ADVANTECH

Enabling an Intelligent Planet



ROBOTIC ARMS REACH FOR A NEW HORIZON

ENHANCING THE EFFICIENCY OF ROBOT ARMS THROUGH SOFTWARE-DRIVEN PLATFORMS

White paper

RISE OF THE ROBOTS

The list of factors driving global market demand for robotics arms continues to extend. Current contributors include:

- Rapid automation adoption across manufacturing facilities
- Warehouses looking to streamline processes
- Skilled labor shortages
- Increasing global competition
- Growing complexity of production operations
- The Industry 4.0/5.0 revolution
- Demand from industries relatively new to automation, such as construction, smart cities, healthcare, and agriculture
- Government initiatives and funding for advanced technology development

It is no surprise that most forecasters are estimating a period of fast growth for robot arm uptake over the coming decade.

Technology will also contribute to growing demand, as new advances can deliver gains in crucial key performance indicators (KPIs). A case in point is the ability of software-driven platforms to enhance the efficiency of robotic arms. Achieving such an ambition could promote significant sales opportunities for robot arm manufacturers.



31%

Global market research company MRFR (Market Research Future) valued the size of the robotic arm market at US$16.2 billion in 2022, projecting it to reach US$55.4 billion by 2032. This dramatic increase would demonstrate an impressive compound annual growth rate (CAGR) of 31.0% during the forecast period of 2024 to 2032.

The future of robotics covers the advancement of robots from handling fixed-purpose and pre-programmed tasks to being capable of adapting to new, real-life inputs with increasing degrees of autonomy and dexterity.

- McKinsey Digital

PC-BASED CONTROLLERS FOR ROBOT ARMS

Among the many reasons why robotic arms are proving so popular is their flexibility. With the right EOA (end of arm) tooling, robots applications extend to:

- Assembly and dispensing
- Handling and picking
- Machining and cutting
- Casting and molding
- Welding and soldering
- Painting and coating
- Cleaning and washing
- Finishing and polishing
- Packing and palletizing
- Transportation and storage
- Inspection and verification

Such a diversity of applications means the controller architecture for robot arms is shifting from traditional single-chip control to PC-based controllers. This transition is helping to meet requirements for:

- Better motion control
- More precise calculations
- Data acquisition



TRIO OF KEY REQUIREMENTS

Undertaking more complex and diverse tasks typically entails increasing the number of robot axes to introduce higher levels of capability and dexterity. The traditional architecture of PC-based controllers involves the integration of motion control cards, the quantity of which rises in line with the number of axes. The direct consequence is higher costs.

Software is now finding preference in place of motion control cards, with computer resources leveraged for better motion control. This approach reduces development costs and further enhances system flexibility for potential future expansion.

Software-driven control also delivers more precise calculations. Robot arms need high-accuracy control to perform the appropriate motion at the correct time. Such an action not only demands precise movements with small error tolerances, but also a need for prompt or even instantaneous responses.

Traditional single-chip controllers issue commands via firmware, while PC-based controllers utilize real-time operations via different control interfaces. These connect to various EtherCAT-enabled robot arms through an Ethernet-independent I/O interface, exercising real-time control over precision tasks that include machine loading or welding. Software integration is simpler than using firmware, making for easier installation and maintenance.

Last but far from least, data acquisition is vital in applications that necessitate accurate production records. PC-based controllers can support common industrial communication protocols such as:

- OPC UA
- Fieldbus
- Modbus

This capability enables the integration of diverse production information for comprehensive record-keeping.

ROBOTIC ARMS: PRIMARY HARDWARE NEEDS

In generic terms, it is possible to categorize robot arm applications into four types:

- Single operation
- Vision integration
- Multitasking collaboration
- High-precision control

For each type, selecting the optimal embedded computer that satisfies the specific controller requirements of these applications will help reduce time-to-market for new robot arms.

In single-operation tasks, the objective of a robotic arm is to repeat a single production action, such as picking. When selecting a suitable embedded computer/controller for such a robot arm, there are key factors to consider. These might include robust support for motion control interfaces like CANopen or EtherCAT. Also preferable would be a multi-core processor that allows for the dedication of a single core to the operating system. With an embedded computer offering this technology, robotic arm builders can achieve more efficient real-time control for the benefit of end users.

Vision integration applications involve the use of robot arms for tasks based on AI (artificial intelligence) image recognition results. Robotic arms operating in warehouse environments, for example, utilize AI image recognition to identify the type and storage location of objects. With this information, the robot arm can execute automatic item retrieval and repositioning. Optimal selection of the controller hinges on robust computing power and the potential to integrate AI acceleration modules that enhance computational efficiency. Such a set-up would meet demand for AI image recognition while boosting the flexibility and autonomy of robotic arms.

