Prototype of a meshless numerical model of additive manufacturing

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1 Motivation

Additive manufacturing techniques, also known as 3D printing, have already become widely used in the manufacturing industry, since they allow to introduce fast prototyping into the project development cycle, can be used to achieve geometrical shapes and functionalities beyond the reach of traditional manufacturing, and reduce the use of natural resources [4]. The name additive manufacturing encompasses several manufacturing techniques with all of them having in common the feature of adding liquid material to an already solid semi-product. The project will be focused on the fused deposition modeling (FDM) or fused filament fabrication (FFF) which is the process in which a polymer filament is fed into a heated nozzle where the filament is melted and then deposited in a two dimensional layers. Such layers are then stacked and their shape varied in order to form the 3D printed part.

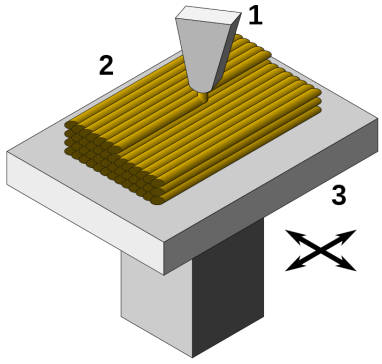

Figure 1: Illustration of fused filament fabrication (source: Wikipedia).

Meshless methods appear to be especially fit to model such process since the process includes complicated geometries that vary with time, but present state-of-the-art models mostly rely on finite element of finite volume methods to formulate the numerical models.

Such models approach the problem from two directions, either by modeling a box enclosing the part and using interface tracking algorithms to describe the geometry of the part [5] or by selectively activating volume elements as the part is constructed [3, 1]. Physical description of such process is usually focused on the fluid flow and mechanical deformation of the part, both of which are driven by heat transfer and solidification.

2 Description

The goal of the project is to produce a prototype model based on the discretization with meshless RBF-PUM method [2]. The method is based on forming a covering of the computational domain with patches, constructing local approximations using radial basis functions and then blending them using partition of unity to obtain global approximation over the computational domain. Such a global approximation can be used to construct a PDE solver. The students will be provided with a Matlab implementation of the meshless method, which can be used as a starting point of their work.

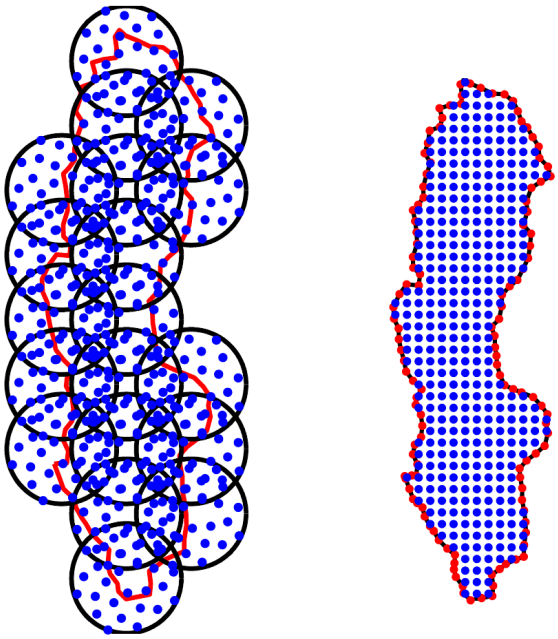

Figure 2: Illustration of RBF-PUM setup used to solve PDE for a computational domain shaped as contintental Sweden. Left figure illustrates the patch cover and the right figure shows the points where PDE is enforced.

The prototype should describe heat transfer in a 2D geometry. Depending on the progress, description of phase change could be added to the problem.

Changes in geometry will require patches to be incrementally added to cover the computational domain, which grows as additional material is deposited during the printing

process.

Important part of the project is also to develop the algorithm that will describe the growing computational domain from the supplied path of the printing nozzle.

3 Supervision

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References

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