide the critical building blocks that permit us to explore the next evolution of human-machine collaboration. Let's establish a clear understanding of the enabling technologies driving today's robotic advancements:

5G AND 6G CONNECTIVITY: EXPANDING ROBOTIC HORIZONS

Engineers are well aware that low-latency communication is essential for the performance of robotic systems in high-speed environments. With 5G networks reducing data transmission delays to milliseconds, and **6G on the horizon** promising even faster, near-instantaneous data transfer, robots can now function with greater precision and responsiveness. However, connectivity is not without its challenges. Engineers have already established ways to address and avoid redundancy through fail-safe strategies and edge computing to maintain operational continuity in case of network disruptions.



ADDRESSING CONNECTIVITY RISKS

It's a recognized fact that even in 5G/6G environments, network downtime or disruptions can occur. To avoid these risks, engineers use several approaches:

- 1. Edge Computing:** By processing data locally on the robot or in nearby edge devices, robots can continue to operate independently of the network. Even if cloud connectivity is lost, edge computing allows robots to make instant decisions and adjustments based on local data to maintain the continuity of operations.
- 2. Redundant Communication Paths:** Engineers design robotic systems with multiple connectivity options, such as switching between 5G and Wi-Fi or satellite networks when one connection fails. This multi-channel redundancy guarantees that robots remain connected to critical systems even in cases of network failure.
- 3. Autonomous Fail-Safes:** Robots can be programmed with fail-safe protocols that enable them to continue basic functions or move into a safe operational state if connectivity is compromised. This includes stopping movement in industrial settings or switching to low-power modes until connectivity is restored.

These solutions help maintain the reliability of robotic systems even in the face of network interruptions, ensuring that essential tasks are not compromised when the network goes down.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING: DRIVING ADAPTABILITY AND AUTONOMY

AI and ML are the engines behind the adaptability of robotic systems and devices. These technologies enable robots to learn from their environments, experiences and interactions, improving their performance over time. Instead of relying solely on pre-programmed instructions, AI allows robots to make informed decisions based on up-to-the-moment data.

Through ML, robots can analyze patterns and optimize their behavior for increased efficiency and accuracy. AI algorithms help robots adapt to new circumstances, fine-tune their tasks and even predict future conditions based on past interactions. This ability to continuously learn and improve drives the evolution of robots from static, task-specific machines to dynamic, autonomous systems.



SENSOR FUSION: CREATING A UNIFIED UNDERSTANDING OF THE ENVIRONMENT

Robotic systems rely on multiple sensors to interpret their surroundings. Sensor fusion combines data from various sources such as LiDAR, cameras, depth and force sensors to create a comprehensive, up-to-date view of the environment. This integration of sensory inputs allows robots to better understand and navigate their worlds.

By merging data from different types of sensors, robots can perceive depth, movement and obstacles with greater accuracy. Sensor fusion empowers robots to process complex environmental data all at once, helping them make informed decisions about how to interact with their surroundings. This unified sensory input allows robotic devices to function reliably and safely, even in dynamic or unfamiliar environments.

FROM AUTOMATION TO EMPATHY: THE FUTURE OF HUMAN-ROBOT INTERACTION

While the foundational technologies discussed have driven the field of robotics to where it is today, the future of robotic technologies will go beyond efficiency and automation. The next frontier lies in robots that can understand, respond to, and even anticipate human emotional and contextual needs. Natural language processing (NLP) and emotional AI represent the bridge between human-machine interaction as we know it today and the emotionally responsive, intuitive robots of tomorrow.

NATURAL LANGUAGE PROCESSING AND EMOTIONAL AI: HUMANIZING ROBOT INTERACTION

As robots become more integrated into everyday life, their ability to communicate effectively with humans becomes increasingly important. NLP equips robots with the ability to understand and generate human language, allowing for smoother and more intuitive interactions.

NLP enables robots to follow spoken commands, engage in dialogue and adjust their actions based on contextual understanding. This not only improves user experience but also expands the range of tasks robots can perform with minimal human input.