Applications that involve multitasking collaboration see multiple robot arms work in unison to complete tasks in packing or palletizing operations, for example. A suitable embedded computer should feature a desktop-grade processor to ensure more precise control or the integration of additional image information. The optimal controller should also support various PCIe/PCI interfaces that robot builders can add to enhance functionality and expand I/O capabilities.

High-precision control applications, perhaps for medical or surgical tasks, demand a versatile, fan-less embedded PC with plenty of connectivity, PCI or PCI Express expansion capabilities, and a wide range of processor options.

ROBOTIC ARMS: PRIMARY SOFTWARE NEEDS

Today's market for robot control software comprises a variety of solutions based on both proprietary technology and the open-source Robot Operating System (ROS) software development kit (SDK). The latest version, ROS2, provides a set of frameworks for robot control while taking advantage of modern libraries or technologies. ROS2 frameworks cover a wide range of robot control applications, including:

- Perception via sensors and/or cameras
- Positioning
- Low-level motion execution and interaction with other devices

A central data bus based on DDS (Dynamic Distribution Service), a middleware protocol and API standard for data-centric connectivity, provides both modularity and flexibility. It is easy to add functionality, features, and interfaces, or customize them as individual packages.

ROS2 typically sits atop a Linux distribution of the user's choice, preferably incorporating real-time patches or low-latency kernels. Appropriate drivers and software stacks make use of robot arm peripherals that include:

- Cameras
- Motor controllers
- Interfaces such as USB, Ethernet, CAN, Wi-Fi, and 4G/5G

If there is one drawback with ROS2, deploying it on hardware can prove challenging. The advice here is to seek out a pre-integrated and pre-validated ROS2 bundle that also contains useful packages like RViz for 3D visualization and MoveIt for motion planning. It should incorporate platform-specific or silicon-specific AI accelerator SDKs to benefit from hardware features such as neural processing units.

HARDWARE AND SOFTWARE INTEGRATION

To expedite the progress of new projects and accelerate product launch, robotic arm manufacturers require multiple development tools with integrated hardware and software.

The reduction of development time and cost is paramount in modern industrial product design. Again, optimal embedded computer selection is key. Choosing one that supports the CODESYS development system and EtherCAT Master Software from Acontis, for example, allows the control of robot arms in real-time operations, regardless of whether the development environment is Windows, Linux, or Ubuntu.

Tools of the trade

In addition, select a hardware and software supplier which can provide a variety of development tools that save valuable time for customers who would otherwise have to write their own software. It is quite simple to enhance the functions of robotic arms using secure and unified smart application programming interfaces (APIs). APIs not only enable capabilities that include I/O control and system detection and monitoring, they can also:

- Simplify and enhance hardware and software application implementation
- Ease programming and configuration tasks when integrating solutions
- Support cross-platform compatibility (Windows, Linux, Android, RTOS)
- Simplify deployment via an SDK

Another supplier attribute to cross-check is the ability to provide a proven IoT management platform that manages connected devices remotely and provides centralized management features. Such a platform will support containerized management and software updates.

In combination with appropriate hardware and firmware for out-of-band management, engineers can remotely repair and restart the device without on-site disassembly or maintenance, even where an OS or application error causes the system to shut down or malfunction. It is also advisable to adopt whitelisting, which will strengthen security against intrusion, illegal operations, and zero-day attacks.



HARDWARE AND SOFTWARE INTEGRATION (CONTINUED)

The right image

In the hardware/software application development of imaging and AI in robotics, most applications involve image-related analysis and processing. The successful execution of these tasks relies on three elements:

- Cameras
- Image computing acceleration cards
- AI development software

Reputable technology suppliers will be able to offer GPU (graphics processing unit), edge AI software with an integrated AI SDK, and multicamera interfaces that help realize the application with pre-design and professional services in image AI for robot arm applications.

The integration of AI and machine learning has been one of the most impactful trends in robot control software development. These technologies allow robots to learn and adapt to new tasks autonomously. With deep-learning algorithms, robotic arms can analyze large volumes of data in real time, optimizing their performance and adapting quickly to changes in the work environment. Used for pattern recognition and decision making, neural networks enable robot arms to perform complex tasks such as quality inspection and fault detection.

In all projects, flexible supplier support tailored to specific product verification requirements is essential. The pre-verification of hardware through Intel Edge Control for Industrial (Intel ECI), for example, can reduce product costs and accelerate robot arm introduction.

New frontiers for AI are redefining the future of industrial robotics. AI is enhancing robots' ability to grip, pick and place. It gives robots unprecedented levels of speed, accuracy, and payload-carrying ability, enabling them to take on more tasks in settings like flexible factories, warehouses, logistics centers and laboratories.

