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DELVITECH TRAINING MANAGER:

Optimizing Neural Network Training for Visual Quality Inspection

A Breakthrough in Self-Adaptive Visual Inspection for Industry 4.0

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01 Introduction

As manufacturing processes grow increasingly complex, the demand for advanced inspection systems that can maintain high accuracy while adapting to new challenges is intensifying.

Modern manufacturing, especially in sectors like electronics, automotive, and medical devices, requires the detection of minute defects that traditional inspection methods might overlook. Machine learning algorithms, particularly those leveraging deep learning, have demonstrated exceptional capabilities in identifying such anomalies.

For instance, convolutional neural networks (CNNs) trained on extensive datasets can discern subtle defects in components, leading not only to a significant reduction in faulty products reaching the market[1] but also, when integrated into Optical Inspection systems, to a notable decrease in false positives, streamlining the inspection process and enhancing overall operational efficiency[2].

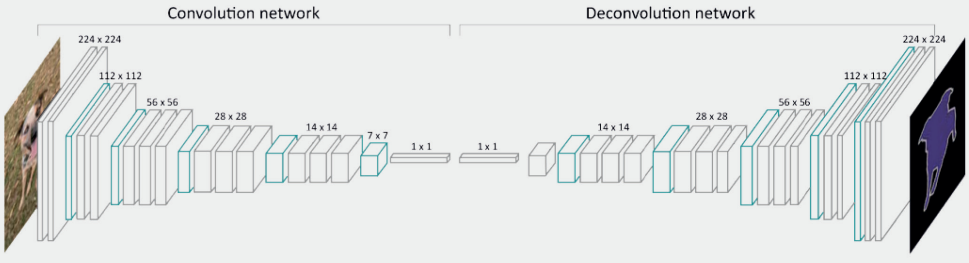
The manufacturing environment is characterized by constant change—be it in product designs, materials, or production techniques. Machine learning algorithms must, therefore, be adaptable, capable of learning from new data and adjusting to evolving inspection criteria.

The adoption of AI-driven optical inspection systems facilitates this adaptability, allowing for continuous improvement in defect detection and pattern recognition[3].

Furthermore, the scalability of AI -powered AOI and SPI systems enables their deployment across multiple production lines with minimal additional costs, ensuring consistent quality control across facilities. This scalability is crucial as manufacturers face increasing demands for defect detection across diverse product categories[3].

CONVOLUTIONAL NEURAL NETWORKS

A Convolutional Neural Network (CNN) is a type of arti cial intelligence algorithm designed to process and analyze visual data, like images or videos. It is a smart system that learns to recognize and understand visual patterns by using lters and layers, making it particularly good at tasks like image recognition or object detection.



The convolution algorithm downsizes an image, reducing its dimensions and retaining important information.

Deconvolution reverses the process of convolution, regenerating the original image while improving contrast and resolution.

02 Economic and Operational Benefits

The implementation of AI-enabled AOI and SPI systems like those of Delvitech has yielded tangible economic benefits.

Manufacturers have reported significant reductions in inspection times, with some noting a 30% decrease, allowing for increased production without compromising quality. Additionally, the precision of these systems has led to a 25% reduction in product returns, enhancing customer satisfaction and loyalty[1][2].

By automating routine inspection tasks, companies can reallocate human resources to more strategic roles, fostering innovation and continuous improvement within teams. This shift not only enhances workforce morale but also drives a culture of excellence, essential for long-term success.

However, the majority of existing solutions still exhibit notable limitations, particularly in the areas of neural network training and lifecycle management. In most existing systems, optimizing inspection performance requires highly specialized personnel to curate, preprocess, and annotate datasets.

This expertise is essential to ensure that neural networks can effectively assimilate new information, adapt to evolving defect patterns, and maintain reliable operational performance across variable production conditions[1][4].

To address these limitations and provide line operators with greater autonomy in managing and adapting inspection workflows—thus improving responsiveness, operational efficiency, and overall cost-effectiveness—Delvitech has developed the Training Manager.

