DATA ECONOMY MEETS INDUSTRY 4.0 TO CREATE THE NEXT GENERATION OF SMART MANUFACTURING THANKS TO FEDERATED LEARNING

1 CHALLENGE

The emerging data economy holds the promise of bringing innovation and huge efficiency gains to many established industries. However, the confidentiality and proprietary nature of data is often a barrier as companies are simply not ready to give up their sovereignty. Solutions are needed to realize the full potential of these new profit pools. Musketeer offers to tackle these two dimensions by bringing efficiency while respecting the sovereignty of data providers in industrial assembly lines. Two challenges are presented:

- **Improving welding quality assessment to develop predictive maintenance for robots while increasing product safety at the same time**
- **Training a welding quality assessment algorithm on large datasets from multiple factories**

The presence of a huge number of machineries in industrial automation factories and the elevated cost of downtime produce large expenses for the production line maintenance. Getting a more accurate evaluation of robot performance helps to avoid damaging the production capacity contingently (by 5 to 20% in certain cases).[1]

The welding quality assessment can be improved using machine learning algorithms which support the machinery status monitoring. But a single factory might offer too few data to create such algorithms. It requires accessing larger datasets from Comau's robots located in different places to boost the robustness and quality of the machine learning model.

However, Comau's customers can be competitors. Those companies do not intend to share data with competitors and simply waive their data sovereignty. With federated machine learning techniques, Comau can offer an appropriate level of security for customers and save them costs at the same time. Besides, the aforementioned data might include personal information regarding operators working in the manufacturing plant which can raise additional privacy concerns that have to be tackled by the solution.

[1] https://www2.deloitte.com/content/dam/Deloitte/us/Documents/process-and-operations/us-cons-predictive-maintenance.pdf

2 ACTION

Collect data from welding robots combined with manual ultrasound testing data and build an algorithm in order to classify each welding point in a privacy preserving way. Data come from different plants which must have their data sovereignty preserved.

At each piece's welding point, some welding parameters are recorded, such as current between the electrodes, resistance, number of points already welded by those electrodes and so on.

FIGURE 1 MODEL OF A COMAU ROBOT USED FOR THE WELDING OF CAR PARTS

Then, a minimum amount of those pieces is sampled from the line to make an ultrasonic non-destructive testing to assess the welding spot quality. An operator applies a probe on each welded spot which sends a signal to a computer to be interpreted (graph representing the reflected sound energy versus time). The operator then classifies the welding points into different categories.

In a production line only one or two pieces are verified each day whereas the total number of welded pieces goes up to 400 per day. Therefore, only a scarce percentage of pieces are subject to ultrasound testing.

Besides, the manual test is limited to a few critical welding points on each piece, called Q+ points, that are always the same. On each car body, there are more than 3,000 welding spots while the Q+ points represent only a very small percentage of them.

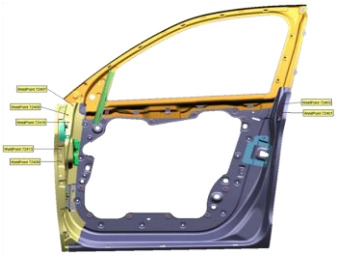


FIGURE 2 PRESENTATION OF Q+ POINTS ON A CAR DOOR

Our action here consists of collecting this manual ultrasound testing data and combining it with the welding data from the robot in order to locally train the algorithm. In parallel, this machine learning model is trained on different datasets from other factories. Trained models are eventually merged on the Musketeer platform (in different location) to provide the final version of the model.

