e-con Systems™
Your Product Development Partner

Embedded Vision: Its role in transforming **Industry 4.0** using **Robotics**

Whitepaper ▶

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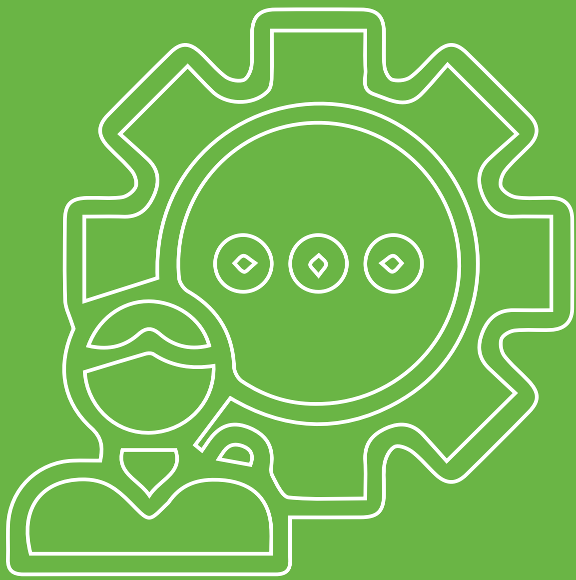


1. SETTING THE CONTEXT

1.1 From the first industrial revolution to Industry 4.0

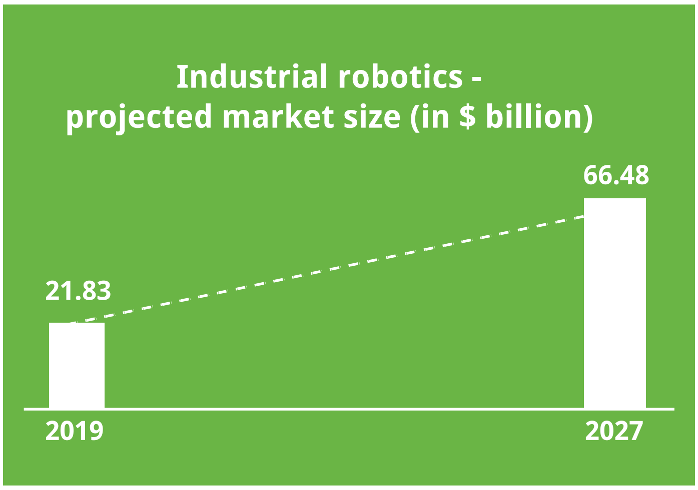
Industrial revolution had its inception in the 18th century. The first industrial revolution was characterized by a shift from an agrarian and handicraft society to a more machine oriented and urban economy. The second saw electricity dominate industries and households in the late 1800s and early 19th century, whereas the third revolution witnessed computers making automation faster and more efficient leveraging processing power and internet connectivity in the second half of the 20th century. The fourth industrial revolution – or Industry 4.0 – is all about making systems smart and autonomous by harnessing the power of machine learning, artificial intelligence, internet of things (IoT), and edge computing to enable faster decision making. And robots play a key role in creating a smart industrial environment leveraging these new advancements fuelled by Industry 4.0.

To derive outcomes effectively from these technologies, robots need to collect data on their surroundings which can further be processed and analyzed to enable smarter decision making. With advancements in processing power, sensor technology and edge AI, embedded vision is now able to augment robots with better and faster data collection through accurate and reliable image and video capture.

This whitepaper attempts to explore how embedded vision contributes to building a smart, connected and efficient industrial environment by becoming the 'eye' of robots to accelerate the outcomes of Industry 4.0.

1.2 A quick look at the market

Industry 4.0 is no more a buzzword. Businesses have already started deriving value from it. McKinsey says Industry 4.0 is expected to deliver between $1.2 trillion and $3.7 trillion in gains by 2025 globally. With increasing focus on automation and autonomous tasks, robotics will play a key role in driving industrial growth. According to Fortune Business Insights, the global industrial robots market stood at $21.83 billion in 2019 and is projected to reach $66.48 billion by 2027, exhibiting a CAGR of 15.1% during the forecast period. Assuming cameras account for 1% of a robot's cost, the size of robotics vision market in the industrial segment will easily exceed $600 million by the end of 2027.



The industrial robotic vision market is expected to cross

$600 million by 2027.

Even though the implementation of vision is not limited to the boundaries of embedded vision, it definitely would take a major share of the pie.