- Marc Segura, President ABB Robotics Division



PRODUCTS SOLUTIONS

Advantech provides embedded computing products featuring the latest technologies from major processor manufacturers such as:

- Intel
- AMD
- NXP
- Rockchip
- Qualcomm
- MediaTek
- TI

Equally important is a comprehensive solution based on Nvidia platforms that use parallel computing technology incorporating GPUs to enhance robot vision applications.

Take control

The Advantech ARK-1221L ultra-slim fan-less embedded computer is ideal for single-operation tasks with its Intel® Atom x6413E quad-core processors and Celeron N6210 DC SoC with GbE, COM, USB, HDMI/DP, and DIO ports.

For vision integration, Advantech recommends its ARK-1250L fan-less box PC featuring Intel® 11th gen Core™ i processor with Triple LAN/ Quadruple CoM (computer-on-module).

With its ARK-3534D, Advantech offers the optimal fan-less embedded PC solution for multitasking applications, thanks largely to its high-performance support for Intel® Core™ 12th,13th,14th Gen i3/i5/i7/i9 processor.



Get smart

AI is a key technology enabler of new robot arm applications, which is why Advantech has close relationships with providers of neural processing unit (NPU) technology like Hailo, Kinara, and Axelera. Products from these innovators enable inference at the network edge.

Further Advantech solutions of interest to robot arm developers include SUSI (Secure and Unified Smart Interface), a suite of application interfaces that lets users monitor and control:

- Digital I/O
- I2C
- CPU stepping speed
- Watchdog timers
- Smart fans

SUSI APIs help produce better, more reliable products, with faster time-to-market. Easy deployment arrives courtesy of Advantech's IoT Translator SDK.

Another product proving popular is Advantech's system-on-module SOM-6883, which essentially provides the common link to all system components (robot arm, motion controller, HMI, and sensor units such as cameras). The SOM-6883 overcomes system challenges that include:

- Ultra-fast boot (<3 s) for quick start-up operations
- High reliability for power on/off cycles (20,000 times)
- Different device connectivity with various I/O interfaces
- Strict quality control of 200 DPPM (under 0.002% fail rate) with precise on-time delivery schedule.

A growing number of robot arm manufacturers are also taking advantage of Advantech's DeviceOn IoT management platform, which manages connected devices remotely and provides centralized management features.

DESIGN-IN SERVICES

Critical for the successful development and implementation of future-proof robot arms will be AI acceleration cards, sensors, real-time motion control systems, and wireless communication. Advantech can accelerate robot application development with its design-in services, which span:

- Embedded hardware platforms
- ROS2 software suites
- Vision AI acceleration
- Wireless connectivity
- Real-time control
- Security
- OTA software updates
- Integration of peripherals

As an embedded design expert, Advantech's design-in services for robot arms help engineers to realize the efficient design of entire robotic systems. Services cover operating systems, machine learning, robot management tools, and many other critical design areas that help accelerate development projects.

EXECUTIVE SUMMARY

Industrial robotic arms, combined with advanced software systems, provide end users with numerous benefits that include:

- Lower labor costs
- Higher productivity
- Greater flexibility
- Enhanced worker safety.



In the near future, robot arms are set to move beyond traditional industrial applications and become more common in such fields as agriculture, healthcare, and smart cities. Manufacturers must therefore expand the application reach of their robots as they enter these new worlds of intelligent automation.

Robotics is a complex and rapidly evolving field, and no single company can possess all the expertise, technologies and resources needed to build autonomous robots. Through its co-creation strategy, Advantech has an ecosystem in place where technology partners like camera manufacturers, sector system integrators and independent software vendors work in unison to accelerate projects and help OEMs shorten the development time for robot arms.

About Advantech
With more than 8500 employees worldwide and a 40-year track record the company is a global leader in innovative products, systems, services and solutions for the world of embedded A-IoT. Our strengths include the comprehensive system integration of embedded hardware and software, as well as customer-oriented design-in services for e.g. Industry 4.0 applications, EV charging, green energy, medical devices, digital signage and gaming platforms. A further focus is on Advantech's local Design & Manufacturing Services (DMS), including the wide range of options for bespoke adaptation of standard products or the completely new development from scratch, of boards or systems according to customer specifications.

Advantech in Europe
As a leader in the embedded field, Advantech Embedded-IoT group not only delivers a wide range of embedded products, solutions and design-in services. With over 25 years of local presence in Europe, the company also offers integrated embedded building blocks and customer-specific adaptations and developments for A-IoT solutions, which include everything from sensor nodes to embedded PCs and gateways to IoT cloud platforms. Over 550 employees in Europe offer Local R&D-, technical-, project-, RMA & business support.