Vision solutions for robotics

Precise position determination the key to more efficiency

Contents

Introduction

This e-book discusses the challenges associated with the precise localization of objects in production and logistics as well as their significance for increasing efficiency and flexibility.

The focus is on modern robotics and associated sensor solutions, in particular in the area of Robot Vision. By being able to determine positions precisely, this technology has the potential to accelerate numerous processes. Challenges, such as integrating the technology into existing structures, are analyzed in this e-book. Solution approaches are also presented and illustrated using practical examples. Detailed insights into the technology and sensor options have also been included.

By using robotics and advanced sensor solutions, companies can respond in a forward-thinking manner and secure a strong competitive position.

Robotics in production and logistics

Future-oriented machine vision solutions

Image-based detection systems and AI-assisted technologies enable a robot to manage complex tasks and make precise decisions. In the following section we will explain in more detail the challenges in production and logistics as well as the potential of modern sensor solutions.

Growing requirements

Determining the current situation precisely

Growing requirements

Robotics

Growing requirements

Determining the current situation precisely

A key challenge in production is keeping up with the pace of technological processes and successfully managing digital transformation. Achieving growth requires flexibility, agility, and the ability to quickly adapt to changes. The key areas of focus are enhancing customer requirements, decreasing product life cycles, increasing complexity of some manufacturing processes, and greater global competition.

Introducing new technologies such as the Internet of Things (IoT) and artificial intelligence (AI) requires investment and automation of production and business processes. Furthermore, sensitive data within a networked production environment must be protected against unauthorized access. Recruiting and retaining qualified employees presents another hurdle with changing demographics and a shortage of skilled workers.

To ensure the future viability of production, companies need to concentrate on lifelong learning and the ongoing development of their teams. Last but not least, sustainability is playing an ever greater role. This makes it necessary to make production processes more resource efficient and environmentally friendly. Overcoming these challenges demands strategic planning, a holistic approach, and a willingness to allow – and drive – innovation.

Determining the current situation precisely

Robotics

Growing requirements

Determining the current situation precisely

Automation in production is of key importance when it comes to utilizing the potential of new technologies. When implemented appropriately, automation significantly increases efficiency. Using suitable systems increases the speed at which goods can be manufactured and made available and minimizes human error. This enables numerous tasks to be performed precisely and reliably. Furthermore, the automation of quality assurance lowers costs by reducing the scrap rate. Industrial robots, cobots and other machines can perform repetitive processes with high (reproducible) accuracy, which leads to a significant increase in productivity. Automation also allows continuous manufacturing around the clock – with no breaks or human fatigue. It also reduces monotonous work for people. Another advantage: Precise monitoring and control of production processes.

There are concerns that the current technological advances are eliminating jobs. Machines are taking over human activities and performing them more quickly, more efficiently and better. This results in job losses, restructuring and social impacts such as unemployment and inequality. A prediction, based on level of qualification, of the potential proportion of jobs in Germany put at risk by automation found the following: 62 % of qualified staff, 23 % of auxiliary staff, and 9 % and 5 % respectively of specialists and experts will be directly affected by this change by 2025.[1] On the other hand, as was the case for every previous industrial revolution, automation opens up new possibilities. Put simply, the manufacturing volume will increase on the same footprint. Associated with this, in the most favorable case, the growth will also result in extended production facilities, which in turn will lead to a demand for trained staff. This will include, for example, the areas of maintenance, control and monitoring of systems. The associated processes will also need to be smoothly and continuously coordinated.

It is important to take the aforementioned concerns seriously and at the same time focus on retraining, lifelong learning, and foster new jobs in growth areas of the economy. This alleviates the impacts of the technological progress on the job market or allows them to be managed and advantages gained from them. Furthermore, German companies need to adjust to international cost pressures and thereby continuously improve their efficiency.

1 ©Statista. (2022). BCG; Institute for Employment Research; Federal Employment Agency.

Determining the current situation precisely

Robotics

Growing requirements

Determining the current situation precisely

By integrating sensors and other advanced technologies, deviations (for example differently arranged items that a robot needs to grasp and place at another location) can be detected in real time. This avoids quality problems, and improves the consistency and standardization of manufactured products as well as picking processes. Modern sensors can do even more (see Section 3). Although the initial investment in automated system can sometimes be quite substantial, the long-term increase in efficiency will reduce the costs and optimize the use of resources. In this way, companies can minimize their material wastage and lower their energy consumption and operating costs.

