Machine and Robotic Vision Markets

Market Scenario and Competitive Landscape

A CURA DI

Francesca Furlan

Ufficio Valorizzazione della Ricerca

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Disclaimer

Context

This report provides an overview of the **machine vision and robotic vision markets**, with the aim of defining their competitive landscape through information and data about relevant market trends and segmentations.

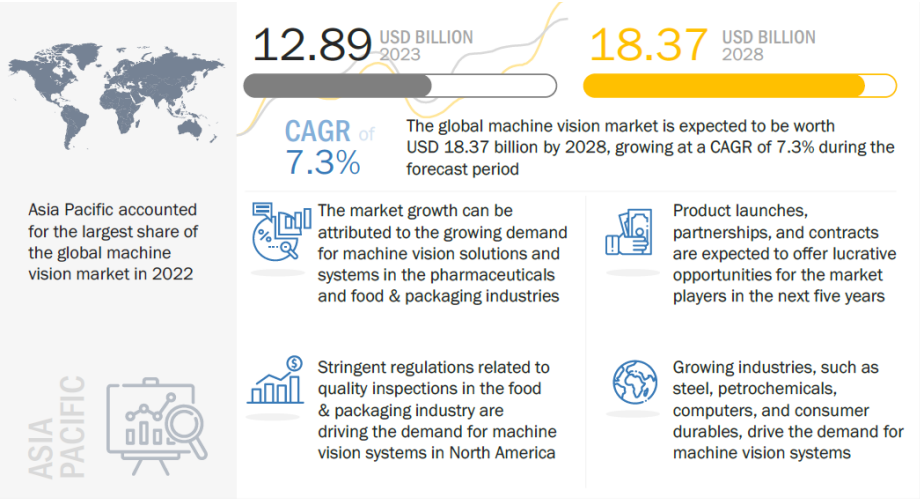
1 Machine Vision Market

Machine vision systems use a combination of hardware and software to provide operational guidance to devices in executing their functions. A machine vision system consists of multiple cameras that capture, interpret, and send signals individually to a control system. Recent technological advancements, such as deep learning software, liquid lenses, vision processing units, 360° cameras, hyperspectral imaging, and hybrid image sensors, have increased the scope for using machine vision systems in various industrial applications.

1.1 Global Market and Market Dynamics

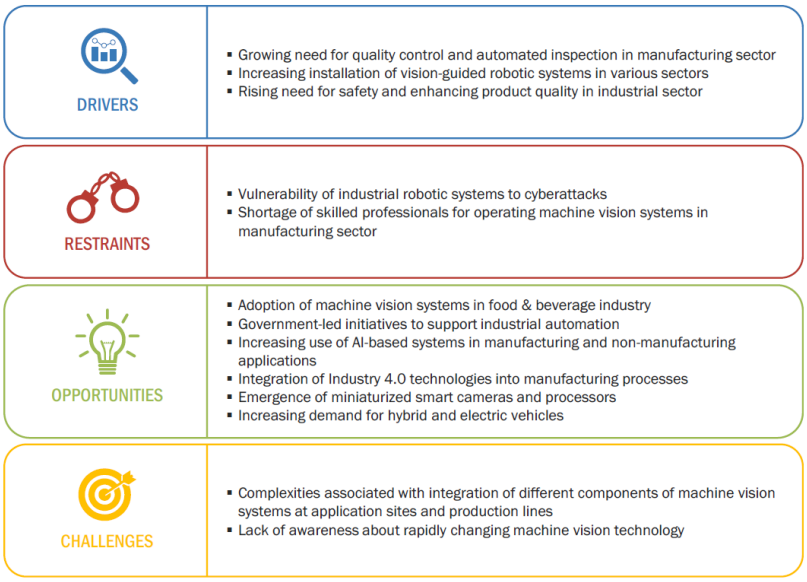
The **global machine vision market** was valued at USD 12,026 million in 2022 and is projected to reach USD 18,370.4 million by 2028; it is expected to grow at a Compound Annual Growth Rate (CAGR) of 7.3% from 2023 to 2028 (Figure 1).

Figure 1. Global Machine Vision Market in the Period 2023 - 2028



Consumer awareness about product quality has led to increased quality inspection and automation for end products. Therefore, many companies increasingly focus on automation systems to reduce production costs. Changes related to high-quality standards lead to factory automation, thereby increasing the demand for machine vision systems in industries. Other key factors contributing to the **growth** of the machine vision market are the increase in the manufacturing of hybrid and electric cars and the rise in demand for vision-guided robotic systems and application-specific machine vision systems (Figure 2). The machine vision market is further driven by the rising adoption of 3D machine vision systems by the manufacturing industries, such as automotive and consumer. However, the varying requirements of end-users and the lack of flexible machine vision solutions are the key factors **restraining** the market's growth.

Figure 2. Machine Vision Market: Drivers, Restraints, Opportunities and Challenges



Vision-guided robotics systems have recently led to significant changes in the machine vision market. There has been a rapid increase in the use of **industrial robots** for automation in the automotive sector and consumer electronics industry. This creates a strong need for machine vision systems with vision-guided robot controllers. These systems enhance the efficiency of robots by allowing them to see and respond to their environments. A vision-guided robot can work with humans in a shared workspace, even without a protective fence, as it safely avoids collision. The integration of machine vision in robots enables them to identify and automatically handle objects of different sizes, even if the object's shape is complex.

The deployment of industrial robots will increase in the coming years as they help to improve system efficiency during peak production periods and can aid in tackling unknown global systemic shocks, such as pandemics. Industrial robots provide the flexibility to respond quickly to the changes demanded by clients or other minor changes. In addition, they help reduce energy consumption, material waste, and operating or capital costs, save space in high-value manufacturing, and increase the production rate.

In conjunction with vision systems, **industrial robots** are utilized for fully autonomous bin-picking applications. Human workers' current inspection activities are expected to be automated using collaborative robots with vision system guidance. Using vision systems in such applications will help eliminate inefficiency, inaccuracy, and waste from modern industries, which is one of the goals of Industry 4.0. Interconnected vision systems on the factory production floor are also expected to drive the use of smart cameras. On the software side, cloud computing is increasingly used in scenarios where coordination with multiple robotic vision systems is required.

1.2 Machine Vision Market Segmentation by Application

Artificial intelligence (AI)-integrated machine vision technology enables automated image-based inspections, replacing manual inspections and measurements with digital cameras and image processing techniques, and is used to expedite the decision-making process. The technology is used in various industries to automate production, increase production speed and yield, and improve product quality. Its major applications include **quality assurance and inspection, positioning and guidance, measurement, identification, and predictive maintenance**.

For instance, in manufacturing, AI helps with object recognition and material inspection to enable machine vision systems to understand acceptable variations in the shape, texture, and color of an object or material.

Quality Assurance and Inspection

For **quality assurance and inspection**, machine vision systems are best suited for different areas, such as detecting defects, contaminants, functional failures, and other non-regularities in manufactured products. For example, machine vision systems can inspect medicinal tablets and detect faults; they can inspect displays to identify and confirm the presence of icons; touch screens can also be inspected for measuring the level of backlight contrast. The system can also inspect the completeness of the product, which includes ensuring a match between a product and its package in the food and pharmaceutical industries and checking safety seals, caps, and rings on bottles.

The automobile industry has moved toward camera-based AI machine vision systems for detecting defects and assembling auto parts. These systems can inspect and validate features such as the presence of correct labels and screws, as well as detect flaws. Pharmaceutical and Fast-moving Consumer Goods (FMCG) companies increasingly use camera-based machine vision systems for packaging purposes. Manufacturers also use these systems for visual inspections that require high speed, high magnification, round-the-clock operation, and repeatability of measurements. Semiconductor and electronics companies depend highly on vision inspection technology to check product quality and speed up production processes.

Positioning and Guidance

Positioning tools are essential for machine vision to inspect high-speed production lines, verify products, or robot-guided pick-and-place. Positioning tools, coordinate locators, or pattern identifiers recognize and determine parts and objects' exact position and orientation. The results can then be transferred directly to material handling devices or used to position other tools required for the inspection. To improve the efficiency of production processes, it is necessary to instantaneously detect the positional relationship between the target and the machine tool or table and control the system carefully. Poor detection accuracy may lead to defective workpieces.

For instance, industrial robots are essential for production procedures such as welding, handling, and assembling. Challenging coordinate education is necessary for origin setting and positioning in conventional systems. A fine adjustment may be necessary depending on the product or the individual. These issues can be resolved by positioning/calibration using image processing.

Measurement

In the **measurement** application, the purpose of a vision system is to measure the physical dimensions of an object; camera-based machine vision systems record the height, length, diameter, volume, depth, curvature, gaps, flushness, and distance of various parts, such as holes, slots, surfaces, edges, studs, and clips. These systems are vital in the automotive and electronics & semiconductors industries. Manufacturing companies adopt machine vision systems for measurement applications that range from the measurement verification of objects to checking high-precision dimensional accuracy and geometrical tolerances.

Identification

A machine vision system for part **identification** and recognition reads bar codes (1D), data matrix codes (2D), direct part marks (DPM), and characters printed on parts, labels, and packages. An optical character recognition (OCR) system reads alphanumeric characters without prior knowledge, whereas an optical character verification (OCV) system confirms the presence of a character string; hence, the machine vision system, using OCR, can also identify parts by locating a unique pattern or identify items based on color, shape, or size.

