In Situ Structural Validation of Components Manufactured Using Fused Filament Fabrication

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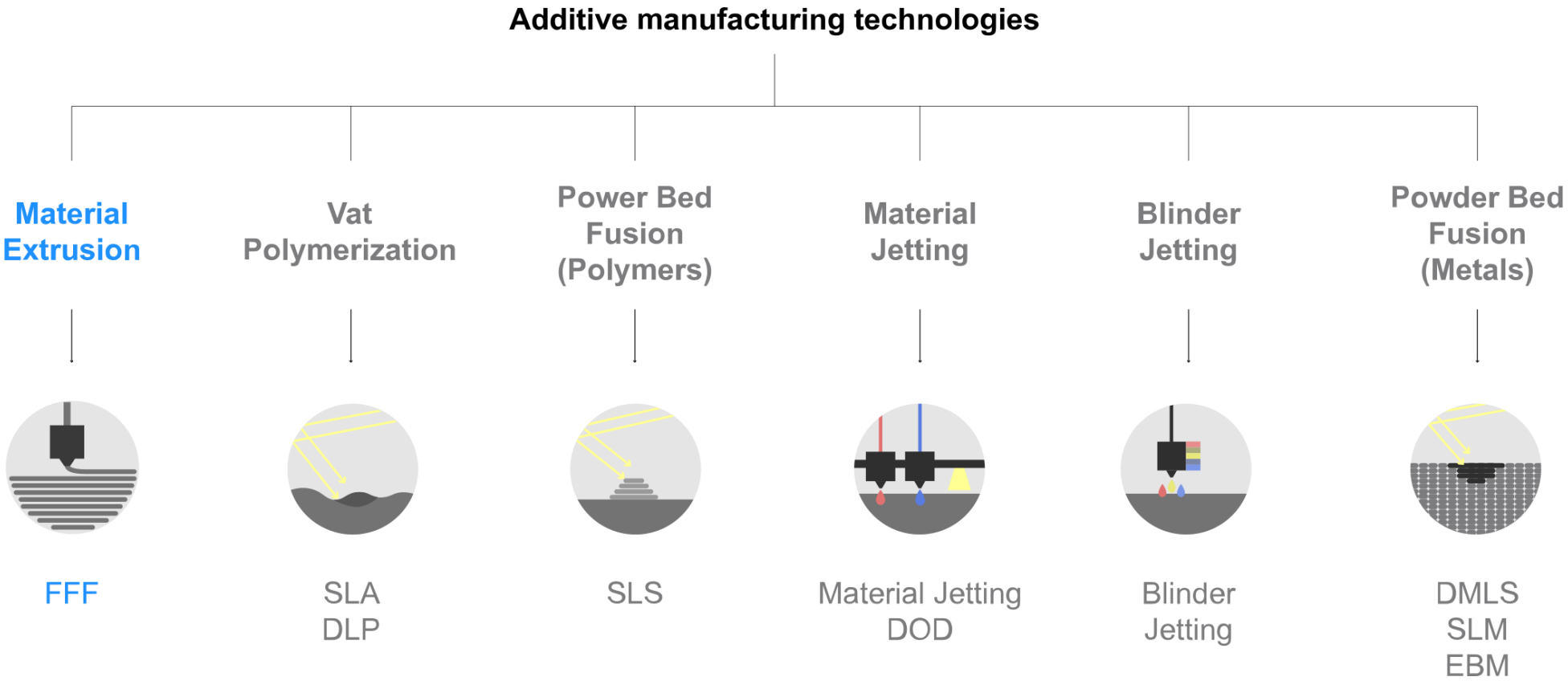
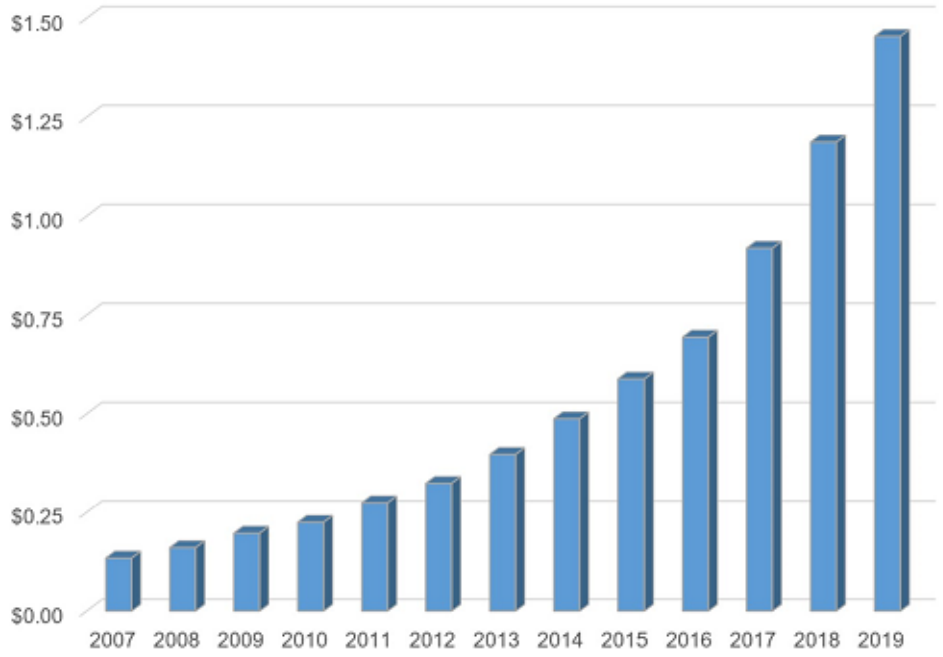


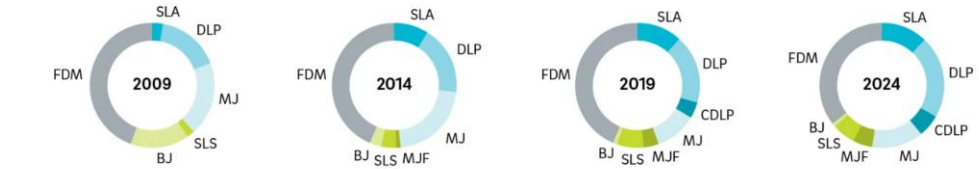
1. https://www.bcn3d.com/introduction-fff-3d-printing-technology-additive-manufacturing-basics/