1.3 Understanding Embedded Vision

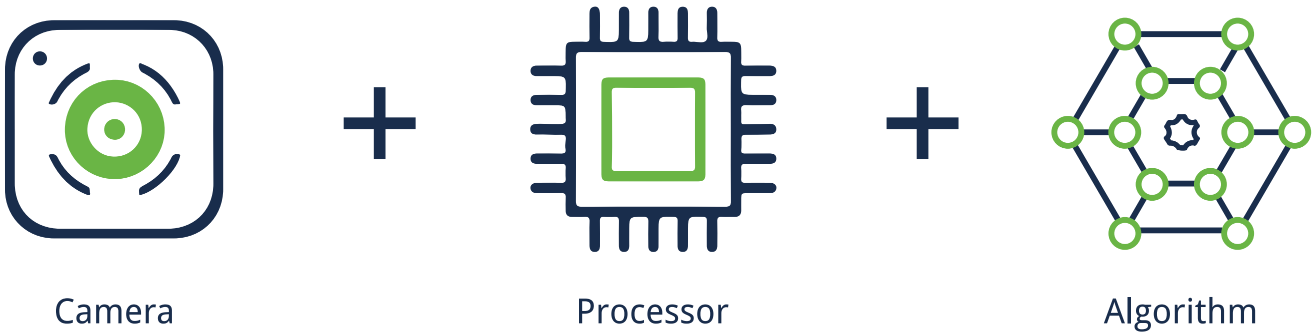
Before we dig deep into how embedded vision can transform Industry 4.0 using robotics, let us first try to understand what embedded vision means.

Embedded vision is a combination of embedded system and computer vision which allows a machine to perform intelligent tasks. Embedded vision involves integrating cameras into embedded products, which opens up the possibility of extending the set of use cases and functionalities embedded devices can serve.

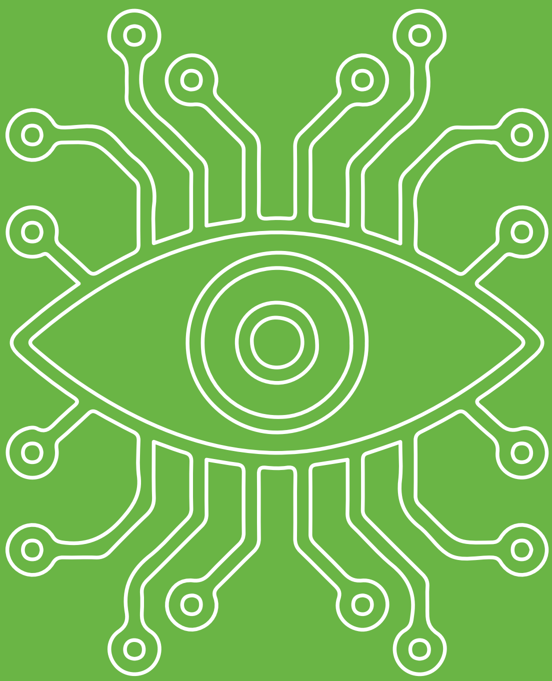
There has been a surge in the adoption of embedded vision technology across a wide variety of industries and applications such as factory automation, advanced driver assistance, gaming & entertainment, medical diagnosis, smart retail devices, and more.

Traditionally, vision systems were comprised of a large PC and a camera. They were equipped with an interface card to import the captured images, and the software to analyze the images and pass on the information to another system. In contrast, embedded vision involves the integration of a camera and a processing board. It can also be called an all-in-one device technology, where the camera is coupled with an image processor for image capture and processing in a single system. Embedded vision – by means of integration of computer vision into machines – enables the use of algorithms to decode meaning by observing pixel patterns in images and videos. The below figure illustrates the various components that form an embedded vision system:

Representation of an embedded vision system



Vision guided assembly robot in a **car manufacturing plant**



2. EMBEDDED VISION FOR INDUSTRY 4.0

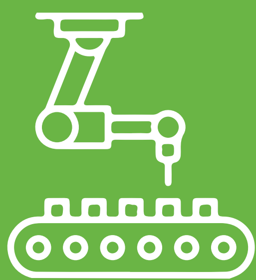
While the focus of this whitepaper is to understand how embedded vision is applied in robotics, it is essential to understand its penetration and how it impacts Industry 4.0 in general, which is what we will attempt to do in this section.

In Industry 4.0, embedded vision made a breakthrough and found its way into a broad range of applications such as inspection & sorting systems, monitoring, material & freight handling, etc. During this revolution, the evolution of image sensors, easy accessibility of computing and storage via remote AWS, Azure or Google cloud, and tiny but powerful embedded processors made embedded vision more affordable and reliable. And it also enabled smart machines to view, compute, understand and make decisions on their own with very less or hardly any human intervention. Manufacturers have integrated embedded vision into robots, driverless vehicles, fleets & heavy equipment, industrial handhelds, conveyor monitoring systems, etc.

One of the reasons for embedded vision taking a huge leap in Industry 4.0 is the application of deep learning and machine learning. Using neural networks, they can power applications to identify specific features from a collection of images – thereby constantly learning to 'see' better and 'think' smarter in warehouses or factory floors.

Embedded vision has positively impacted Industry 4.0 predominantly in three different ways:

Enabling smarter technology on the floor



Accelerating the production line

Maximizing the power of robotics

Let's look at these three in detail.

2.1 Enabling smarter technology on the floor

The advancements in technology concerning the quality of imaging, efficiency of sensors, and processing power have increased the impact of embedded vision in the industrial segment. These improvements have made transmission of data easier and hassle-free in factory and warehouse floors. From being the eye of rugged industrial tablets to enabling autonomous navigation, embedded vision has led to a high degree of automation and acted as a catalyst to Industry 4.0.

