Automated Defect Detection using Deep Learning

Avyuct LLC
8/10/2021

Presenters -
Dr. Rajesh Aggarwal
Ayushi Tiwari

Agenda

1

Understanding the Need:

- What is the current technology?
- The issue with current technology.

2

Technology Overview:

- Process Diagram
- Workflow of an automated defect detection Deep Learning model

3

Our Results

- Automated defect detection using Deep Learning

Background

- Defect detection is becoming an increasingly important task in the manufacturing process.
- The early detection of faults or defects and the removal of the elements that may produce them are essential to improve product quality and reduce the economic impact caused by discarding defective products.
- This point is especially important in the case of products that are very expensive to produce.
- There are vision inspection systems that are used for defect detection in industries.

Vision Inspection

The traditional automated vision system for inspection detects defects, contaminants, functional flaws, and other irregularities in manufactured products.

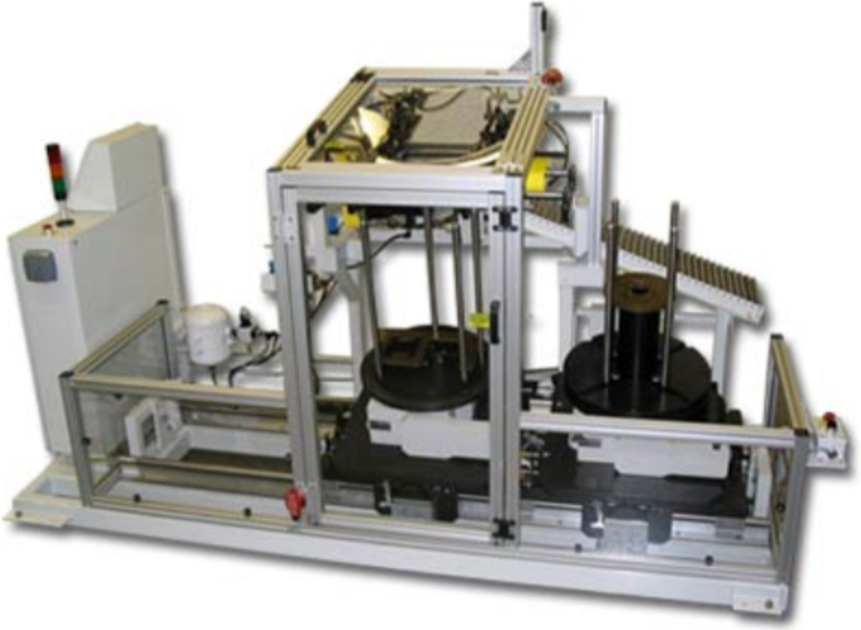
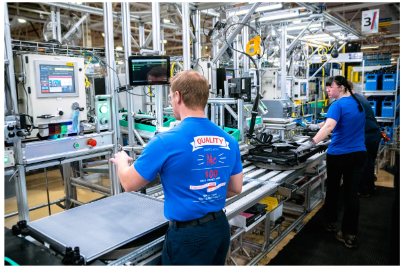
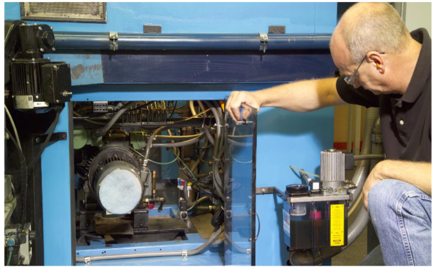


Image credits - https://www.machinevisionsystems.net/vision-inspection-systems/

Issues with current methodology





Traditional inspection machinery can cost millions of dollars per device

Although vision inspection technology has improved in the last few years, they are still incapable of adapting quickly to new environments

Troubleshooting devices requires expert resources and the process can be time consuming

From Traditional Vision Inspection to Machine Learning

With recent advances in the field of Machine Learning, it can can now be applied to automated vision inspection, granting machines some of the power of the human brain.

These systems tend to be good for inspection tasks that can’t be setup for high contrast on the features of interest.

Defect Detection in Industry

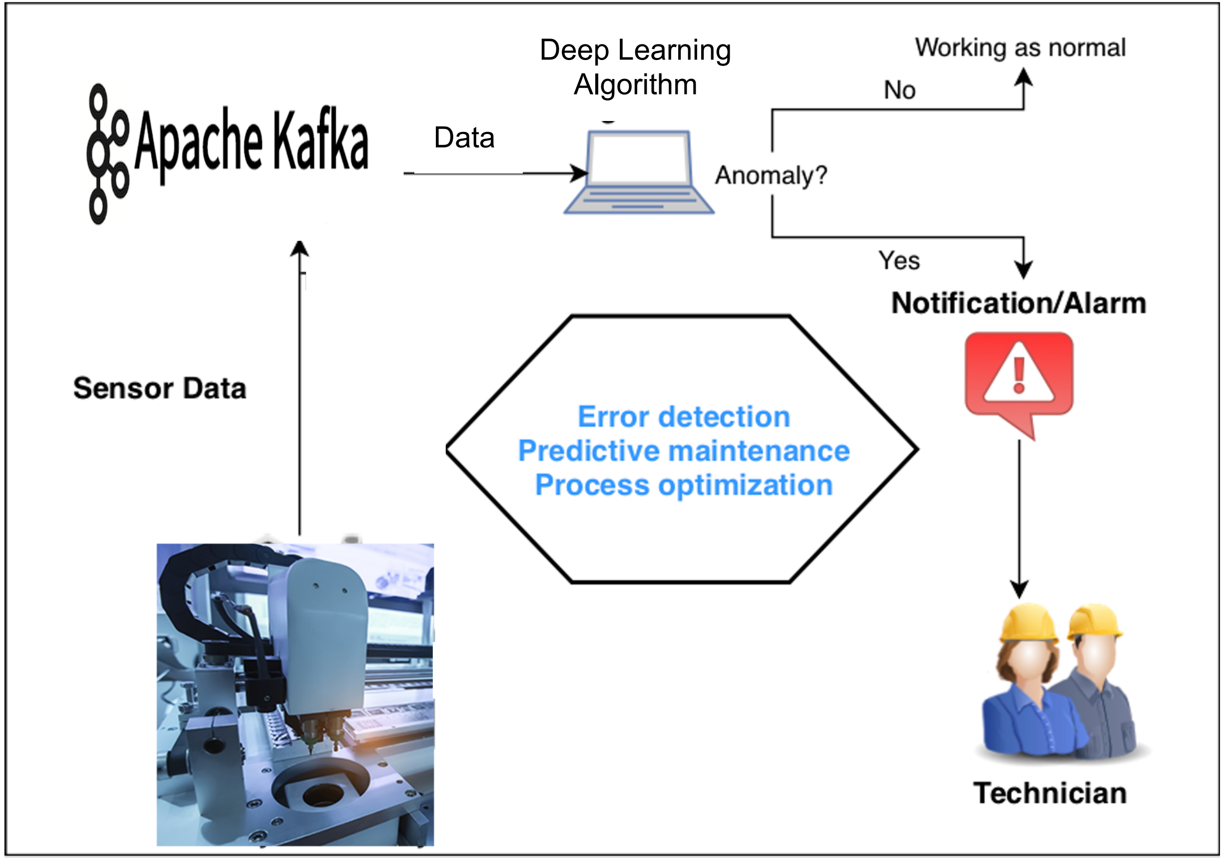


Image credits - https://icosys.ch/machine-learning-for-anomaly-detection-in-industrial-processes

