

Git Project: Image Analysis and FEM

G. Bowker, S. Lister, J. Collins, S. Rehman, F. Livera

0.1 Introduction

Simple finite elements in Python (SfePy) uses finite element methods to solve coupled partial differential equation (PDE) in systems up to three dimensions. SfePy is a powerful software that allows complex physical problems to be coded quickly and easily. It has been used successfully in a variety of disciplines, ranging from biomechanical modelling [1] to the computational analysis of acoustic transmission coefficients [2].

In this report, the input file to the SfePy software is a microstructural image which must first be 'cleaned' through segmentation, mesh generation and noise reduction. It can then be imported into the software as a mesh file, where boundary and initial conditions are applied. Fields are then created which can be used to define variables which may be 'unknown field', 'test field' or 'parameter field' [3] and the material properties are defined.

0.2 Aims and Objectives



0.3 Image Analysis

A key requirement for this project is to build a python script which will allow PNG images to be converted to data, which can then be manipulated and processed with python packages such as Sci-Kit Image (skimage) [4]. Several microstructure images have been used in this project, from a variety of sources including previous research data, scientific literature and the provided database, all with full and sufficient permissions. Images were then pre-processed accordingly through various techniques such as segmentation, removal of noise and measurement, before being imported into FE simulations to be used to create a mesh. This section will further detail how this process was undertaken and broken down through the use of test cases to ensure that the python script and skimage were performing accurately and as desired.

The first test case that was carried out was processing an image of a ferritic microstructure taken from the Materials Science and Engineering: An Introduction by Callister [5].

0.4 Finite Element Modelling

Test!

0.5 Results

Test!

Bibliography

- [1] Robert Cimrman and Eduard Rohan. Two-scale modeling of tissue perfusion problem using homogenization of dual porous media. *International Journal for Multiscale Computational Engineering - INT J MULTISCALE COMPUT ENG*, 8:81–102, 01 2010.
- [2] E. Rohan and V. Lukeš. Homogenization of the acoustic transmission through a perforated layer. *Journal of Computational and Applied Mathematics*, 234(6):1876 – 1885, 2010. Eighth International Conference on Mathematical and Numerical Aspects of Waves (Waves 2007).
- [3] Robert Cimrman, Vladimír Lukeš, and Eduard Rohan. Multiscale finite element calculations in python using sfepy. *Advances in Computational Mathematics*, 45(4):1897–1921, 2019.
- [4] Stéfan van der Walt, Johannes L Schönberger, Juan Nunez-Iglesias, François Boulogne, Joshua D Warner, Neil Yager, Emmanuelle Gouillart, Tony Yu, and The scikit-image contributors. scikit-image: image processing in Python. *PeerJ*, 2:e453, 2014.
- [5] William D Callister Jr. Materials Science and Engineering - An Introduction (5th ed.). *Anti-Corrosion Methods and Materials*, 47(1), 2000.