DPM applications mark a code or character string directly onto the part. Manufacturers in all industries commonly use this technique for error-proofing, enabling efficient containment strategies, monitoring process-control and quality-control metrics, and quantifying problematic areas in a plant, such as bottlenecks. Traceability by direct part marking improves asset tracking and part authenticity verification. It also provides unit-level data to drive superior technical support and warranty repair service by documenting the genealogy of the parts in a sub-assembly that makes up the finished product. Machine vision is used to read bar codes and data matrix codes for identification purposes, including defect detection and reject tracking in high-speed applications in the automotive, consumer electronics, food & packaging, and pharmaceuticals industries.

Distributors from the **food and packaging industry** and players from the consumer-packaged goods (CPG) industry usually rely on smart camera-based machine vision systems due to their ability to quickly identify bar codes and verify date and lot codes. In addition, due to increasing regulations on healthcare products, several **pharmaceutical** manufacturers worldwide are preparing to implement serialized packaging in support of full traceability and authentication requirements. However, the traditional approach of deploying serialization solutions that are integrated with PC-based machine vision systems can be expensive to install, validate, and maintain. Hence, to avoid that, nowadays, users are using smart camera-based machine vision systems.

Predictive Maintenance

The **predictive maintenance** technique is designed to determine when maintenance must be performed. It helps reduce maintenance costs compared to other approaches/methods, such as time-based preventive maintenance. Predictive maintenance has emerged as the primary analytics in the manufacturing industry; it helps increase operational efficiency and productivity. Predictive maintenance is conducted and executed by AI to improve productivity and efficiency. The aim is to provide cost-saving over schedule-based preventive maintenance or unplanned reactive maintenance, resulting in the unavailability of machinery during critical periods. Predictive maintenance can also be beneficial when there is machine downtime. Machine downtime occurs due to unplanned maintenance, tool breaks, and even adjustments of machines, which cause revenue loss.

1.3 Machine Vision Market Segmentation by Component

The major **components** of an industrial machine vision system considered in this report are **hardware** and **software** (Table 1). **Hardware** components constitute devices, namely **cameras, optics, frame grabbers, LED lighting, and other components** (interfaces, cables, and accessories). Cameras can be further classified into digital cameras and smart cameras. The market for the **hardware** segment is expected to hold a larger share of the overall market during the forecast period. The segment was valued at USD 9,766.4 million in 2023 and is expected to reach USD 13,234.9 million by 2028.

Software tools in the industrial machine vision software suite provide an interface for production lines and cameras. Typically, older cameras use closed systems – only the software from the same supplier can be deployed. This approach directly contrasts with modern automation goals that call for customization, flexibility, and scalability. By deploying smart cameras with Linux OS, the programmer can maximize the productivity of a vision system at a lower price. Therefore, major companies are focusing on developing open-system smart cameras so that the system integrators can integrate the needed application software either from a third-party or open-source software provider. The development of deep learning-based vision software contributes to the high growth of the software segment.

Table 1. Machine Vision Market, by Component, 2023–2028 (USD Million)

Component	2023	2024	2025	2026	2027	2028	CAGR (2023–2028)
Hardware							
Cameras	*5,704.9*	*6,143.9*	*6,617.3*	*7,108.4*	*7,620.1*	*8,134.3*	*7.4%*
Optics	*1,450.3*	*1,530.8*	*1,612.3*	*1,696.3*	*1,780.9*	*1,864.3*	*5.2%*

Component	2023	2024	2025	2026	2027	2028	CAGR (2023–2028)
Frame Grabbers	*734.6*	*755.0*	*776.5*	*794.5*	*810.0*	*820.0*	*2.2%*
Processors	*925.0*	*992.0*	*1,059.8*	*1,132.2*	*1,207.1*	*1,283.6*	*6.8%*
LED Lighting	*739.0*	*771.5*	*804.0*	*842.7*	*876.6*	*907.5*	*4.2%*
Others	*212.6*	*220.3*	*219.5*	*217.2*	*218.0*	*225.1*	*1.2%*
Total Hardware	9,766.4	10,413.4	11,089.5	11,791.3	12,512.8	13,234.9	6.3%
Software							
Traditional	*2,828.6*	*3,089.3*	*3,356.9*	*3,645.7*	*3,914.3*	*4,213.5*	*8.3%*
Deep Learning	*296.9*	*381.8*	*479.6*	*593.5*	*757.6*	*922.0*	*25.4%*
Total Software	3,125.5	3,471.1	3,836.4	4,239.2	4,671.9	5,135.5	10.4%

Other hardware components include interfaces, cables and communication accessories.

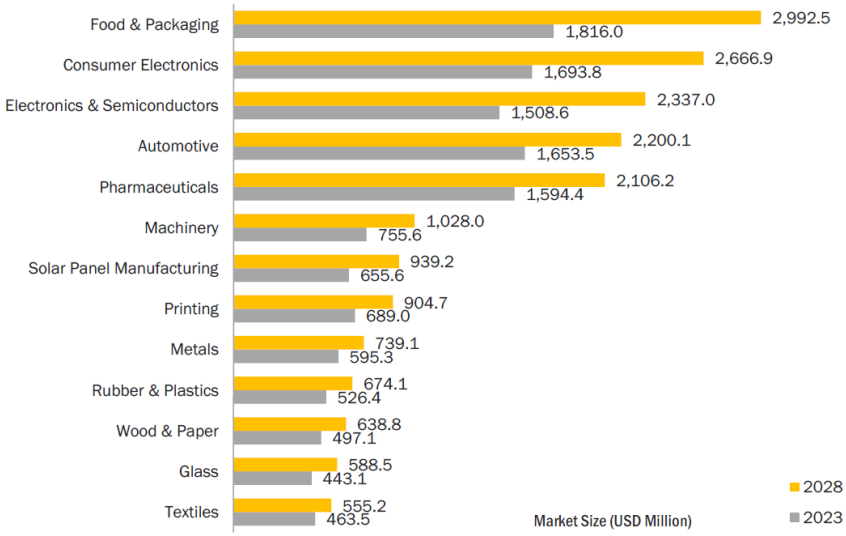
A camera lens is an **optical lens**, or an assembly of lenses used in conjunction with a camera body, with a mechanism to capture images of objects. The images can be captured on a photographic film or other media capable of storing an image chemically or electronically. The lens delivers the captured image through the image sensor present in the camera to the end-user. The two main types of lenses machine vision systems offered are fixed and interchangeable lenses. As part of a standalone vision system, the fixed lens could be a mechanical or liquid lens, which can focus automatically. Typically, autofocus lenses have a fixed field of view. Except for the detailed design and construction of lenses, there are no major differences between a lens used for a still camera, a video camera, a telescope, a microscope, or other apparatus.

1.4 Machine Vision Market Segmentation by Industry

Machine vision enhances production capabilities and helps in customizing manufacturing processes. Several **industries**, such as automotive, electronics and semiconductor, and consumer electronics, have started adopting machine vision systems owing to stringent government regulations on the safety and quality of products and the rising focus of manufacturers on quality maintenance and inventory management activities. For instance, the food industry is highly labor-intensive. The labor costs are approximately half of the product cost; therefore, the demand for industrial automation in the food & packaging industry is increasing.

The machine vision market can be segmented based on **industry** into: **automotive, electronics & semiconductors, consumer electronics, glass, metals, wood & paper, pharmaceuticals, food & packaging, rubber & plastics, printing, machinery, textiles, and solar panel manufacturing** (Figure 3).

Figure 3. Machine Vision Market, by Industry, in the Period 2023 - 2028



Automotive

The **automotive** industry plays a vital role in the manufacturing sector. Machine vision technology has a range of applications in the automotive industry, such as gauging and inspecting sealant beads, error-proofing thread presence, verifying piston assembly, inspecting rivet staking heights, inspecting dashboard graphics, verifying airbag assembly, color sorting door handles, identifying tires and wheels, error-proofing component assembly, reading 2D matrix codes, as well as robotic guidance and assembly. Machine vision systems are used to detect defects and align and assemble parts. These systems are also used for painting and robotics guidance. They improve accuracy in critical activities, including bin picking and positioning parts, such as doors and panels, for assembly. Due to the shortage of skilled laborers, automobile companies focus more on automation in their production processes. The automotive industry was the early adaptor of machine vision technology in production.

Machine vision enables the dimensional gauging of precision-machined components, such as fasteners, transmission elements, and other sub-assemblies such as IVS-ASAi. In machine vision systems, dimensional gauging measures lines, angles, diameters, and tolerances. The growing production of hybrid and electric vehicles is also expected to provide growth opportunities to the machine vision market in the automotive industry. Moreover, in line with Industry 4.0 and smart factory scenarios, the automotive industry increasingly relies on collaborative robots and autonomous forklifts that are independently moving about in production buildings. In this case, 3D-based machine vision methods reliably analyze the direction of robot and human movement, ensuring more fluid, flexible, and secure interactions.

Electronics & Semiconductors

Machine vision cameras have revolutionized the inspection process in **electronic** components, including semiconductors. Machine vision systems help detect macro and microscopic defects, missing components, small cracks, and temperature issues. The main objective of deploying these systems is to improve product quality and increase production volume quickly. The demand for machine vision systems in the electronics & semiconductors industry is increasing mainly because of the declining prices of electronic chips and the high production of electronics and semiconductor components in countries such as China, Japan, and South Korea. Manual inspection cannot detect various macro-defects within multiple display pixels, resulting in quality issues and low productivity. Thus, automatic inspection systems for identifying macro-defects are needed on high priority.

