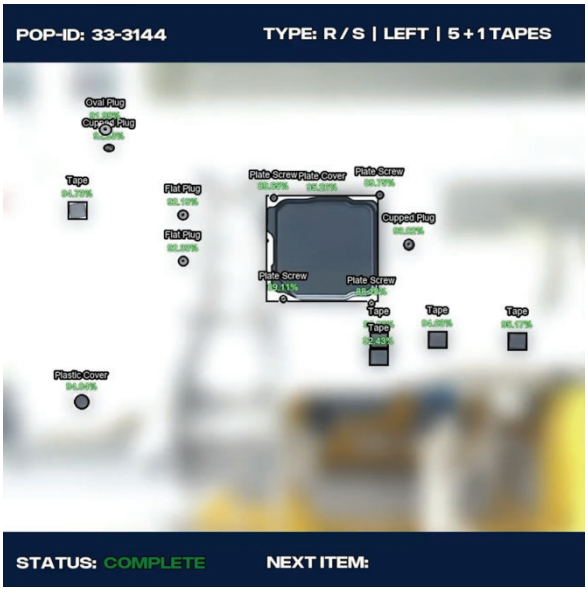
Final Report on Deep Learning for Quality Control in Cab Assembly

Executive Summary

This report summarizes the findings and outcomes of a research project that explored the potential of deep learning technology for enhancing quality control in cab assembly operations at Scania. The project was a collaboration between Scania, RoboFlow, and Vinnova, and involved identifying relevant use cases, developing and training deep learning models, and testing their performance in the production environment. The main objectives of the project were to improve production flexibility and efficiency, reduce waste and human error, and foster a better work environment for the factory personnel. The project also aimed to assess the readiness and maturity of deep learning technology for reliable and sustainable quality control in a diverse and complex production setting.

The project adopted a platform-like tool that utilizes cutting-edge artificial intelligence (AI) to facilitate computer vision and deep learning for executing quality control within the production environment, prioritizing ease of use and user-friendliness. The tool, provided by RoboFlow, enabled the project team to capture images, model, and train a deep learning model using a diverse team of around 12 to 15 individuals, including blue-collar workers and engineers. The tool also allowed the team to iterate and refine the model with the input from both production and quality personnel until it was deemed reliable for deployment in the production process. The project focused on one specific use case, namely the front plug inspection on cabs, which presented challenges for traditional, non-self-learning systems due to the high variance in components and the complexity of production processes. The data for the project was created at the line 1 in Cab Assembly Oskarshamn.

The project achieved partial success in meeting its objectives, demonstrating the capability and potential of deep learning technology for quality control in cab assembly. However, the project also identified several challenges and areas for improvement, such as distinguishing objects in closely matching colors, integrating the technology with existing production systems, and developing the necessary competencies and methods within the organization to work effectively with this type of advanced technology. The project concluded that while deep learning technology has reached a level of maturity sufficient for conducting quality control, its integration requires a balanced approach that combines technological innovation with human oversight and competence development. Future research will delve into integration strategies, ease of use, and expanding the technology's application across Scania and beyond, highlighting the ongoing journey towards digital transformation in manufacturing.



Background

Scania is a global leader in the production of trucks, buses, and engines, with a strong commitment to sustainability and innovation. Scania operates in more than 100 countries and employs about 52,000 people. Scania's production network encompasses Europe, Latin America, and Asia, with cab assembly operations located in Oskarshamn, Sweden, and Meppel, the Netherlands. Scania's cab assembly operations are characterized by a vast array of articles, such as buttons and plugs, of varying designs, sizes, and colors, which present challenges for quality control. Quality control is a vital part of Scania's production process, ensuring that the products meet the high standards and expectations of the customers. However, quality control is also a non-value-adding activity that consumes time and resources, and is prone to human error and variability. Therefore, Scania is constantly looking for ways to improve and optimize its quality control processes, leveraging new technologies and methods to enhance production flexibility and efficiency, reduce waste and human error, and foster a better work environment for the factory personnel.

One of the emerging technologies that Scania has been exploring for quality control is deep learning, a branch of artificial intelligence (AI) that enables machines to learn from data and perform tasks that normally require human intelligence, such as image recognition, natural language processing, and decision making. Deep learning has been advancing rapidly in recent years, thanks to the availability of large amounts of data, powerful computing resources, and improved algorithms and frameworks. Deep learning has shown remarkable results in various domains and applications, such as face recognition, speech recognition, natural language translation, self-driving cars, and medical diagnosis. Deep learning has also been applied to quality control in manufacturing, where it can be used to detect defects, anomalies, and deviations in products and processes, using computer vision and image analysis techniques.

However, deep learning is not a one-size-fits-all solution that can solve all quality control problems. Deep learning also poses several challenges and limitations, such as data quality and quantity, model interpretability and explainability, integration with existing systems and processes, and human-machine interaction and collaboration. Moreover, deep learning is not a one-size-fits-all solution that can be easily transferred from one domain or application to another. Each use case requires careful analysis, design, and customization of the deep learning model, taking into account the specific characteristics, requirements, and constraints of the problem and the data. Therefore, deep learning requires a high level of expertise and competence, both technical and domain-specific, to be applied effectively and efficiently.