Additionally, emotional AI is enhancing the way robotic systems interact with humans by enabling them to recognize and respond to emotional cues. By analyzing tone of voice or facial expressions, robots can adjust their behavior immediately to accommodate the user's emotional state. This human-centered interaction fosters a deeper sense of engagement and makes robotic systems more versatile in a wide range of settings.

These technologies are pushing robotic capabilities beyond traditional automation applications, transforming them into intelligent, adaptive systems that can operate autonomously, communicate effectively and respond to their environments in real time.

FROM ASSISTANTS TO EMPATHETIC COMPANIONS: WHAT'S AHEAD IN HOME ROBOTICS

Robots have come a long way since the original robotic vacuum cleaners. Today, they're not just tools for basic chores — they're becoming companions that can anticipate user needs, understand emotions and seamlessly integrate into the home. More and more, robotic technologies are creating systems that enhance daily life — like a smart assistant that learns your preferences, automatically adjusts the lighting and temperature when you walk in, or even starts your coffee maker based on your morning routine.

ADAPTING TO COMPLEX HOME ENVIRONMENTS

At the core of this transformation are advancements in sensor fusion and ML, allowing robots to operate independently in complex environments. Technologies like LiDAR and RGB-D cameras enable robots to map their surroundings, detect obstacles and interact with people and objects more intuitively. Instead of simply following commands, robots now use simultaneous localization and mapping (SLAM) to constantly update their understanding of the environment.



Imagine a robot adjusting your home's lighting and thermostat the moment it senses you approaching the front door. With deep learning models like GPT, widely known for its natural language processing capabilities, and BERT, an open-source ML framework developed by Google, these systems learn from past interactions, becoming more responsive to your preferences. As these technologies grow more sophisticated, robots will adapt to new environments seamlessly — whether it's rearranged furniture in a room in which it operates or engaging differently depending upon varying levels of human activity.



PROACTIVE CARE THROUGH PREDICTIVE AI

The next generation of home robots is moving beyond reacting to commands to learning how to anticipate our needs. By analyzing data from **wearable health monitors**, smart home sensors and environmental inputs, these robotic devices will predict potential issues before they occur. In home settings, especially for elder care, robots and connected devices equipped with accelerometers and other sensors can monitor movement patterns and vital signs. Rather than waiting for an incident to trigger an alert, they can detect subtle changes, like a shift in gait or mobility, and intervene to prevent falls or other medical emergencies.

This predictive AI takes home robots from reactive helpers into proactive care providers, boosting safety and improving quality of life in home settings.

EMOTIONAL AI: ELEVATING USER INTERACTION

Emotional AI is already transforming how robots can offer personalized support in home settings. For example, robots equipped with emotional AI can adjust their behavior based on a human's emotional state, providing companionship or suggesting wellness activities. As this technology evolves, it could even play a critical role in supporting mental health, using emotional insights to promote well-being and provide proactive care.

MOLEX SOLUTIONS FOR HOME ROBOTICS



Magnetic and Modular Jacks and Plugs

provide secure and flexible connectivity for home robots, allowing easy integration with various smart home devices and systems.



FFC / FPC Connectors are ideal for the flexible and compact design of home robots, enabling streamlined connections between delicate sensors and other critical components.



Single-Pair Ethernet (SPE) Connectors provide the high-speed, low-latency data transmission necessary for real-time communication between robots and home systems, ensuring seamless operation.

SMARTER HOMES WITH RAPID RESPONSIVENESS

For robots to function effectively, they require high-speed connectivity. Current Wi-Fi and 5G networks already provide the bandwidth and low latency needed for today's systems, facilitating seamless interaction between smart devices and home systems. But as robots handle more data, the next frontier will be 6G networks. These advanced networks will empower robots to make split-second decisions — whether it's avoiding an obstacle or reacting to a sudden change in the environment — by aiding fast and reliable data transmission.



Another critical piece is local data processing. With edge computing, robots can process data within the home, significantly reducing latency and enabling immediate decision-making. This allows robots to adjust home settings or navigate complex environments promptly, without the delays caused by sending data to the cloud.

