OTTO VON GUERICKE UNIVERSITÄT MAGDEBURG FACULTY OF COMPUTER SCIENCE

Project Proposal for Digital Engineering Projects

Project Topic:	Improving a software tool developed to perform coupled phase-field and finite-cell-method simulations
Project abbreviation:	
Institute/ Chair/ Research Group:	Chair of Computational Mechanics Institute of Mechanics Faculty of Mechanical Engineering
Advisors:	Prof. Dr.-Ing. Daniel Juhre Dr.-Ing. Fabian Duvigneau Dr.-Ing. Resam Makvandi M.Sc. Márton Petö
Preferred group size:	1-3
Desired project period:	6 months
Required/Desired knowledge:	• Good programming skills • Basic understanding of the finite element method (FEM)

Is any external affiliation involved (e.g., industrial partner, affiliated institute)?

yes ☐ no ☒

Which one(s)?

Project Description:

General description:

In our department, we are interested in solving mechanical problems such as crack propagation and phase transformation (for instance, eutectic solidification) using numerical tools. Over the years, we have developed several modules to handle these problems using the phase-field method. This method is usually exploited in the context of the finite element method (FEM). One drawback of using classical FEM in dealing with phase-field problems is that, due to the need for a very fine mesh in the so-called interphase regions, an adaptive mesh refinement is required to avoid unreasonable computational costs.

On the other hand, we have developed an in-house code for the finite cell method (FCM), which

(in contrast to the conventional FEM) deploys a non-geometry conforming discretization together with higher-order shape functions. The aim of the current project is to use a coupled approach to utilize the advantages of both methods (phase-field and FCM) while overcoming some of their drawbacks. In the past, we have successfully shown that the coupled approach is working within a proof of concept example. Now the developed tools for these coupled simulations need to be optimized and to be extended for further functionalities. Our legacy code is based on different programming languages. In this project a joint Matlab implementation has to be developed.

Hopefully, we have arouse your interest. It is not possible to elaborate all the details here, please contact us if you are interested in working on this topic.

Please note, that the overall project is designed in a modular fashion. Consequently, it is possible to work on this project with one, two or three persons. Naturally, the amount of work will be adapted/reduced, if the team is smaller. That is to say, three persons are not the maximum; more persons are also possible. We have further subtasks for the same project, which we have not sketched here. Therefore, if you are more than three people, just contact us and we can discuss how we could realize it.

<u>Project goals:</u>

- *The overall aim is one code (written in Matlab) including the developed parts of all group members. The combination of all separate codes to one code is the task of all the group members. A version control system (for instance, git) has to be used.*

- *1st Person: Eutectic solidification with phase-field and FCM*
    - *Translation of existing implementation in FEAP (FEM) to Matlab (FCM)*
    - *Implementing an analytical tangent instead of the existing numerical one*
    - *Activation/deactivation of the necessary nodes/cells*
    - *Documentation*

- *2nd Person: Crack propagation with phase-field and FCM (code is existing)*
    - *Add energy split (compression/tension) – all famous different variations*
    - *Implementation of geometric and non-geometric cracks*
    - *Add irreversibility – with history variables*
    - *Documentation*

- *3rd Person: Improving the efficiency of the overall code*
    - *Realizing CPU parallelization*
    - *Realizing GPU parallelization*
    - *Comparing CPU and GPU parallelization*
    - *Further code optimization*
    - *Documentation*