Purpose, Research Questions, and Method

The purpose of this research project was to investigate the potential of deep learning technology for enhancing quality control in cab assembly operations at Scania, focusing on one specific use case: the front plug inspection on cabs. The front plug inspection is a critical quality check that verifies the presence and correctness of the plugs that protects the cab before the chassis and the electrical system are assembled. The front plug inspection is currently performed manually by human operators, who visually inspect each cab and compare it with a reference image. This process is time-consuming, labor-intensive, and error-prone, as human operators may miss or misjudge some quality issues, especially when dealing with a large number of variants and subtle differences.

The research questions that guided this project were:

- How can deep learning technology be used to automate and improve the front plug inspection on cabs, using computer vision and image analysis techniques?
- What are the benefits and challenges of using deep learning technology for quality control in cab assembly, in terms of accuracy, reliability, flexibility, efficiency, and usability?
- How mature and ready is deep learning technology for quality control in cab assembly, and what are the requirements and implications for its integration into the production environment?

The method used in this project was experiential, involving sourcing, developing, testing, and evaluating a deep learning tool for quality control in cab assembly, in collaboration with RoboFlow, a startup company that provides a platform for computer vision and deep learning. The method consisted of the following steps:

- Identifying and defining the use case and the problem statement, in consultation with Scania's production and quality personnel.
- Collecting and labeling images of cabs with different variants of front plugs, using RoboFlow's platform and Scania's factory workers and engineers.
- Developing and training a deep learning model that can detect and classify the front plugs in the images, using RoboFlow's platform and Scania's factory workers and engineers.
- Testing and evaluating the performance of the deep learning model, using RoboFlow's platform and Scania's production and quality personnel.
- Comparing the performance of the deep learning model with that of human operators, using Scania's production and quality data and feedback.
- Identifying the benefits and challenges of using deep learning technology for quality control in cab assembly, and the requirements and implications for its integration into the production environment.

Goals

The goals of this project were to:

- Automate and improve the front plug inspection on cabs, using deep learning technology, to increase the frequency and accuracy of quality checks, and reduce the time and resources required for quality control.
- Leverage deep learning technology to recognize base forms, like a plug, and adapt to new variants rapidly, surpassing the adaptability of current systems, and improving production flexibility and efficiency.
- Reduce waste and human error in quality control, by minimizing the occurrence of missing parts, and ensuring product quality for the rest of the supply chain and the end customers.
- Foster a better work environment for the factory personnel, by improving ergonomics, reducing cognitive load, and enhancing reliability and confidence in quality control processes.
- Assess the readiness and maturity of deep learning technology for quality control in cab assembly, and identify the requirements and implications for its integration into the production environment.

Results and Goal Achievement

The project achieved its main objectives of assessing the readiness and maturity of deep learning technology for quality control in cab assembly, identifying the requirements and implications for its integration into the production environment, and exploring the potential benefits for waste reduction, ergonomics, and reliability. The project also identified some challenges and limitations of the technology, such as the difficulty of detecting objects with similar colors or textures, and the need for human supervision and intervention to refine the models and handle exceptions. The project demonstrated that deep learning technology can perform well in recognizing different variants of components and assemblies, and can adapt quickly to new variants with minimal training data. The project also showed that deep learning technology can improve the frequency and accuracy of quality checks, reduce the cognitive load and physical strain on factory personnel, and foster a better work environment.

Publications

The project did not result in any publications, as the dissemination of the findings was internal and confidential. The project was mentioned during Södertälje Science week with visitors to the Smart Factory Lab. The project team collaborated closely with Roboflow, the external partner that provided the tools and platform for developing and deploying the deep learning models. The project team also communicated regularly with the relevant stakeholders within Scania, such as the cab assembly managers, the quality control engineers, and the IT specialists. The project team shared the progress and results of the project through presentations, demonstrations, and reports. The project team also received feedback and suggestions from the stakeholders, which helped to improve the performance and usability of the technology. It is possible to discuss with Roboflow about publishing findings jointly and publicly.

Conclusions and Further Research

The project concluded that deep learning technology is ready and mature enough for quality control in cab assembly, but that further research and development is needed to integrate it seamlessly into the production environment. The project also concluded that deep learning technology can offer significant advantages for waste reduction, ergonomics, and reliability, but that it also poses some challenges and limitations that need to be addressed. The project suggested some directions for future research, such as:

- Developing methods for integrating the deep learning models with the existing production systems and equipment, and ensuring that they can communicate and respond effectively to each other.
- Enhancing the ease of use and adoption of the technology for the factory personnel, and providing appropriate training and tools to enable them to work with the technology effectively.
- Expanding the scope and application of the technology to other parts of the cab assembly process, and to other production processes within Scania and beyond.
- Improving the performance and robustness of the technology, especially in dealing with objects that have similar colors or textures, and in handling exceptions and anomalies in the production process.