THE NEXT CHAPTER IN HOME ROBOTICS

The next wave of home robotics will transform how we manage personal well-being and security. With advancements in AI, robots will become more proactive, learning to anticipate not just daily tasks but also health-related needs and potential security risks. Imagine a home robot that monitors your wellness, tracks daily habits and can alert you or emergency services if something seems “off.” These innovations will create deeper, more personalized interactions and provide peace of mind by enhancing both convenience and safety in our lives.

INDUSTRIAL ROBOTS: PARTNERS IN INNOVATION AND CO-CREATION

With the arrival of **Industry 4.0**, robotic systems have advanced beyond simple automation, transforming into collaborative partners working alongside people. These machines are becoming smarter by using AI-driven insights, helping with efficiency and innovation. Instead of simply following orders, future robots will play an active role in improving workflows, cutting costs and even contributing to product design through simulations and data analysis.

This marks a shift from automation to co-creation. In tomorrow's factories, robotic systems won't just build products — they'll help develop them. By analyzing production data and running simulations, robots will be able to make real-time recommendations that streamline operations and increase output quality.

FLEXIBLE COBOTS FOR HIGH-PRECISION TASKS

Collaborative robots, or cobots, are designed to safely work alongside human operators and are equipped with force-limiting technology that ensures they stop when they detect contact. While cobots are already known for handling repetitive or simple tasks, they're increasingly capable of handling more complex tasks.



For example, torque sensors, which measure rotational force, now permit cobots to detect minute variations in pressure and force, enabling precise adjustments in real time. This is especially critical in industries like electronics, where even the smallest deviation can affect product quality. Machine vision and, in some cases, LiDAR, allow cobots to map and navigate complex industrial environments autonomously, ensuring high productivity and safety, even as conditions change.



STAYING AHEAD OF PROBLEMS WITH PREDICTIVE MAINTENANCE

Looking ahead, cobots are set to become even more integral to production lines through AI-driven process improvements and predictive maintenance. Cobots will not only assist with current workflows but will soon be able to analyze data instantly and adjust processes on the fly, optimizing performance without human intervention. Additionally, they'll use ML algorithms to anticipate mechanical issues before they occur, helping prevent costly downtime by making repairs or adjustments proactively.

For example, a cobot might use vibration sensors to monitor a machine's health. When it detects vibrations outside of the normal range, it can adjust the machine or alert human operators before a failure occurs. This application of AI goes beyond simply responding to issues — robots are becoming adept at predicting and preventing problems before they affect production.

Robots can also analyze real-time data to identify inefficiencies on the factory floor. They can suggest improvements that keep production moving smoothly by spotting bottlenecks or slowdowns. Combined with ML, this predictive capability means that robots won't just react to problems but actively work to prevent them.

AI-POWERED COLLABORATION IN MANUFACTURING

Artificial intelligence is powering the deepening relationship between humans and robots. NLP helps robots to understand spoken commands, while advanced AI algorithms allow them to learn from their interactions and become better at supporting human counterparts. Over time, robots will be able to recognize patterns in human behavior, adapting their roles to be even more useful.

Imagine a cobot that can assist an engineer on the spot by running simulations, analyzing results and providing feedback on improving production. This kind of AI-driven collaboration enhances human creativity and speeds up decision-making. Unlike home environments, where AI personalizes interactions, industrial AI focuses on efficiency, optimization and guaranteeing seamless workflows in the manufacturing process.

MINIMIZING DOWNTIME WITH EDGE COMPUTING

In the modern manufacturing world, fast and reliable connectivity is critical to keeping robots at peak performance. 5G networks are already enabling rapid data exchange, but as factories grow more automated, 6G networks will be essential for handling even greater volumes of live data.

In these environments, edge computing can reduce latency to as little as 1/1000th of a second and empower robots to make decisions without delay. The ability to respond instantaneously is critical for tasks that require split-second precision on production lines.