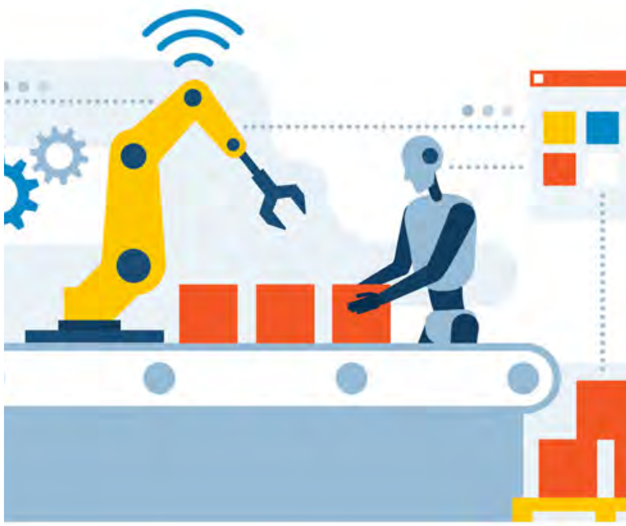
2.2 Accelerating the production line

Embedded vision has played a major role in accelerating and simplifying production/packaging lines. For instance, a multi-camera setup can not only evaluate the right measurements, but also share this information with PCs for intelligent business automation. Even a single camera setup can speed up existing production lines by helping automate tasks like Non Destructive Testing (NDT).

2.3 Maximizing the power of robotics

Robots have become part and parcel of the Industry 4.0 dynamics. They have been acting as guided systems to carry out a variety of critical tasks across warehouses and factory floors. Embedded vision contributes to this by providing vision to robotic pickers and forklifts, telepresence robots, inspection robots, etc.

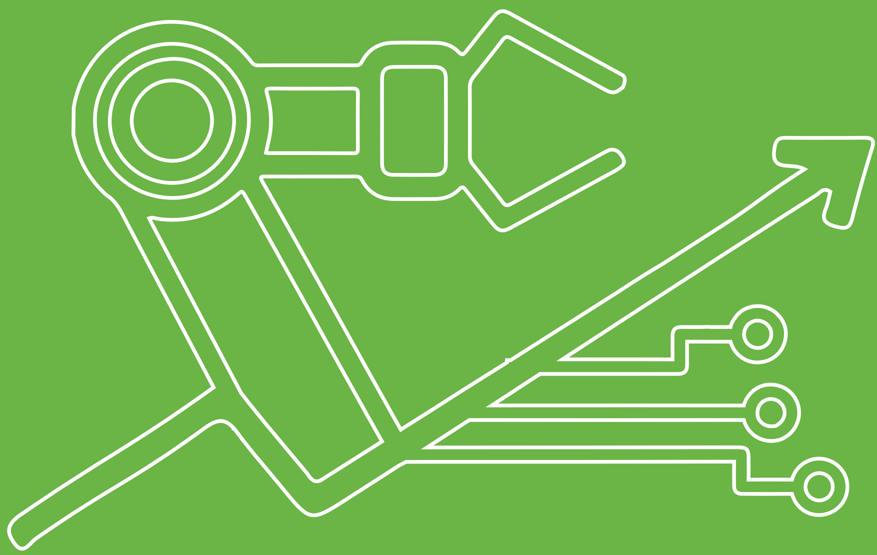
As with its previous phases, Industry 4.0 also is dictated by the latest trends that future-ready businesses have capitalized upon. In that sense, the leaders in this space are setting the standards for the rest to follow.



Let's look at five recent trends pertaining to embedded vision in industry 4.0.

- 3D measurement and guidance support – with an accurate measure of depth and real-time data on positioning.
- Cameras with short-wave infrared technology for higher resolution imaging in difficult lighting conditions.
- Liquid lenses for smarter barcode reading.
- Automated anomaly detection with higher accuracy using computer vision and AI algorithms
- Augmented thermal imaging analysis for a wider visible spectrum.

The 5 trends stated above cut across different types of robots used in the industrial environment. Robotics is a fast-evolving space, and many a times, its trends can change at lightning speed. The typical lifetime of robots is in the range of 5-10 years (or sometimes more). Hence, cameras also have to be designed and built keeping that in mind, and camera manufacturers need to ensure supply for such a longer period. So, the trends we see today are likely to drive the change in these years when it comes to embedded vision in Industry 4.0.



3. EMBEDDED VISION – CHALLENGES AND PITFALLS IN ROBOTICS, AND HOW TO OVERCOME THEM

According to an independent study conducted by e-con Systems among companies with a potential camera-based product, 80% of the respondents said that they are planning to develop a vision-based product, or intend to upgrade an existing one. So, there seems to be an innate need to build camera-based products among technologists and product engineers. However, integrating vision into a product comes with its own set of challenges and pitfalls. Hence businesses are recommended to work with a specialized camera partner to navigate past these.

