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AI POWERED QUALITY INSPECTION

Driving The Future Of Quality Assurance Systems

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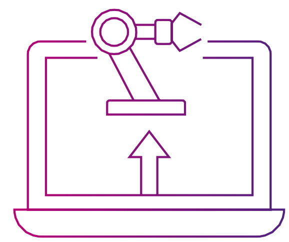
Significant advancements in Artificial intelligence (AI) and Automation technologies are diminishing the difference between machines and humans. One of the most significant advancements is the ushering of cognitive capabilities in machines, like processing visual information, speech recognition, natural language processing, sentiment analysis, risk assessment and more.

These developments are instrumental for improving crucial industrial metrics like operational efficiency, productivity, creating new revenue models and customer experiences. In the Manufacturing and Heavy Engineering Industries, AI, Machine Learning and Deep Learning techniques can be leveraged to optimize operations across the entire value chain from product design and development to operations and servicing.

In the Engineering and Manufacturing space, some of the key innovations include integration of computer-aided engineering (CAE) with several innovative data-driven computing technologies—Artificial Intelligence/Deep Learning (AI/DL), Internet of Things (IoT), and others. The economic impact of these innovations is enormous.

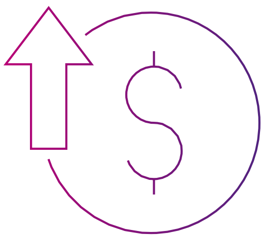
According to a recent research from Google Cloud, 76% of the manufacturers around the globe have accelerated their use of digital technologies due to the COVID-19 pandemic and have increased the adoption of AI, data analytics and cloud. Moreover, IDC predicts that global spending on cognitive and AI solutions will reach 97.9 billion in 2023 and will increase at a compound annual growth rate of 28.4% for the 2018–2023 forecast period.



In terms of Industry verticals, the top industries deploying AI are automotive/OEMs **(76%)**, metals **(75%)**, industrial assembly **(72%)** automotive suppliers **(68%)** and makers of heavy machinery **(67%)**.

Source:
Mckinsey, Google

AUTOMATED QUALITY INSPECTION IN MANUFACTURING



Hidden quality costs can be 3 to 6 times higher than visible quality costs

Source: KPMG – Quality 2030:Quality Inside

Whether companies are manufacturing cars, semiconductor chips, or food and beverages, their performance is evaluated based on two fundamental metrics: product yield and production quality. Poor production quality control results in significant operational and financial costs in the form of reworked parts, reduced sellable yield, voluminous scrap, increased post-sale recalls, high warranty claims, and repairs. Despite all technological advancements in various arenas, Visual Quality inspection (VQI) still relies on manual efforts to a large extent. This is due to the challenging task of codifying the logic of what constitutes a 'defect'.

The manual process involves trained personnel referring to detailed descriptions of what constitutes a 'defect' in company manuals, and then deciding whether a product meets the quality standards.

In addition to the manual techniques, there are a few machine vision inspection solutions that provide rule-based algorithmic platforms to automate the quality inspection activity. These solutions, however, come with a heavy initial investment and some of these platforms are not capable of scaling up efficiently.

Also, most of these approaches follow a visual comparison of an ideal reference image with an image of the specific product meant for testing. Such methods are only feasible, if all environment-related preconditions are met. These methods are not designed to adapt to the changing demands of the workplace.