Defect Detection in Industry

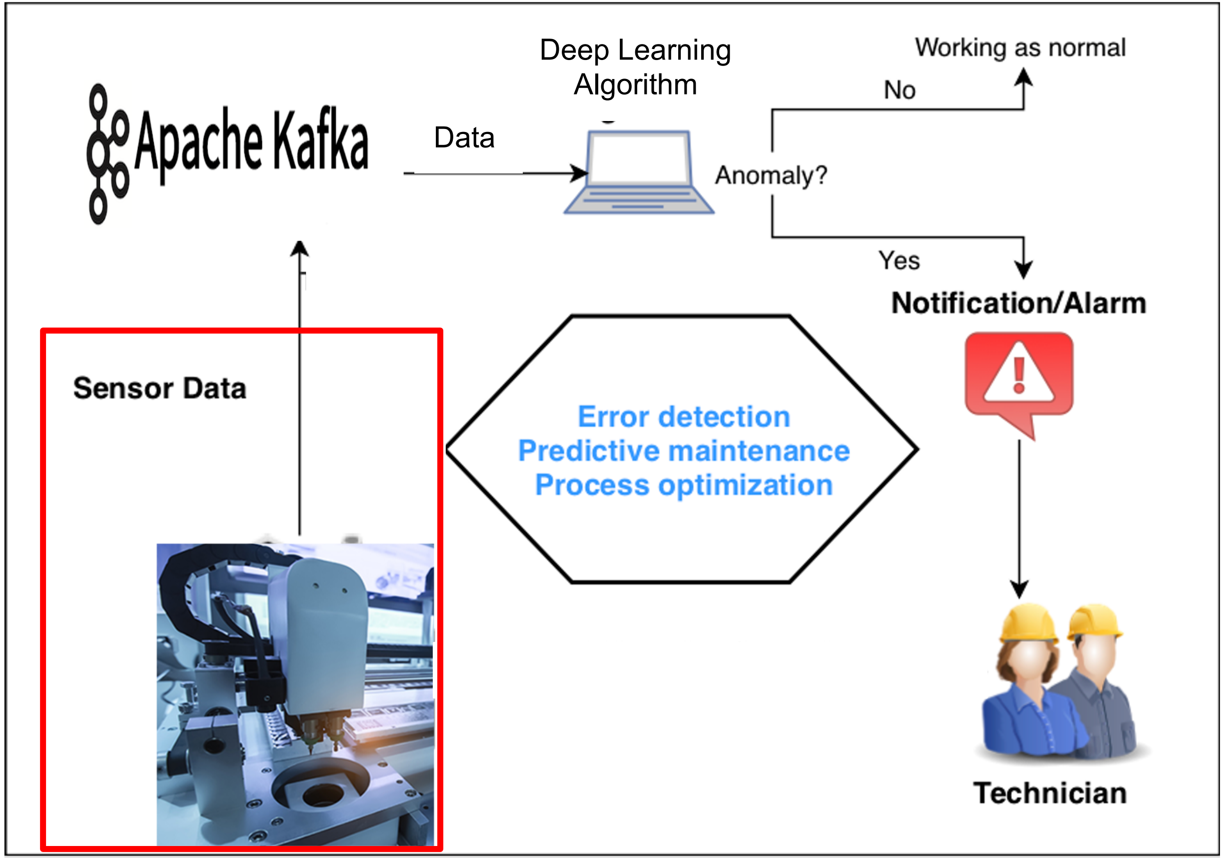
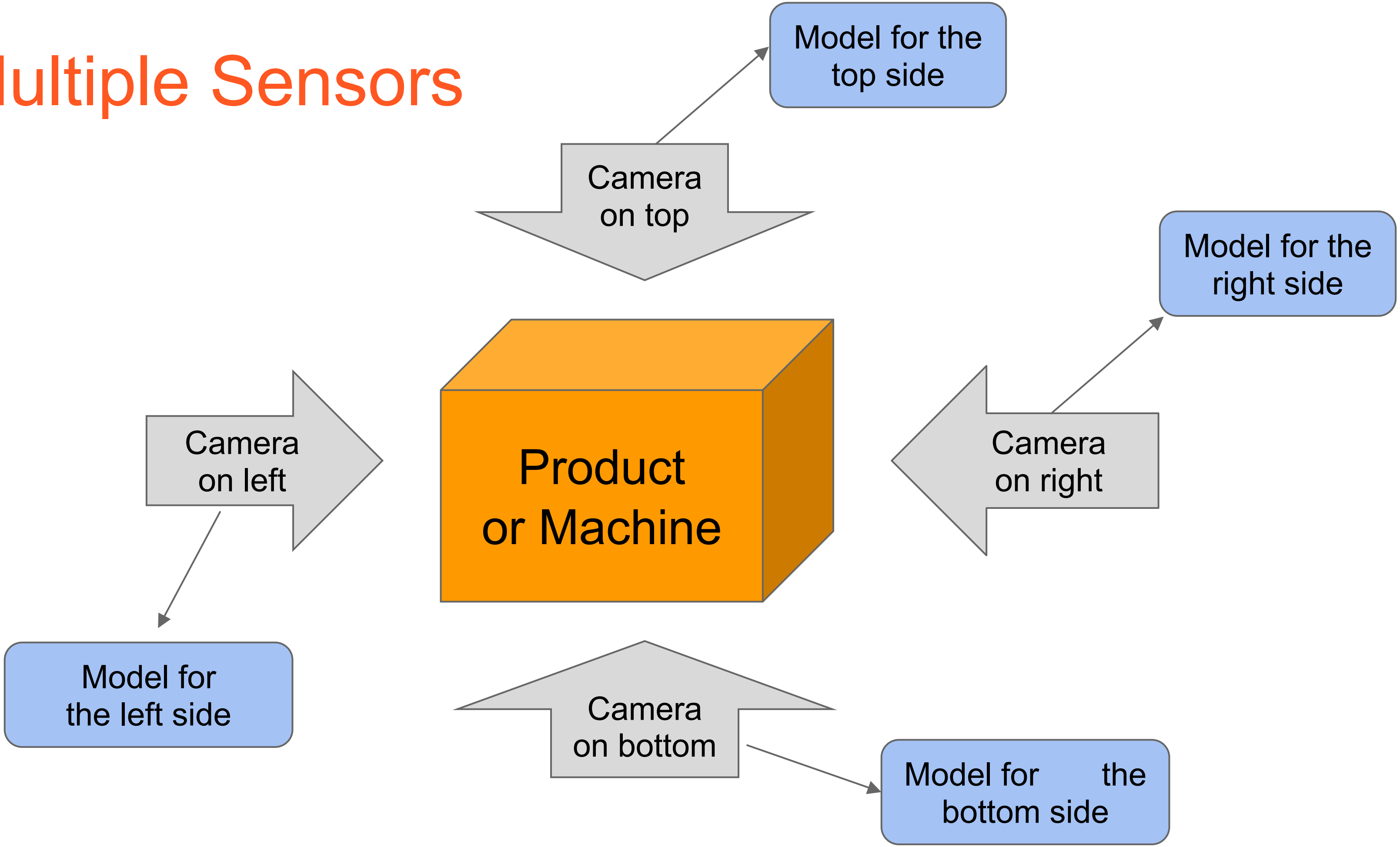