PCB (printed circuit board) inspection is also one of the growth factors for the machine vision market in the electronics and **semiconductor** industry. Defects are detected in multi-layer printed circuitry by machine vision systems. Semiconductor fabrication depends greatly on vision inspection technology. Machine vision systems inspect silicon wafers, processor chips, and subcomponents, such as resistors and capacitors, at high speed with precision and accuracy. The output of computer chips might be greatly reduced without the use of machine vision systems.

Consumer Electronics

Electronic assembly uses machine vision to aid production and test circuitry. Key consumer electronics manufacturers increasingly deploy machine vision systems to improve quality and productivity. For example, Foxconn uses cameras by Microscan throughout its operations. Typical machine vision applications in this industry include cover glass assembly, touch panel lamination, and screen-printing alignment in display manufacturing. In mobile and wearable device assembly, which requires fast production ramp-up with quick product changeover, machine vision is used for pre-assembly insertion check, post-assembly verification, precision robot guidance, and serial number and bar code reading. Machine vision is also used in alignment, gauging, and machine tending for original equipment manufacturers (OEMs) and machine builders' display manufacturing and module assembly needs.

Glass

Glass production is a process characterized by large volumes and high speed. A machine vision system is used for the quality inspection of flat glass products. The system evaluates a glass jar/bottle with a 360- degree view for tiny cracks in the rim, cracks running along the sidewalls, cracks in the bottom, and foreign materials such as cardboard and glass shards at 120 ppm. Machine vision systems are also used to inspect and measure the size and shape of lighting bulb tubes at every step of the manufacturing process. Machine vision technology improves operational efficiency, fastens the tracing of defects, reduces wastage, and provides detailed statistical information. According to Glass Alliance Europe, Europe is one of the largest glass producers in the world. Flat glass is primarily used to make facades and windows for buildings and homes. With positive trends in the automotive, construction and building, and food & beverage industries, the demand for glass will increase, ultimately driving the demand for machine vision systems.

Metals

A machine vision system can detect mechanical deformations, missing coatings, compound missing, cut or bent, die marks, ink or grease, foreign objects, dents, holes, and scratches during **metal** sheet production. This system enhances product quality by inspecting in 3D views and can be easily incorporated into the existing manufacturing systems to enhance the quality of the overall production process. The shortage of skilled labor and intense competition in the market are the two primary factors responsible for the increasing adoption of machine vision systems in the metal industry. Machine vision plays a vital role in improving product quality and streamlining operations within the metal industry by ensuring precision and consistency in production.

Wood and Paper

Machine vision plays a critical role in the **wood & paper** industry. It provides information about the visual defects and determines the optimal way to cut the boards to produce desired products. Machine vision systems can work efficiently in different environmental conditions, such as wood dust, heat, smoke, water, and chemicals. Value-added wood product firms also use machine vision technology to scan boards for knots and other visual defects in doors or windows. Paper machines typically have a healthy number of cameras monitoring the product as it goes through the various parts of the machine to analyze sheet breaks or other products or process variations made visible by the monitoring cameras. These machine vision systems help resolve issues and defects in the machine itself.

Pharmaceuticals

Machine vision in the **pharmaceutical** industry is used for various applications, such as cap/seal inspection, empty glass inspection, stopper position inspection, powder/liquid fill inspection, seal surface inspection, Optical Character Recognition (OCR)/Optical Character Verification (OCV) inspection, serialization track and trace, e-pedigree marking inspection, component inspection (stoppers/caps/glass), particle inspection, final product inspection, and box/label inspection. Quality checks and quality assurance are two essential processes in the pharmaceutical industry. Machine vision plays a vital role in quality checking, processing, and packaging operations. The machine vision market for this industry is growing at a significant rate. Stringent government regulations and the increasing need to combat counterfeit products are driving the growth of this market.

Food and Packaging

The **food** industry provides several opportunities for the machine vision market, and several companies have responded by developing application-specific solutions in grading, sorting, portioning, processing, and quality checking during processing and packaging. Dairy is the most automated industry in the food sector. Machine vision systems help in the sorting of tea leaves, vegetables, and fruits. Vision systems are pre-trained with the required algorithms, which help them

understand characteristics such as size, stage of growth, and variety. Labeling reflects the brand; incorrect labeling can harm the brand name and lead to legal implications.

One of the essential processes of any industry is product **packaging**. Machine vision helps inspect packaging processes, reduce errors, and handle multiple packaging inspections simultaneously. Machine vision systems monitor glass containers to cull out any reject conditions. At the fillers, systems do a pre-fill inspection to assure the quality of bottles and overall conditions, such as scuff marks, empty bottles, and finishing concerns. Post-fill inspection ensures the containers are filled up to proper levels, caps are correctly installed, and correct labels are present on the containers.

Rubber and Plastics

Machine vision systems play a pivotal role in the **rubber and plastics** industry by automating and enhancing various processes. These systems employ cameras, sensors, and sophisticated image-processing algorithms to ensure product quality and operational efficiency. Key applications include quality control and inspection to detect defects or irregularities, precise dimensional measurements, color verification to maintain consistency, material sorting for efficient manufacturing, surface inspection for imperfections and barcode reading for tracking and management. The increased consumption of Plastics in the construction, automotive, electrical, and electronic industries is going to be the main driver of the market.

Printing

Machine vision systems are widely used in the **printing** industry, mainly in label printers. Line-scan cameras take images of large swaths of web-based printed materials and verify that the advertisements, texts, and other patterns on the materials are being printed with the required accuracy. Area-scan cameras verify the quality of pictures and graphics and register multi-colored screens used to create full-color images. The printing systems reduce printing waste, increase product quality, and provide quality assurance by incorporating area and line charge-coupled device (CCD) cameras, sophisticated image processing algorithms, and industry knowledge. Machine vision systems used in digital printing applications check for readable texts, the correct number of collated pages based on the individual recipient, and the right pages in suitable envelopes.

Machinery

Machine manufacturing includes producing different machines used in the agriculture, mining, construction, and manufacturing sectors. A few important processes involved in manufacturing this machinery are forging, stamping, bending, forming, and machining, which are used to shape individual pieces of metal. Processes such as welding and assembling are used to join separate parts together. All these processes consume time if done manually; machine vision systems help complete these processes in much less time. They also help detect defects and validate product quality.

Solar Panel Manufacturing

Manufacturing **solar panels** involves a precise layering of materials, including glass, semiconductors, metals, and anti-reflective coatings, and then exposing them to etching, bonding, and electrochemical processing steps. Along with governments, private industries and consumers are increasingly seeking energy sources that are eco-friendly yet affordable. Thus, solar cell manufacturers are under pressure to manufacture quality products with reduced costs. Therefore, they are focusing on the complete inspection of each panel after every major processing step. Industrial machine vision-based inspection is an important tool for inspecting the quality of solar panels. Solar cell and module manufacturers use machine vision systems for three general purposes: inspecting the products, identifying and tracking the products, and assembling the products, typically as a guidance system for a robot.

Textiles

Textiles is one of the largest and most competitive industries in the world. To ensure that the final products are of high quality, manufacturers must set up quality control processes right from the first process in production. Machine vision systems enable producers to make high-quality textiles for the lowest possible cost and highest possible profit. Machine vision systems enable manufacturers to provide nearly defect-free goods, minimize waste, and advance a sustainable environment by identifying flaws in textiles before they reach customers. These systems also enable manufacturers to supply defect-free goods and minimize waste.

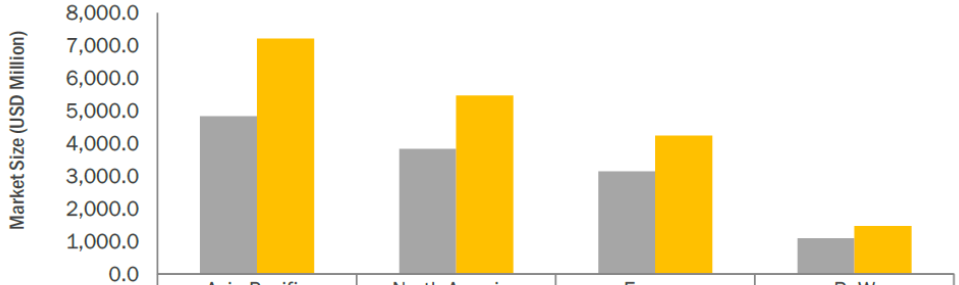
1.5 Machine Vision Market Segmentation by Region

The machine vision market has been segmented into four major regions: **North America, Europe, Asia Pacific, and RoW** (Figure 4). North America and Asia Pacific are the top two markets for machine vision systems due to their increasing need for quality inspection and automation, growing demand for application-specific machine vision systems, rising adoption of Industrial 4.0, developing new connected technologies, and government initiatives to support smart factories.

The **Asia Pacific** machine vision market is projected to reach USD 7,205.8 million by 2028, growing at a CAGR of 8.3%. The machine vision market, by region, was dominated by Asia Pacific in 2020, primarily because most manufacturing activities occur in countries such as China, India, and Vietnam. **North America** is the largest producer of pharmaceutical products, making it the second-largest market for machine vision systems in 2022.

