Early Student Engagement in the Development of Process Monitoring Tools for Additive Manufacturing

Michael Moeckel

University of Applied Sciences Aschaffenburg, Faculty for Engineering,
Wuerzburger Str. 45, 63743 Aschaffenburg, Germany
e-mail: Michael.Moeckel@th-ab.de, web page: http://www.th-ab.de

ABSTRACT

The development of advanced physics-based simulations techniques and data-driven process monitoring tools is required to improve process control in additive manufacturing, in particular for 3D printing of metals, alloys and oxides. For this purpose, a substantial number of qualified experts will be required both in industry and academic research groups. To allow prospective PhD students to quickly enter productive research, early training of students on mathematical techniques as well as familiarity with real experimental data is highly desirable.

Here I present newly designed work done with undergraduate students (4^{th} semester) in the programme "Electrical Engineering and Information Technologies" at the University of Applied Sciences Aschaffenburg. While the university already offers a well-established research group on experimental additive manufacturing techniques and process development led by Prof. Ralf Hellmann, questions related to simulation and process monitoring will gain additional relevance in the near future. These approaches will require competences in mathematical algorithm development as well as software implementation.

Sensor and image data from real selective laser melting building processes performed on a DMG MORI Lasertech 30 printing machine was kindly provided by Prof. Ralf Hellmann's group. The data consisted of more than 70 sensor outputs which were collected continuously during the building process. Moreover, photographic images of the powder bed where taken each 50 µm.

Students sitting a course on software engineering were involved in current platform development. A software tool was designed for the purpose of quickly inspecting data sets which had been previously obtained from building processes. The software was developed in python as part of a collaborative software development project. Modularized functionalities included the pre-processing of the raw data, visualization of process dynamics based on moving window averages and statistics, Fourier analysis for signature detection in the frequency representation, dimensionality reduction based on simple PCA methods and pixel-based image correlation methods.

Implementations of mathematical routines were mostly taken from standard python libraries after critically testing any used routine. Flexible and adaptive usage has been achieved by combining machine-specific configuration data located in easily replaceable files with a user-friendly graphic user interface (GUI) for data selection and analysis. A full documentation of the project based on current standards of professional software development.

Lessons learned from the project include the critical use of existing routines, a basic familiarity with fundamental concepts of classical concepts of data analysis and process monitoring, Students learned about fundamental aspects of the selective laser melting (SLM) process and typical sensors currently in use for monitoring. Subsequent thesis projects can approach new concepts e.g. using machine learning techniques for error detection or for state prognostics,

REFERENCES

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