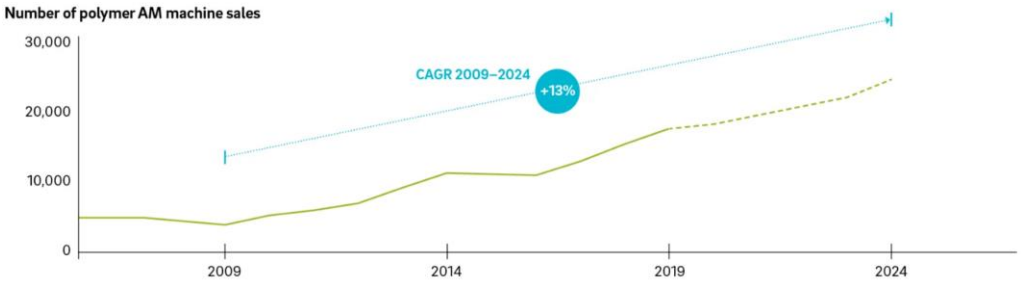
Introduction



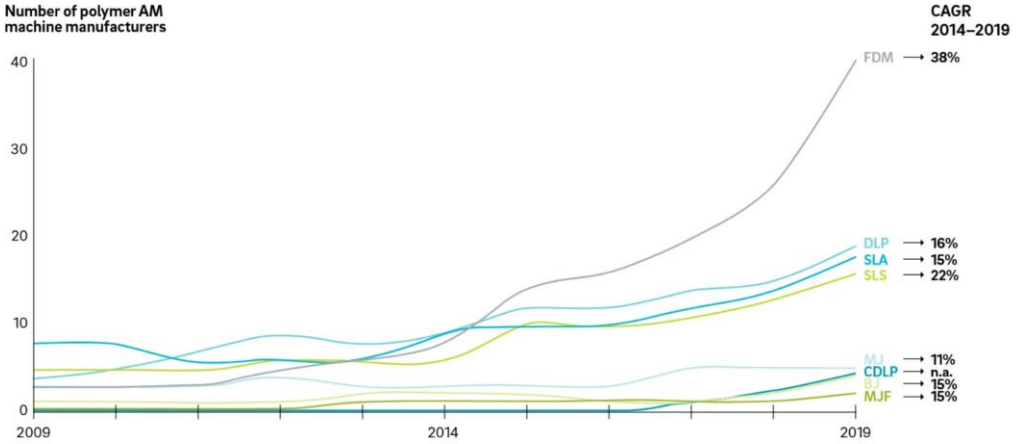
Money spent annually on final part production by AM worldwide
Values are in billions of dollars. Source: Wohlers Report 2020

Polymer AM machine sales and technology share





Number of polymer AM machine manufacturers



1. https://wohlersassociates.com/2020report.html
2. https://www.rolandberger.com/en/Point-of-View/Polymer-additive-manufacturing-Market-today-and-in-the-future.html

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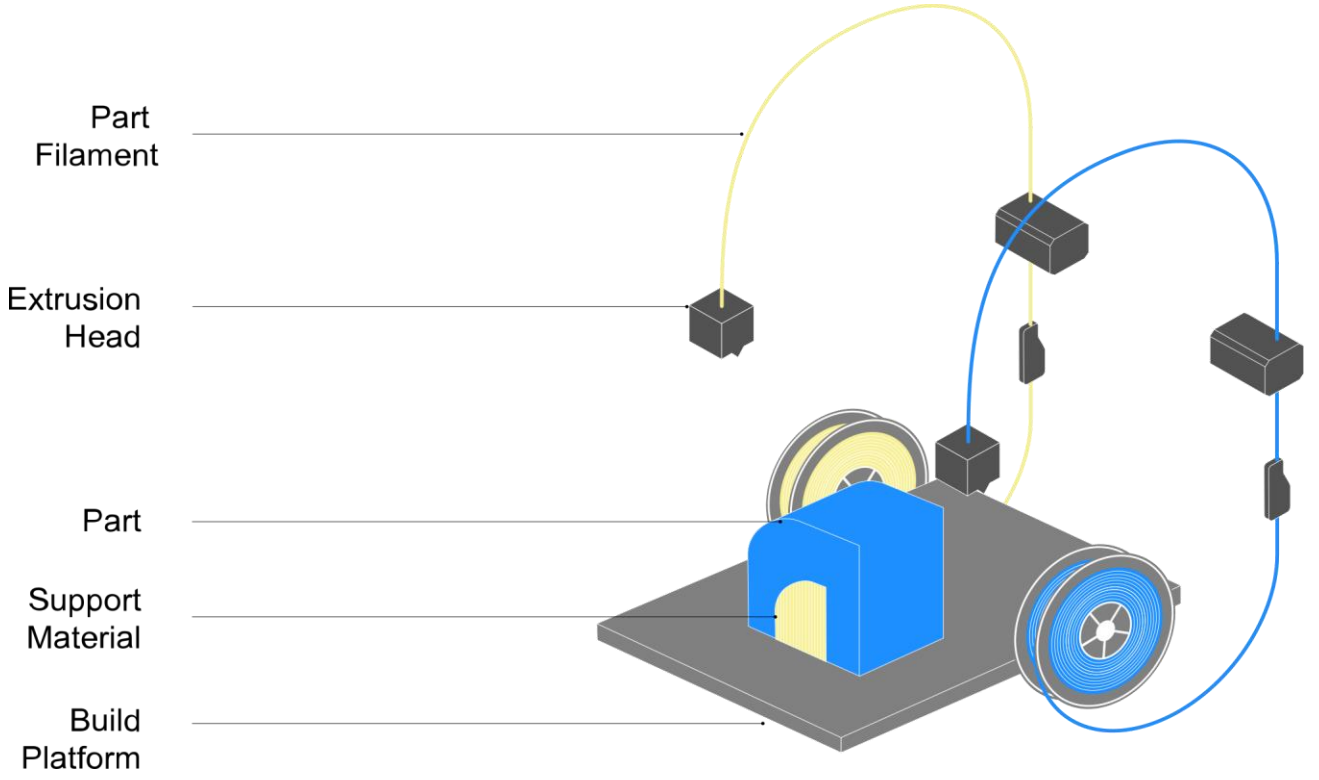

