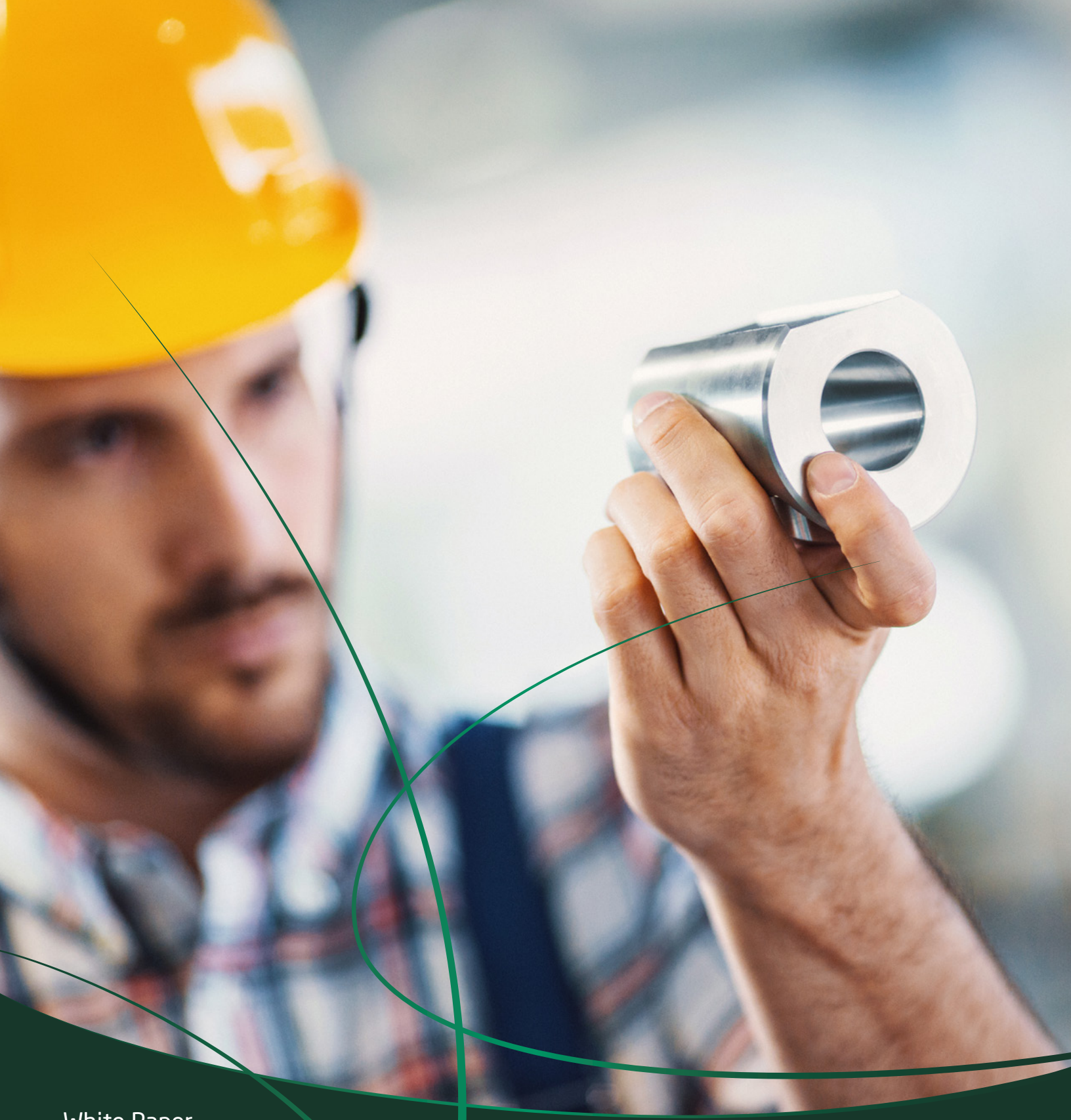

White Paper

Industrial Visual Inspection Using Deep Learning AI

\Orchestrating a brighter world NEC

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Industrial Visual Inspection Using Deep Learning AI

Abstract

Accurate, fast and efficient identification of defective components is a crucial capability for manufacturing processes in industries ranging from automotive and aerospace to medical equipment and food & beverage. Advances in artificial intelligence and deep learning technologies have recently enabled automated visual inspection systems that can outperform previous human or machine vision processes.