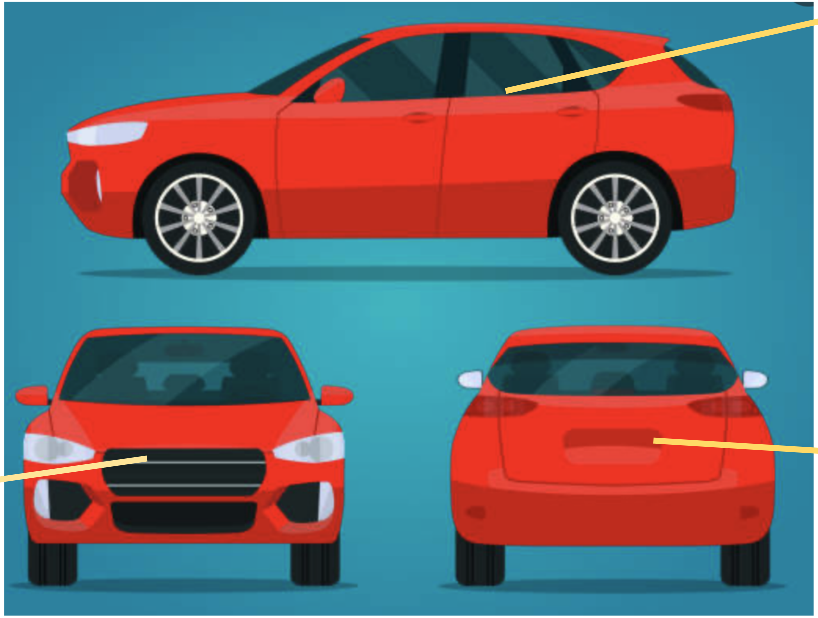
Image credits - https://icosys.ch/machine-learning-for-anomaly-detection-in-industrial-processes