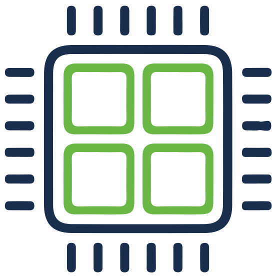
80%

people in companies with a potential camera based product said they are developing a vision based product, or upgrading an existing one.

3.1 Common challenges of robotic vision

When we say ‘robotic vision’, we are referring to the integration of cameras or vision into robots. Following are some of the most common challenges that you need to be wary of or consider while choosing a camera for your robots:

Camera mobility



Specialized processor

High-speed inspection

- **Camera mobility**

A vast majority of robots are mobile in nature. It could be the entire robot that is moving, or any of its parts – like a robotic arm – which is in motion. In either case, the quality of the images captured is badly affected due to continuous movements and jerks. Typically to overcome this, a global shutter camera or a high frame rate camera is recommended.

- **Specialized processor**

Robotic vision systems require a high-end processor with sufficient processing power to run the workloads. For pixel-level processing, specialized programmable devices such as GPUs and FPGAs can efficiently process streaming data and algorithms with large amounts of parallelism.

- **High-speed inspection**

One of the functions of an industrial robot is to inspect objects on a fast-moving conveyor belt or a production line. This limits the time available to capture an image effectively. Here also, a global shutter camera or a high frame rate camera is advised. We will talk more about this in the next section.

3.2 Common pitfalls of robotic vision

Many of the common pitfalls of embedded vision apply to robotics as well. And there are a few which are specific to robotics. Let us have a look at some of the most common of those:

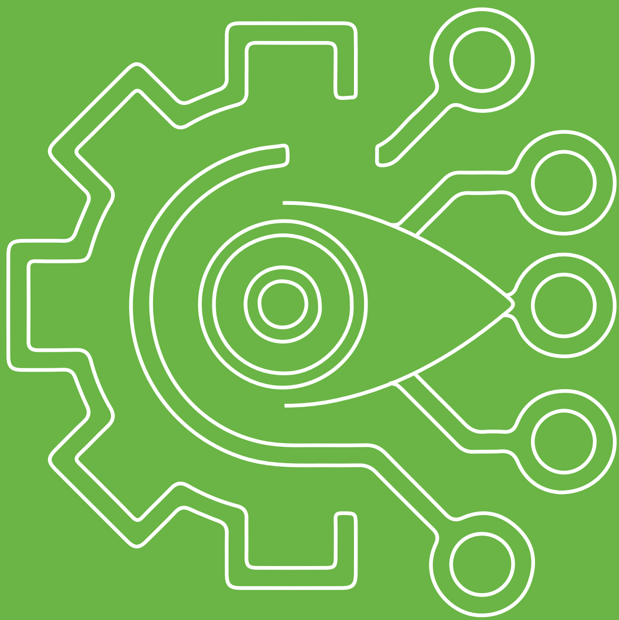
It is to be noted that not all applications which involve a moving camera or object will require a global shutter camera with a high frame rate. Many a time, either a basic global shutter camera or simply a high frame rate rolling shutter camera with low exposure time might do the job. It heavily depends on the application or use case.

1. Not every robotic application requires a global shutter and/or a high frame rate camera: It is a common misconception that all robots need a global shutter camera or a high frame rate camera, which is not true. It heavily depends on factors such as the distance to the target object, details to be captured, purpose of capture, whether the robot or object is in motion or not etc. Also, all applications involving the motion of objects or robots do not need a global shutter camera or a high frame rate camera. If the images captured exhibit rolling shutter artifacts, there are two ways to fix it. The first method is to use a global shutter camera. The second approach is to have a rolling shutter camera with a fast readout time. Further, if the cameras exhibit motion blur, simply changing the shutter speed to a very high value, that is minimizing the exposure time would solve this problem. Rolling shutter artifacts and motion blur are discussed further in section 5.1 of this whitepaper.

2. A 'one size fits all' approach does not work: Robots are used for a wide variety of tasks. And an off-the-shelf camera need not meet the requirements of the use case all the time. Cameras need to be customized in terms of the form factor, temperature tolerance, image quality, lens calibration etc. to help robots perform their desired functions reliably. Also, cameras need to be chosen by considering sensor characteristics such as resolution, shutter type, active pixels, pixel count, pixel size etc. It is also important to look at lens characteristics such as field of view, type of mount, aperture etc.

3. Vision integration is sometimes taken for granted: Integrating cameras into robots is more often complex and requires the right technical expertise in choosing the right sensor, interface, ARM platform etc. It also involves designing a solution in a way that the camera fits into a robot's architecture by doing necessary customizations. All these demand the help of a specialized camera partner who has the capability to travel with the customer throughout the product development journey – from evaluation to prototyping to mass production – and ensure that the camera is smoothly integrated into the end product.

4. Cheapest camera is not always the best camera: Every project is bound by a certain budget. However, compromising the quality of the camera used for the purpose of restricting the budget might end up in a disaster. Low-quality cameras might earn you a few dollars today, but will lead to losing thousands and even millions in the future. So, product managers and engineers need to focus on picking the best-fit camera, and not the cheapest one.



