MTRL 466: Design Project 2019

Low Cost, Non-contact error detection during fused deposition modelling (FDM)

Fused deposition modelling along with other forms of 3D-printing has grown out of the rapid prototyping field into an established manufacturing route. While perhaps the simplest and cheapest methods of 3D printing, FDM shares many commonalities with more sophisticated 3D printing techniques. One of the challenges for all 3D printing/additive manufacturing technologies is to reduce part rejection – while not generally reported, the rate of rejection of 3D printed parts is much higher than the rejection rate coming from more mature process technologies. One of the great challenges in 3D printing/additive manufacturing is then to reduce this rejection rate by improving on the process itself. While one can improve various aspects of the process there will always be variations that arise from the inherent variability of the material, changes in the characteristics of the machine over time and due to the inherent limitations of the process itself. With this in mind, one would like to leverage the explosion of cheap sensing and computing capabilities to be able to detect, and possibly fix in real time, a manufacturing process so as to correct for variations that might arise in the process.

As additive manufacturing (including 3D printing, and SLA printing in particular) moves away from its rapid prototyping roots toward the fabrication of structural engineering components, there is an increasing need to optimize for part quality, cost and reproducibility. The rapid assent of additive manufacturing has meant that much of the "recipes for success" are hidden in trade secrets, empirical know-how and educated guesses. The next leap in additive manufacturing, the one which will allow it to be accepted as a bulk manufacturing technique, requires that we reduce empiricism with quantitative understanding of inter-linkages between design, processing and part. This is also very much aligned with the ideas of "Industry 4.0" and the use of sensing technologies within the context of the "Industrial Internet of Things".

The Problem

We are approaching you to help us identify a technology that would be compatible with (first and foremost) the in-situ, non-contact detection of "defects" during the process of 3D printing using Fused Deposition Modelling. The aim of this technology should be to reduce part rejection rate, material waste and inefficient machine use, by being able to identify the most common forms of defect occurring during FDM modelling. The technology identified must be able to be deployed at low cost. A technology that is more expensive that the printer itself would be undesirable. The technology, in its ideal form, should be transferable to other platforms, including perhaps to other forms of 3D printing/additive manufacturing. We expect that you are able to fully explain and illustrate (as quantitatively as possible) the working principle of your selected technology and to be able to fully justify the further cost and time associated with the development of this technology (to the satisfaction of your customers, Daan&Chad Co.) into a prototype (for Term 2). As part of this justification you should be able to illustrate the working principles of the technology both through analytical calcualtions as well as (possibly) physical examples.

Toolbox

You will have at your disposal a large variety of tools that you can employ to interrogate this problem.

People: Aside from Chad and Daan, you may interact with Department technicians and select PhD students who will be introduced during the process of this course.

Hardware:

1) FDM printer: You will have open access to a small Prusa FDM printer if you would like to test print geometries to test ideas surrounding supports. This printer will be setup in Frank Forward and will be available when you want.

Software:

1) CAD & Slicer software: Sicer software (e.g. https://www.slicer.org) is needed to generate the code (gcode) fed to the 3D-printer. This software also typically will generate supports. This can allow you to test and see what the conventional software suggests for supports for a given design of your choosing.
2) Python/matlab/etc etc – you may wish to employ some relatively simple calculations to manipulate measured signals from your selected sensor. This can be done in the software of your choice, though the preference of your sponsors would be Python (open source, flexible, simple to learn and use for basic tasks)
3) Life cycle analysis: One can make use of the basic LCA functionality incorporated in the CES software used in MTRL 280.