While the current inspection technology is capable of automatically handling approximately 98% of standard production scenarios across various industries, achieving 100% coverage requires the ability to manage edge cases that fall outside conventional process boundaries.

These residual cases typically arise in sectors characterized by exceptionally high product variability, non-standardized manufacturing workflows, and elevated complexity in component configurations or assembly processes.

The Training Manager enables domain experts and process engineers to efficiently train and validate AI-based inspection models tailored to these specific and atypical use cases, ensuring complete inspection coverage and maintaining the highest levels of quality assurance in even the most demanding environments.



03 Training Manager

The Training Manager is an advanced tool engineered to streamline and accelerate the annotation and training lifecycle of neural network models, significantly reducing the dependency on highly specialized personnel.

It integrates Delvitech's proprietary Knowledge Retention Technology (KRT), a continual learning technique that mitigates the challenge of catastrophic forgetting, a well-known problem where a model forgets previously learned information when it is trained on new data[4].

Thanks to KRT, the system can learn from new image datasets without compromising previously acquired knowledge, thus supporting the progressive evolution of multiple models.

04 Key Features and Application

The Training Manager user interface is designed for maximum efficiency and ease of use.

Core functionalities include:

→ Image and dataset management: upload, annotate, and delete images and their annotations.

→ Model management: create, train, and delete neural network models.

→ Training history panel: a dedicated view provides a clear overview of past training sessions, aiding version tracking and model performance monitoring.

In its first release, the Training Manager supports training for the recognition of:

1. Component bodies
2. Pins
3. Solder joint goodness

These capabilities are essential for powering automated inspection modules such as the Solder Joint Inspector.

DATA-DRIVEN LEARNING: FROM ANNOTATION TO ADAPTIVE MODEL TRAINING

Within the annotation module, users can select visual elements—such as pins on solder joints—and assign them labels such as Good or Bad.

These labels serve as the input data for the classification neural network, helping it learn to distinguish between acceptable and defective conditions.

When the model misclassifies a feature (e.g., labeling a good joint as defective due to shadows or visual artifacts), manual correction of the label allows the image to be reintroduced into the training dataset, thus improving the model's accuracy.

Annotated images are organized into thematic categories, stored in dedicated subfolders.

These categories can be combined to form complete datasets ready for training. The system is highly scalable: it allows for large sample collection to refine model quality, or quick training with just a few examples—even a single image—to test or rapidly correct model behavior.

In addition, once the trained model successfully passes the validation phase, it can be seamlessly deployed across the entire Delvitech ecosystem.

This includes all inspection machines within a single production line, throughout an entire facility, and—when required—across multiple geographically distributed production plants.

This centralized model sharing ensures consistent inspection standards, accelerates the rollout of updates, reduces redundancy in model training efforts, and enhances overall scalability and operational efficiency in multi-line or multi-site manufacturing environments[3].

A standout feature of the Training Manager is its ability to train models with minimal data, ideal for production environments where rapid adaptation is critical. Even one accurately labeled image can significantly enhance the model's performance, enabling fast, targeted iterations.

In addition to classification, the Training Manager supports semantic segmentation. Users can manually draw polygons to precisely define the shape and contour of an object (e.g., a pin), generating a dataset tailored for segmentation model training.

04 Key Features and Application

Missing components can be flagged with the Missing label, further improving the model's sensitivity.

Training in this mode is also extremely fast, typically taking less than one minute.

Finally, to support continuous production environments where pausing the line for model training is not feasible, the Training Manager is also integrated into offline programming stations—a standard practice in both AOI (Automated Optical Inspection) and SPI (Solder Paste Inspection) workflows.

These offline stations are typically used for creating, configuring, and validating inspection programs without interrupting live operations.

By enabling model annotation, training, and validation directly within these offline environments, operators can develop and refine neural network models in parallel with active production.

Once validated, these models can be seamlessly deployed to in-line systems, ensuring uninterrupted throughput while maintaining the adaptability and accuracy of AI-driven inspection processes.