Multiple Sensors



Integrating multiple sensors

2:14:37 p.m
Aug 7 left

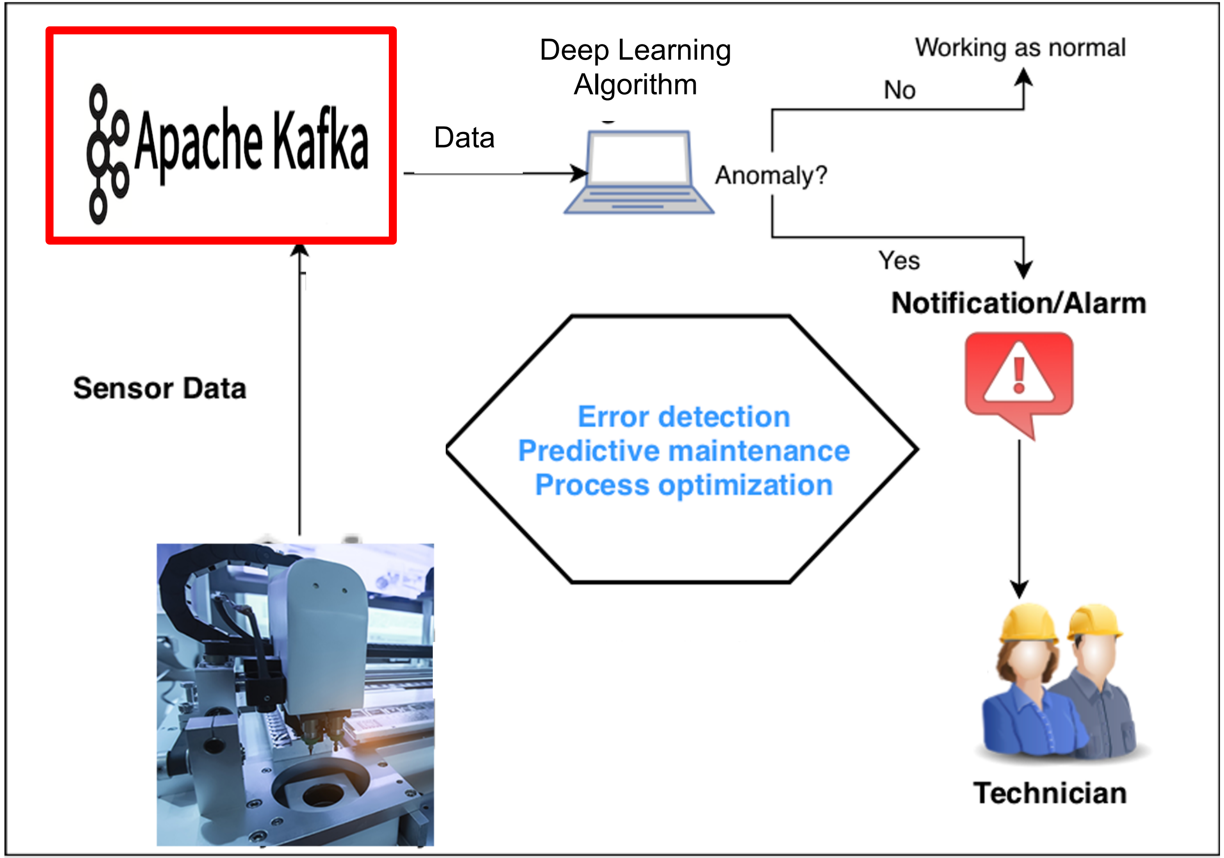


2:14:37 p.m
Aug 7 front

2:14:37 p.m
Aug 7 back

Image credits - https://www.istockphoto.com/photos/car

Defect Detection in Industry

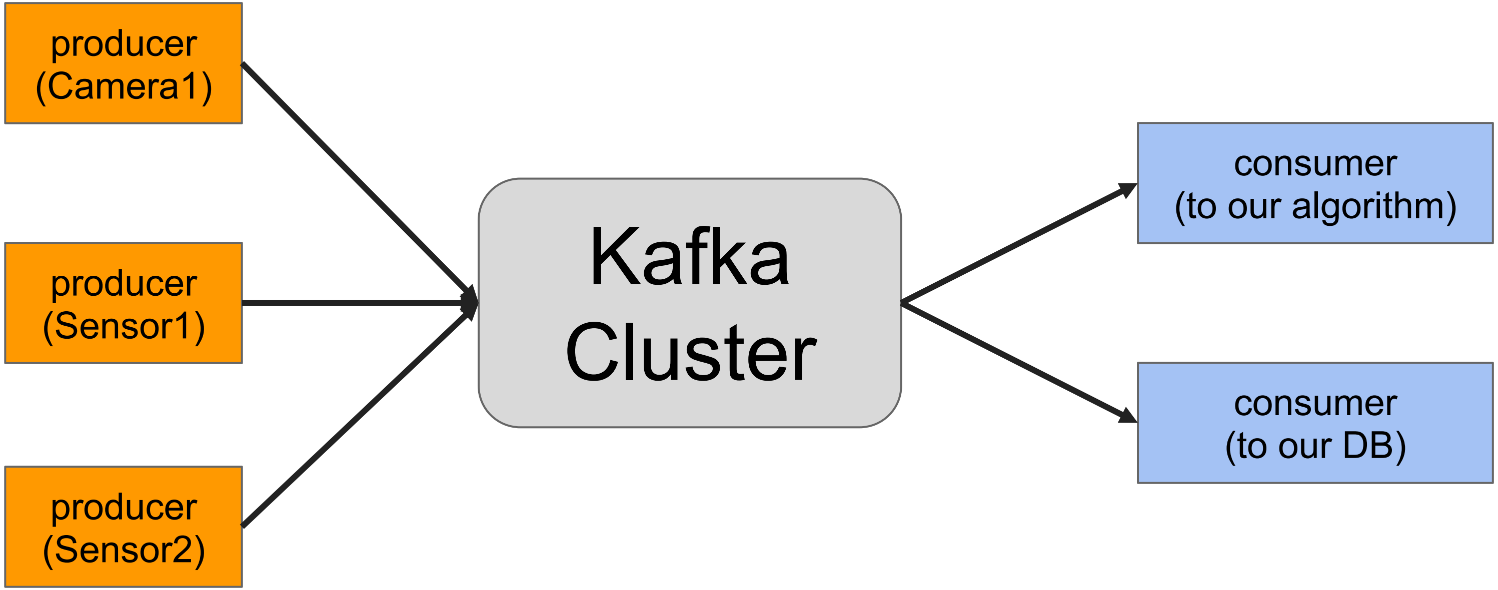


Ayyuct LLC Confidential

Image credits - https://icosys.ch/machine-learning-for-anomaly-detection-in-industrial-processes

Streaming Data with Apache Kafka

Kafka Architecture



Surface defects of Steel Plate

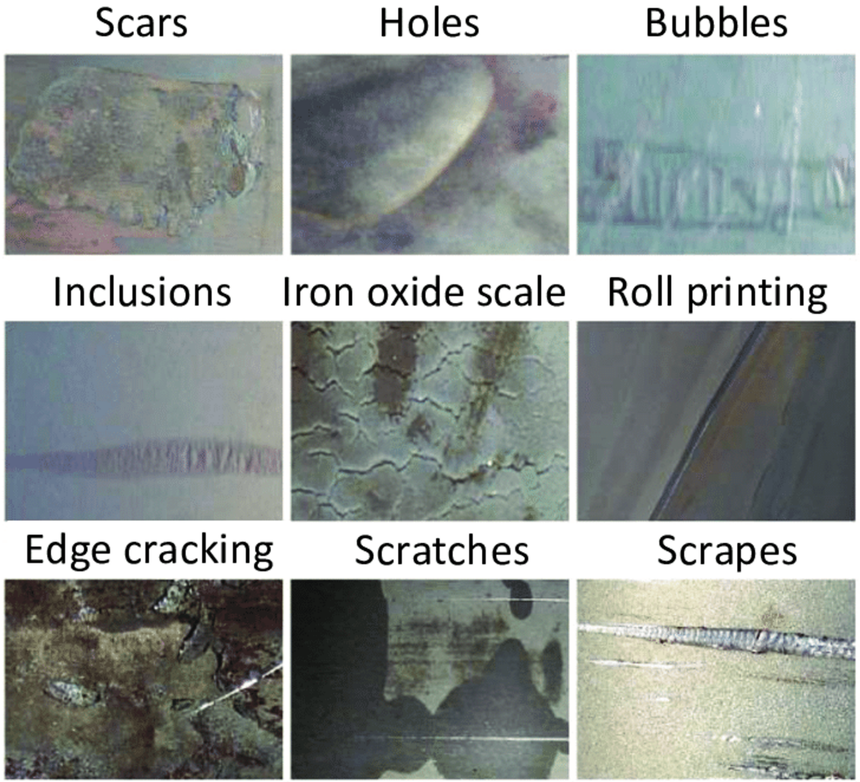
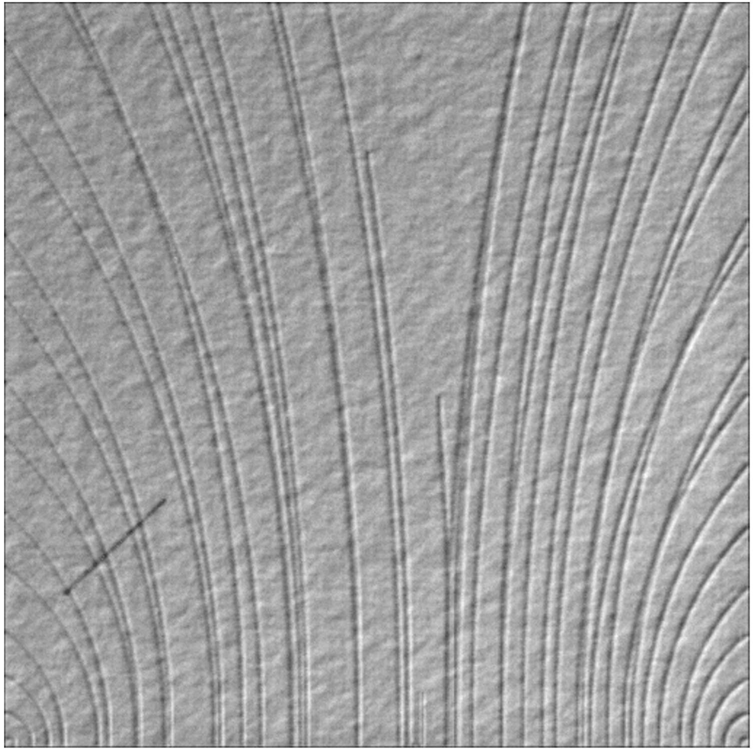


