Scientific Area	Synchrotron Light Applications		
Project Title	Deep learning for the derivation of finite element models from 3D synchrotron X-ray tomography data		
Recruiting Institution	Synchrotron-light for Experimental Science and Applications in the Middle East (SESAME)		
PhD awarding Institution	The Cyprus Institute (CyI)	**PhD Duration**	36 Months
Supervisor/Institution	Dr. Mihalis Nicolaou / CyI		
Co-Supervisor/Institution	Dr.-Ing. Gianluca Iori / SESAME – BEATS Dr. Charalambos Chrysostomou / CyI - CASTORC		
Secondment(s)	Computation-based Science and Technology Research Center (CASTORC), Cyprus		

Project Description

The PhD project will be carried out at the BEATS beamline of SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East), located in Allan, Jordan. The beamline hosts the first synchrotron full-field X-Ray Computed Tomography (CT) experiment of the region, and will become operational in 2022. It will collect and generate a vast database of 3D microscopic images, enabling the study of the internal composition and morphology of materials to scientists from fields including materials science, biology, medicine, and cultural heritage. Finite Element (FE) simulations can be developed from 3D CT data and applied to study a variety of problems from solid and fluid mechanics. Machine Learning (ML) has been successfully applied to CT datasets for the segmentation of anatomical structures, pathological features, fossils, rocks, and multiphase or composite engineering materials. This project's aim is to implement a ML approach for the derivation and mapping of local material properties from synchrotron CT scans. The approach will be applied to the generation of 3D FE models of different samples and materials.

The project is divided in three tasks:

Task 1: CT data collection at the BEATS beamline for X-Ray tomography of SESAME. Identification of key examples from materials engineering, geology, or biomechanics. Development of routines for the collection and registration of multi-scale datasets. Development of phantoms for density and materials properties calibration.

Task 2: FE simulations of mechanical tests from synchrotron CT images. The data required for this task will be acquired within Task 1. An automated pipeline for the generation of finite element models derived from synchrotron CT scans will be implemented. The candidate will become familiar with applications of ML for automatic 3D image segmentation during FE model generation.

Task 3: ML application for material property mapping. Training of a deep neural network for the automatic mapping of local material properties on FE models derived from synchrotron CT scans. Explore transfer learning for the adaptation and extension of existing models to materials from different domains with common microstructural and mechanical features.

Project Objectives

The PhD candidate will work closely with the beamline staff, implementing automated image analysis routines and exploring the application of ML to different steps of the CT data processing and FE model generation pipelines. In particular, the candidate's work will i) produce and advance tools for the generation of finite element models of the mechanical performance of materials from 3D CT datasets and ii) develop methods for the extraction of mechanical and microstructural properties of materials from synchrotron CT images.

Required Candidate Qualifications

- M.Sc. in one of the following relevant fields: Applied Mathematics, Engineering, Computer Science, Physics.
- Proficiency in a programming language such as Python, Julia, Matlab, C++, etc.
- Experience with Signal and Image Processing.
- Good academic records in the relevant fields.
- Good communication and writing skills; ability to work as part of an interdisciplinary team.
- Proficiency in oral and written English.

Desirable skills:

- Knowledge of Artificial Intelligence.
- Experience with numerical simulations with the Finite Element Method.
- Experience with a Machine Learning library such as TensorFlow, PyTorch, Keras etc.
- Previous experience with synchrotron radiation facilities.