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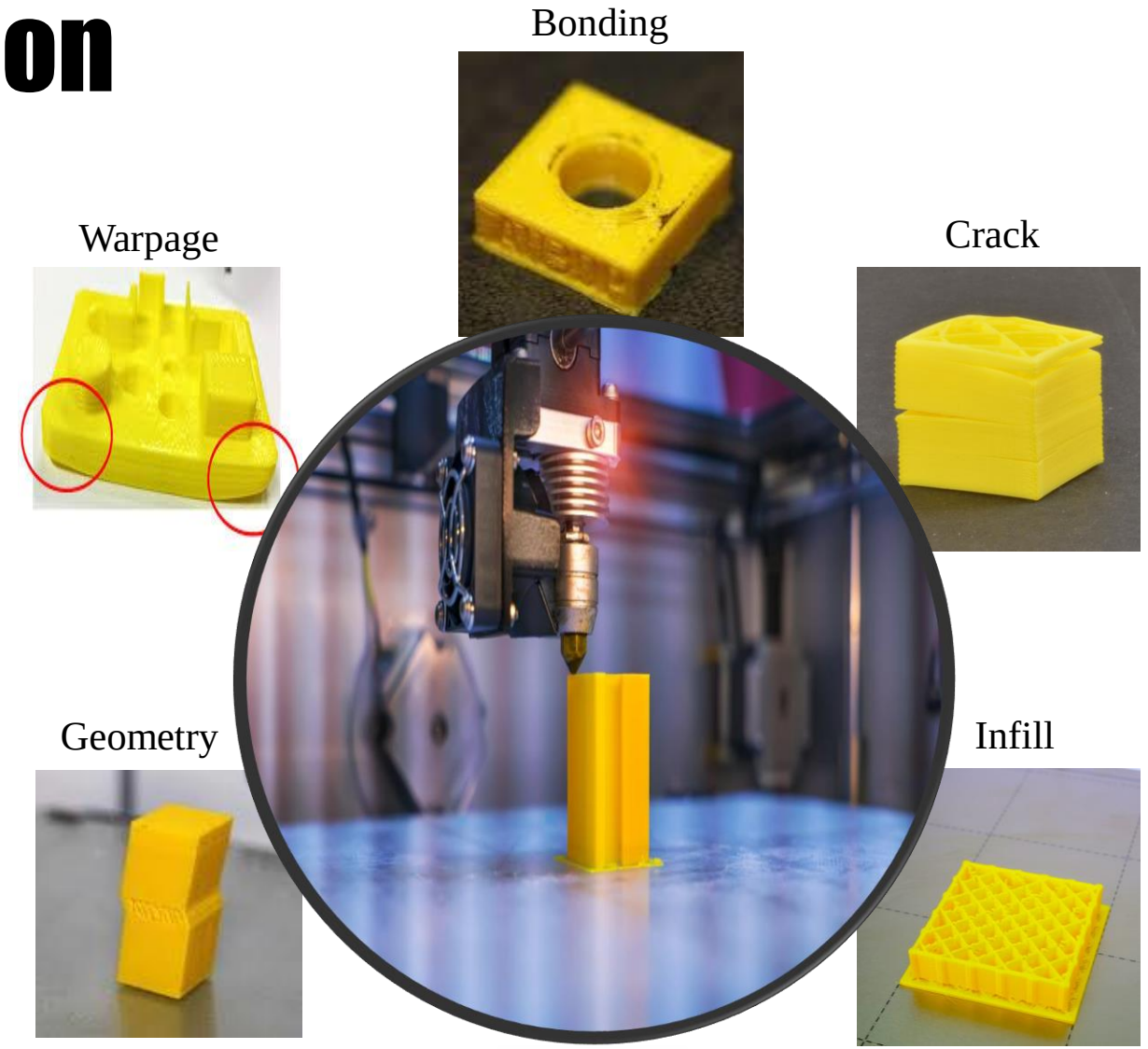
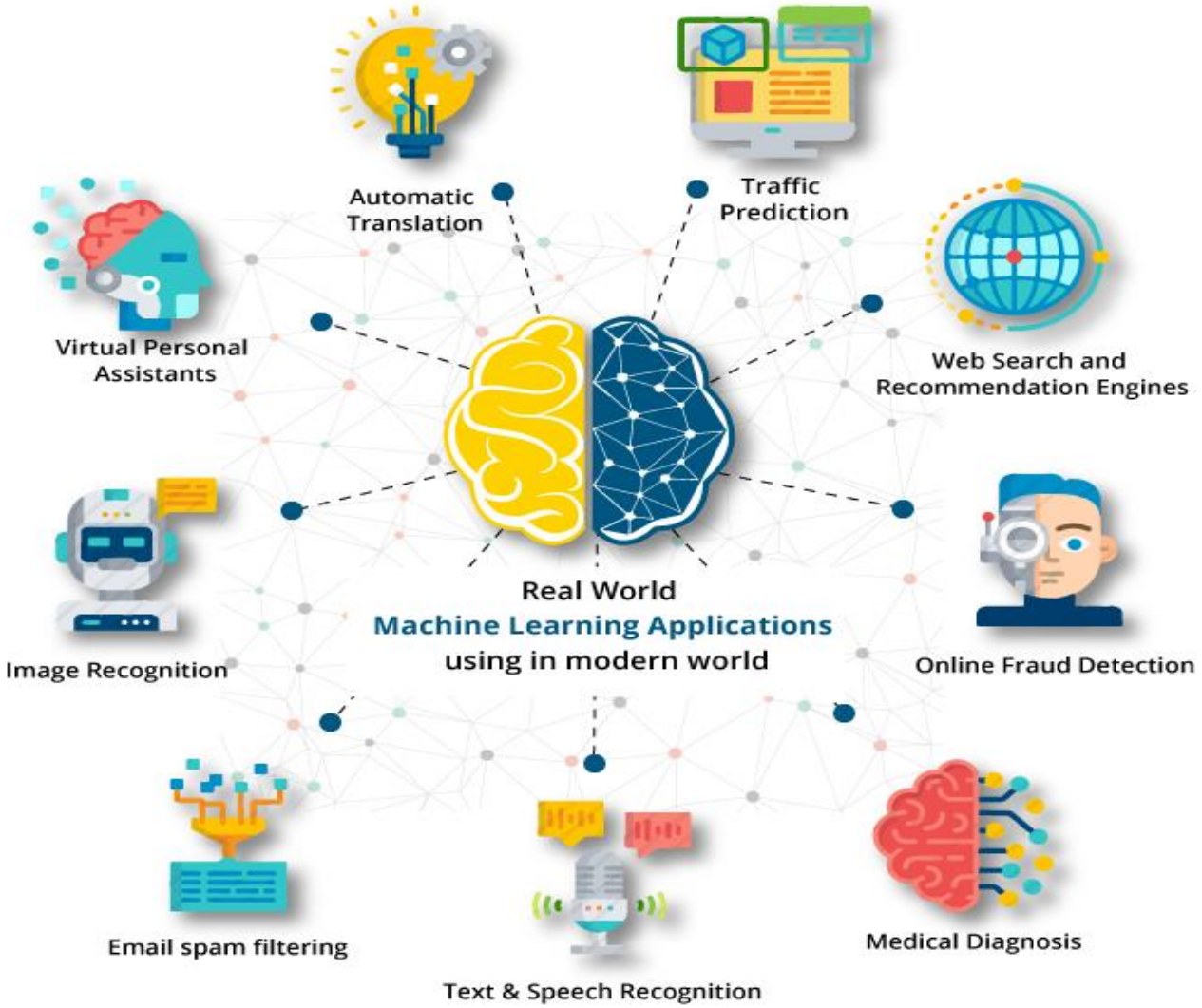