The **European** machine vision market is projected to reach USD 4235.8 million by 2028 from USD 3139.1 million in 2023, growing at a CAGR of 6.2%.

Figure 4. Machine Vision Market, by Region, in the Period 2023 - 2028

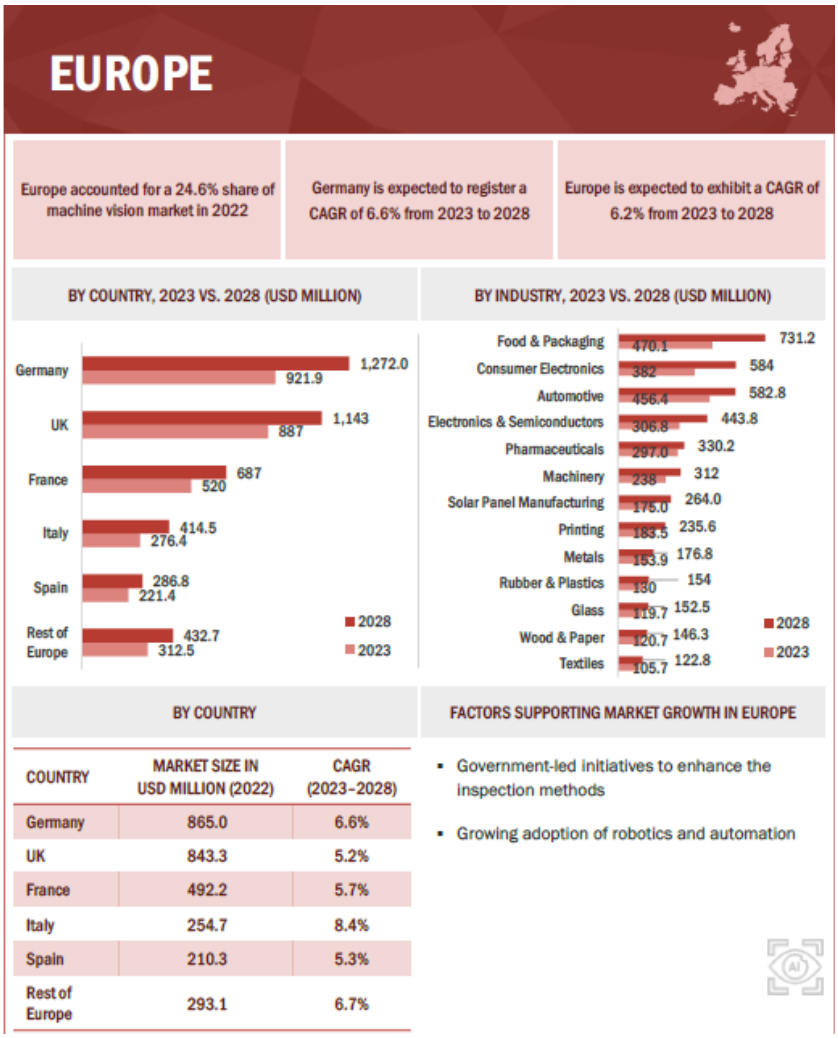


	Asia Pacific	North America	Europe	RoW
2023	4,830.0	3,827.9	3,139.1	1,094.9
2028	7,205.8	5,462.0	4,235.8	1,466.8
CAGR (2023–2028)	8.3%	7.4%	6.2%	6.0%

1.5.1 Focus on Europe

The **European machine vision market** is growing as the region serves numerous highly active industries, such as automotive and innovative companies. The UK dominates the machine vision systems market in Europe, followed by Germany and France. Eastern Europe is also experiencing significant industrial growth, with the automotive, pharmaceutical, and food industries playing a pivotal role. These traditional customer industries are expected to remain the backbone of the vision technology companies' turnover in Europe. As a result, the machine vision market in Europe is expected to experience significant growth.

Figure 5. Europe: Machine Vision Market Snapshot



Rest of Europe includes Sweden, Switzerland, Finland, Spain, the Netherlands, Belgium and Turkey

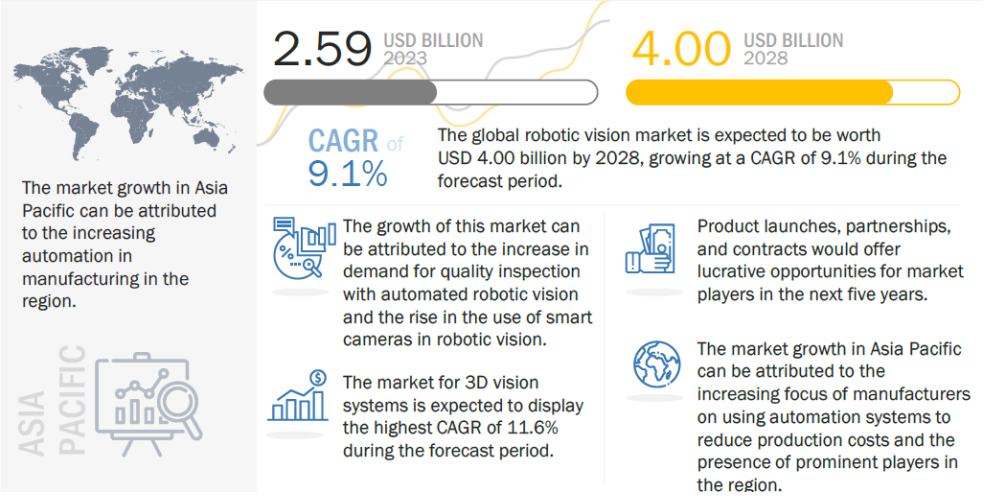
2 Robotic Vision Market

Robotic vision empowers machines and robots to perceive and interpret visual information from their surroundings, akin to human vision capabilities. This transformative technology enables robots to navigate autonomously, interact with the environment and make informed decisions based on the visual cues they receive, making them increasingly valuable in various applications such as industrial automation, autonomous vehicles, healthcare, surveillance, and more.

2.1 Global Market and Market Dynamics

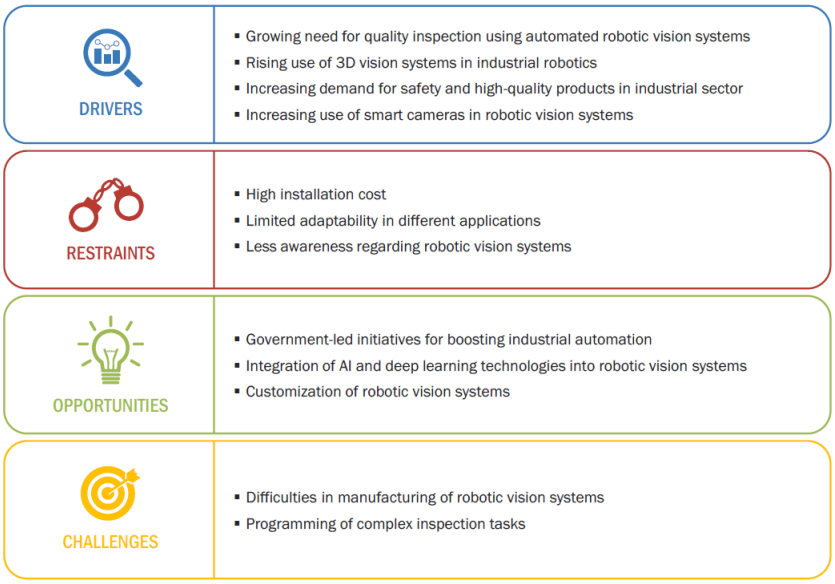
The **global robotic vision market** was valued at USD 2,591.4 million in 2023 and is projected to reach USD 3,998 million by 2028; the market will record a CAGR of 9.1% between 2023 to 2028 (Figure 6).

Figure 6. Global Robotic Vision Market in the Period 2023 - 2028



The major factors **driving** the robotic vision market are the growing need for automation and quality inspection in the industries and the capability of 3D vision systems allowing robotic systems to perform more than one task without reprogramming (Figure 7).

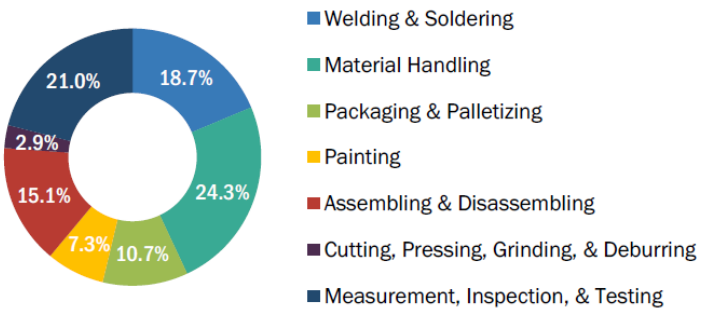
Figure 7. Robotic Vision Market: Drivers, Restraints, Opportunities and Challenges



2.2 Robotic Vision Market Segmentation by Application

Robotic vision systems are rapidly being adopted in industries such as automobiles, electronics, food & beverages, and pharmaceuticals. Automated tasks with the help of robotic vision systems save time, enhance product quality, and boost the industry's overall performance. Depending on their wide usability, the applications considered for robotic vision systems include: **material handling, measurement, inspection, and testing, welding and soldering, assembling and dissembling, packaging and palletizing, painting and cutting, pressing, grinding and deburring** (Figure 8).