The key features of automation are:

- Avoidance of errors
- Increase in productivity
- Greater flexibility
- Precise monitoring of production processes
- Cost savings

Determining the current situation precisely

Robotics

Growing requirements

Determining the current situation precisely

Automation thereby contributes significantly to the success of a company and enables it to remain competitive as well as meet growing customer requirements. Efficiency can be significantly increased, in particular in manufacturing industries such as automotive production, electronics manufacturing, food processing, or the pharmaceutical industry. In the logistics sector, automated storage and dispatch systems offer a multitude of possibilities for generally optimizing processes and accelerating supply chains.

The automation of processes is already firmly anchored strategically in a growing number of companies. In a study involving 317 decision makers in total from Germany, Austria and Switzerland, three-quarters of the respondents stated that they attach “very high” or “high” importance to end-to-end process automation (a process in the company that starts and ends again with the customer). Around 51 % of respondents have a separate automation strategy, while 48 % view process automation as part of their general business strategy. For 43 %, the automation strategy is part of the digitalization strategy.

The importance of process automation varies depending on the decision maker’s position within the company. Process automation has a “very high importance” for 61 % of C-level decision makers, but only 38 % for IT managers and just 24 % for decision makers in technical departments.[2]

To improve processes in production and logistics in a targeted manner, the following questions need to be posed and answered:

- What specific production processes need to be automated?
- What goals is the company pursuing with automation?
- What automation technologies and solutions are suitable?
- What financial resources are required?
- What are the expected impacts on the existing employee structure?
- How can production processes be optimized and efficiency gains be achieved?

2 Uipath; Manfred Bremmer. (2023). IDG study on the topic of Intelligent Process Automation (IPA) in the PDF Page 3.

Determining the current situation precisely

Robotics

Growing requirements

Determining the current situation precisely

The following questions also need to be clarified:

- What technical requirements need to be met?
- What risks and challenges can arise – and how can these be managed?
- How can the quality of the produced parts be improved?

The automation of production processes is closely linked to the integration of intelligent sensors and digital systems in machines. Employees will, however, also need to undertake training and professional development to obtain the necessary qualifications. Data protection and safety also need to be given a high priority. Continuous monitoring, analysis and optimization of automated processes allows continuous improvements and secures a long term competitive advantage.

Considerable advances have been achieved to date, in particular in the area of robotics. Intelligent sensor solutions are the key to this.

> “Automation applied to an inefficient operation will magnify the inefficiency”
>
> Bill Gates

More value adding thanks to smart sensors

Robots are becoming more intelligent and gaining eyes

This section discusses the challenges faced by Robot Vision systems. It also presents the advantages in a cost-benefit comparison.

- Robot Vision
- Identifying challenges
- Costs vs benefits

Robot Vision

Robot Vision refers to the use of 2D and 3D cameras and other imaging sensors in conjunction with robots. This involves capturing, processing and utilizing visual information. The technology enables machines to perceive their environment and perform a wide variety of tasks based on the visual data. These processes extend well beyond just rigid, pre-defined operations: Modern Robot Vision uses intelligent image processing techniques and algorithms to detect objects, determine their position and alignment, measure distances, or analyze complex patterns. This enables robots to interact precisely, reliably and safely with their environment.

The ranges of application are diverse: In industrial manufacturing, these types of sensor solutions perform, for example, part identification/sorting and quality controls, or ensure the traceability of the flow of goods in the production process. Handling tasks of the robot, such as mounting, screwing, gluing as well as fitting and welding are substantially improved through the use of sensors. In logistics and intralogistics, they are useful for palletizing, depalletizing or sorting goods. There have also been enormous advances in the area of safety in recent years (see Section 4).

With the help of Robot Vision, robots can adapt immediately to changing conditions and new tasks. This capability is not only advantageous for continuously optimizing products, but also for individualizing them.

Added value
Robot Vision
Identifying challenges
Costs vs benefits

Identifying challenges

Added value
Robot Vision
Identifying challenges
Costs vs benefits

When a company decides to use advanced robot guidance systems, such as bin picking systems, it needs to first analyze the current situation (see Section 2.2) and find a solution tailored to its own processes.

The challenges in implementation include:

1. **Accuracy:** Exact positioning of robots is decisive for a precise and reliable interaction with objects. The necessary camera resolution depends on the specific task. A high resolution of several megapixels may, for example, be required. An appropriate balance between expense and added value needs to be found.
2. **Speed:** The process speed plays an important role. The image processing must match the cycle time of the robot. In some applications, for example code reading in hubs, information needs to be captured in milliseconds to allow processes to run smoothly and efficiently.
3. **Ambient conditions:** The environment in which Robot Vision is used can create a variety of challenges. Poor light conditions, contamination, or complex structures, for example, can negatively impact on the capturing and processing of visual data.
4. **Costs:** Besides the expenditure on cameras and sensors, other aspects such as integration of the devices into existing processes, training of employees, and servicing costs need to be taken into account (see Section 3.3).