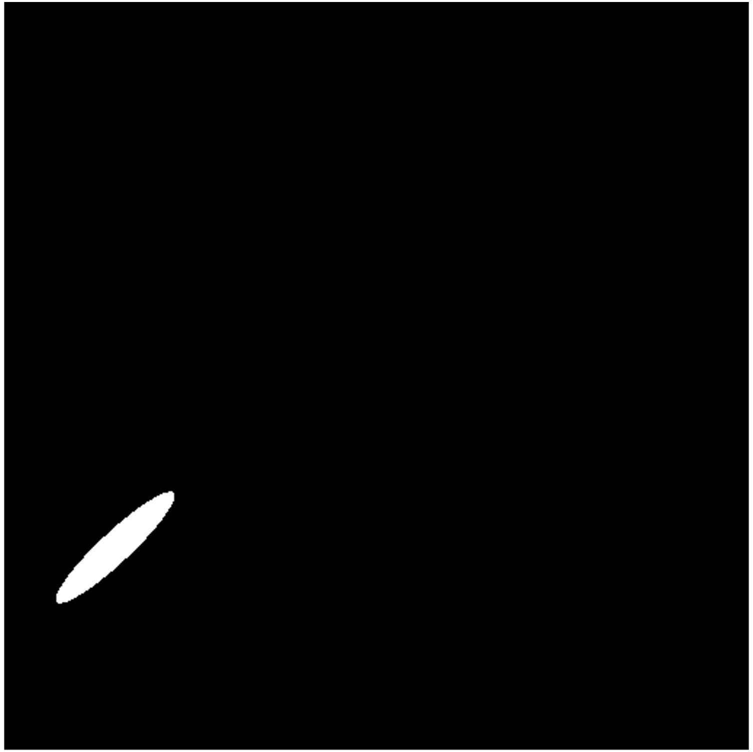
Image credits - https://www.researchgate.net/figure/Surface-defects-of-steel-plate_fig1_348643477

Training dataset used by our DL model

- The publicly available dataset was acquired from a competition for **DAGM 2007 Symposium**.
- The data is artificially generated, but similar to real world problems.
- Dataset folder consist of 10 datasets each consisting of manufactured part images with their respective defect labels.
- Each development (competition) dataset consists of 1000 (2000) 'non-defective' and of 150 (300) 'defective' images saved in grayscale 8-bit PNG format.

Sample Image from Dataset





Data Augmentation

1. Horizontal and Vertical Shift Augmentation
2. Horizontal and Vertical Flip Augmentation
3. Random Rotation Augmentation
4. Random Brightness Augmentation
5. Random Zoom Augmentation

Benefits of Data Augmentation

Modern deep learning algorithms, such as the convolutional neural network, or CNN, can learn features that are invariant to their location in the image.

Nevertheless, augmentation can further aid in this transform invariant approach to learning and can aid the model in learning features that are also invariant to transforms such as left-to-right to top-to-bottom ordering, light levels in photographs, and more.

Semantic labeling of data

Input

segmented

1: Person
2: Purse
3: Plants/Grass
4: Sidewalk
5: Building/Structures

3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	1	1	3	3	3	3	5	5	5	5	5	5
3	3	3	3	3	1	1	1	1	3	3	3	5	5	5	5	5	5
3	3	3	3	3	3	1	1	3	3	3	5	5	5	5	5	5	5
5	5	3	3	3	3	1	1	3	3	5	5	5	5	5	5	5	5
4	4	3	4	1	1	1	1	1	1	4	4	4	5	5	5	5	5
4	4	3	4	1	1	1	1	1	1	4	4	4	4	4	5	5	5
4	4	4	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	1	1	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	2	2	1	1	1	1	1	4	4	4	4	4	4	4
3	3	3	1	2	2	1	1	1	1	1	4	4	4	4	4	4	4