And so, companies leveraging either of these existing techniques grapple with a myriad of challenges

KEY CHALLENGES IN EXISTING QUALITY INSPECTION TECHNIQUES

Lack of Efficiency

- Oversight during quality inspection leading to product replacements and recalls
- Inability to scale up the solution with increasingly changing internal quality compliances and product specifications

High Total Cost of Ownership and Cost of Quality

- High upfront investments required in terms of license fees, annual maintenance charges, labor cost and training costs
- High direct and indirect costs arising from product recalls (CRM Efforts, liability lawsuits and class-action lawsuits)

Limitations of Human Workforce

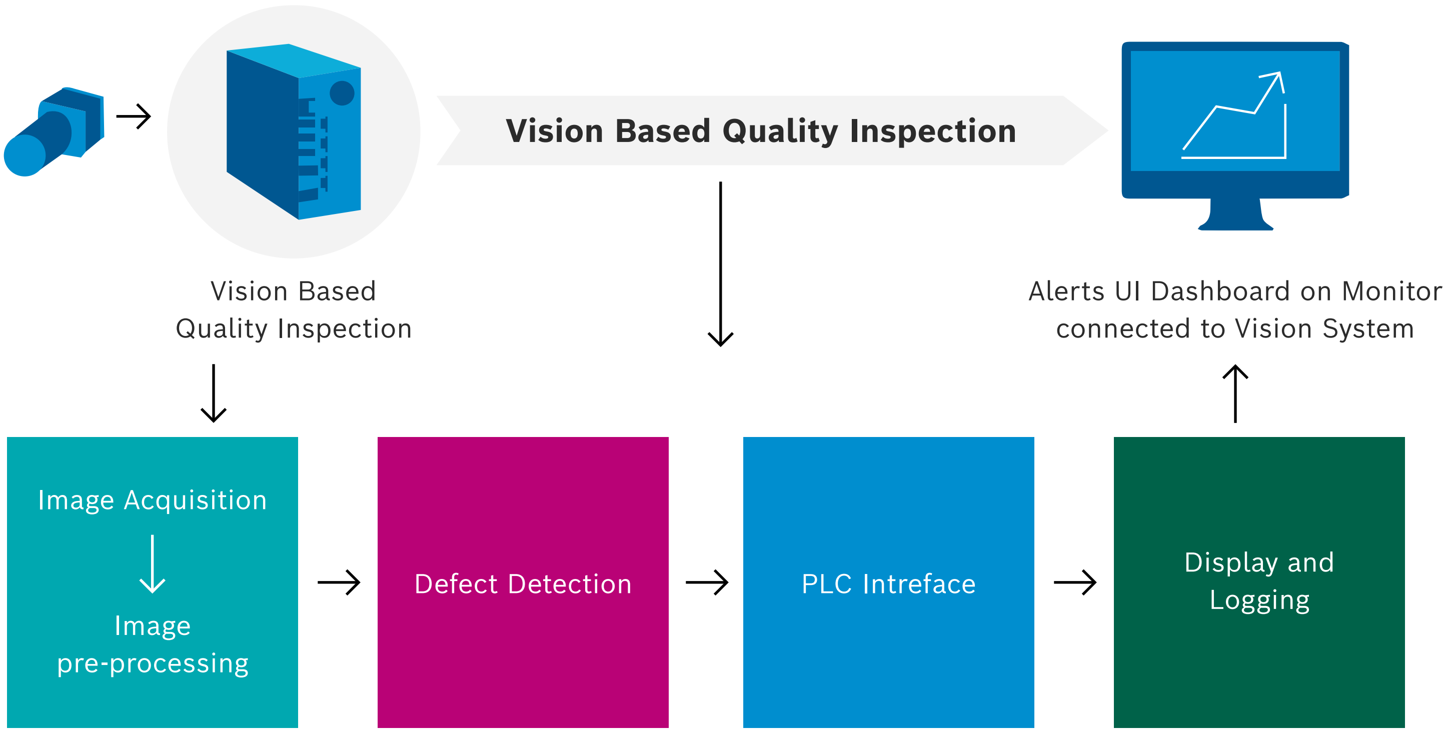
- Process largely dependent human labor, which is a function of both perception and experience
- Low speed and fatigue arising from continuous work which acts as a bottleneck for consistent throughput
- Frequent need for social distancing in production lines and factories due to in the current pandemic times
- Need for warranty support for defective products that could not be detected during manual/machine inspections

Regulatory Mandates for Quality & Human labor force

- Existing regulations which prohibit hazardous working environment for human workforce
- Increase in external quality compliances from regulatory agencies
- Stringent regulations for safety & working hours for manual inspection

AI-POWERED COMPUTER VISION TO THE RESCUE

The new-age Visual Quality Inspection (VQI) Solution is an AI Powered computer vision-based solution for quality inspection. With algorithms using deep learning technologies at its core, the solution can make decisions based on problem-based heuristics, and image processing.