Mastering these challenges requires sound expertise and advice. Only then is it possible to strike the right balance between accuracy, speed, ambient conditions, and costs and successfully implement the use of Robot Vision in robot guidance systems.

Costs vs benefits

Added value
Robot Vision
Identifying challenges
Costs vs benefits

One of the key concerns when retrofitting modern sensor solutions to robots is integration. The time and costs involved are issues that all companies deal with in relation to this.

The most important questions here are:

- How large is the investment?
- How quickly will the investment pay off?
- Do we have planning certainty or can unforeseen costs arise?
- To what extent do processes need to be adapted?
- How easy is the solution to integrate, maintain and scale up?

Costs vs benefits

Added value
Robot Vision
Identifying challenges
Costs vs benefits

Although the acquisition costs for sensor solutions can initially be high, they pay off – when carefully planned – over the long term. Through efficiency increases, productivity increases, and a reduction in errors, companies can lower costs and significantly improve the profitability of their robot systems. When performing their tasks, modern sensor solutions ensure precision, efficiency and flexibility and contribute to safety in the workplace. Investment in high-quality sensors and systems pays off over the long term through improved productivity, increased quality and cost savings, and are indispensable for automation using robots.

Sensor solutions from SICK are characterized by their high level of integratability. SICK is one of the leading suppliers in the area of Robot Vision and has a global presence. A wide range of interface options ensure a seamless connection of the devices to existing systems, including industrial automation systems, robotics, logistics solutions, or vehicle technology. These options include commonly used communication protocols such as Ethernet, PROFIBUS, ROS, PROFINET and lots more. This makes it easier to connect the device to different control systems. Programmable functions enable the device to be adapted to specific requirements. The sensors can be programmed and therefore flexibly configured and individually optimized for the particular processes and environments. The sensors and system are equipped with intuitive user interfaces and configuration options that contribute to their simple setup and parameterization. This makes integration easier and reduces the training required for operators.

SICK's comprehensive service rounds off the product offering and supports customers in the medium and long term with training and online resources, including product information, operating instructions, technical documentation or software downloads (for configuring and diagnosing the SICK sensors).

One of the reasons why companies choose Robot Vision systems from SICK is the fast and easy integration of these systems.

Innovative machine vision for precise objection localization

Simple integration and future-proof solution

Read here why the sensor solutions from SICK operate so accurately and how they can be successfully integrated into existing environments.

Precise position determination

Integration

Trends and developments

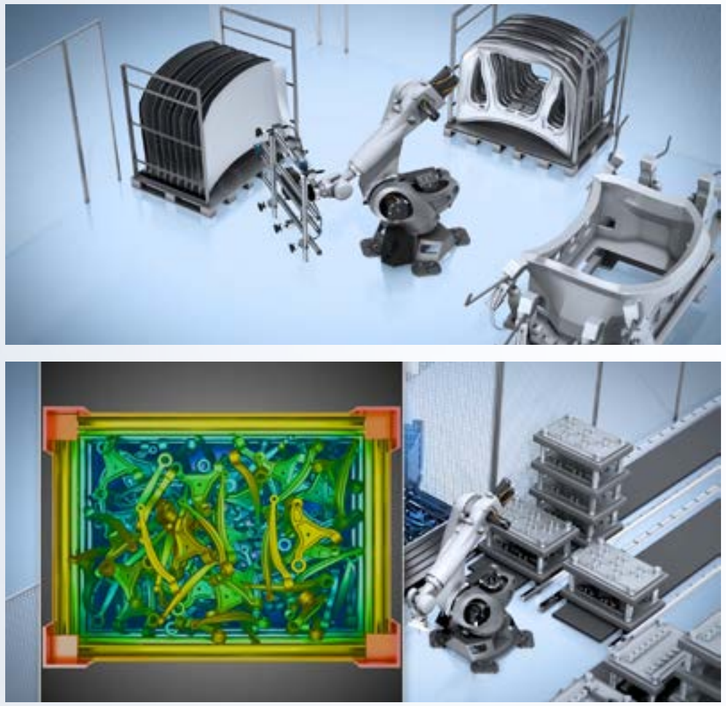
Precise position determination

Innovative image processing

Precise position determination

Integration

Trends and developments



Random arrangement of differently shaped objects:
Modern sensors enable the robot to detect and grasp these.