4. BENEFITS OF EMBEDDED VISION FOR ROBOTICS

In the last section, we discussed the most common challenges and pitfalls of embedded vision in robotic product development. But it is worthwhile to also look at some of the key benefits embedded vision offers, which significantly impact the performance of robots.

Increased productivity and efficiency

Lower resource consumption

Lower cost

Faster time to market

4.1 Increased productivity and efficiency

Robots have been delivering huge efficiency gains in Industry 4.0 across multiple areas such as manufacturing, supply chain & logistics, inventory management etc. They do this by completing tasks faster with greater accuracy. Robots are also automating mundane – and to some extent intelligent – tasks so that employees are able to focus on their core or business-centric activities.

With vision, robots are able to read barcodes reliably, detect and identify objects, and navigate shop floors effectively. They are also able to perform actions which otherwise needed humans such as remote inventory management (using telepresence robots), pick and place, automated quality inspection etc. These lead to reduced defect rate in a production line, ability to operate during non-working hours, and better production output owing to reduced hours on routine tasks.

Given below are the images of a pick and place robot and telepresence robot.

Pick and place robot

Telepresence robot

4.2 Lower resource consumption

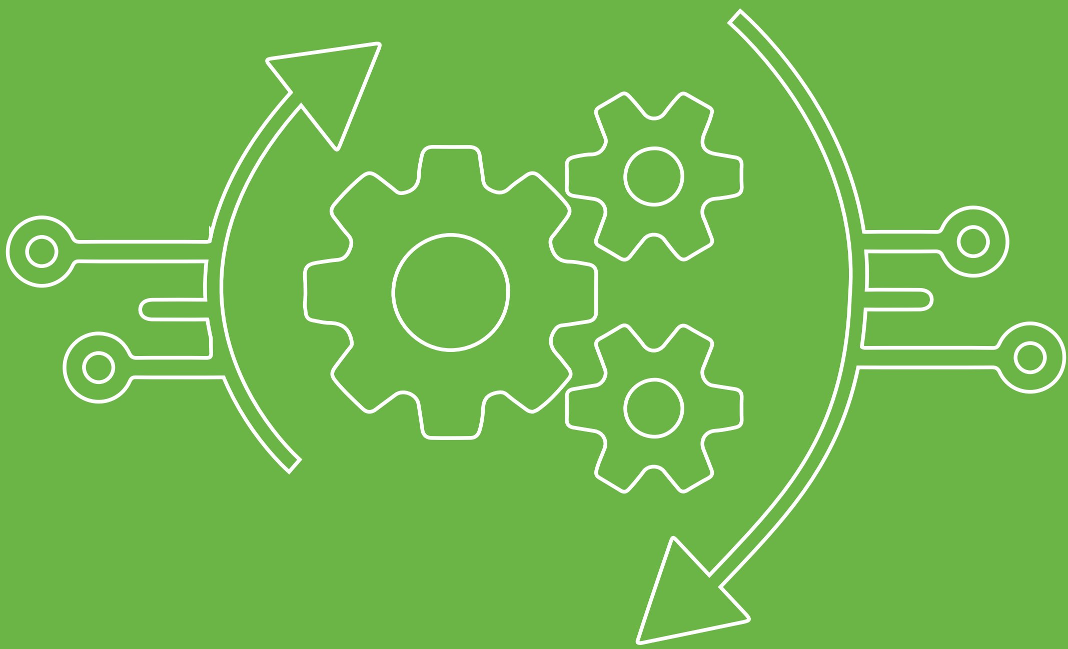
We are in an era where traditional machine vision PCs can be replaced using much smaller and compact edge computing devices. Also, with the level of research undergone to improve computer vision algorithms over the past decade, traditional algorithms require lesser computing power & memory to run on.

4.3 Lower cost

With embedded vision starting to replace bulky machine vision systems in industrial environments, robots will penetrate into more applications and use cases. In addition to the cost savings achieved by using a compact system, an increased amount of automation is also likely to deliver lower costs owing to higher productivity and efficiency.

4.4 Faster production

Embedded vision is faster to set up, easier to program, and more convenient to replace if the devices fail. Also, increased automation in quality inspection, product sorting, predictive maintenance, product and component assembly etc. will also result in faster and more efficient production.



5. EMBEDDED VISION IN ROBOTICS: A KEY TO TRANSFORMING INDUSTRY 4.0

We have already discussed how embedded vision impacts Industry 4.0 in section 3. In this section, we will focus on how vision makes a difference to Industry 4.0 by enhancing robots and their functionalities. As per the World Robotics 2020 - Industrial Robots Report - published by the IFR (International Federation of Robotics), 2.7 million robots are operating in factories around the world in 2019. This was an 85% increase from 2014.