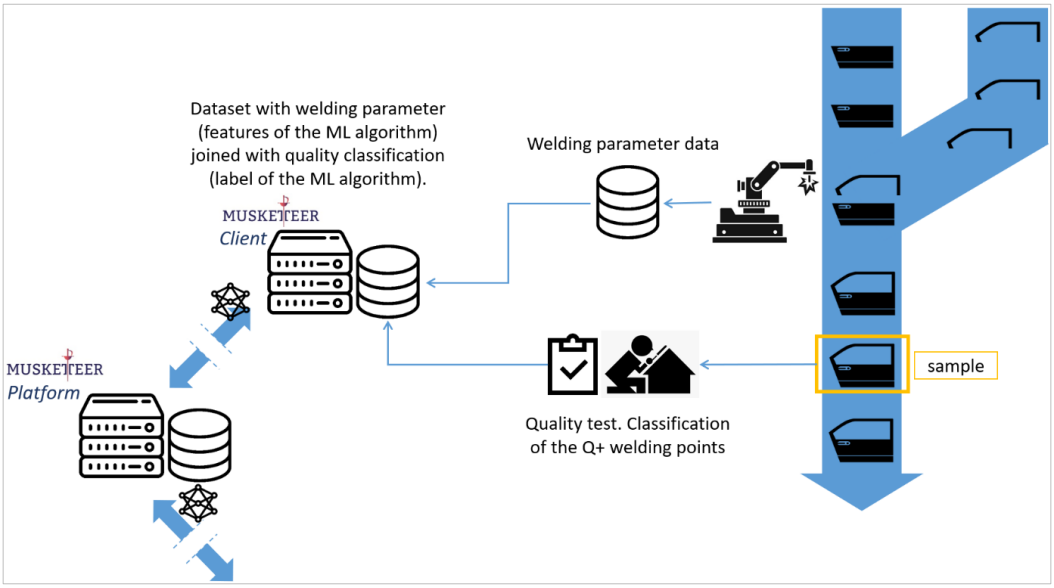


FIGURE 3 DATA COLLECTION AND PROCESSING IN FEDERATED LEARNING ENVIRONMENT

As mentioned, collecting data from different factories also raises privacy issues. These data can be sensitive company data but also lead to personal data concerns (e.g. data can include information about operators working at the plant). Using the Musketeer platform provides a robust solution mixing a federated machine learning approach (local training) with privacy preserving technologies (highly customized encryption, data poisoning attacks mitigation) while respecting sovereignty of the stakeholders as defined by IDSA standard[2].

3 RESULT

Implementation of a machine learning algorithm able to classify the welding points using only data coming from a welding robot.

Based on the combined data coming from robots and ultrasound tests, a robust model is built . Once the model is trained and has a satisfactory accuracy, thanks to the federated approach, it becomes possible to provide the classification of the welding spot directly from the welding data.
This leads to numerous advantages over the limited manual testing:

- Opportunity to estimate the quality of all the welding points (not only the Q+ points) and raise the safety of products accordingly
- Opportunity to understand if a specific combination of parameters helps to weld with fewer defects
- Data sharing is allowed while sovereignty of each participant is preserved, and privacy concerns are tackled

[2] https://www.internationaldataspaces.org/wp-content/uploads/2019/03/IDS-Reference-Architecture-Model-3.0.pdf

QUOTES

Quote from Comau:

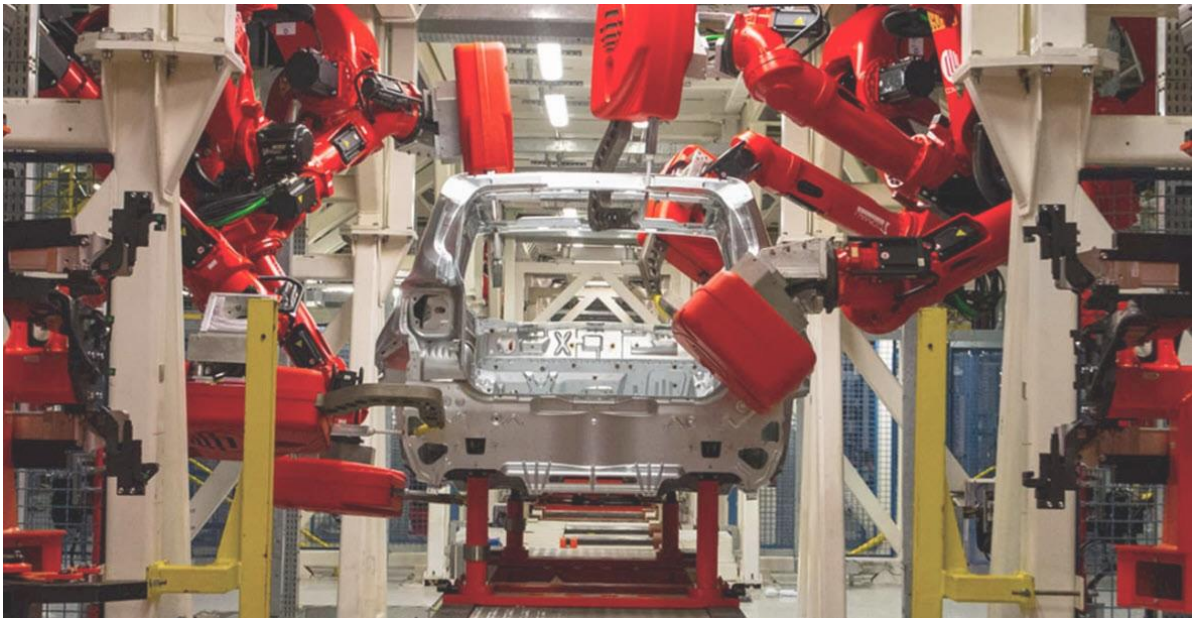
"Using federated and collaborative Machine Learning techniques, Comau will be able to provide innovative maintenance services to their customers providing them more robust and more accurate predictive models, using data coming from different customers plants, while at the same time preserving privacy issues related to Company data."

Massimo Ippolito, Head of Digital Innovation & Infrastructure

Quote from FCA-ITEM:

“Using machine learning for welding quality assessment has the potential to extend our ultrasound non-destructive testing from a sample to every single welding point on a car door. Information technologies solutions could also help to better understand robot behaviour and anticipate potential failure in the process without putting pivotal data at stake, contributing to design an efficient manufacturing process.”

Giacomo Fecondo, ICT Industrial Applications & Services Specialist



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