Localizing objects in industrial environments presents a variety of challenges. This includes various light sources that can affect the localization accuracy. Vision systems from SICK cope with these influencing factors. Internal and external illumination along with optical filters on the cameras optimize the lighting and minimize the disruptive effect of ambient light. Some objects have weak contrasts or are very similar in color, which makes determining the precise position of the object more difficult. One example is a black object on a black substrate. Sensors and systems from SICK therefore capture additional information on the shape and depth of the object, which leads to a more precise three-dimensional localization.

SICK sensor solutions offer a whole range of specific advantages. For example, the PLR 3D system can precisely detect large parts, and the PLB 3D system bulk materials in bins. Depending on the requirements, an all-in-one Smart Sensor solution such as the PLOC2D can also be used.

The 2D camera technology from SICK comprises smart cameras with resolutions from 1 to 8 megapixels as well as streaming cameras with a resolution up to 12 megapixels. The 3D technologies employ 3D time-of-flight (TOF), light-section triangulation, and stereometry with active or passive illumination. The 2D and 3D data are evaluated using traditional vision libraries and
Deep Learning algorithms.

Integration in existing environments

Innovative image processing

Precise position determination

Integration

Trends and developments

The simple and fast sensor and system integration into existing environments leads to a significant time saving and ensures that production and logistics processes can be disrupted as little as possible or fully automated. A particular advantage of SICK devices is their specialization for specific fields of application and their high level of user-friendliness, which simplifies teach-in and integration. No specific expertise is required for a successful implementation. All the necessary steps can be planned. The wide range of interfaces (plug-ins) for a variety of robots also makes integration easier. Furthermore, a comprehensive technical service is available to assist with initial setup, if questions or problems arise, and with future developments.

A good example is the flexibility of part handling in the manufacturing industry. The openness of the sensor interfaces and systems is an important aspect here when it comes to communication between devices and robots. **Thanks to their seamless integration into robots and programmable logic controllers as well as communication with these, SICK sensors and systems can be incorporated into customer networks with ease.** This makes it possible to efficiently control part handling. The sensor solutions from SICK also provide the ability to automatically detect and localize parts. This capability ensures correct sorting and handling of components and does not involve any manual work.

This results in significantly more process agility because tasks such as localization and sorting of objects can be performed automatically by robots. By combining open communication, automated part detection, and independent sorting, SICK sensors and systems are contributing significantly to the flexibility of part handling in the manufacturing industry.

A close collaboration between SICK, the customer, and robot manufacturers before implementation is useful. To effectively eliminate possible risks, the sensor and system solutions should generally be planned and implemented with a practical perspective and with the necessary care.

Trends and developments

Innovative image processing
Precise position determination
Integration
Trends and developments

In a large-scale study on the topic of “Automation by robots” [3], data from several thousand manufacturing companies was evaluated. The team lead by Prof. Marcel Smolka from Europa-University Flensburg focused on a period of 27 years (1990 to 2016). The results of the analysis showed that through the introduction of robots, a production increase of between 20 and 25 % was able to be achieved within the first 4 years. At the same time, there was a reduction in labor costs of 5 to 7 percentage points accompanied by a net job creation of 10 %.

3D vision and machine vision will in future make the handling of in particular formable and flexible objects even easier, e.g., the handling of packaging: A robot needs to grasp these at the correct angle and with the correct compressive force.

Furthermore, even more capable and compact sensors are being developed that will also be able to be seamlessly integrated into robots. The combination of sensors and advanced data analysis methods such as AI and machine learning is opening up further possibilities for the development of intelligent, autonomous robots. This includes independent learning for process improvement as well as increasing adaptability to changing conditions.

Given its economic and environmental advantages, it is clear that Robot Vision will play an even greater role in production and logistics.

3 Europa-University Flensburg; Prof. Marcel Smolka. (2022). Robots and Firms.
https://www.uni-flensburg.de/hochschulkommunikation/pressemitteilungen/news/best-paper-royal-economic-society-prize-fuer-flensburger-oekonomen-marcel-smolka

Customer-focused solutions

Hand in hand for more efficiency

Using the reference client “Mitsubishi Electric” as an example, this section will illustrate the importance of a close collaboration with the customer. It also covers the topic of safety: Modern sensor solutions help companies comply with statutory standards and regulations such as the Machinery Directive “2006/42/EC”.