1. https://www.simplify3d.com/support/print-quality-troubleshooting/

Introduction

Machine Learning is everywhere in our daily life!



1. https://rampavanphd2018.blogspot.com/2019/06/machine-learning-in-real-world.html

Introduction

Why MACHINE LEARNING?

- Machine Learning provides smart alternatives to analyzing vast volumes of data.

- For FFF product structure validation:
  - ML can offer new insight as its ability to discover implicit knowledge.
  - ML can build the relationship between the printing parameters and product quality.
  - ML can discover new knowledge from large databases (data mining).

Contents

Methodology

Innovation:

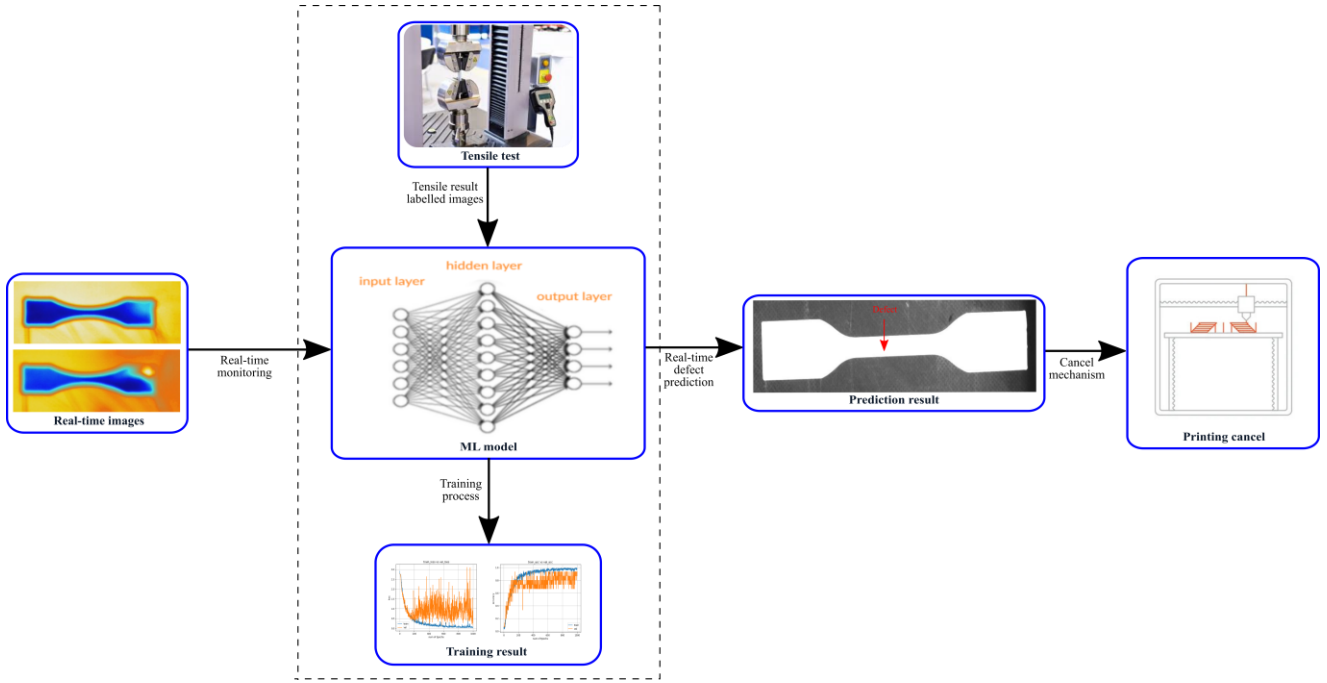
No matter which defects are detected for FFF; the final purpose is guaranteeing the printed product quality for real utilizing. So, we want to investigate **the printing product structure validation with defect detection by using ML.**