KEY COMPONENTS OF THE SOLUTION

Image Acquisition and pre-processing

Data Ingestion of Source images, ensuring the ‘data sanity checks’, which involves checks on file sanity, as well as the presence of annotations and labels attached to the uploaded images

Defect Detection and Status

The following are leveraged for defect detection:

- Generative Adversarial Networks

  Focusses on automatically discovering and learning the regularities or patterns in input data

- Transfer Learning Techniques

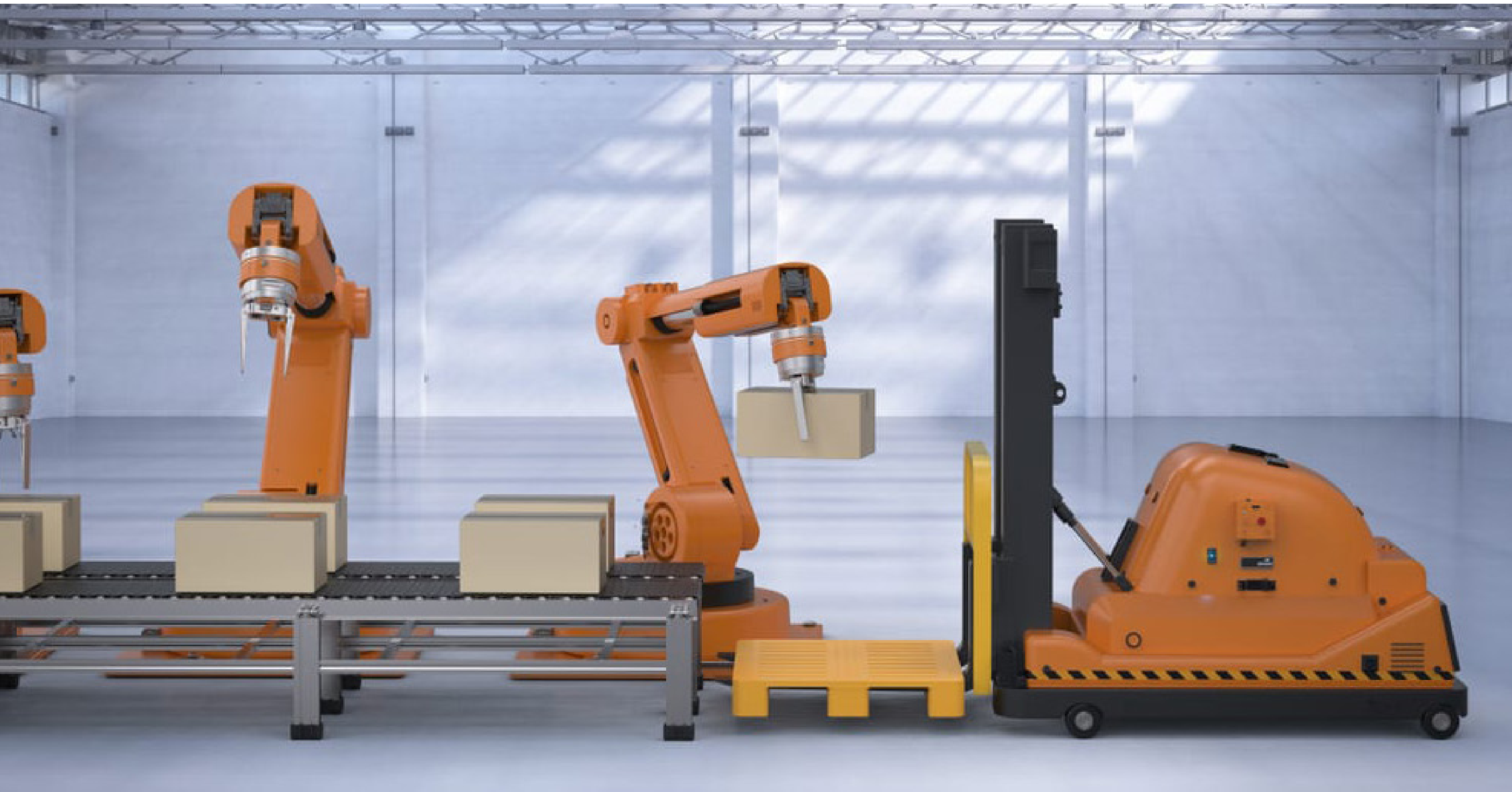
  Deep Neural networks to leverage techniques of pretrained algorithms to complex models which serve to identify images and defects