2.7 million

industrial robots are operating in factories globally

Number of industrial robots in factories increased by

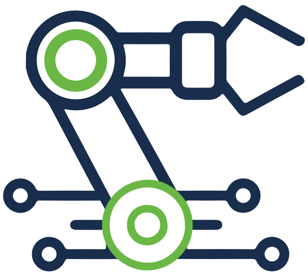
85%

from 2014 to 2019

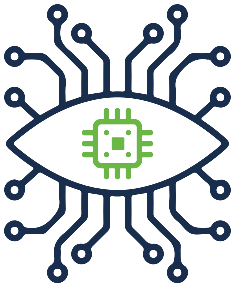
"The stock of industrial robots operating in factories around the world today marks the highest level in history," says Milton Guerry, President of the International Federation of Robotics.

Also, the adoption of human-robot collaboration is also on the rise. The IFR report says that co-bot (or collaborative robots) installations grew by 11% in 2019. Interestingly, embedded vision finds applications in traditional robots as well as collaborative robots.

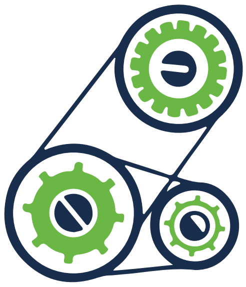
We would look at the importance of vision in robotics and Industry 4.0 through three different lenses:



Vision system in robotic arms



Processors for a robotic vision system



Vision based applications of robotics in Industry 4.0

Let us dive deep into each of them

5.1 Vision system in robotic arms

One of the key functions of a vision system in a robot is to provide the exact coordinates of the target objects which are placed disorderly in the camera's field of view (FOV). This enables the robot's arms to focus the attached end effector on the selected component, thereby helping in barcode reading, picking, lifting etc.

A perfect example for a use case involving the above would be conveyor tracking in a packaging application. When the product or target object is in motion on the conveyor belt, the vision system assists in determining the accurate position of the object in the moving belt. This allows the robotic arm to pick the object while it is in motion. Here the vision system simplifies the design of the production line and enables the robot to accurately pick objects without having to stop the conveyor using expensive fixturing. This also results in significant cost reductions in factory operations.

While designing a robotic arm, there are some key factors you should consider with respect to vision:

2D vision, 3D vision or a multi camera vision system?

As already discussed, choosing the right vision or camera system heavily depends on the end application. A 2D vision system will capture an image, and provide the object's length and width. However, a 2D vision system cannot capture the height information of the target object. 2D cameras are typically used when the robotic arms need to inspect and identify objects by capturing barcodes pasted on a box and pick it based on the barcode values.

At the same time, a 3D vision system can capture information along all the three axes. There are numerous applications where a robotic arm needs to recognize the right object by capturing and analyzing three-dimensional coordinates and other details. In such cases, a single camera or multi-synchronized camera system that can act as a stereo pair for 3D is recommended. Also, it is important to choose a processor which has the capability to handle data captured by a multi-camera setup. For instance, the NVIDIA® Jetson AGX Xavier™ processor comes with the ability of receiving and processing image data from up to six Full HD cameras.

Motion blur and rolling shutter artifacts

In general, robotic arms move fast. While picking a pack from a moving conveyer belt or checking the quality of a finished good in motion, cameras in a robot need to capture images of fast-moving objects. This leads to motion blur in the output image. For better understanding, have a look at the below comparison to see the difference between images captured using a low shutter speed camera and a high shutter speed one:

Image captured with low shutter speed camera

Image captured with a high shutter speed camera

Motion blur can be avoided by using a camera with low exposure time (faster shutter speed). This will ensure that the maximum number of frames is captured in less time. A caveat of this method is that this could sometimes lead to underexposed frames depending upon the lighting condition. It is crucial to take into consideration the lighting in the scene before adjusting the exposure time. Additional lighting can be added at the scene to compensate for the reduction in exposure time.

Now, let us try to understand rolling shutter artifact. In rolling shutter mode, a frame is exposed line by line. Due to this, images of fast-moving objects could appear distorted. Have a look at the below comparison to understand the difference between images captured using a rolling shutter and global shutter camera

In a global shutter camera, each pixel on the sensor begins and ends exposure simultaneously. Since the entire frame is exposed at once, an exact image of the scene is replicated. Hence, if the motion of the target object is fast enough to create artifacts, a global shutter camera is recommended. However, global shutter sensors are more expensive, and need not be used for low-end applications where the output quality is not significantly impacted by the motion of the object.

Long cable

MIPI CSI-2 is the most popular embedded processor interface for Edge AI. However, the limitation is that the length of the cable cannot be beyond 1 meter. Many robots require long-distance transmission due to their complex structure and the kind of use case involved. Today, technologies such as GMSL and FPD link allow to take MIPI data up to a distance of 15 to 20 meters. In addition to this, selecting a rugged industrial connector is also critical for seamless connectivity.

Edge AI capable processor

A robot is a complex machine. And to make intelligent decisions, they need to run heavy computer vision algorithms on multiple camera streams. They further apply machine learning to process and analyze the data at the edge. In computing, floating point operations per second (FLOPS) is used to measure the performance of a computer or edge processor. The higher the FLOPS better is its computational performance. It is imperative to choose a processor capable of running such algorithms to provide the required output.