Semantic Labels

Defect Detection in Industry

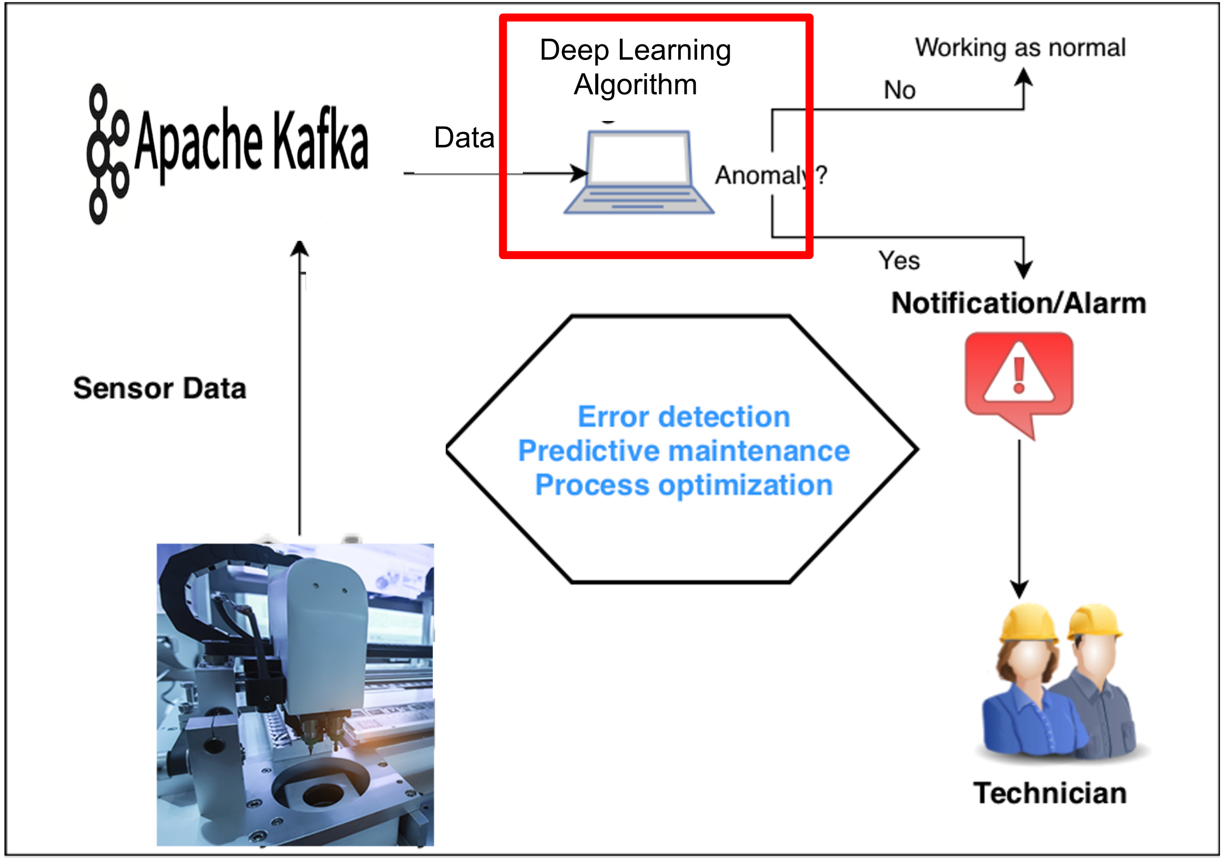
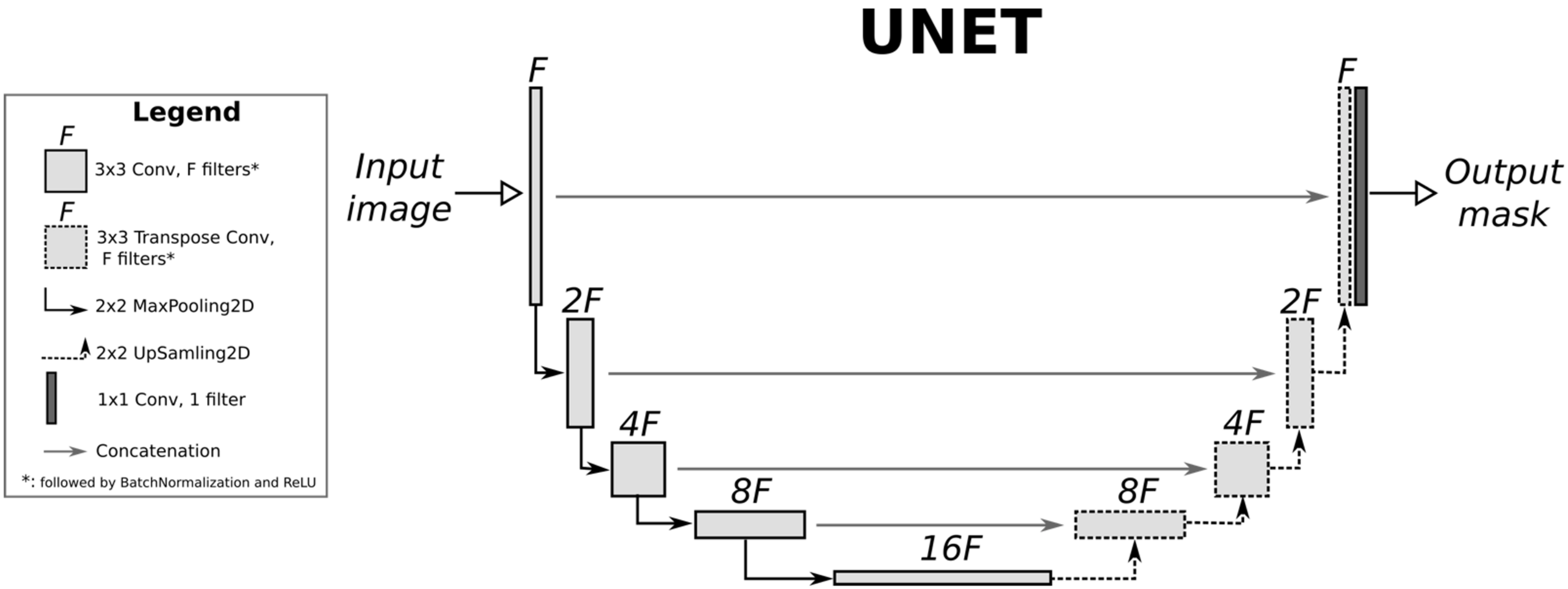


Image credits - https://icosys.ch/machine-learning-for-anomaly-detection-in-industrial-processes

Deep Learning Model

- Deep Learning algorithm U-Net was used
- Based on Class 10 of the dataset which has 2300 images split between train and test.
- We combined the dataset and split 90% train and 10% test data
- Images with defect in training set - 274 out of 2070
- Images with defect in test set - 26 of 230

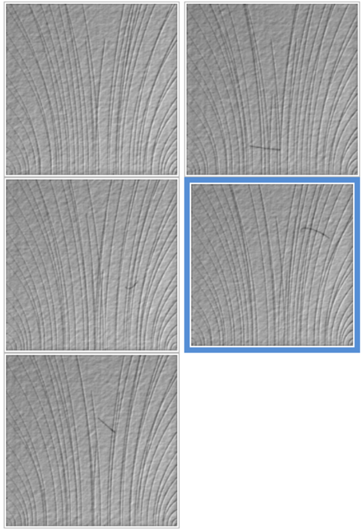
U-Net Architecture



https://nchlis.github.io/2019_10_30/page.html

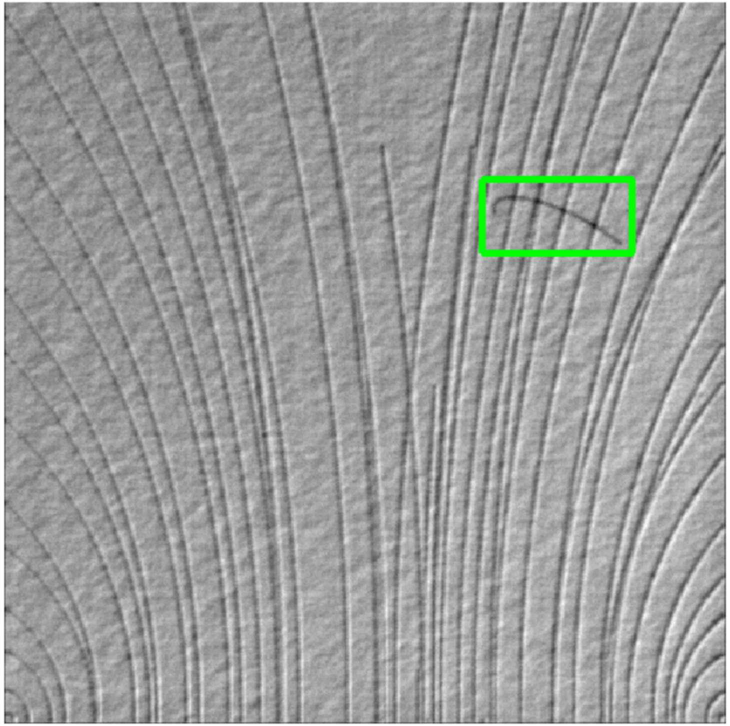
Deep Learning Model Results

Select Image



Result

Anomaly detected and labelled



Model Evaluation metrics

	There's a crack	There's no crack
Predicted as crack	26 (Model found 2 cracks twice -> Type 1 error)	2 (Type 1 error)
Predicted as non-crack	0 (Type 2 error)	202

Model Accuracy : 98.3 %

Type 1 Error : 1.7%

Type 2 Error : 0%

Why Type 2 Error matters?