Figure 8. Applications Market Share for Robotic Vision



Welding and Soldering

Welding is one of the applications which requires a superior level of accuracy and precision. Welding metals is highly risky, as it utilizes a blowpipe or electricity for generating heat. Traditional methods of metal welding in industries such as automobiles, furniture, and electronic parts are done manually. However, the introduction of new designs and systems has forced manufacturers to move toward the welding automation process using robotic vision. Welding automation using robotic vision offers numerous benefits, from improved productivity and consistency to minimized production, labor, and material costs. For instance, in the automotive industry, robotic welding through vision systems is used in components such as chassis, seats, and axles.

Similarly, **soldering** operations are primarily used in the electronics industry. Vision systems utilized for soldering have their respective monitoring software, which gives real-time information on the accuracy and quality of the weld. This minimizes instances of defective items. Hence, vision systems are also used in conjunction with robots for greater precision in welding and soldering tasks. Furthermore, vision systems are extensively used for soldering applications in the electronics industry. In the automotive industry, vision systems are utilized by automotive part suppliers, as they must guarantee the quality of manufactured items. 2D vision systems can accurately gauge most welding tasks. Hence, they are the most commonly used type of vision system for welding and soldering. However, as 3D vision systems can measure the height of a weld, they are being increasingly used in situations where a greater degree of accuracy is required.

Material Handling

Material handling using robotic vision can significantly reduce the human labor involved with handling applications. The use of robotic vision in material handling reduces labor costs, increases uptime for production processes, and provides a safer environment for humans. A robotic vision system can detect the position of an object and send the information to a robot to pick it up. Pattern identifiers in software recognize and determine the exact position and orientation of parts and objects, which can be transferred directly to a robot that performs the necessary operation. Therefore, both vision hardware and software play an important part in high-speed handling tasks.

Material handling includes different applications such as bin picking, part tracking and handling, loading and unloading, transferring stampings between presses, pick-and-place, dispensing, palletizing, packaging, part transfer, and machine tending or assembly. Among all these applications, bin picking is a big challenge for many industries due to many random factors, such as loose parts and random piling. The robotic vision material handling outperforms humans in the bin picking tasks as they work consistently with speed. The human eye fatigue for such tasks is also replaced efficiently with the help of robotic vision.

Packaging and Palletizing

Packaging is an application where vision guidance is critical. The products to be packed are run down on conveyor belts, which arrive randomly and at high speed, especially in the food industry. Food products often come down from a conveyor or slide down a ramp into a pickup area with no repeatable positioning. Subsequently, the products end up in unusual positions and need to be picked up, oriented, and placed in the package. 3D vision allows the robots to find the product and make the right packaging.

Vision guidance provides the precise part location to robots in many **palletizing** applications where processing multiple parts and eliminating costly precision fixtures are required. 3D vision also offers performance advantages when stacking parts on a wooden pallet or removing them. Parts can not only be shifted from side to side but can also be at different heights or angles.

Furthermore, a robotic vision system can also identify defective products while packaging. In the dynamic manufacturing industries, the packaging is the first impression of a product and the brand. Any discrepancy in the product packaging, be it a defect or incorrect labeling that goes unnoticed, may prove disastrous for the product. Defects unnoticed by the human eyes can be spotted in less than a second with robotic vision solutions. This gives a better choice for a packaging process that is fast and repeatable. This prevents the company from losses and is cost-effective by reducing wastage. End users such as the food & beverage industries, where packaged food consumption is growing, are estimated to be the driver of the packaging application of the vision robotics market. Furthermore, the pharmaceutical industry, where packaging plays a vital role, will also boost market growth.

Painting

Painting typically consists of multiple operations in the coating process, such as applying primer, base coat, finish coat, clear coat, and spray dispensing (by using water-based solvent, powder, glaze, and glue/adhesive materials). Painting with the help of vision robots gives benefits such as precision and evenness. Less wastage of paint with maximum coverability is also possible with vision-guided robots. This has been used for many years in the automotive industry to paint cars, but in recent years, painting with the help of vision robots has been highly adopted in commercial, residential, and industrial applications. Coatings such as vibration damping, anti-fog coating, sound-absorbing, anti-bacterial coating, and so on may include chemical fumes, which are hazardous for humans. Hence, in recent years, industries such as electrical, automobile, and aerospace, among others, have adopted vision-guided robots for coatings as well as paintings.

3D vision systems can be used to further enhance the detection of paint imperfections by introducing a 3D display of defect positions and automatic color marking. Deep learning vision software can then automatically classify the detected defects. Vision systems are predominantly used in the automotive industry to guarantee perfect paintwork and prevent additional costs associated with reworking or customer complaints. As vision systems mounted on industrial robots can closely follow the contours of the vehicle body, 3D vision systems are not required in most cases, especially where fast cycle times need to be observed. Hence, 2D vision systems are more prevalent for painting applications than 3D vision systems.

Assembling and Disassembling

In industries such as automotive, aerospace, and electronics & electrical, components are located, identified, and inspected during the automated **assembly** process, enabling manufacturers to realize costs, quality, and throughput improvements. The manual process is slow and may lack quality and consistency. A vision-enabled robotic system employed for the assembly of the parts of the product in a specified configuration facilitates the industries in consistent and precise assembling. The robotic vision assembly process enhances speed and precision without compromising accuracy. In assembling, discrete parts and components are brought together with the help of vision-guided robots and assembled to form a specified configuration.

A vision-guided robot can identify and locate the objects they are assigned to assemble. Using vision-guided robots in assembling and disassembling parts facilitates accuracy and functionality in assembly operations. They reduce downtime and improve the productivity of the assembly process.

Assembling electrical connectors for the aerospace industry is a complex operation traditionally performed manually. In the process, trained operators insert numerous metal pins, plastic insulator seal plugs, and sockets into diverse sizes and shapes of electronic connectors, which can be better performed by robotic vision. Hence, vision-guided robots maintain micro-precision and quality in the automotive and electrical & electronics industries while assembling parts and accessories. Similarly, electronic manufacturing processes are largely automated.

Cutting, Pressing, Grinding and Deburring

Many robots are designed for specialized purposes such as grinding, polishing, buffing, or other material removal tasks where the robot uses a material removal tool (wire brush, sandpaper, knife) over the part surface or contours. The process of removing burrs, edges, inconsistencies, or fins of parts is **deburring**, which is conducted manually as well as robotically. Nevertheless, robotic deburring is gaining momentum as it has more advantages over the manual process. The robotic arm with a vision system deployed to deburr helps maintain consistency of products, with timely delivery and high precision in a safer environment. To remove burrs, automated deburring is used extensively in automotive manufacturing for parts, such as engine blocks, crankshafts, cylinder heads, wheels, grills, and bumpers, in conjunction with multiple vision systems. Four types of robotic vision-assisted cutting techniques are used in the manufacturing industry: oxy-fuel, laser, ultrasonic, and water jet.

Grinding using vision systems and robots is used for quickly and efficiently processing parts of various objects, from vehicle bodies to wooden planks. The use of robotic vision saves time and costs while processing complex designs and simultaneously improving the uniformity of each workpiece. Vision system-assisted grinding also reduces metal or wood dust due to its efficiency.

With the increase in capabilities of 3D vision systems, they are being increasingly utilized for **cutting** operations in the automotive industry. Cutting, grinding, pressing, and deburring are major applications in the automotive industry, and this process requires precision. Hence, efforts are being made to replace human workers with automated robot cutters. Vision systems play an essential part in automation, as they can detect irregular objects and more effectively guide the robot for the cutting operation.

Measurement, Inspection and Testing

The robotic vision used for **measurement** purposes is utilized to measure the dimensions of any object. It is used to measure the length, breadth, height, diameter, volume, curvature, and distance of various parts and holes, slots, surfaces, edges, studs, clips, gaps, and flushness of an object. Vision cameras combined with the right optics and stable lighting provide precision repeatability to ensure manufacturing accuracy. The vision system used for inspection detects defects, contaminants, functional flaws, and other irregularities.

Dimension inspection is widely used in manufacturing industries where the vision system makes decisions to accept or reject the object depending upon the product's specifications. This facilitates the manufacturing industry in streamlining the manufacturing process. Measurement and inspection are critical tasks in industries such as automobile, aerospace, electronics, and semiconductors.

2.3 Robotic Vision Market Segmentation by Component

In a robotic vision system, several components perform with agility and maximize productivity. These components are classified into **hardware** and **software** (Table 2). The **hardware** components market is expected to hold a larger market share in the forecast period. The segment is valued at USD 1966.0 million in 2023 and is expected to reach USD 2971.6 million by 2028. Hardware components play a crucial role in robotic vision systems, and they constitute the majority of the cost. Combining the cost of all the hardware components, the segment holds the major share of the market.

The development of deep learning-based vision **software** contributes to the high growth of the software component. Deep learning software that leverages AI hardware capabilities are growing at a significantly higher rate compared to traditional software.

The market for **cameras** is expected to register the highest CAGR of 9.7% during the forecast period. The segment is estimated to dominate with a value of USD 1150.1 million in 2023 and is expected to reach USD 1829.7 million by 2028. In the near future, robotic vision is expected to have a higher installation of 3D vision systems requiring smart camera installation, owing to the automation in industries.