PLC Interface

Interaction with the external hardware including programmable logic controllers (PLC) using digital signals. The system retains the security and reliability of the process while ensuring efficiency of communication within the setup

Interactive User Interface

User-friendly UI to monitor key KPIs with role-based management which can be configured basis changing requirements



DELIVERING VALUE WITH AI POWERED VISUAL QUALITY INSPECTION

Organizations are keen to leverage technological advancements to enable fundamentally new ways of delivering quality. This requires integrating compliance and product quality into operations while enabling effectiveness and faster time-to-market. AI powered Visual Quality Inspection (VQI) solution can bring significant positive outcomes for businesses wanting to streamline their processes, increase productivity and provide high-quality products that meet customer demands.

Improved Efficiency

- Ability to learn intelligently and over time detect varying complexities of defects, not visible to human eye
- Ability to detect highly complex and even the most subtle defects at various stages of the assembly process, on any kind of surface
- Significantly less human intervention leading to freeing up of resources for other tasks

Accelerated Time-to-market

- High throughput rates for defect detection as compared to human operations
- Increased clearance rates resulting in lowering processing costs

Reduced Cost

- Lesser upfront capital investment in the form of license fees as well as related direct and indirect costs
- Significantly reduction in product warranty costs
- Reduction in training costs for personnel and quality engineers

Higher Accuracy

- Constant training/re-training of models with new categories of defect data to improve accuracy of predictions, with constant updates to the AI model with latest training data with new defect categories
- Dramatically reduces false positives and costly product recalls

Compliance to Regulatory mandates

- Ensures compliance with stringent external quality regulations accommodating to the varying needs of defect detection over time

Alleviate Human Health & Safety Concerns

- Reduces/eliminates human intervention, thereby improving human health and safety, especially in hazardous working environments

IMPLEMENTATION – KEY SUCCESS FACTORS

In order to leverage the full potential of this solution, Visual Quality Inspection systems should provide a collaborative platform that allows engineering teams to discover issues easily, dig deeper into failures, and implement corrective actions immediately, once implemented.

Some of the key success factors of this solution are its ability to retain model accuracy with changes in internal and external environmental factors, flexibility in changing environments and an ergonomic human-machine interaction, with a seamless user experience enabling role-based access and automated model training/re-training. Details below:

Automated Model Training/Retraining mechanism

Automated model training and retraining allows businesses to recognize and address new defect categories at the earliest. It creates and updates a centrally maintained repository of defect categories and manages the defect labels on the images that are captured from different cameras across lines and sites.

Automated Model Drift Mechanism

An automated drift detection pipeline can be put in place, which generates alerts whenever model performance metrics fall below the pre-defined thresholds. The models are also trained to imbibe new information over time, with data generation and data labelling.