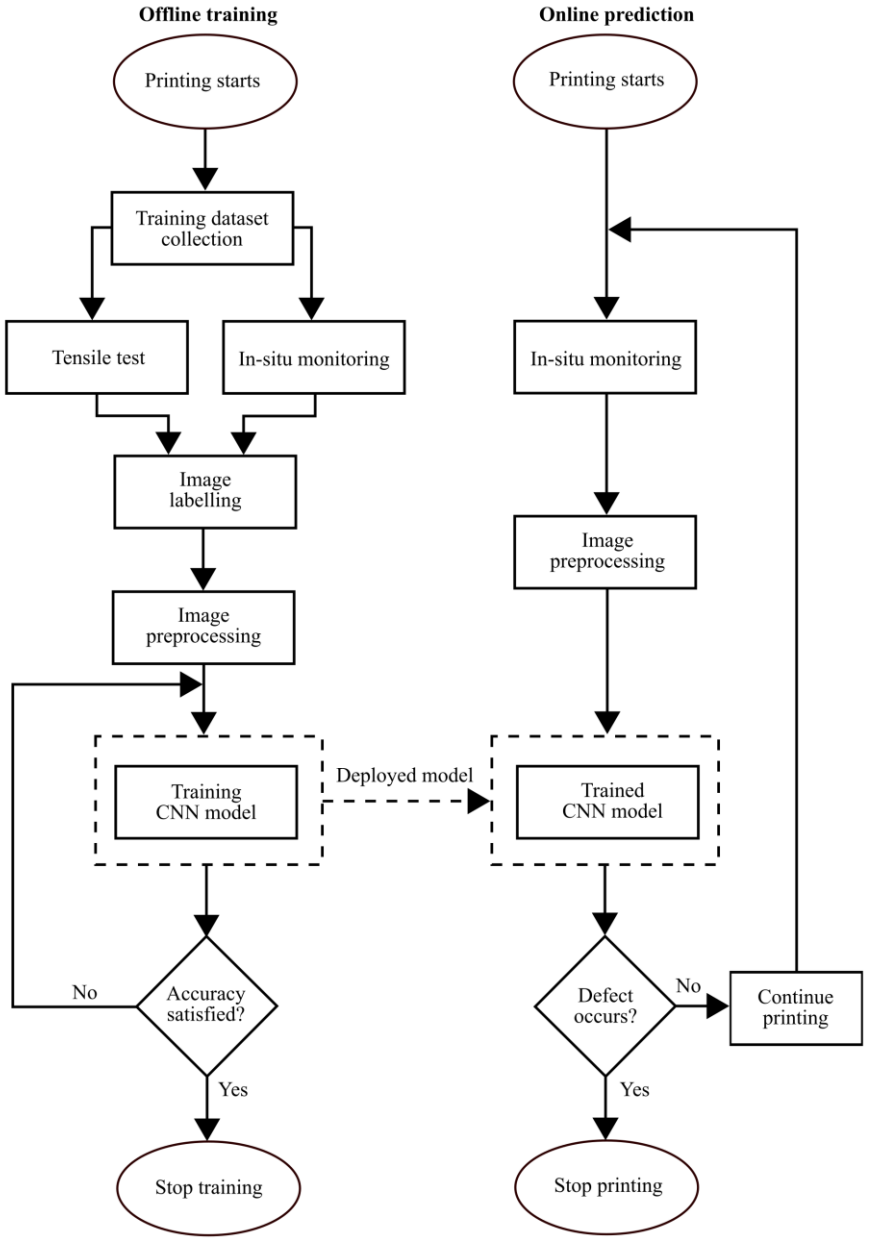
Research purpose:

1. In situ defect detection platform

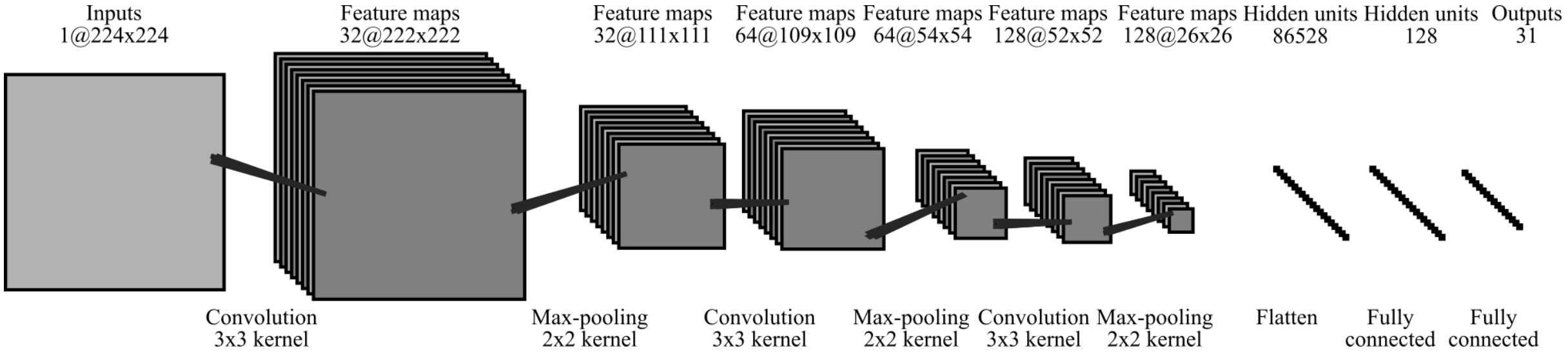
2. **Real-time structural fault detection**