Table 2. Robotic Vision Market, by Component, 2023–2028 (USD Million)

Component	2023	2024	2025	2026	2027	2028	CAGR (2023–2028)
Hardware							
Cameras	*1,150.1*	*1,253.9*	*1,371.9*	*1,505.2*	*1,656.6*	*1,829.7*	*9.7%*
Lighting	*149.1*	*157.3*	*166.5*	*176.9*	*188.3*	*201.1*	*6.2%*
Optics	*291.6*	*311.0*	*332.9*	*357.0*	*384.2*	*415.0*	*7.3%*
Processors & Controllers	*182.8*	*197.2*	*213.5*	*233.2*	*254.5*	*278.8*	*8.8%*
Frame Grabbers	*149.8*	*157.2*	*165.3*	*172.9*	*182.2*	*192.4*	*5.1%*
Others	*42.6*	*44.2*	*45.9*	*49.1*	*51.7*	*54.6*	*5.1%*
Total Hardware	1,966.0	2,120.8	2,296.1	2,494.3	2,717.6	2,971.6	8.6%
Software							
Traditional Software	*614.5*	*672.1*	*737.6*	*813.2*	*898.2*	*995.6*	*10.1%*
Deep Learning Software	*10.9*	*13.7*	*17.0*	*20.9*	*25.4*	*30.8*	*23.0%*
Total Software	625.4	685.8	754.6	834.0	923.6	1,026.4	10.4%
Total Market	2,591.4	2,806.5	3,050.7	3,328.3	3,641.2	3,998.0	9.1%

Other hardware include cables and communication modules

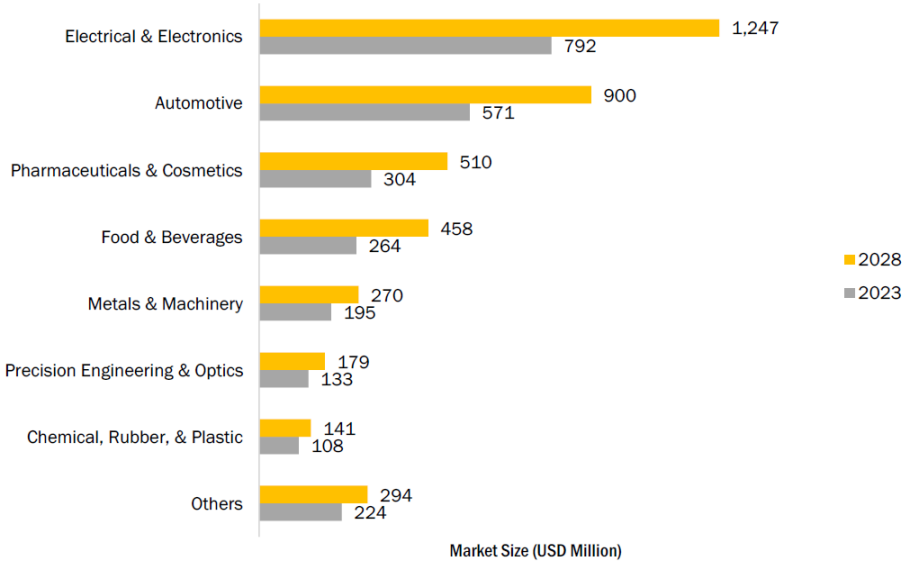
Optics is an integral part of a traditional as well as a smart camera. A camera lens is an optical lens or an assembly of lenses used in conjunction with a camera body and mechanism to take images of objects. This can be done either on photographic film or other media that can store an image chemically or electronically. The lens delivers the captured image to the image sensor in the camera by adjusting the appropriate focal length. Two main types of lenses offered by vision systems are fixed and interchangeable lenses. As a part of a standalone vision system, the fixed lens could be a mechanical lens or a liquid lens, which focuses automatically. Typically, autofocus lenses have a fixed field of view. Except for the detailed design and construction, there are no significant differences between lenses used for a still camera, a video camera, a telescope, a microscope, or other apparatus.

The other two types of lenses that are being widely used in the robotic vision system are entocentric and **telecentric lenses**. Additionally, other types of lenses, such as zoom, standard, wide-angle, etc., are used in a vision system based on the application. The entocentric standard lenses, which have fixed focal lengths, are normally used for general applications such as pick-and-place, barcode reading, and print image inspection. For applications such as visual testing and measurement and defect detection that need precise measurement, **telecentric** lenses are used.

2.4 Robotic Vision Market Segmentation by Industry

Robotic vision systems are being rapidly deployed in various industries to increase productivity, save time and cost, and enhance overall performance. Based on industry, the robotic vision market has been categorized into: **automotive, electrical & electronics, chemicals, rubber, & plastics, metals & machinery, food & beverages, precision engineering & optics, pharmaceuticals & cosmetics and others** (paper & printing, foundry & forging, ceramics & stone and wood) (Figure 9).

Figure 9. Robotic Vision Market, by Industry, in the Period 2023 - 2028



Electrical & electronics has emerged as the industry with the largest share in the robotic vision systems market. This can be attributed to the significant increase in the use of industrial robots in the afore-mentioned industry. Vision systems enable the handling of small and delicate parts with precision, allowing manufacturers to increase uptime and minimize waste. As robots are being used in every stage of electronics production, so are vision systems.

Automotive

The **automotive** industry plays a major role in the manufacturing sector. The industry is the early adopter of automated robotic arms for manufacturing and assembling vehicle parts. It has several applications such as welding, assembly, measurement, detection and testing, cutting, painting and coating, gauging and inspecting sealant beads, error-proofing thread presence, verifying piston assembly, inspecting rivet staking heights, inspection of dashboard graphics, verification of airbag assembly, color sorting door handles, identifying tires and wheels, error-proofing component assembly, and robot-guided assembly, which require vision systems. Owing to the shortage of skilled laborers and the reduced manufacturing prices of vehicles, automobile companies are focusing more on automation in their production processes. Cognex Corporation (US) offers various vision system solutions for the automotive sector ranging from assembly to final inspection. OMRON Corporation (Japan) and Keyence Corporation (Japan) are other key companies providing robotic vision solutions to the automotive sector.

Most of the welding processes in the automotive industry utilize vision systems to accelerate and verify their welding process.

For instance, KWD Automobilitechnik (Germany), a manufacturer of vehicle parts and accessories, developed a system using 3D vision systems and vision software from Cognex Corporation (US) and industrial robots from KUKA AG (Germany). The system inspected the location and accuracy of spot welds. 3D vision systems are also increasingly used to handle and assemble complex automotive parts.

Electrical and Electronics

Robotic vision systems have the potential to transform production for increased throughput, quality, and productivity in the **electrical & electronics** industry. Material handling and automated inspection are the most common applications for vision systems. Vision systems have revolutionized the process of inspection of electronic components, including semiconductors. The electrical & electronics industry is adopting a new trend of miniaturization and low-profile designs of appliances such as home electronics, smartphones, gaming consoles, and PCs. The developing and inspecting phases of electronic components need high accuracy. Thus, low-profile designs of appliances require vision systems for inspection and detection of defects, boosting market growth.

Chemicals, Rubbery and Plastics

Robotic vision systems are utilized for material handling and inspection in the **rubber & plastics** industries. Robotic vision systems help in the inspection as well as supporting the high-speed production demand. In the plastics industry, vision system inspection can pick up a minute variation between parts and reject defective pieces with astounding accuracy. Vision systems help determine the presence and absence of safety seals, cap heights, colors, proper alignment of parts, and correct labels. Most of the other processes in the plastics industry include thermoforming, blow molding, compression molding, and extrusion. These processes are automated using vision systems to enhance productivity, quality, and flexibility. Secondary operations or tasks, such as processing, finishing, pick-and-place, and packaging, are also handled using vision systems.

Metals and Machinery

In the **metal** industry, robotic vision systems are utilized during the entire process. In the metal industry, applications such as shape control, analysis, testing of casting material components, and measurement of fundamental processing are conducted with the help of robotic vision. Additionally, the metal industry performs functions such as welding, cutting, grinding, pressing, and deburring, which are dangerous if performed manually and hence require robotic vision for an efficient and safe environment.

Robotic vision systems inspect, count, and measure products; it also performs laser cutting and welding. This enables the automation of dangerous and repetitive tasks, improving safety and production. The robotic vision system is reliable in conducting processes in a controlled atmosphere. Hence, the robotic vision market in the metal processing industries shows a steady increase in the forecast period. Besides, a robotic vision system can detect mechanical deformation, missing coating, missing compound, cuts, or bents, die marks, ink or grease, foreign objects, dents, holes, and scratches during metal sheet production processes. This system enhances product quality by inspecting in 3D views and can be easily incorporated into the existing manufacturing systems to enhance the quality of the overall production process. The costs incurred in this process are nominal.

Some important processes involved in manufacturing machinery are forging, stamping, bending, forming, and machining used to shape individual pieces of metal. Welding and assembling are among the processes used to join separate parts together. These processes consume time if done manually. The shortage of skilled labor and intense competition in the market are the two major factors responsible for the increasing adoption of vision systems in the metals industry. SICK (Germany) offers 3D vision systems to inspect metal components in harsh, high-speed environments.

Food and Beverage

Robotic vision has prominent applications in the **food & beverage** industry, such as production and processing, packaging and distribution, and tracking and tracing. In the industry, specifications such as product color, ripeness, spoilage, or damage, and whether an item is undercooked or overcooked play a very important role. Robotic vision is employed to carry out inspections for the above conditions.