Easy to Use User-Interface

A user-friendly User-Interface to monitor KPIs related to multiple roles within the organization needs to be created and configured as per requirements. These personas can be created for various roles such as Administrator, Quality Manager, Model Hub Manager, and Shop Floor Inspector, to name a few. Also, the User Interface needs to support intelligent workflows to be used by quality managers for change management and monitoring.

Full Edge-to-Cloud Capability

The inspection models should have the flexibility to be deployed as a complete Edge based solution as well as on the Cloud. Edge deployment systems are decentralized and offer production units the benefit of improved performance, compliance, data privacy and address data security concerns, along with providing reduced operational cost and production downtimes. At the same time, integration on cloud enables manufacturers to combine insights from the models with other data sources on the shop floor and beyond, for better root cause analysis of quality problems.

Requirement of Quality Data

Similar solutions should provide rigorous ‘data sanity checks’ for every image/data which is ingested into the platform, including checks on file sanity, presence of annotations and labels on images, etc. There should be automated alerts provided to the team when the initial dataset of images is insufficient to develop a model, considering the quality of these images so that corrective actions can be taken to augment the quality of incoming data, to enable accurate and consistent labelling when training AI models.

ENVIRONMENTAL FACTORS FOR DEPLOYMENT

Manufacturers need to ensure that unpredictable changes to products or environments do not harm inspection operations or quality. In the past, it required thousands of lines of code for a traditional machine vision system to adapt to changes in internal and external environmental factors. But now, Visual Quality Inspection Solutions which leverage advanced AI models are very forgiving and flexible in changing environments and maintain high standards of accuracy while operating in varied environmental conditions. One of the key factors which determine the overall efficiency of similar platforms is the quality of data that is procured. A few success factors to ensure optimal quality in data generation are described below:

Camera Specifications and Imaging Factors

Ensuring camera specification based on the dimensions of the minimum defect size to be imaged can help create high quality data for analysis. Other factors which impact the quality of the images can be the working distance available for mounting the cameras and the individual imaging requirement of each manufacturing line which can address any potential challenges in creating quality images.