SHAPING THE NEXT STEP FOR INDUSTRIAL ROBOTICS

As **industrial robotic systems** continue to develop, robots will move from basic automation tools to beneficial manufacturing partners. These systems will become more adaptive, learning from their environment and optimizing real-time processes. They'll help keep production lines running smoothly, prevent breakdowns and even contribute to designing better products. For instance, Amazon's upcoming Louisiana fulfillment center, powered by robotic systems like Sequoia, is expected to set a new bar for industrial efficiency and scale. This evolution toward smarter, more adaptive systems extends beyond manufacturing, enabling breakthroughs in areas where accuracy and reliability are critical.

MOLEX SOLUTIONS FOR INDUSTRIAL ROBOTICS



Network Interface Cards enable rapid, reliable communication between robotic systems and industrial networks. These cards improve system performance by offloading network tasks from the host system and ensuring fast, synchronized data exchange critical for robotics in dynamic industrial environments.



Industrial Ethernet Switches provide high-performance, reliable connectivity in challenging environments with options for managed, unmanaged and PoE configurations. Rated IP20 and IP67, these switches support data speeds up to 1,000 Mbps and are built to withstand extreme conditions such as temperature swings, dust and moisture.



Industrial Ethernet Connectivity solutions offer certified products for reliable communication and control across industrial environments. Featuring EtherNet/IP technology, these solutions provide fast, efficient data transmission and integration support for factory automation, robotics and other demanding applications. Molex provides interoperability and flexibility with certified stacks, harsh-environment I/O modules and engineering support.



Heavy-Duty Connectors, including **GWConnect Heavy-Duty Connectors** and **CRC Connectors**, provide robust, reliable solutions for industrial applications. GWConnect Heavy-Duty Connectors feature durable die-cast aluminum or thermoplastic enclosures and offer high resistance to harsh environments. CRC Connectors provide a compact, shielded option, supporting up to 50 circuits for signal and power, making them suitable for space-constrained environments in industrial automation.



HEALTHCARE ROBOTICS: PRECISE AND PATIENT-CENTERED CARE

Healthcare robotics is reshaping how medical professionals deliver care, enhancing precision and improving patient outcomes. From **assisting in surgeries** to providing personalized patient care, robots are transforming healthcare settings, ranging from operating rooms to home care environments.

AI-DRIVEN SURGERY: REDEFINING PRECISION IN THE OPERATING ROOM

Robotic systems have profoundly altered surgical practices. Take the Da Vinci Surgical System, for example, which enables surgeons to perform minimally invasive procedures with greater precision. Similarly, the Stryker Mako robot assists in orthopedic procedures, allowing for highly accurate joint replacement surgeries, while Medtronic's Hugo system integrates AI-driven analytics to enhance minimally invasive surgery across many types of procedures. The use of these systems and others like them can result in faster recovery times, reduced pain and fewer complications. Surgeons can now rely on AI-driven insights to guide them through complex operations, offering a level of control previously unattainable.



Picture this: during a delicate surgery, an AI system doesn't just follow pre-programmed instructions — it actively analyzes the patient's body in real time, suggesting subtle adjustments. These robotic systems can automate routine tasks like suturing, allowing the surgeon to focus on higher-level decisions. As AI and robotics continue to advance in healthcare, we can expect their role in surgery to expand, leading to even greater consistency and safety.



POST-OPERATIVE CARE AND CONTINUOUS PATIENT MONITORING

After surgery, robots are becoming crucial in post-operative care, rehabilitation and patient monitoring. For example, the Moxi robot assists with tasks such as delivering medications and keeping track of vital signs, ensuring patients receive timely care.

Now consider a patient recovering at home, equipped with sensors that let a robotic system monitor their vital signs and movements around the clock. The robot could detect subtle shifts in the patient's condition, triggering early interventions before complications arise. This proactive approach moves beyond merely reacting to problems but instead aims to prevent them. These advancements not only enhance patient safety but also reduce the burden on nurses and caregivers, allowing them to focus on more complex tasks.

