MONASH University
Engineering

Summer Research Program 2011/2012

Simulations of pattern formation by microbial swarms

Supervisor: Dr. Prabhakar Ranganathan
Email: prabhakar.ranganathan@monash.edu
Phone: 9905 3480
Department: Mechanical & Aerospace Eng.

Objective

Many biological populations display an amazing, but as yet poorly understood, ability to self-organize and form coherent patterns in order to secure advantages for the group as a whole. This kind of motion is also observed in microbial colonies, including in those that use such means to spread quickly on tissue surfaces and cause nasty infections. Remarkably, we are beginning to understand such behaviour using traditional fluid mechanics: if you just squint a bit, large flocks of birds or shoals of fish appear fluid-like in their motion. The goal of the project is to set up simulations of large populations of mobile microbes to serve as "computer experiments", so that we can later compare them with fluid mechanics simulations and calculations.

Description

The simulations are to be set up using a technique known as the Discrete Element Method. Microbial cells are modelled as self-propelled rod-like particles that interact with each other through elastic and frictional forces. Each particle is governed by ordinary differential equations obtained from Newton's laws of motion. Expressions for interparticle forces are available from literature. These equations are to be numerically integrated using standard "molecular dynamics" techniques.

We take a software-engineering approach to developing the computational code, and implement it in modules. The code is to be written in Fortran 95/2000. The project will involve the following key steps:

- understanding model equations
- modular code structure and algorithms for critical modules
- learning the programming language, and the supercomputing environment
- development of validation tests for code modules
- implementation
- testing

Prerequisites: good background in engineering mathematics (at undergradute level); demonstrable programming skills
Desirable, but not essential: experience with Fortran 90+