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Establishing In-Process Inspection Requirements for Material Extrusion Additive Manufacturing

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Introduction

Additive Manufacturing (AM) techniques compared to conventional manufacturing techniques offer production of low-volume, highly customised, geometrically complex parts^[1]. In recent years, as a result of significant improvements in materials properties and processes accuracy, AM processes are increasingly being utilised for the production of highly complex and quality critical components within sectors such as the aerospace industry^[2,3,4]. Therefore inspecting the surface quality, dimensional accuracy, inter- and outer-structural defects of components become critically important^[5,6].

Typically manufacturers are leaning towards the in-process and non-destructive inspection of their components, therefore enabling them to identify defective parts during the primary manufacturing phase, and consequently leading to savings in costs and time. Various studies have been performed to investigate the in-process monitoring approach for a number of AM techniques^[7,8,9,10].

With substantial growth and availability of Material Extrusion (ME) based AM systems, improvements in the quality and monitoring of the components which they are able to manufacture is important. Therefore the presented study outlines a concept for the development of a non-destructive system for the in-process monitoring of the ME-based AM process.

In-Process Monitoring Concept

The intention for the in-process inspection concept is to provide live feedback to the operator relating to the quality of the printed component(s). An overview of the in-process monitoring concept is shown within Figure 1.

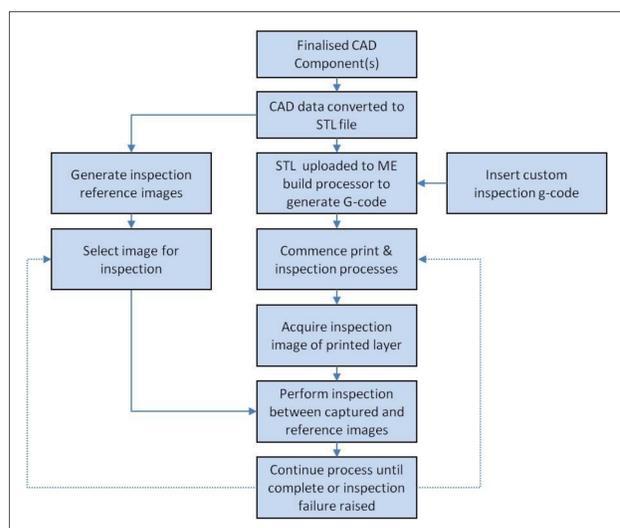


Figure 1: In-process inspection concept overview

The proposed concept works on a basis of comparing a range of sliced inspection images against captured image layers printed via a ME system - reporting any deviation within the captured image within established tolerances. An example of the reporting mechanism is shown within Figure 2.

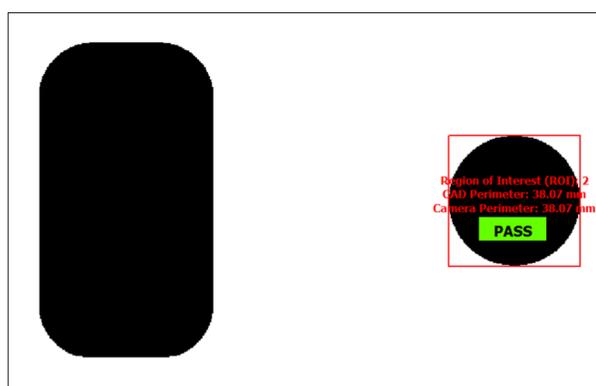


Figure 2: An example comparison between reference and captured image

The rate at which inspection occurs can be defined by the operator and can be dependent on a number of factors such as the inherent size of the component, the critical nature of the part, inspection requirements as defined by international standards, etc.

Hardware Implementation

The dedicated in-process inspection concept consists of the following hardware components:

- 1) A high specification camera and lens, 2) Inspection lighting and power supply units, 3) An appropriate I/O box, 4) An industrial personal computer

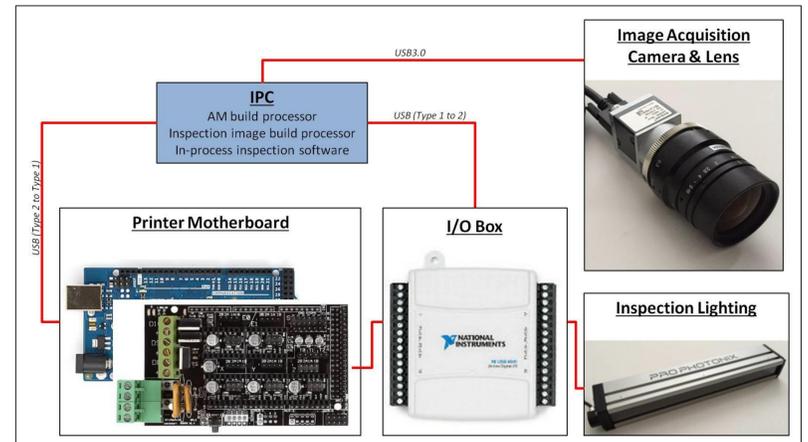


Figure 3: Inspection hardware components and primary connections

The appropriate selection of a high specification camera(s), associated lens, and their acute set up are essential to ensure a high quality image of the top printed layer can be captured. An example of this setup is depicted within Figure 4.

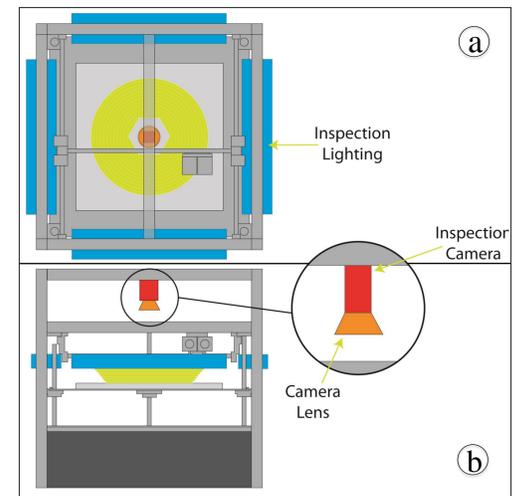


Figure 4: Inspection hardware placement within ME system - top (a) & side (b) views

A dark field lighting set-up is utilised to illuminate the printed top layer – therefore maximising the quality of the captured image. Due to the nature of the system and hardware, the outline concept has the potential to scaled up/down depending on the required inspection footprint.

Software Implementation

To facilitate the realisation of the proposed in-process inspection concept, a number of software requirements need to be satisfied, including:

- 1) Generating reference image data from the original 3D drawing
- 2) Appropriately preparing/coding the I/O box
- 3) Establishing the custom G-code to trigger the inspection system
- 4) Designing and implementing the in-process software inspection system

The latter of the outlined requirements is currently under development within the CassaMobile project and may therefore be the subject of future dissemination activities.

Conclusion

This poster outlines a proposal for the development of an in-process monitoring system for use with ME-based AM systems to provide quality feedback with regards to manufactured components. The development of such a system has inherent benefits, beyond savings in time and money, manufacturers will be able to identify defective regions within the build – which may have potentially lead to the premature in-service failure of their products.

A range of hardware and software components have been highlighted within this concept. The specification of any components outlined are for demonstration purposes, instead the proposed concept has the potential for scaling up/down depending on manufacturing or quality control requirements.

Due to the complex nature of the interaction between the various hardware and software components, continued development of the proposed concept and demonstration system is being performed as part of the CassaMobile project.

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