Based on half a century of AI research, the NEC Visual Inspection System enables manufacturers to accurately identify defects and dramatically reduce costs with an efficient solution that can be easily and affordably deployed. The system utilizes a deep learning one-class classification architecture that allows it to be trained using only images of non-defective components, as opposed to architectures that require images of both good and defective parts to learn the classifiers. This has significant advantages in many industrial settings, especially where defect rates are already low.

The NEC system has been tested in over 80 manufacturing facilities since 2017 and has proven to be highly effective at identifying defective components and reducing the cost of inspection.

Leveraging Half a Century of AI Leadership

In recent years, three major breakthroughs have combined to enable vastly improved AI systems that are powered by deep learning:

- The ability to collect and analyze very large amounts of data
- Faster, less expensive computing resources
- New neural network algorithms

Across more than half a century of artificial intelligence research and development, NEC has both accelerated these trends and leveraged them to create landmark products. The NEC AI technology portfolio includes many advances in image recognition systems that revolutionized major industries. In the 1960s, NEC pioneered the technologies that automated letter sorting in postal services around the world by developing optical character recognition systems that could accurately read addresses and sort the mail. In the early 2000s, fingerprint identification technology created by NEC was adopted by more police agencies worldwide than any other. NEC also developed facial recognition algorithms that are relied upon for immigration control and other critical applications.

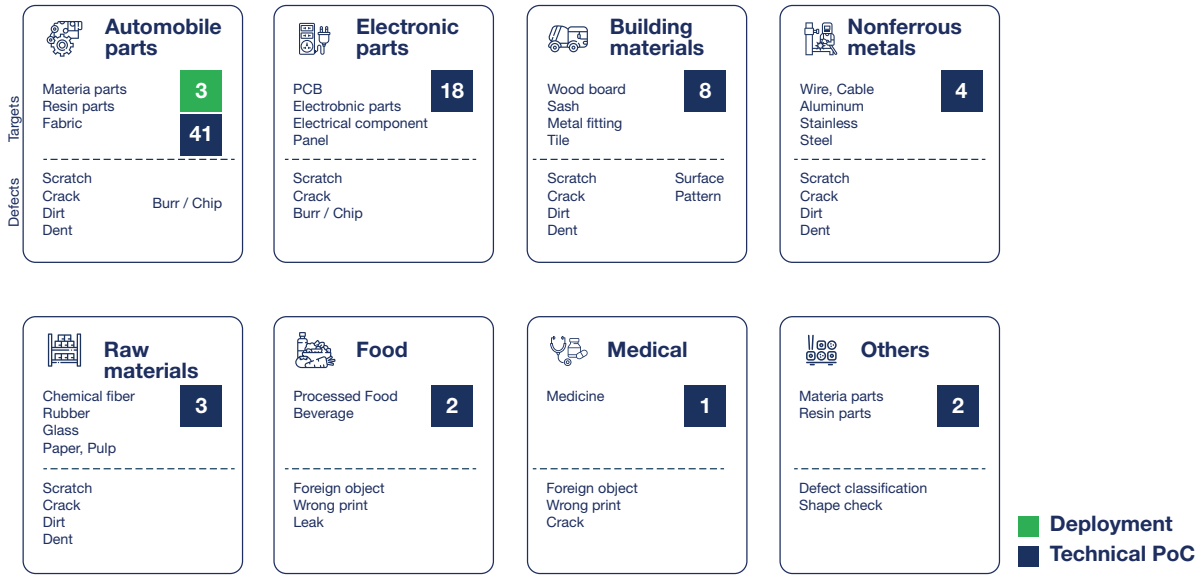
This broad experience in utilizing visual information to recognize, identify, and categorize objects laid the groundwork for NEC's development of the deep learning visual inspection system.

Augmenting this rich history, the NEC Deep Learning Visual Inspection system is a recent innovation that takes advantage of all three breakthroughs. In particular, the system utilizes a one-class classification algorithm. This enables the system to build classification models when the positive class is either absent, poorly sampled or not well defined. For example, a manufacturer may be able to provide many images of correctly manufactured parts, but very few images of defective parts. Unlike previous machine vision systems, the NEC Visual Inspection System is able to define class boundaries with knowledge of the negative class only (the "good" parts).

