BLUE TENSOR
Grow your business with Artificial Intelligence

A reference industrial laboratory benefits from quality control automation using AI-based computer vision

by Jonni Malacarne
BlueTensor

The TEC Eurolab, based in the heart of Emilia's motor valley, is the industrial laboratory of reference in Italy for the aeronautical and automotive sectors – providing essential life support for industrial materials in which safety is fundamental.

The laboratory offers an unparalleled integrated service for performing all the analyses necessary to ensure customer satisfaction without mishaps, as well as for the continuous improvement of product performance and reliability.

After installing the diondo D7 6 MeV LINAC tomograph, which can penetrate particularly dense components, the laboratory's industrial tomography department can now provide services in a unique range of applications.

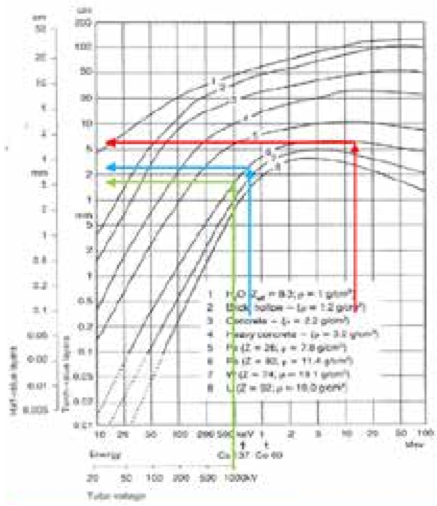
Tomographic scanning (or 3D radiography, similar to medical CT (computerized tomography) scanning) enables the detection, identification, and characterization of defects within objects without affecting their structure.

The object to be analysed is placed on a rotating table between X-ray sources inside a concrete bunker that shields the radiation. As the object rotates, a computer system collects thousands of X-rays to create a 3D model.

This is a critical job for the safety of components for these two sectors and it requires the utmost care and extensive training to minimize errors and maximize control reliability. On the other hand, it is also rather expensive work: defect analysis using tomography requires specialized technical personnel to view the 3D-models section by section, checking thousands of images every day when they have to check entire production runs. To understand the significance of this undertaking, consider a turbine blade as an example.

Turbine blades power aircraft engines and power generation plants, so they are subject to extreme mechanical, thermal, and fatigue stress. In short, they are one of the most stressed objects in the field of industrial mechanics.

A turbine blade measuring 40cm high with a tomography cross-section of one-tenth of a millimetre would require an operator to scroll through 4,000 images and analyse them one by one to check for any defects.



Manipulator:	6-Axes granite-based
Variable FDD:	1500 – 4000 mm
Scanning envelope:	D = 1000 mm, H = 2000 mm
Max payload:	200 kg
Max dose rate:	2.5 Gy/min @ 3 MeV, 9.0 Gy/min @ 6 MeV
High resolution Line Detector Array:	length 600 mm, pixel pitch 200 µm
3K Flat Panel Detector 4343 HE:	active area 417 x 417 mm, pixel pitch 139 µm

Fig. 1. The diondo D7 6 MEV LINAC was developed to reliably analyse objects that are difficult to penetrate due to their high density or thickness.

This is extremely laborious, but it is also indispensable for ensuring process reliability. The analysis has a high cost because it requires a lot of human time.

Previously, the TEC Eurolab team performed its various automation tests using industry-specific image analysis software. Unfortunately, it was almost impossible to configure the software to unambiguously identify all defects due to the wide variability in their shape and contrast.

A deep learning algorithm is ideally suited to cases like these improving the process by making it more efficient, reliable, and objective. This is why TEC Eurolab turned to BlueTensor.

The method

In our experience as AI experts, one of the biggest obstacles in the development of artificial intelligence systems is encountered in the initial phase.

Data preparation is one of the most essential and arduous activities in implementing an AI system: an algorithm needs tens of thousands, if not hundreds of thousands, of images to learn correctly so that it can increase efficiency.