Robotic vision is further used to inspect, detect, track, and trace the safety of food products. The system helps the food & beverages industry enhance sanitation, correct packaging, and material handling operations to follow strict government regulations regarding food & beverage safety. Keyence Corporation (Japan) has provided both 2D and 3D vision systems to the food & beverage industry for tasks such as robot-guided candy packaging and chocolate bar inspections.

Automated packaging and palletizing has introduced quality and efficiency in packaging lines in the food & beverage industry. A major benefit of vision systems is that they are able to effectively pack objects of varying sizes and shapes. Vision systems and robots can be combined with mass and weight sensors for filling applications. Most common applications include filling vegetables or fruit trays, clamshell trays, and ready-to-eat solutions. Hence, vision systems and robots provide food automation without the need for investment in costly platens, tooling, and dedicated product lines.

Precision Engineering and Optics

Robotic vision enables the dimensional gauging of **precision-machined components**, such as fasteners and other sub-assemblies. 2D and 3D vision systems can measure these angles and diameters more accurately than the most sophisticated manual methods. The growing requirement for the supply of precision-engineered components to major industries, such as aerospace and automotive, is expected to provide growth opportunities for vision systems. In the aerospace industry, it is crucial to conduct aircraft maintenance with utmost detail. This is carried out by 3D vision technologies in the robotic system so that safety standards are maintained and preserved for a safer flight system.

For the manufacturing of solar panels, precise layering of materials, including glass, semiconductors, metals, and anti-reflective coatings, is required and then exposing them to etching, bonding, and electrochemical processing steps. The high resolution, high speed, and near-infra-red (NIR) sensitivity of robotic vision cameras allow inspection systems to reduce inspection time and boost throughput.

In precision engineering, robotic vision systems are being primarily utilized for material handling tasks. GKN (US), a precision part production supplier for the automotive industry, utilized vision systems and robots to handle transmission clutch plates and power steering components in a production line. In precision engineering, part orientation is one of the most common tasks that ensures the least amount of angular correction. Due to the small size of precision engineered components, vision systems are increasingly used for assembly operations.

Pharmaceuticals and Cosmetics

In the **pharmaceutical** industry, the inspection of packaged medicines is a critical application carried out by robotic vision systems. Inspections such as code validation, package integrity, fill level, surface defect, contamination, safety seal, cap integrity, and labeling are crucial stages of inspection in the pharmaceutical industry, which require a high level of scrutiny process for which robotic vision systems are employed at the industry premises. Additionally, the robotic vision system is also used to detect and separate foreign materials from the large batches of raw materials while processing. Besides, quality checks and quality assurance are the two critical processes in the pharmaceutical industry.

Robotic vision plays a vital role in quality checking, processing, and packaging operations. Robotic vision performs several material handing applications in potentially hazardous settings in proximity to biological dangers, such as threats of radioactive contamination and toxic chemotherapy compounds, which can be harmful to humans. High-speed inspection and sorting of blister packs, pills, syringes, and catheters are also some of the major operations in this industry. Stringent government regulations and the increasing need to combat counterfeit products are driving the growth of this market.

Others

Other industries considered are paper & printing, foundry & forging, ceramics & stone, and wood. Robotic vision plays a critical role in the **wood & paper industry**. It provides information about the visual defect and determines the optimal way to cut the boards to produce desired products. In the wood industry, vision systems also help identify defects in pulp bales, paper rolls, and paper stacks at the converting stage. The vision ensures adequate product quality as well as improved manufacturing efficiency and increases safety in the mill.

In the **paper and print industry**, vision systems help monitor and control print defects, such as plate squeeze, fill-in or spread, striation, roller marks, beading, rugged edges, chalking, pinholes, etc. Apart from these, vision systems permit the printing industry to run faster with quality printing. Machine vision systems, mostly label printers, are also used in the printing industry. These systems ensure quality in the printing processes.

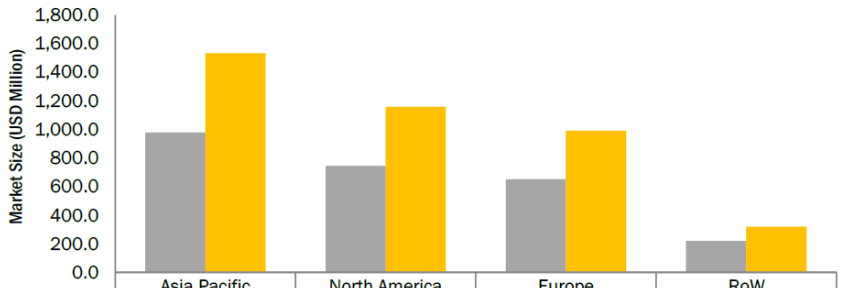
2.5 Robotic Vision Market Segmentation by Region

The robotic vision market has been segmented based on four main regions: **North America, Europe, Asia Pacific, and the Rest of the World** (RoW) (Figure 10). In North America, the US has the largest market for vision systems due to the increasing use of automation in large-scale industries such as automotive and food.

Asia Pacific dominated the robotic vision market in 2022 and is expected to reach USD 1531.7 million by 2028, at a CAGR of 9.4% between 2023 and 2028. The market growth in Asia Pacific is projected to be led by countries such as Taiwan and India, which are pushing for increased automation in manufacturing.

The robotic vision market in **Europe** is expected to reach USD 989.4 million by 2028, at the highest CAGR of 8.7% between 2023 and 2028. Industrial growth has been observed in various Eastern European countries, leading to increased penetration of vision systems in manufacturing. The presence of prominent market players, the increased importance of vision systems in various industries and the increased use of automation in large-scale industries fuel the demand for the robotic vision market worldwide.

Figure 10. Robotic Vision Market, by Region, in the Period 2023 – 2028



	Asia Pacific	North America	Europe	RoW
2023	977.1	744.6	651.7	218.1
2028	1,531.7	1,157.1	989.4	319.8
CAGR (2023–2028)	9.4%	9.2%	8.7%	7.9%

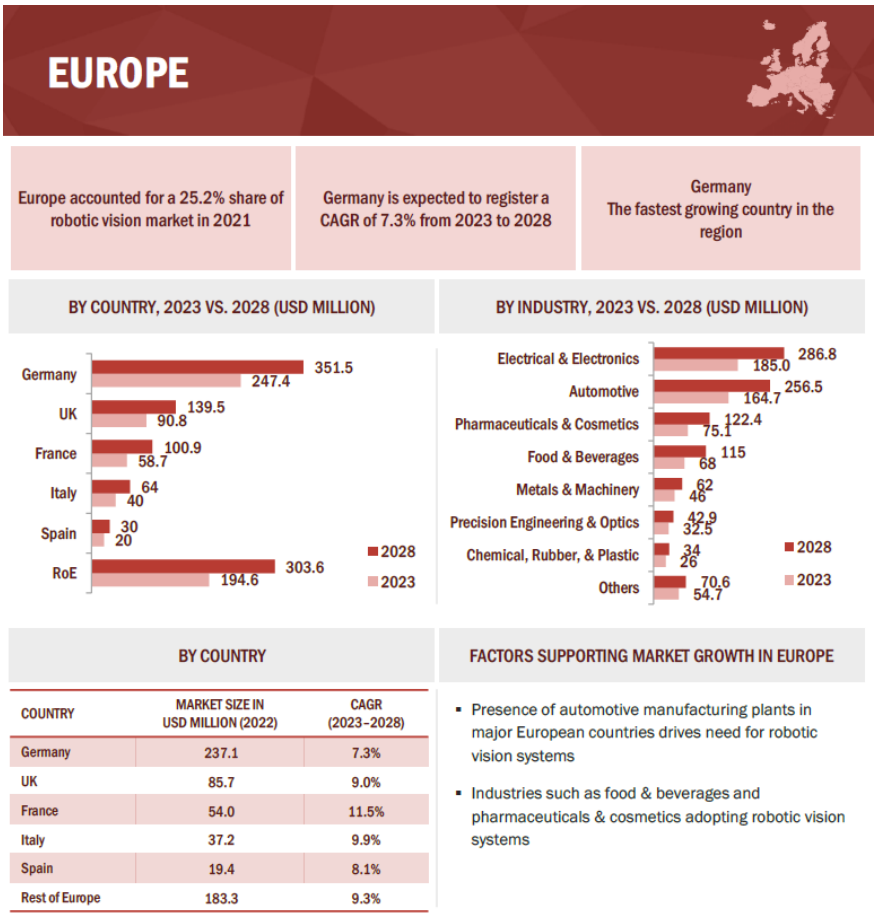
2.5.1 Focus on Europe

The robotic vision market in Europe is witnessing growth as the region serves numerous active industries and companies. The European industry possesses a strong technical and commercial competence in the robotic vision sector in several Member States – notably, France, Germany, Italy, Sweden, and the UK. In Europe, vision systems are relevant not only for large enterprises but also for smaller enterprises. Government initiatives, such as Industry 4.0 and the penetration of IoT and AI, are expected to boost vision software development in the coming years.

The European Machine Vision Association (EMVA) has supported the success of the machine vision industry in Europe and has forecast a positive outlook for the market in this region. The EMVA continuously supports robotic vision technology by offering and expanding the range of member benefits and acting as the European industry voice of the machine vision community.

