Additive Manufacturing: Multi Material Processing and Part Quality Control - DTU Orbit
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Additive Manufacturing: Multi Material Processing and Part Quality Control
This Ph.D dissertation, Additive Manufacturing: Multi Material Processing and Part Quality Control, deals with Additive Manufacturing technologies which is a common name for a series of processes that are recognized by being computer controlled, highly automated, and manufacture objects by a layered deposition of material. Two areas of particular interest is addressed. They are rooted in two very different areas, yet is intended to fuel the same goal. To help Additive Manufacturing technologies one step closer to becoming the autonomous, digital manufacturing method of tomorrow.

Vision systems
A paradox exist in the field of Additive Manufacturing. The technologies allow for close-to unrestrained and integral geometrical freedom. Almost any geometry can be manufactured fast, e ciently and cheap. Something that has been missing fundamental capability since the entering of the industrial age. Now, with the geometrical freedom given back to the designer and engineer, a technology stale-mate keep us from benefitting from this freedom. Parts can easily be designed and manufactured beyond the capabilities of all common industrial measurement and verification methods, the designer and engineer is left to design parts that from a geometric metrology point of are view possible to verify the tolerances of. A proposal of a method for altering the stale-mate to a check-mate is given. An inline vision system is developed that allow for verification of parts of a complexity that leave the only industrial alternative to the field of CT scanning. The background knowledge to develop such system is synthesized from an analysis of existing additive manufacturing processes and vision systems. The system is implemented and benchmarked throughout the scope of this Ph.D dissertation.

The proposed inline vision system has been put through several tests against several additive manufacturing systems. Till now the system has proven to be up to the task of reconstructing geometries otherwise only possible by CT scanning. The system outcompeted a reference CT scan of a large metal part by to an indisputable degree. The system finally showed promising results when applied indirectly to reconstruct geometries from a DLP system. In general, the system has a potential for being implemented in different AM machines and processes and provides traceable measurements of the complex parts. As the technology of inline layered reconstruction of additively manufactured parts has just been proposed within this thesis, the technology is at a dawning level, and there is an abundance of open questions to be answered and much yet to be investigated. It is impossible but leaving this part of the project open-ended. What is to hope is that future research will tie these ends with the emerge of a fully developed system.

Additive Multi Material Manufacturing
Additive Manufacturing share close family bonds with CNC machine tools. State-of-the-art CNC machine tools of today are multi-axis hybrid machines. Abendofathes.mills.grindersonineplatform. Ihistoryrepeatitself, hybrid additive manufacturing machines will emerge as the field evolve. It is sought to fuel this, by developing a flexible multi material manufacturing platform that will permit fundamental research towards a second generation additive manufacturing system that truly will be a universally applicable manufacturing machine. A desktop sized factory. Not merely the development of such machine is undertaken, also examined is the possibility to additively manufacture complex electromechanical systems, as a step towards being able to autonomously additively manufacture readily functional complex products. Based upon a synthesis of the applicability for each industrially accepted additive manufacturing process, the platform deemed most suitable was selected. The result was an Open and fully customizable FDM based multi material platform. The design solicit flexibility and the ability to alter the platform to conform to a multitude of experiments involving multimaterial extrusion. The resultant platform is also able to reproduce itself and as such future generations of the platform can e ciently be iterated through. Two generations of this platform was realized within the scope of this project.

To empathize why, and how versatile the prospect of multi-material platforms is, a set of subsystems that can be realized by multi-material manufacturing using FDM extrusion has been conceived. A functional battery is built using multi material extrusion. Composites that allow for the additive manufacturing of electrical conductors and resistors are engineered. A proposed method for additive manufacturing of linear actuators is assessed and proved promising. It is proposed that a library of additively manufacturable subsystems are built as a part of a knowledge sharing network. This systems library can over time grow to an extend where it is applied in the same manner as traditional engineering elements such as ball bearings, nuts, screws, washers, guide-rails, wires, batteries, electrical components and their like are used today.

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