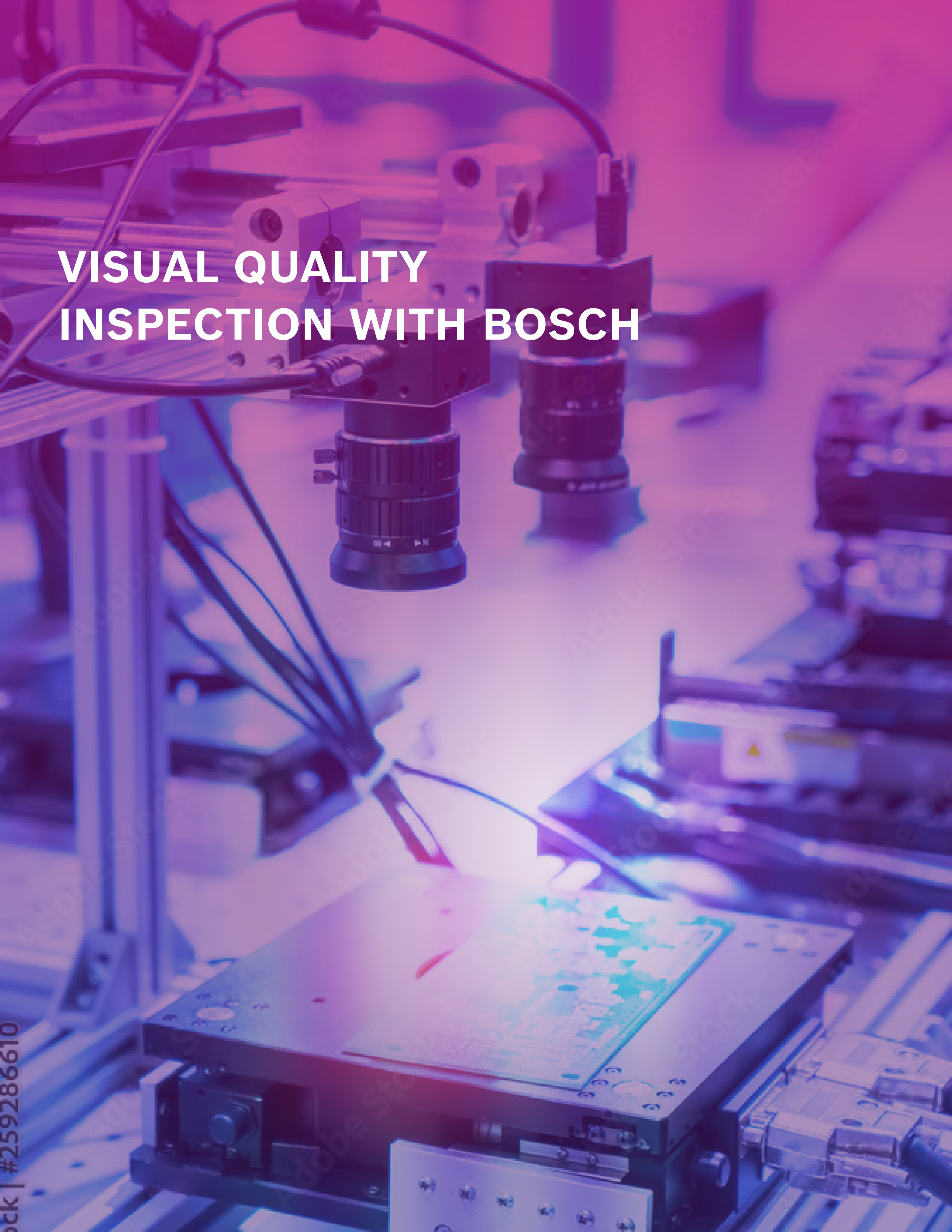
Lighting and Sound Reduction

To ensure good quality product imaging, the product needs to be uniformly well-lit, while minimizing stray ambient light. This would also require considerations for appropriate filters and shrouds, and the requirement of indirect lighting setups for reflective items. Noise reduction, or Motion artifact minimization, aims at removing blurs or loss of information due to movements caused due to movement. This can be achieved using short exposure times and cameras with global shutters with the use of vibration dampeners. Image preprocessing, use of appropriate filters, and controlling heat and temperature within the production unit can also help reduce the amount of noise in the images.

Integration with Programmable logic controllers (PLC) Systems

To remain relevant over the long-term, the Visual Quality Inspection solution should facilitate interaction with the external hardware, including programmable logic controllers (PLC). Utilizing interactions with programmable logic controllers (PLC) using digital signals, the system must retain the security and reliability of the process while ensuring efficiency of communication within the setup. Also, the solution should be able to create, deploy, manage, and scale industrial AI models for quality inspection by leveraging the data from these systems.

VISUAL QUALITY INSPECTION WITH BOSCH



We understand that deep-learning based VQI might not be a one-size-fits-all setup but should be customizable to fit specific customer needs. To offer our clients with the most optimised version of the VQI technology, RBEI has developed a dynamic model which is suited to varying customer requirements. VQI enables effective communication with Edge-based interfaces, and seamless integration with PLCs, AR and mechanical extensions such as robotic arms to provide a holistic quality control ecosystem.

The first step towards improving your plant's productivity and product quality is to identify the processes that can benefit from a deep learning solution. Once you've identified the processes, appropriate peripherals for data capture can be identified which will enable the building of a central dictionary.

Engineered to be compatible with standard image acquisition interfaces, Bosch's VQI gives its clients the ability to find a setup that blends into their existing operations seamlessly. This, along with the appropriate computation hardware, relevant algorithm type, and efficient workflows can help the VQI technology to empower manual work set-ups and improve accuracy and simplify user-experience.

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