Application examples

Customized solutions

Putting safety first

Solutions for leading robot manufacturers

We are proud to be a reliable partner globally to leading robot manufacturers. Sound technical knowledge combined with state-of-the-art technology enables us to develop tailored solutions that optimize the processes of our customers. SICK understands the demanding requirements on robot manufacturing and is continuously working on developing innovative solutions to give them a competitive advantage.

These robot manufacturers in particular trust in our longstanding experience and commitment to highest quality and safety:

KUKA
Universal Robots
Yaskawa
ABB

Solutions
Application examples
Customized solution
Putting safety first

Customized solution for Mitsubishi Electric

Solutions

Application examples

Customized solution

Putting safety first

Collaborating closely with the customer is crucial for improving sensors. Synergies between SICK and various large automotive manufacturers are a good example of this and have already significantly optimized various manufacturing processes. For example, the times for determining the position of car bodies have been successfully shortened in several cases. As a result of the precise and efficient localization of the chassis, the companies have gained more time for welding the parts. In the end, this increases the productivity and overall output of the relevant customer.

Mitsubishi Electric and SICK have jointly developed a pioneering robot application with a flexible and user-friendly 2D position determination. The goal was to equip the robot as follows: It needs to be able to pick up tiny dental implant bodies that fall out of a lathe and onto a plate and then precisely place them on pins in a tray. The key to success was to connect the SICK PLOC2D camera system with a special program that was developed specifically for the development software of Mitsubishi Electric: The SICK system is located directly on the gripper of the Assita, a “MELFA robot” (MELFA: Mitsubishi Electric Factory Automation). With the help of the camera system, this cobot precisely detects the position of the workpiece and aligns its gripper accordingly.

The flexibility of the system benefits from the movable construction of the cobot: Thanks to folding rollers, the cobot can move about freely within the factory hall. This enables it to be used at different stations according to requirements, which leads to better personnel planning and optimal utilization of the robot. Noteworthy is also the simplicity and user-friendliness of the application: Thanks to the graphical web interface and the innovative brush technology, setting up the robot guidance system is very intuitive and time-saving. The brush technology allows the personnel to effortlessly and quickly configure the required settings and make the necessary adjustments. This shortens the setup time significantly – even for users without in-depth programming knowledge.

Modern sensor solutions help companies comply with statutory standards and regulations such as the Machinery Directive 2006/42/EC.

Putting safety first

The advanced sensors and systems from SICK deliver reliable results even in demanding conditions, for example strong vibrations or fluctuating light conditions. Furthermore, the devices meet stringent safety standards: Functions such as collision avoidance and real-time monitoring ensure a collision-free robot-human collaboration. SICK is continually investing in the development and improvement of its Robot Vision systems so they can also meet very high safety requirements while at the same time enabling an efficient and precise automation.

Solutions
Application examples
Customized solution
Putting safety first

Summary

Successful human-robot collaboration

The requirements on automating, accelerating and individualizing processes in production and logistics will increase in future. New technologies and processes, the growing demand for ever more complex products, and the ongoing globalization (with increased competition) require that companies optimize their value adding chains. This is a long-term, continual process.

Robot Vision plays an important role in increasing efficiency and flexibility. By precisely determining positions, the technologies from SICK allow a more efficient process design and provide significant advantages with regard to competitiveness and meeting specific customer requirements. Thanks to their reliability, precision, easy operation, and high level of adaptability, the sensor and system solutions optimize processes and accelerate workflows in production and in supply chains.

Especially worth highlighting is the ease of integration: Sensors, systems and software can be easily adapted to the existing processes – not the other way around.


1
2
3
4

SICK at a glance

SICK is a leading manufacturer of intelligent sensors and sensor solutions for industrial applications. With more than 12,000 employees and over 50 subsidiaries and equity investments worldwide, as well as numerous agencies, SICK is always close to its customers. A unique range of products and services creates the perfect basis for controlling processes securely and efficiently, protecting individuals from accidents and preventing damage to the environment.

SICK has extensive experience in various industries and understands their processes and requirements. With intelligent sensors, SICK delivers exactly what the customers need. In application centers in Europe, Asia and North America, system solutions are tested and optimized in accordance with customer specifications. All this makes SICK a reliable supplier and development partner.

Comprehensive services round out the offering: SICK LifeTime Services provide support throughout the machine life cycle and ensure safety and productivity.

That is “Sensor Intelligence.”

Would you like to find out more about these possibilities?
Then visit our website or contact us.