Germany, the UK, and France are some of the leading markets for robotic vision systems in Europe. Industrial growth has also been observed in Eastern Europe, leading to increased penetration of vision systems in manufacturing. Automotive, electrical & electronics, pharmaceuticals, and food & beverages are the primary adopters of European robotic vision systems. Due to the upswing of the automotive industry and economic fluctuations in the pharmaceutical and food & beverage industries, traditional customer industries are expected to remain the backbone for the turnover of vision technology companies in Europe. All these factors are expected to boost the robotic vision market in this region. Some of the major **players** operating in the robotic vision market in Europe include Basler AG (Germany), SICK AG (Germany), ISRA Vision (Germany), Tordivel AS (Norway), Hexagon AB (Sweden), ABB (Switzerland), and IDS (Imaging Development System) (Germany).

Figure 11. Europe: Robotic Vision Market Snapshot



BY COUNTRY

COUNTRY	MARKET SIZE IN USD MILLION (2022)	CAGR (2023-2028)
Germany	237.1	7.3%
UK	85.7	9.0%
France	54.0	11.5%
Italy	37.2	9.9%
Spain	19.4	8.1%
Rest of Europe	183.3	9.3%

FACTORS SUPPORTING MARKET GROWTH IN EUROPE

- Presence of automotive manufacturing plants in major European countries drives need for robotic vision systems
- Industries such as food & beverages and pharmaceuticals & cosmetics adopting robotic vision systems

3 Competitive Landscape of Machine and Robotic Vision Market

The **machine vision** and **robotic vision systems** have the **major players in common**, and more precisely:

- **Machine vision**: **Cognex Corporation (US), Basler AG (Germany), Keyence Corporation (Japan)**, Teledyne Technologies (US), and TKH Group (Netherlands), which cumulatively accounted for **20–30% market share in 2022**. Other companies working toward strengthening their market position by developing innovative technologies include **Omron Corporation (Japan**), National Instrument Corporation (US), **Sick AG (Germany)**, Sony Corporation (Japan), Texas Instruments Incorporated (US), Intel Corporation (US), Atlas Copco (Sweden), and Microsoft (US).
- **Robotic vision**: **Cognex Corporation (US), Basler AG (Germany), Keyence Corporation (Japan),** National Instruments Corporation (US), and FANUC Corporation (Japan), which cumulatively accounted for **49-54% market share in 2022.** Other companies working toward strengthening their market position by developing innovative technologies include Teledyne DALSA (Canada), **SICK AG (Germany**), Tordivel AS (Norway), Hexagon AB (Sweden), Advantech (Taiwan), Yaskawa Electric Corporation (Japan), ISRA Vision (Germany), **OMRON Corporation (Japan)**, ABB (Switzerland), Qualcomm Technologies, Inc. (US).

Italian players cited in the reports consulted include the following:

- Alkeria: is a starting block company that design and manufacture high-performance machine vision cameras for scientific and industrial applications and operates in the consumer electronics, solar panel, pharmaceutical, textile, food & packaging and automotive market;
- Euclid labs: manufacturer 2D/3D vision system for robotics and industrial automation and operates in the metals & machinery and precision engineering market;
- Datalogic: global technology leader in the automatic data capture and factory automation markets, specialized in the designing and production of bar code readers, mobile computers, sensors for detection, measurement and safety, RFID, vision and laser marking systems;
- Keyence: subsidiary of Keyence Corporation, global leader in the production of components for industrial automation;
- Qbrobotics: company active in the development of *soft robotics* systems. Qbrobotics offers the qb SoftHand hand-shaped gripper in two variants: industry and research. The gripper consists of five human-like fingers that can hold or grasp objects.

The main players active in the **robotic vision market**, are reported in the Table 3. Many players are European, especially located in **Germany**.

Table 3. Main Players in the Robotic Vision Market

Company	Geography	Description	Website
ABB	Switzerland	Leading supplier of **industrial robots** and modular manufacturing systems and services. The company operates mainly in robotics, power, heavy electrical equipment, and automation technology	https://new.abb.com/it
Basler AG	Germany	Basler AG is one of the leading suppliers and manufacturers of image-processing components for vision system technologies. The company offers area and line scan cameras, **lenses**, frame grabbers, light modules, software, embedded vision modules, and solutions	https://www.baslerweb.com/en/
Cognex Corporation	USA	Cognex Corporation is one of the leading providers of robotic vision systems. The company offers a variety of vision system components such as cameras, smart cameras, sensors and software	https://www.cognex.com
FANUC CORPORATION	Japan	One of the leading companies offering **robotics** and vision systems worldwide	https://www.fanuc.eu/it/it

Company	Geography	Description	Website
Hexagon AB	Sweden	Global leader in sensor, software and autonomous solutions	https://hexagon.com/it/
IDS Imaging Development Systems GmbH	Germany	The company has a diverse range of cameras, including Ensenso 3D, uEye and IDS NXT cameras	https://en.ids-imaging.com/
Industrial Vision Systems	UK	Manufactures and integrates vision systems for **inspection**, guidance, production, identification, measurement, tracking and counting. The company also provides vision components such as vision cameras, vision sensors, and integrated vision systems	https://www.industrialvision.co.uk/
ISRA VISION	Germany	Leading companies developing **surface inspection** systems. The company is among the leading providers of image processing systems and specializes in 3D machine vision, particularly for 3D robot vision and 3D precision metrology	https://www.isravision.com/en-en
Keyence Corporation	Japan	The player offers vision system line-ups, from vision sensors with integrated lighting to modular vision systems supporting area cameras, line scan and 3D cameras, and laser profilers. These hardware and advanced software algorithms combine to make Keyence robotic vision the most stable solution for appearance and defect inspection, counting, positioning, measurement and code reading applications	https://www.keyence.it/
National Instruments Corp.	USA	National Instruments Corporation (NI) provides advanced vision system products and offers customers low-cost solutions. NI offers a wide range of vision systems and is known for being a strong manufacturer and distributor of vision products	https://www.ni.com/en.html
OMRON Corporation	Japan	The company's product portfolio includes vision systems, PC vision systems, smart cameras, industrial cameras, lighting systems, and **lenses**	https://www.omron.com/global/en/
SICK AG	Germany	The company is focused on developing and marketing sensors, systems, and services for industrial automation technology	SICK Germany | SICK
STEMMER IMAGING Ltd.	Germany	The company offers 2D and 3D smart vision systems, multi-cameras, smart cameras, 3D cameras, area scan cameras, cables, **optics**, vision computers and software in its robotic vision product portfolio	https://www.stemmer-imaging.com/s/?language=en_US
Tordivel AS	Norway	Leading **robotic vision** company that develops and delivers vision systems based on scorpion vision software technology	Tordivel AS (scorpionvision.com)
VITRONIC	Germany	Vitronic offers 2D and 3D **robotic vision** systems	https://www.vitronic.com/en-us/corporate-home
Wenglor Sensoric GmbH	Germany	The company provides smart cameras, vision sensors, illumination, **lenses**, optical character recognition (OCR) readers and vision systems	https://www.wenglor.com/it/
Zivid	Norway	The company provides vision components for **robotic vision** systems, such as cameras and software	https://www.zivid.com/

4 Conclusions

Machine vision technology facilitates a computing device to identify, evaluate, and inspect still or moving objects. Machine vision systems are integrated with critical components such as digital cameras, back-end image processing hardware, and software.

Robotic vision systems involve a robot fitted with one or more vision cameras used as a visual aid to provide a feedback signal to the robot controller or PC (personal computer) to move the robot to a target position or object. Robotic vision comprises 2D and 3D vision systems. The vision system performs tasks such as material handling, measurement, inspection, and testing, welding and soldering, assembling and disassembling, packaging and palletizing, painting and cutting, pressing, grinding, and deburring to automate the production process in the manufacturing industry. The demand for robotic vision is increasing owing to the growing demand for quality products as well as the rising need for quality inspection with automated robotic vision systems.

The **global robotic vision market** was valued at USD 2,591.4 million in 2023 and is projected to reach USD 3,998 million by 2028; the market will record a CAGR of 9.1% between 2023 to 2028. The major factors driving the robotic vision market are the growing need for automation and quality inspection in the industries and the capability of 3D vision systems allowing robotic systems to perform more than one task without reprogramming.

The **electrical & electronics industry** held the largest market share of 30.4% in 2022 and is projected to grow at a CAGR of 9.5% from 2023 to 2028 to reach USD 1246.8 million by 2028. The growth of the segment is attributed to the significant increase in the use of industrial robots in the electrical & electronics industry. Vision systems enable precise handling of small and delicate parts, allowing manufacturers to increase uptime and minimize waste. The **food & beverages industry** is witnessing the highest CAGR due to increased food automation worldwide. Growing demand for packetized food & beverages worldwide, along with stringent regulations from the food authorities, is increasing the need for robotic vision systems in the food & beverages industry.

The two types of lenses that are being widely used in the robotic vision system are entocentric and **telecentric** lenses. The entocentric standard lenses, which have fixed focal lengths, are normally used for general applications such as pick-and-place, barcode reading, and print image inspection. For applications such as visual testing and measurement and defect detection that need precise measurement, **telecentric** lenses are used.

5 Sources

MarketsandMarkets Knowledge Store - Multisectoral database that collects market research reports in various technological fields and designed to process some information interactively. More than 1,200 market reports are published each year (https://www.mnmks.com/)[1]. The information provided have been extracted by the reports:

- "Machine Vision Market – Global Forecast to 2028", October 2023;
- "Robotic Vision Market – Global Forecast to 2028", July 2023.