5.2 Processors for a robotic vision system

We already discussed the relevance of using high-end processors in robotic vision systems in the previous section. Now let us have a look at the different types of processors that can be used in robotic vision systems.

NVIDIA® Jetson™ processor family

NVIDIA®'s Jetson family of processors are a powerful solution for the development of embedded AI applications. NVIDIA® Jetson™ is a series of embedded computing boards designed for accelerating time to market. These processors span from affordable options such as the Jetson Nano to the more advanced AGX Xavier with a wide range of computing performance ranging from 0.472 TFLOPS to 32 TOPS. They can be used for low-end applications to extremely complex edge AI and deep learning-based applications.

Intel® Atom processor family & FPGAs

The low-powered Atom series of processors from Intel provide a good balance of performance and power for low-end compute applications. Intel FPGAs are recommended when high speed and very low latency I/O are required. They can be used for applications which require a customized architecture and faster acceleration of business logic. The Intel Myriad X from the Movidius™ family is an edge AI accelerator which allows to perform deep learning at the edge with its 1 TOPS of AI compute power.

Google Coral edge Tensor Processing Unit (TPU)

The Edge TPU from Google is a custom ASIC designed for edge AI applications. It is designed to complement a host CPU for accelerating AI workloads while the main CPU performs the business logic. The Google Coral Edge TPU accelerator is available in USB and PCIe variants to enable integration with a variety of host processors. Its AI compute performance of 4 TOPS with a power budget of 2 Watts allows it to be used in many edge-based robotic vision systems.

NXP i.MX series of application processors

Based on the ARM architecture, the NXP i.MX series of processors can be used for creating power-efficient robotic vision systems. Because of their capability to interface with multiple MIPI CSI2 based cameras as well as perform edge computing, they make a good choice for building intelligent solutions for robots and industrial use cases. i.MX7 series of application processors are great for building low-end solutions such as industrial grade tablets, while the i.MX8 family of applications are much more powerful and can be used for much more advanced machine visual inspection solutions.

Xilinx MPSoCs & FPGAs

With a wide portfolio of FPGAs, SoCs and MPSoCs, Xilinx caters to both the low-end and high-end industrial requirements. The heterogeneous embedded processing capabilities of the Zynq UltraScale + MPSoCs allow for complex use cases. They can be used to run business logic on the ARM core as well as the FPGA core in a single die. This provides a lot of flexibility and scalability to customize an industrial solution such as vision-guided robots with advanced motor control. The recently launched Kria K26 SOMs are powerful enough to run deep learning workloads on the edge at a low power budget. It allows for configurable AI performance using the Vitis AI toolkit.

5.3 Vision based applications of robots in Industry 4.0

In the previous section, we focused primarily on the technical details of robotic vision systems. To better comprehend how robotic vision impacts Industry 4.0, it is important to understand its applications in an industrial environment. The following infographic illustrates some of the key applications of embedded vision in industrial robotics:

- **Cutting and sawing**
- **Non Destructive Testing (NDT)**
- **Machine tending**
- **Material handling, picking, packaging and placing**
- **Automated dimensioning**
- **Remote warehouse management**

Cutting and sawing

Robots integrated with a vision system can understand the orientation of an object in order to cut it precisely. Assessing the coordinates, shape, size, orientation etc of the target object will be challenging without the help of a camera. Industrial cutting robots and machines are used to cut wood, cardboard, metals etc. Another example for this application is detecting and stopping a sawing machine if it reaches the close proximity of a human being or human hand.

Introducing vision to a traditional industrial process like cutting and sawing has improved safety and precision by leveraging edge processing and artificial intelligence, thereby forming an integral part of the Industry 4.0 transformation.

Material handling, picking, packaging, and placing

Material handling involves automated picking, packaging, lifting, moving and placing of objects in factories and warehouses. Vision plays a significant role here in identifying the object using depth mapping and barcode reading. Vision also allows for seamless navigation using accurate obstacle detection.

Non Destructive Testing (NDT)

Non Destructive Testing is one of the most common use cases of robotic vision across industries. It helps to assess product quality and reduce defect rate. By leveraging connected systems created by the influence of Industry 4.0, the data obtained from NDT systems have been utilized for further analysis to optimize production and factory & warehouse operations.

Automated food inspection is a classic use case for quality assurance using robots in an industrial environment. It replaces the need for human inspectors for manually evaluating the quality attributes of food items. It helps to inspect food quickly, objectively, reliably and non-destructively.

Cameras help in NDT by identifying cracks and fissures on product surfaces, detecting adulteration in food, recognizing color variations etc.

Automated dimensioning

Automated dimensioning systems help to eliminate the problem of inaccuracy and inconsistency in measuring freight by hand, which results in inefficiencies across your supply chain, logistics and warehouse systems. Cameras in such systems help to capture images of the object to be measured along the three axes, which are further analyzed by algorithms to automatically derive dimensions. While all dimensioning systems are not robots, many robots come with automated dimensioning capabilities that are utilized for the purpose of freight management, warehouse layout optimization, load planning etc.