This approach enhances flexibility, reduces downtime, and supports rapid iteration cycles essential in high-mix, high-volume manufacturing settings.

ANNOTATION AND SEGMENTATION AT A GLANCE

VISUAL ANNOTATION
Operators label key features (e.g., pins) as Good or Bad, teaching the model to distinguish defects through supervised learning.

ERROR CORRECTION
Misclassifications are manually corrected and reintroduced, refining model accuracy through iterative feedback.

ORGANIZED DATASETS
Annotated images are grouped by category into subfolders, ready for flexible dataset creation and model training.

RAPID TRAINING
Train with thousands of images for depth or a single annotated image for quick adaptation and corrections.

SEMANTIC SEGMENTATION
Operators draw precise polygons around objects (e.g., pins), generating detailed masks for segmentation training.

MISSING LABELING
Tag absent features as Missing, enhancing detection sensitivity in real-world production scenarios.

FAST & OFFLINE-COMPATIBLE
Training takes under 1 minute and can be done on offline stations, avoiding production interruptions.

SCALABLE DEPLOYMENT
Validated models are deployed across multiple lines, sites, or facilities, ensuring standardization and efficiency.

04 Key Features and Application

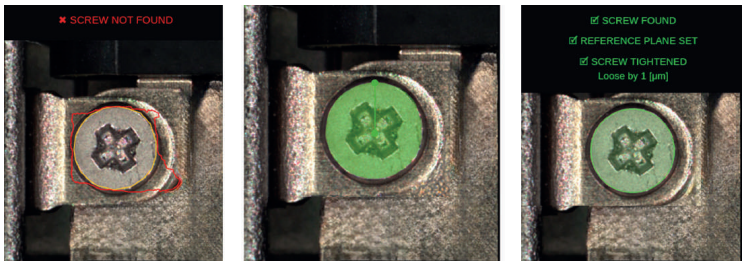
TECHNOLOGY APPLICATION IN REAL-WORLD SCENARIOS

This section presents the practical application of the proposed technology, highlighting its effectiveness in addressing specific operational challenges.

1. Body Segmentation

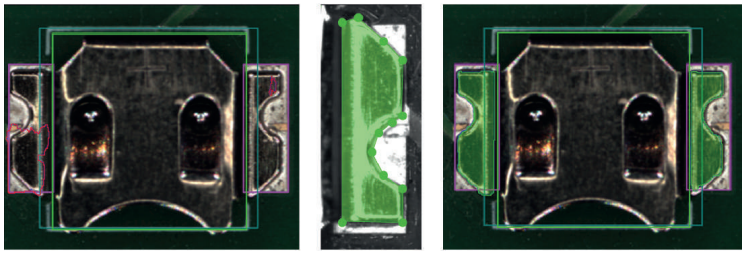
The first case addresses body segmentation involving a non-standard component—a screw. Initially, the system fails to detect the screw. However, after manual selection by the operator using the Annotation Tool and subsequent network training, the system is capable not only of reliably identifying the presence of the screw but also of analyzing specific characteristics.

For instance, in this particular scenario, the system assesses whether the screw is properly fastened. If not, it flags the anomaly and quantifies the deviation, which in this case amounts to 1 micron.



2. Pin Segmentation

In this second case, the system fails to correctly detect the presence of a pin. The operator uses the Annotation tool to manually identify the pin and initiate the neural network training. Once the process is completed, the system reliably recognizes the pin on its own.



3. PTH Resistor Segmentation

In this case, the system initially fails to correctly identify the presence of a PTH resistor, as it was not originally trained to inspect PTH components. Using the Annotation tool, the operator manually highlights the resistor location and triggers the neural network training process. Once training is complete, the system learns to recognize the PTH resistor body reliably and autonomously, demonstrating the network's ability to adapt to new component types through guided annotation.