Methodology





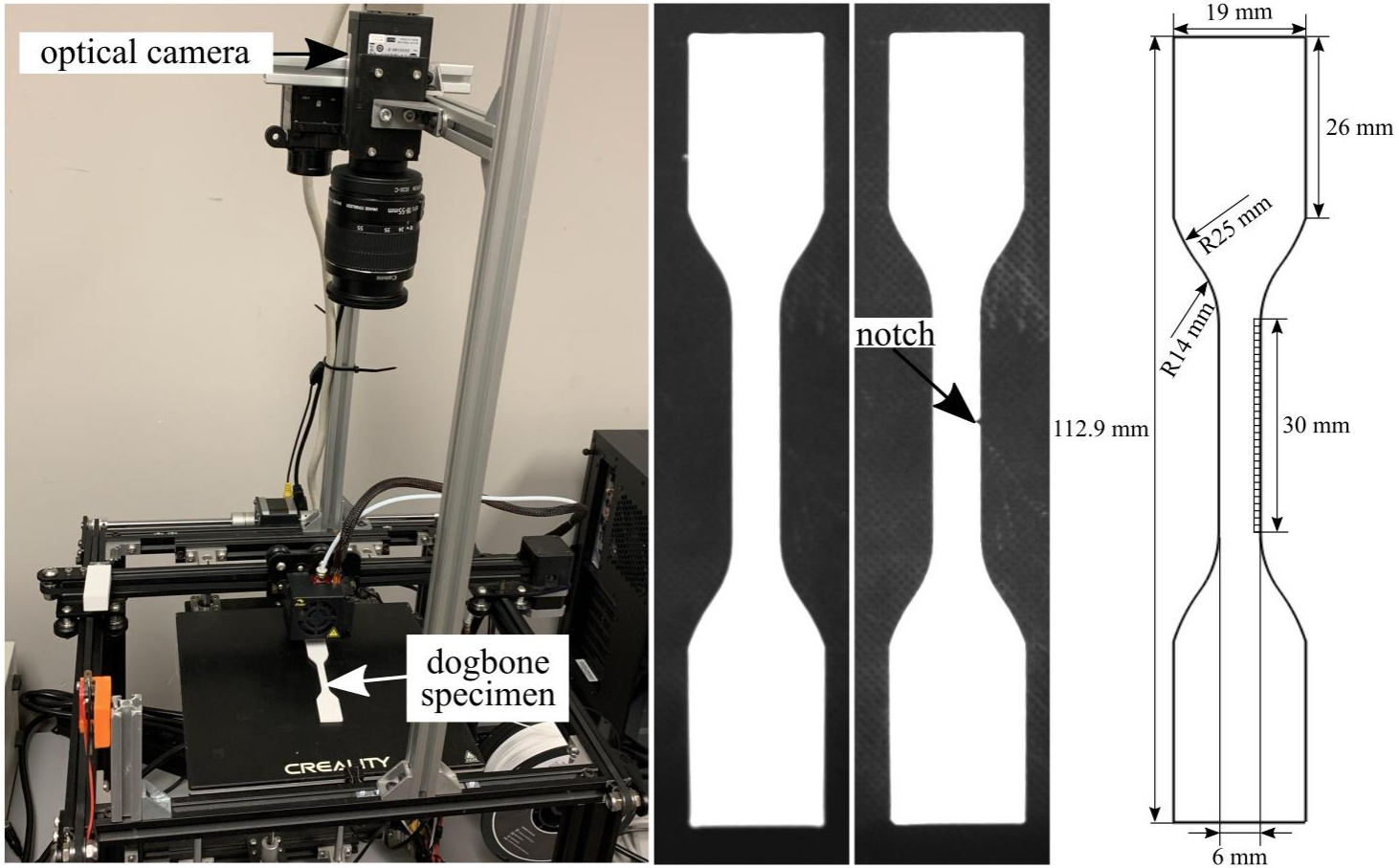
Methodology



Designed CNN model structure based on LeNet

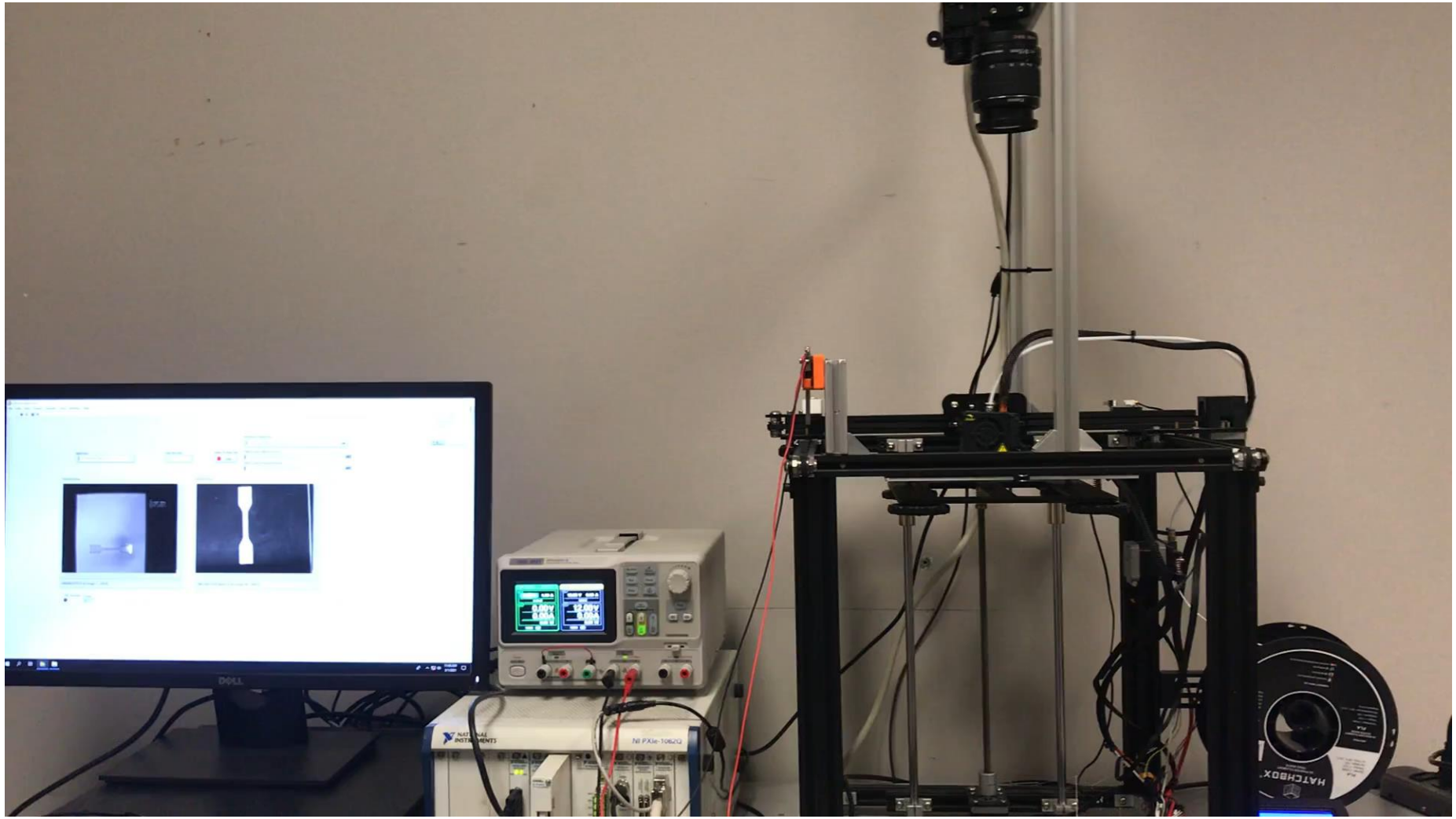
1. LeCun, Y., Bottou, L., Bengio, Y., and Haffner, P., \Gradient-based learning applied to document recognition," Proceedings of the IEEE 86(11), 2278{2324 (1998).