NANOROBOTS: PRECISION AT THE MICROSCOPIC LEVEL

Nanotechnology is opening up new possibilities in healthcare, particularly through the use of nanorobots—tiny machines capable of navigating the bloodstream to deliver highly targeted treatments. These microscopic robots can focus on specific cells, such as cancerous tissues, to deliver medication directly, minimizing the side effects that often come with broader drug treatments.

Envision a future where nanorobots can detect early signs of disease and administer treatments exactly where they are needed, long before symptoms appear. Such a capability promises to redefine disease management by providing more effective, less invasive treatment options that minimize risk and accelerate recovery.

AI-ENHANCED PERSONALIZATION: TAILORED CARE FOR EVERY PATIENT

Perhaps one of the most exciting developments in healthcare robotics is the growing ability to deliver personalized care. Using live data, AI-powered robots can continuously monitor vital signs, track activity and even gauge emotional states to adjust care plans dynamically. Picture a home healthcare robot that adapts rehabilitation exercises based on a patient's current physical and emotional condition. If the robot detects signs of stress, it might recommend adjusting the exercises or pausing for a few minutes. This level of personalization makes healthcare not only more efficient but also more sensitive to the needs of each patient. Its clinical care is tailored specifically to the individual, unlike the broader personalization seen in other industries.



MOLEX SOLUTIONS FOR HEALTHCARE ROBOTICS



SlimStack Connectors facilitate the miniaturization of healthcare robots, making them ideal for high-precision systems such as surgical and monitoring devices.



Mini-Fit Connectors ensure reliable power delivery for healthcare robots, supporting consistent and safe operation in medical environments.



GWConnect Heavy-Duty Connectors feature durable die-cast aluminum or thermoplastic enclosures and offer high resistance to harsh environments.

BRIDGING THE GAP BETWEEN TECHNOLOGY AND HUMANITY

While healthcare robots bring significant technical advancements, their greatest value lies in how they complement human professionals. By automating routine tasks such as delivering medications or monitoring vitals, robots free doctors and nurses to focus on the personal, compassionate aspects of patient care that require human empathy and critical judgment. In essence, healthcare robotics is about merging technology with humanity. These systems make care more reliable and precise while allowing healthcare professionals to engage with patients on a deeper, more meaningful level.

NAVIGATING THE JOURNEY AHEAD FOR HEALTHCARE ROBOTICS

Because of AI and meaningful robotic advancements, healthcare is on the verge of becoming more personalized, efficient and proactive. From AI-guided surgeries to nanorobots delivering precision treatments, the next wave of healthcare robotics will reshape how care is delivered.

As these technologies are increasingly integrated into healthcare workflows, robots will help create more individualized, human-centered care environments, improving patient outcomes and enhancing the overall healthcare experience.



ROBOTS IN EDUCATION: PERSONALIZED LEARNING COMPANIONS

Robots in education are set to go beyond assistance, shifting how students engage with learning. As AI-driven intelligent tutoring systems (ITS) advance, these robots will evolve from passive tools to active, personalized learning companions. These companions will adapt to student progress in real time, providing tailored experiences that exceed traditional instruction.

FROM TOOLS TO TUTORS

Educational robots today are often used to assist with repetitive tasks or to support classroom instruction. But the next generation of these machines will be far more than useful tools — they'll function as tutors, using AI and ML algorithms to analyze student performance and adjust teaching methods. This approach is particularly impactful in STEM fields, where reinforcement learning allows robots to fine-tune lessons to match each learner's unique needs.

For example, a robot teaching mathematics might recognize a student's struggle with calculus and offer alternative explanations or real-world applications. This flexibility allows students to approach challenging topics at their own pace, making the learning experience far less intimidating.



Educational robots are designed to support emotional resilience as well. By offering encouragement during difficult moments, they help build confidence in students, seeing to it that tackling tough problems becomes a rewarding experience.



SOCIAL AND EMOTIONAL LEARNING (SEL)

Beyond academics, educational robots will play a pivotal role in social and emotional learning (SEL). Using NLP and emotional AI, these robots can detect emotional cues like frustration or excitement. By recognizing these signals, robots will change their approach, offering encouragement or suggesting a break when needed.