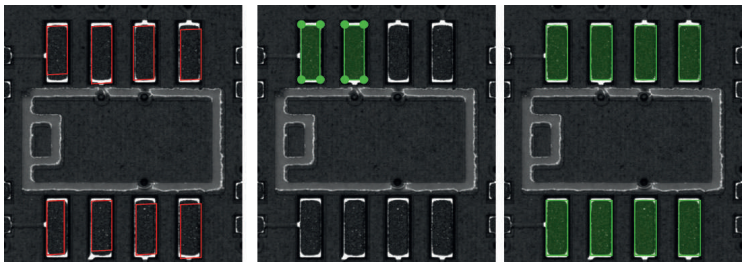


04 Key Features and Application

TECHNOLOGY APPLICATION IN REAL-WORLD SCENARIOS

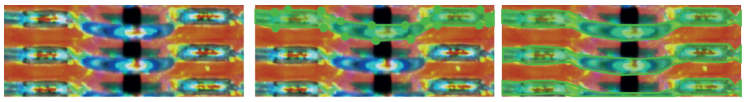
4. Paste Deposit Segmentation

In this case, the system initially fails to correctly identify the solder paste deposits, as the neural network has not yet been trained on this specific feature. Using the Annotation tool, the operator manually labels just a few paste deposits and initiates the training process. Once training is complete, the system learns to recognize all eight paste deposits accurately and autonomously, demonstrating the network's ability to quickly adapt and generalize.



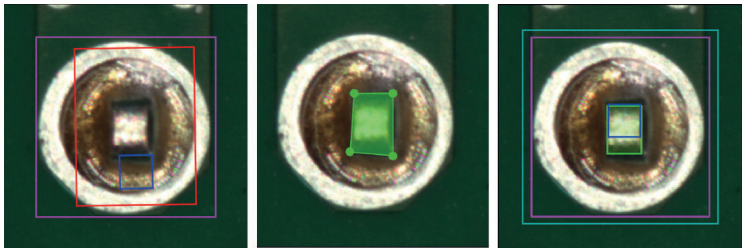
5. Wire Bonding Segmentation

The system initially fails to detect any wire bonds, as the neural network has not been previously trained on this type of feature. Using the Annotation tool, the operator manually marks a few wire bonds and initiates the training process. Once training is complete, the system accurately identifies all wire bonds autonomously.



6. Pin in Paste Segmentation

In this example, the system initially struggles to reliably detect the pin-in-paste features because the neural network has not yet encountered this specific scenario.
Using the built-in annotation tool, the operator quickly labels a few representative pin-in-paste locations, which then initiates the training process. After training, the system successfully and autonomously identifies all pin-in-paste features, demonstrating how the neural network can efficiently learn and generalize from just a small set of guided examples.

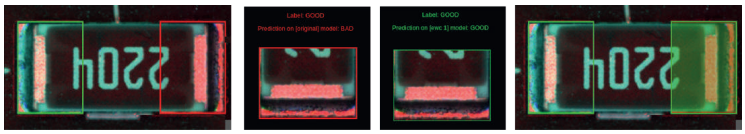


04 Key Features and Application

TECHNOLOGY APPLICATION IN REAL-WORLD SCENARIOS

7. Solder Joint Classification

The last case involves a solder joint that is incorrectly classified as bad due to suboptimal lighting conditions, despite being compliant. The operator manually reclassifies it as good, and this correction is absorbed by the neural network.





05 Conclusion

The Training Manager is a cornerstone of Delvitech's strategy for advanced industrial automation. Thanks to its flexibility, speed, and precision, it enables:

- Reduced development and adaptation times for AI models
- Enhanced in-line quality control performance
- Increased operational efficiency through smart data management

With the Training Manager, AI model training evolves from a complex, time-consuming task into a streamlined, accessible process seamlessly integrated into daily production workflows—positioning it as a key enabler of agile and intelligent manufacturing in the face of ever-changing inspection challenges.

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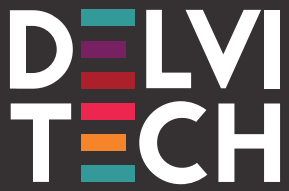
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