Project Reports in the Course Introduction to Advanced Manufacturing Technologies. Skoltech, Fall 2020

By A. Buchnev

Project 1: Modeling of the Dynamical and Statistical Properties at the Nanoscale

Advisor(s): Timur Aslyamov

1. Goals of the Project

This project aims to create theoretical models of fluid and gas filtration (transport through nano-porous materials) and complement it with numerical calculations and computer models. The application of nano-porous materials is wide and includes storage of gases and liquids, direct filtration of media and actual now supercapacitor development and production. Such model, especially when solved analytically, can discover multiple important dependencies and effects that can influence the effectiveness of supercapacitors by far.

The project involves solving mathematical equations based on statistical physics and molecular dynamics. Programming skills are needed to be able to numerically compute the equations and contribute in form of writing own solver for the developed model.

2. Background

While the knowledge of basis of Mathematics and Physics is undoubtable, the participation in the project requires pre-studying specific literature and reading related articles. Also an introduction by advisor is necessary. The immersion will take the form of weekly seminars, where I will report on the learned material and be corrected by the advisor if needed. Simultaneously to that I will carry some programming and numerical calculation.

Participation in this project is a great start for a scientific-industrial career. The knowledge obtained during MSc Thesis on this topic is relevant in many fields, such as electronics, oil and gas business, filtering technologies. By the end of MSc, it will give a great choice whether to apply for PhD in Skoltech and to continue the research (which itself is a long-term project) or to utilize the knowledge and contacts and promote the results of the research to the industry. For example, I know at least one company (Airlife) that would be extremely interested in such collaboration.

Project 2: Electrical Rim Driven Fan for UAV

Advisor(s): Loic Salles

1. Goals of the project

The project goal is to design and study an electric rim driven fan as a possible replacement for conventional center-rotor fans. This design could be a perspective upgrade not only for VTOL aircrafts, but also for upcoming wave of conventional electric powered aircrafts. Its core idea is creating a rim-style rotor with rotor blades connected to it at the outer perimeter, contrary to the classic rotor design where the blades protrude inside-out. This new design could reduce (to zero) the vortex loss at the blade-shroud clearance and solve multiple issues related to resonant vibrations that may lead to complete engine destruction if not accounted for during construction. If paired with magnetic levitation bearing, the design can deliver a very high efficiency rate.

To participate in this project, it is desirable to have a strong understanding in core aircraft and aerodynamics principles. General physics and mathematics are a requirement. According to the tasks (which are the whole steps from designing up to production and testing) an experience in CAD software and general programming are a must.

2. Background

My background includes all the required knowledge (Gen. Phys., Mathematics). Additionally, my research interest happens to coincide with the topic. I have a higher-than-beginner understanding of aircraft engine types and operation. I am familiar with CAD design, with different approaches to aircraft building schemes. My Military Training classes in MIPT covered the principles of aircrafts and jet engines in-depth.

Elaborating on innovative and perspective aircraft propelling systems has a great potential to beat the ceiling and come up with a game changing product. In case of success this project has all chances to eventually turn into a startup or, in case of patent restrictions, a whole new product line in the hosting company. Besides that, during the project a set of extremely useful skills and contacts will be developed. By the end of the MSc, it might be enough to continue in the PhD or to start a career as an aircraft engine developer/researcher in an industry leading company.

Project 3: Geometric Modelling and Heterogeneous Volume Modelling

Advisor(s): Evgenii Maltsev, Alexander Pasko

1. Goals of the project

This project, development of 3D modelling software in general, involves a lot of research in FRep modelling of 3D objects. It is a perspective approach to represent 3D models with lack of drawbacks inherent in traditional representations (vertex, BRep, and constructive, CSG). Considering a skyrocketing progress in manufacturing of extremely complex and topologically optimized objects (like prosthetics, bioprinted parts and ultra-light construction parts), this approach holds a great potential for optimizing the workflow and parametrizing the development of such complex 3D objects, also allowing for creating the structures that would be impossible with traditional representations.

The main requirements are a solid knowledge of one or more programming languages and an understanding of computer graphics.

2. Background

My background, besides programming, covers computer modelling and developing simple interactive physics models with graphics and animations. Also, I'm a long-time 3D printing enthusiast and have experience in 3D modelling in CADs and slicing.

I am eager for taking the course on Geometric Modelling, which is essentially writing your own graphics engine from scratch.

Working on this project can give valuable and in-depth experience and knowledge on the insides of CAD systems and slicing software, which will allow to contribute to the 3D printing world in form of improvements to the modelling and slicing software.