The objective is to flag steel plate with defects thereby avoiding the false negatives or Type 2 error.

Consider the scenario where the model misclassifies a defective part. This is considered to be Type 2 error and we want to avoid it.

A scenario where the model classifies a good part as defective is the Type 1 error.

This also needs to be avoided but it is not an alarming scenario like Type 2 error.

Defect Detection under Predictive Maintenance

The evolution of maintenance strategies

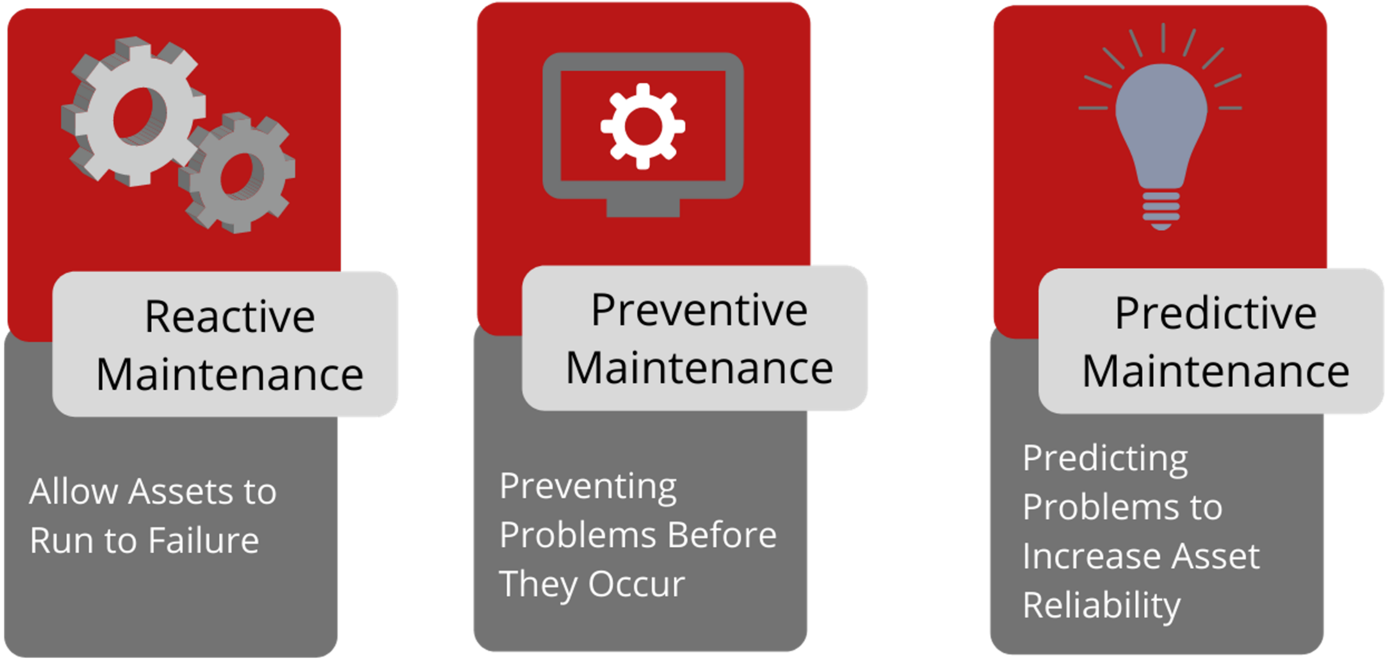


Image credits - https://www.prometheusgroup.com/posts/reactive-vs-preventive-vs-predictive-maintenance

What is Predictive Maintenance?

*Predictive maintenance refers to the **use of data-driven, proactive maintenance methods** that are designed to analyze the condition of equipment and help predict when maintenance should be performed.*