Industrial Applications

Virtually all manufacturing processes include some kind of method for identifying flawed components. Many manufacturers still rely completely on human inspection, as automated visual inspection has previously been too inaccurate, slow, and expensive. Where AI automation has been deployed, it has generally required large investments of money, time, and expert resources.
The NEC Visual Inspection System addresses all of these challenges, and has been tested in over 80 facilities across multiple industries.

03.1 Deployments and Technical Proofs of Concept



Case Study: Automotive Parts Manufacturer Reduces Inspection Costs by 66%

To date, the automotive industry has implemented the NEC Visual Inspection System more than any other vertical.

In one example, a leading automotive parts manufacturer faced the challenge of detecting scratch and dent defects on metal surfaces. This is very difficult for human inspectors. It is hard to see small nicks and dents on shiny, curved metal surfaces, and the strong lighting that is required stresses the eyes of inspectors. This demanding work environment leads to high turnover among the inspection team, making it difficult to maintain consistent quality standards.

Faced with this situation, the manufacturer decided to invest in a way to automatically detect defects. They first turned to traditional machine inspection, but this also failed to produce the desired results since traditional machine vision is good at measurement of parts, but not at seeing unpredictable dent or scratch defects.

In addition, the system had to be trained by human inspectors using images of defective parts to teach it how to distinguish good from bad. This meant that the reliability of the system was completely dependent on the example images of defective parts that were used to train it. Because the facility had low defect rates to begin with, it took a long time and a lot of work to find images that represent the range of possible defects.

After months of investment, the manufacturer found they were still dependent on a large and expensive team of human inspectors. At this point, the manufacturer turned to NEC for an answer, and the NEC Visual Inspection System provided the easy, cost effective solution they needed. Immediately, the manufacturing team recognized the value of the deep learning one-class technology. With the NEC system, machine training does not require the time-consuming and often difficult task of collecting images depicting defective, unacceptable parts. Using images of good parts only, the system can actually learn to accurately identify all kinds of dent and scratch defects. This greatly reduces dependence on human inspectors.

Once the company trained and tested the new NEC system, they deployed it to the production line. Due to the effectiveness of the system, they were able to significantly reduce the size of the human inspection team while maintaining or even improving key quality metrics.

They quickly realized these improvements:

- 66% reduction in inspection cost
- 33% reduction in the False Positive rate (from 3% to 2%)
- False Negative rate maintained at 1% or less

Advantages of the NEC Visual Inspection System

As the above case study illustrates, the NEC Visual Inspection System provides many valuable benefits for manufacturers:

- Reduced inspection cost: New installations often pay for themselves within 12 months, through cost savings
- Easy to deploy: Minimal hardware requirements, and simple integration
- Secure: No dependence on cloud technologies
- Fast to train: Optimized neural networks learn to distinguish good and bad parts quickly
- Easy training with images of good parts only: “One Class” classification deep learning algorithms do not require images of defective components in order to be trained
- Consistent, accurate inspection, as compared with human inspectors

Deploying the NEC Visual Inspection System

Perhaps what is not required is more relevant than what is required when deploying the NEC Visual Inspection System. Due to the advantages of one-class deep learning, many of the complexities that were part of deploying traditional machine vision systems are now avoided. These simplifications include:

- No need for manually programed rules
- No need to find and categorize defect types
- No need to collect images of defective parts

While deployment requirements vary from site to site, generally the necessary hardware includes only computing and data storage, standard commercial cameras, and standard commercial lighting.

The deployment process occurs in three phases:

- Capture images. Capture images of “good” parts to be used to train the one-class deep learning model.
- Train and test the Deep Learning Model. Using the image of good parts, the software will develop a model containing the classes and recognition algorithms necessary to recognize defective parts. Then the model can be tested to verify that false positive rates and false negative rates are within target limits.
- Deploy to production line. When the system has been trained and tested, it can be deployed to the production line.

The reliability of the NEC Visual Inspection System has been proven, as has its ability to deliver improved quality consistency by decreasing instances of human error. Given its ability to detect manufacturing defects on diverse material surfaces, the system has also been shown to be highly adaptive—ideal for a wide range of industries, and the perfect solution for a broad scope of hard-to-solve manufacturing applications. Designed specifically for precision manufacturing, the NEC Visual Inspection System’s simplified deployment with flexible interface and reduced need for manual inspectors makes it an effective and cost efficient solution for optimal quality control operations.

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