KEY TECHNOLOGIES DRIVING PERSONALIZED LEARNING

Several critical technologies are driving the development of educational robots into dynamic, personalized tutors. Reinforcement learning, for instance, is a powerful ML technique that enables robots to adapt their teaching strategies in response to live interactions. This continuous feedback loop ensures that each student receives instruction that's most effective for them.

Another important technology is natural language processing. Through NLP, robots engage with students in intuitive, context-driven conversations. By interpreting what students say and how they say it, educational robots respond more precisely, fostering meaningful, productive interactions that feel natural and supportive.

Emotional AI plays an equally crucial role. Recognizing emotional states such as disengagement allows robots to modify their approach, offering a more personalized and emotionally supportive experience.

BRIDGING TECHNOLOGY AND HUMAN INTERACTION

While educational robots can handle routine tasks and offer personalized instruction, it's essential to remember that they won't replace teachers. The irreplaceable human element — empathy, critical judgment and deep personal connection — will always be vital to education. What robots can do, however, is enhance and supplement these human strengths.

Teachers might rely on robots to handle basic tasks like grading or monitoring progress during individual assignments, freeing up time for deeper one-on-one interactions. In this way, robots and teachers will work together, leveraging the strengths of both to create a more efficient and personalized educational experience.



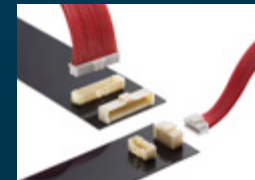
MOLEX SOLUTIONS FOR EDUCATIONAL ROBOTICS



KK Connectors offer durable solutions for educational robots, providing secure electrical connections in designs that are robust enough for student use.



Micro-Fit Connectors are an excellent choice for educational robots that require compact power and signal solutions, allowing for versatile and easy-to-use designs in classroom environments.



Pico-Clasp Connectors support miniature robotics applications in educational settings, allowing for lightweight and flexible designs that make hands-on learning more accessible for students.

ROBOTICS SYSTEMS FOR DEFENSE: AUTONOMOUS SYSTEMS IN MODERN MILITARY APPLICATIONS

The future of defense robotics will find autonomous systems are becoming essential partners on the battlefield, capable of analyzing data in real-time, making decisions and enhancing human operations. These robots are elevating military operations from surveillance to logistics by adding precision and speed while reducing human risk. Their purpose isn't to replace soldiers, but to add more intelligence to defense strategies.

AI-DRIVEN SITUATIONAL AWARENESS

One of the key strengths of autonomous defense robots is their ability to provide enhanced situational awareness. These systems use a combination of sensors (including LiDAR, radar, thermal imaging and optical cameras) to create instant maps of their surroundings. By processing multiple data streams simultaneously, robots detect threats more accurately and quickly than human operators.

Consider an autonomous robot enhancing situational awareness in complex environments. It can monitor changes in terrain, assist with environmental mapping or support critical missions where visibility is limited. On the ground, autonomous robots can operate in difficult-to-reach areas such as dense vegetation or urban landscapes, providing valuable data for decision-making.



These systems are designed to improve operational efficiency and safety, allowing personnel to make more informed and proactive decisions during critical operations.

But these robots don't just gather data. With advanced AI algorithms, they can recognize patterns in movement or predict potential threats, enabling military personnel to anticipate dangers before they escalate.

ADVANCED TACTICAL DECISION-MAKING

Modern defense demands rapid, accurate decisions, a role increasingly filled by autonomous systems. Powered by ML, robots and drones are taking on more complex tasks such as reconnaissance, targeting and combat support.



Picture a drone surveying challenging environments from the air, providing real-time data to support decision-making in complex operations. Ground robots, on the other hand, can handle critical tasks like clearing hazardous areas. These systems can operate with precision in environments that would otherwise pose significant risks to humans.

By managing these responsibilities, robots allow personnel to focus on strategic planning and coordination, enhancing operational efficiency and overall safety.

TRANSFORMING DEFENSE LOGISTICS

Logistics is critical to mission success, and autonomous systems are changing how military supplies are delivered and managed. Autonomous cargo drones can quickly transport supplies like ammunition, medical supplies or food, keeping troops equipped without putting human lives at risk.