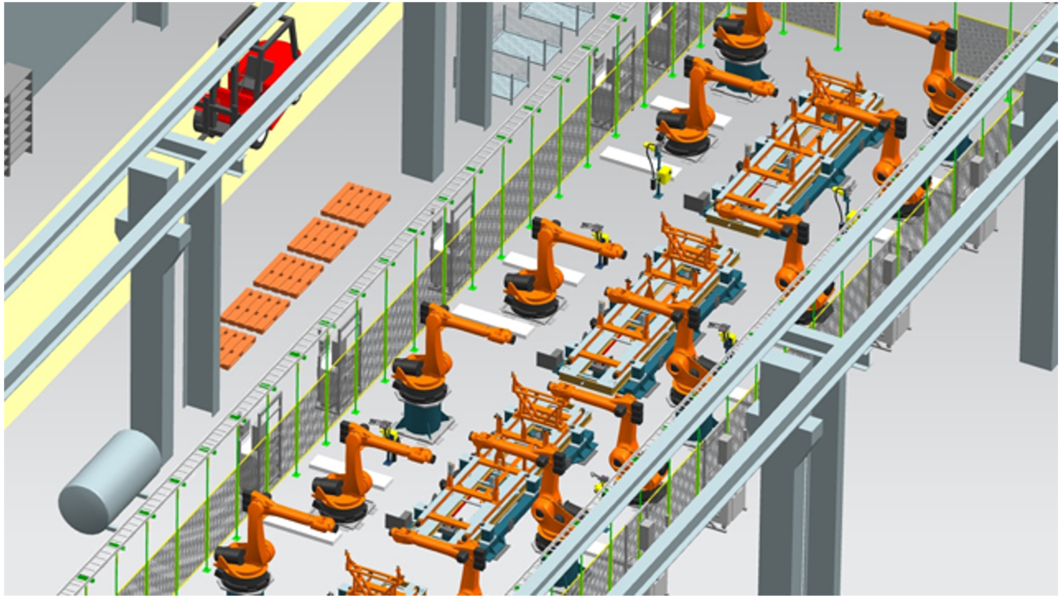
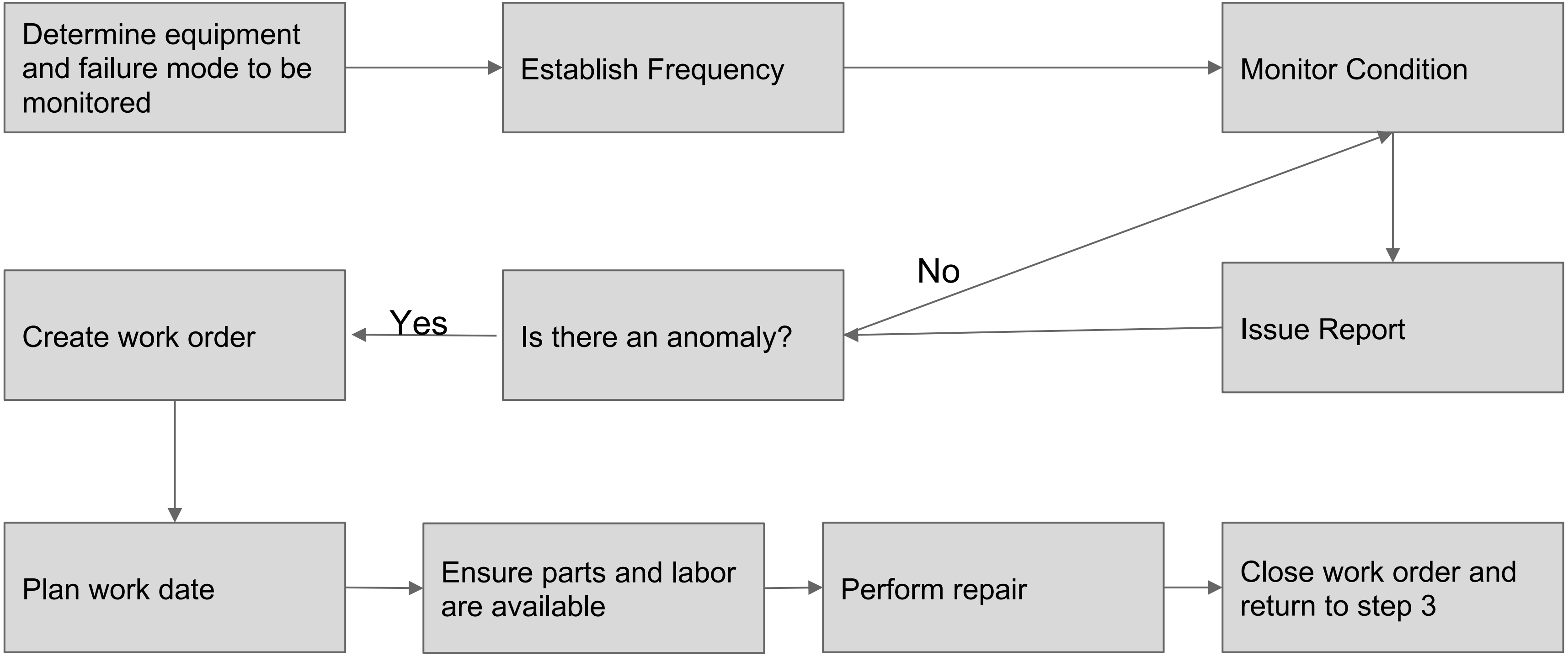
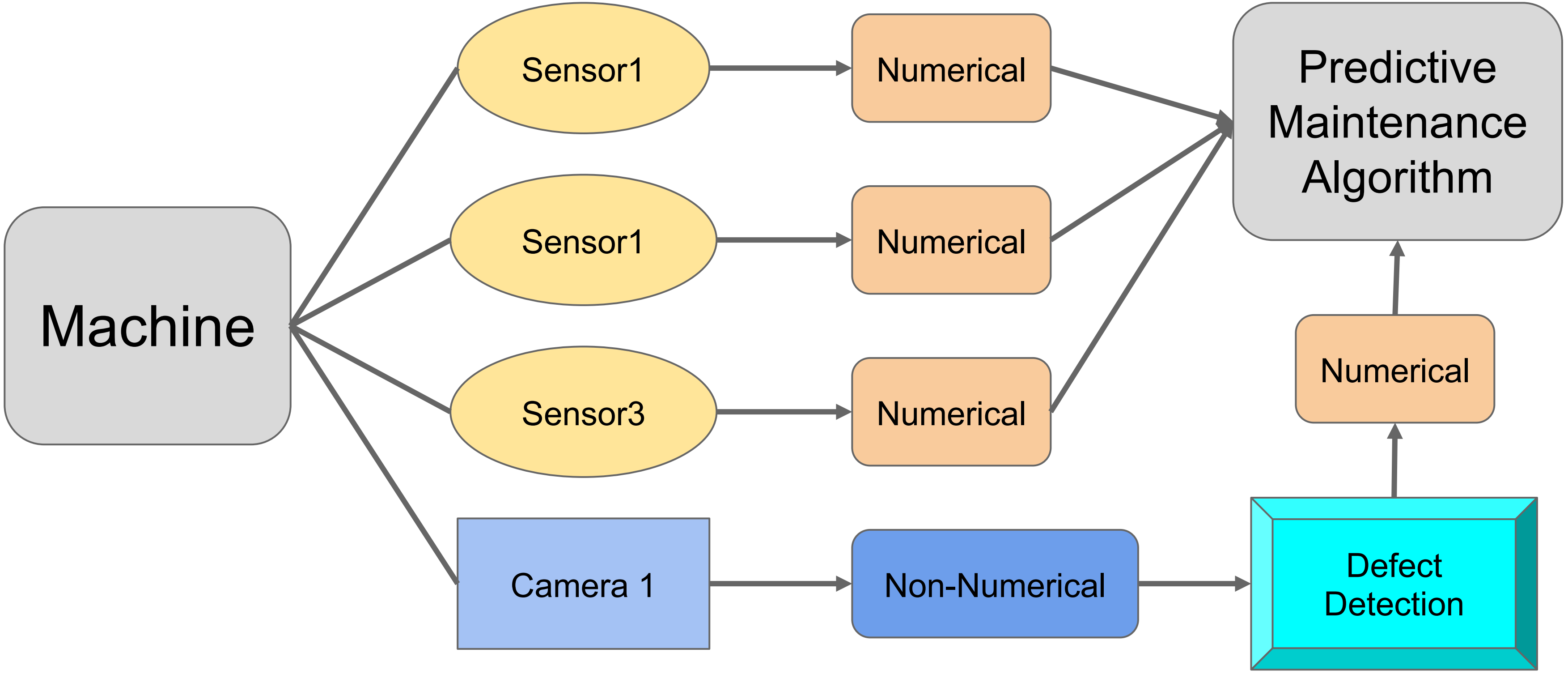


Image credits - https://www.plm.automation.siemens.com/global/en/products/manufacturing-planning/factory-line-design.html

Predictive Maintenance process workflow



Predictive Maintenance & Automatic Defect Detection



Conclusion

More manufacturers are becoming comfortable with Machine Learning based defect detection systems, thanks to lower costs, simpler designs, increased flexibility, higher reliability, more powerful algorithms and increased processing speed.

For tackling the removal of defective parts, a robotic arm can be deployed and integrated with the defect detection system.

Automated defect detection allows to reduce the cost of industrial quality control significantly.

Thank You

For any further information please visit our website www.avyuct.com.

If you find our work interesting, feel free to reach out to us at ***info@avyuct.com***

Dr. Rajesh Aggarwal
Founder/CEO
ra@avyuct.com

Questions?