Methodology

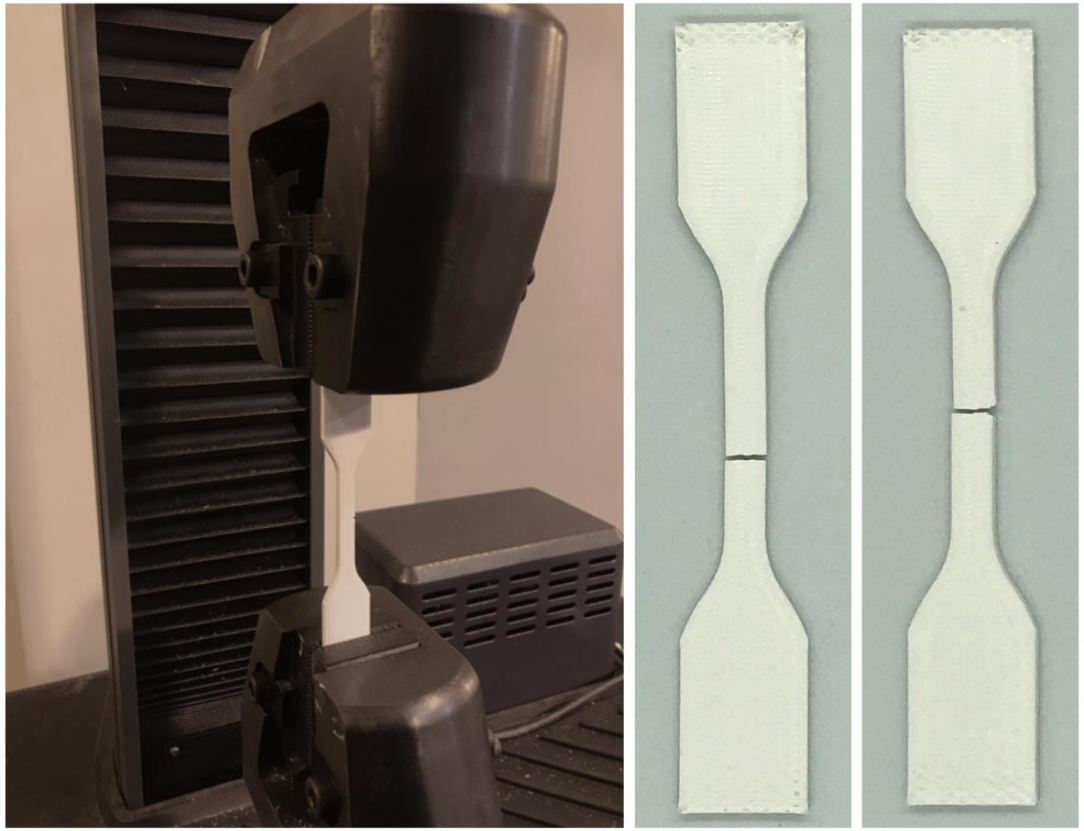


Defect detection platform and specimen for the FFF printing process: a) the fault detection platform; b) and c) good quality specimen and specimen with fault (1 mm x 1 mm); and d) the specimen's dimension.

Methodology



Methodology



a) b) c)

Printed sample tensile test: a) the tensile test setup; b) the broken good quality specimen; and c) the broken specimen with fault.

1. https://www.directindustry.com/prod/mts-systems-ltd/product-54100-1158099.html

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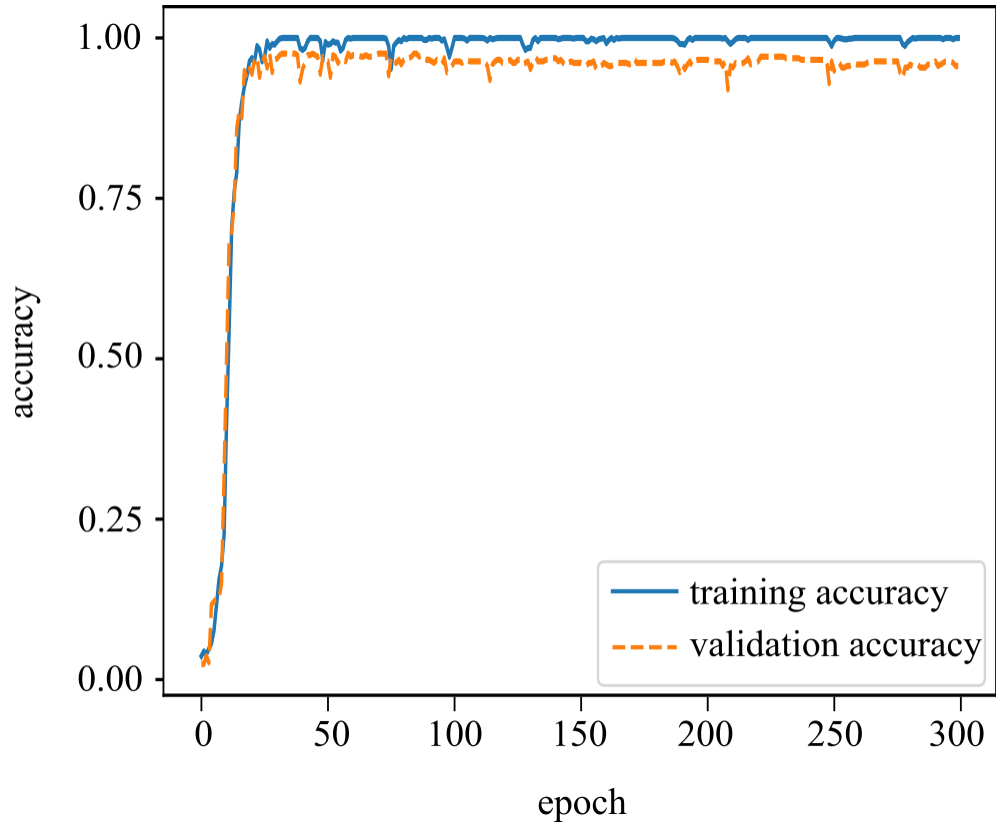
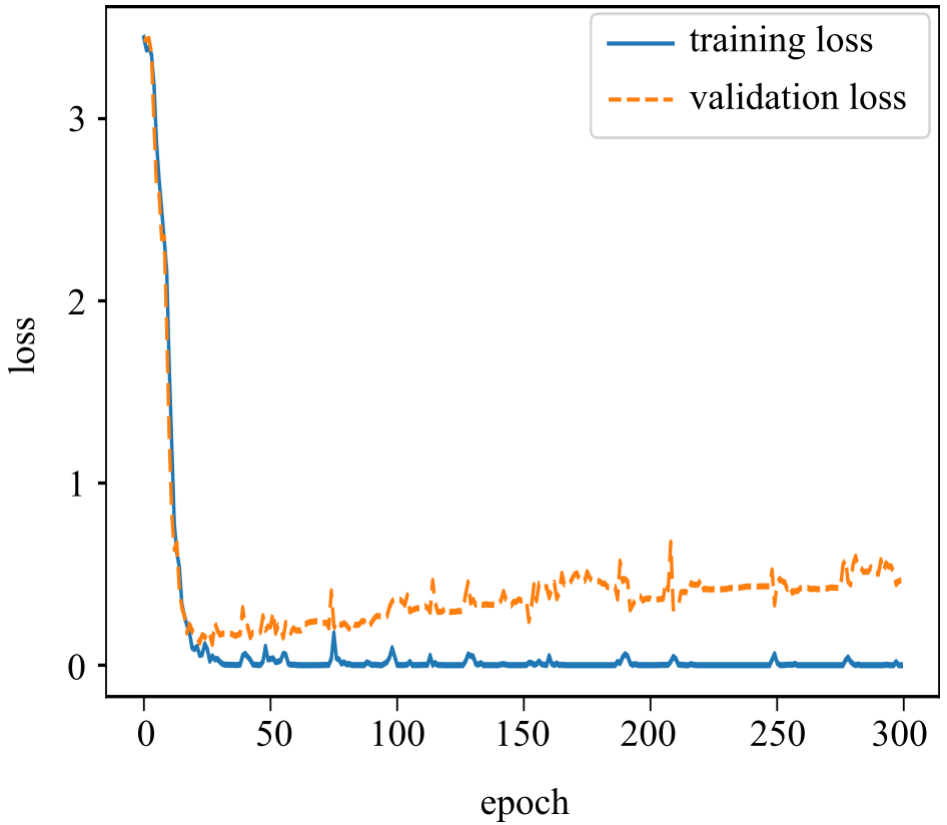
Result