Ground-based autonomous vehicles have the potential to deliver heavier materials to combat zones, ensuring operations continue smoothly. The automation of logistics not only speeds up resupply missions but also minimizes the need for human involvement in high-risk environments.

DATA AND CONNECTIVITY: OVERCOMING KEY CHALLENGES

Autonomous defense systems rely heavily on secure, live communication to operate in dynamic settings. Reliable data transmission is essential

MOLEX SOLUTIONS FOR DEFENSE ROBOTIC SYSTEMS



Micro-Change M12 Connectors ensure compact, rugged connections in defense environments, providing critical power and data connections for autonomous systems in the field.



Brad M12 Power L-Code Connector System offers secure and high-power delivery for robotic systems, making certain that defense robots have the necessary power supply for extended operations in critical conditions.



Zero-Hachi Connectors are designed for high-reliability applications, enabling precise data transmission and control for defense robots tasked with critical reconnaissance, logistics or combat support duties.

for ensuring that robots can continue performing tasks smoothly, even in unpredictable environments.

Next-generation 5G and 6G networks will support the high bandwidth and low latency these systems need. These advanced networks enable faster, more reliable communication between robots and human operators, ensuring smooth coordination even in volatile conditions.

Additionally, security is a must. Autonomous systems must be equipped with robust encryption to protect against interference or hacking, especially in combat situations.

Edge computing will play a crucial role here as well. By processing data locally, robots can help make prompt decisions without relying on external servers, reducing latency and ensuring they can act swiftly, even when communication networks are compromised.

THE ROLE OF ROBOTS IN TOMORROW'S MILITARY

The realm of defense robotics is expected to expand far beyond current applications. As AI and sensor technologies advance, autonomous systems will take on even more complex roles — from intelligence gathering to direct combat support. These robots will operate with minimally required active management, handling high-risk missions while ensuring human decision-makers remain central to ethical considerations.

Autonomous systems are already proving their value in humanitarian missions, such as search and rescue operations or clearing explosive devices in post-conflict zones. The precision and resilience of these robots are becoming indispensable in these critical situations.

In the future, collaboration between human soldiers and robots will only deepen. Robots will take on dangerous, repetitive or physically demanding tasks, while humans focus on strategic planning and problem-solving. The future of defense robotics seeks to empower soldiers, combining human ingenuity with machine precision.

CONCLUSION: MOLEX AND THE FUTURE OF ROBOTICS

As the world of robotics marches steadily forward, Molex's commitment to innovation will drive the seamless integration of advanced robotics across diverse sectors. By focusing on interconnect solutions that address the increasing complexity of these systems, Molex positions itself as a key enabler of robotic transformation in industries ranging from healthcare and education to defense and manufacturing.

In the future, robotics will augment human capabilities, enhancing precision, efficiency and decision-making. Molex solutions will maintain the robustness, responsiveness and interconnectedness of these systems, supporting everything from high-precision medical procedures to advanced autonomous defense systems. With technologies like AI, real-time data processing and sensor fusion reshaping robotics, Molex will provide the components that make this future possible.

As robotic systems take on increasingly critical tasks, such as performing surgeries or making real-time decisions on the battlefield, it is imperative to consider the ethical responsibilities that come with these advancements. Developing autonomous systems that can make decisions independently requires careful oversight, clear accountability and a focus on safety.



Defining and applying strong ethical principles to guide these systems is absolutely essential to building trust, especially in high-stakes applications. While Molex provides the technologies that power these innovations, we are dedicated to supporting our partners in maintaining high ethical standards, ensuring that these systems are used responsibly and in line with legal and societal expectations. Ultimately, the responsibility for the ethical use of these technologies lies with those who design and implement them.

Robotic systems will become integral partners in daily life and industry, and the demand for connectivity, power management and data processing will only grow. Molex is uniquely equipped to meet these challenges, helping to shape a future where robotics drives positive societal change while enhancing human potential.



creating connections for life

molex