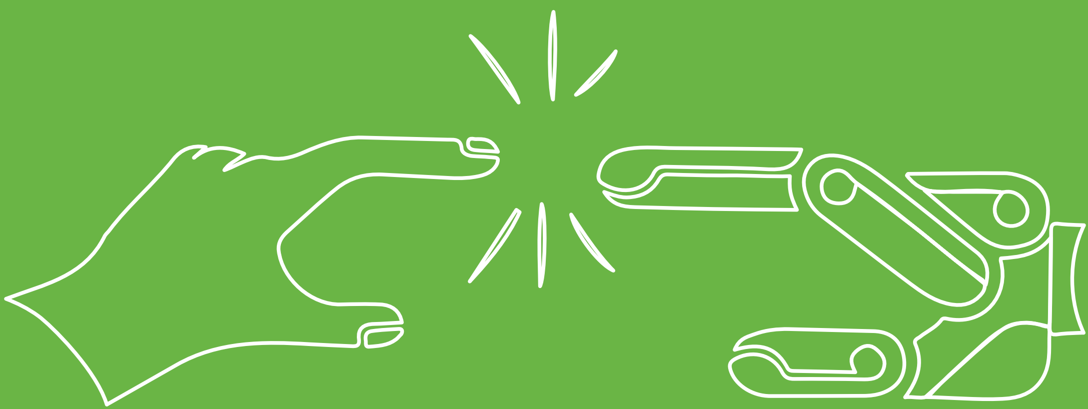
Automated dimensioning systems are finding their place in more and more smart manufacturing and warehouse environments. By providing more accurate data to Transport Management Systems (TMS) and Warehouse Management Systems (WMS), automated dimensioning will play a key role in accelerating Industry 4.0 led growth.

Machine tending

Machine tending is the process of loading and unloading raw materials and components into machinery for the purpose of cutting, shaping, milling etc. Such systems involve robotic arms picking and placing the components by leveraging cameras for accurately locating and positioning them. A process that had been traditionally done by humans, industrial automation with the help of embedded vision has enabled machine tending to evolve and grow leaps and bounds.

Remote warehouse management

With the pandemic creating a new normal, managing robots remotely is becoming a necessity than a luxury. This has led to the ability to carry out warehouse operations partially without any physical human presence on the floor. Such robots which are controlled remotely to do various tasks are called telepresence robots. In an industrial setting, they are mostly used for remote inventory management and analysis. Here also vision contributes by helping the robot to ‘see’ for the purposes of navigation, object detection, positioning etc.



6. THE FUTURE OF EMBEDDED VISION IN ROBOTICS AND INDUSTRY 4.0

Embedded vision as a technology has already been transforming multiple industrial domains such as manufacturing, supply chain and logistics, warehouse management, factory automation etc by leveraging robotics. Today, even though vision-enabled robots have been able to automate numerous tasks, many of them rely on human-machine collaboration. Use of high-quality vision systems with inbuilt algorithms along with advancements in other robotic technologies will reduce human dependency over time. However, we are far from completely eliminating human intervention. The International Federation of Robotics says that collaborative robots accounted for as many as 4.8% of the global robots shipped in 2019, and this was an 11% growth from the previous year (as we saw in section 5). So, robots will continue to work alongside humans for many years to come.

Collaborative robots accounted

for 4.8% of robots

shipped globally in 2019.

New sensors, ISPs (Image Signal Processors), and powerful ARM platforms coupled with deep learning algorithms will pave the way for embedded vision to enable this change from 'partial automation' to 'self-sufficient automation'. This tectonic shift will lead to industrial automation and robotics expanding the set of use cases they could potentially serve. We are also likely to see multi-purpose robots becoming more common instead of robots built for specialized tasks. This would increase the complexity of robotic vision systems, and would expand the feature set a camera needs to cover. Technologists and product owners would leverage this change to come up with innovative robotic solutions where cameras will not only be the 'eye', but also will become the 'heart' of such systems.

About the authors

Gomathi Sankar

Gomathi Sankar is a camera expert with 15+ years of experience in embedded product design, camera solutioning, and product development. In e-con Systems, he has built numerous camera solutions for robots, industrial handhelds, quality inspection systems, smart city applications, industrial safety systems, and more. He has played an integral part in helping hundreds of customers build their dream products by integrating the right vision technology into them.

Dilip Kumar

Dilip Kumar is a computer vision solutions architect having more than 8 years of experience in camera solutions development & edge computing. He has spearheaded research & development of computer vision & AI products for the currently nascent edge AI industry. He has been at the forefront of building multiple vision based products using embedded SoCs for industrial use cases such as Autonomous Mobile Robots, AI based video analytics systems, Drone based inspection & surveillance systems.

e-con Systems™
Your Product Development Partner

About e-con Systems

e-con Systems™ strives to become a global leader in the embedded vision space through continuous innovation, and helping its customers accelerate product development and reduce time to market. It has built over 250+ product solutions and shipped over millions of cameras around the globe. What sets the company apart is its deep expertise in building customized product designs while ensuring rapid prototyping and custom modifications in hardware as well as software.

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