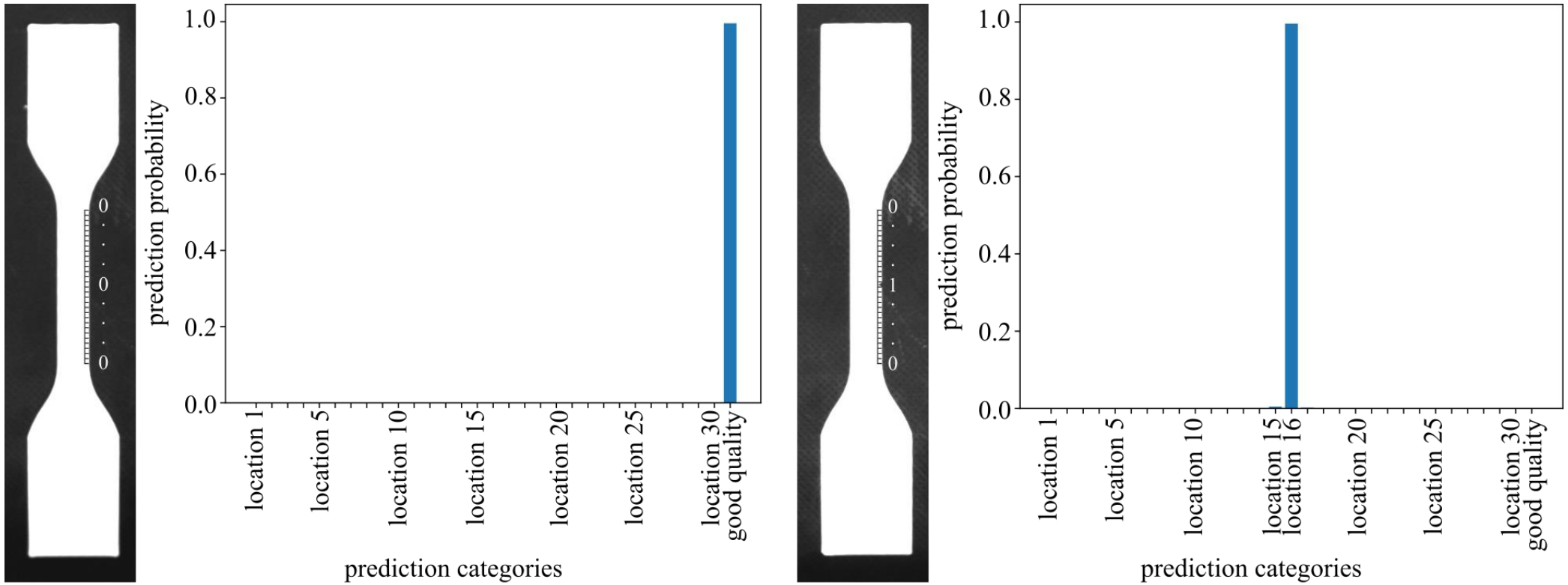


Training and validation accuracy



Training and validation loss

Result



Specimen quality prediction result: a) prediction result for the good quality specimen; and b) prediction result for the specimen with fault.

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Conclusion and future work

1. This paper presented an online methodology of detecting structural faults for FFF.
2. The approach integrates the product structure validation into the online fault detection, rather than just focusing on surface faults.
3. The designed FFF printer integrates an optical camera that can capture the product's printing process images used to train a CNN model. After training, this method can detect structural faults online.
4. Results show that the proposed fault detection approach has a promising accuracy, which is verified to be a feasible method for FFF product fault detection.
5. Future work will include an investigation of printing temperature variation effects on product quality.

THANKS!