In addition to teaching the algorithm what defects were, we also had to teach it which indications are not defects, so that it can exclude them from analysis. During the development phase, our team used many solutions to make this process more robust, repeatedly varying many detection parameters, including the distance from the surface, and the dimensions of the defects, while also implementing solutions to reduce false positives. After the development phase ended, the algorithm was ready to work with the data, formulate hypotheses, propose solutions, and make judgments. During the first six months, human operators identified and reported

Fig. 2. When the AI system recognizes a defect, it must be validated by a human operator.

defects to the AI system so that it could start learning to recognize them. Our developers applied a mathematical filter that hypothesized possible indications to accelerate this initial phase. After these first six months, the AI system started to find many defects.

The algorithm's purpose is to recognize defects and alert the operators. Consequently, the operator validate its input. Thereafter the indication becomes material to further train the algorithm.

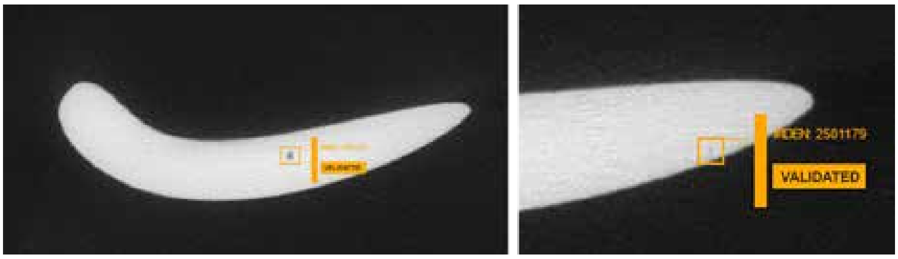


Fig. 3. The AI system achieved a level of reliability about 12% higher than human operators.

Once the deep learning algorithm had been engineered and the prototype built, we created a simple user interface for training.

This allowed TEC Eurolab's staff to add new images of anomalies gradually and independently and continue training the AI, thus increasing the quality and reliability of the results.

The results

Thanks to the progressive refinement of our deep learning model, the reliability of anomaly identification has exceeded 95%, with peaks of 99%. These are already outstanding results, which will be further improved as we continue teaching the algorithm.

The operator now validates the anomalies identified by the AI and add new ones. These anomalies are automatically processed by the algorithm, which periodically re-trains to improve its performance.

The training method adopted, with monitoring by experienced users (who functioned as AI teachers), enable the algorithm to identify critical defects and anomalies in any position, and of any shape and size.

Subsequently, thanks to the dynamics of deep learning, the algorithm has been able to identify anomalies that human operators alone could not identify, and this has made it possible to render the verification process of industrial materials more objective, reduce the time required, and improve reliability.

We recently performed a test on 57 components: the human operator detected 91 defects while the AI system detected 103. So not only did it detect all those already identified by the operator, but also others, thereby exceeding even our expectations for the outcome.

Conclusion

The Deep Learning system has enabled TEC Eurolab to improve the reliability of defect detection by compensating for the human factor. The human factor cannot be excluded because the operators are responsible for managing the non-destructive testing and for the outcome. Therefore, they will continue their verification and validation activities.

Not checking would compromise the usability of the industrial products themselves because the companies in this sector cannot use products with internal defects. However, with the help of artificial intelligence, the human time spent on this vital task has been reduced by 50%.

AI also ensures the scalability of this production flow and the sustainability of the undertaking. Additive manufacturing enables material performance that is often much higher and more flexible than that achieved by other production processes. However, this is only feasible if control of the parts produced is also scalable and sustainable.

In conclusion, we created an anomaly detection system based on computer vision technology that improved the process and made it more sustainable for both the organization and for the operators.

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About BlueTensor

BlueTensor, based in Trento in northern Italy, through a proprietary framework, develops highly customized Artificial Intelligence solutions designed to grow client companies' business through increased productivity and cost reduction. The company supports Italian and international companies with a qualified team of specialists focused on customer needs and on developing cutting-edge solutions. The key technologies are computer vision, predictive analysis, and natural language processing, and BlueTensor's goal is to identify and implement the best Artificial Intelligence tools by developing solutions for specific problems and achieving operational and strategic objectives.

BlueTensor is also the founder and sponsor of the Doctorate in Industrial Innovation at the University of Trento and collaborates with leading research centres in Italy and Europe, having at its disposal the latest innovations applicable in the field of AI.

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