MA4198 PROJECT PROPOSAL (PROJECT CUM SEMINAR GROUP)

SUPERVISOR'S INFO

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PROJECT ID: PS2610-08

TITLE

Mathematical Models of Collective Behavior: Modeling, Analysis and Simulations

BRIEF DESCRIPTION OF PROJECT

Collective behavior refers to the formation of macroscopic patterns from interactions among individuals, and such phenomena can be commonly observed in bird flocks, pedestrian crowds, opinion dynamics, and coupled oscillators. This project will introduce students to some fundamental mathematical models for collective behavior, such as the Kuramoto model for synchronization and the Cucker–Smale model for flocking. Students will investigate how simple interaction rules at the individual level can lead to coherent group-level patterns, and perform mathematical analysis and numerical simulations.

EXPECTATION/S

The project will combine model derivation, rigorous mathematical analysis, and numerical simulations. Students may analyze equilibria and stability, derive the mean-field limits, simulate particle systems, and compare different regimes of collective dynamics. Each student will produce a coherent and readable report focusing on one selected model. Depending on each student's interests and strengths, the report may place greater emphasis on either mathematical analysis or numerical simulation.

PREREQUISITE/S (at level 3000 or below, with at most one course at level 3000)

Students should have taken either MA3220 Ordinary Differential Equations, or MA3264 Mathematical Modelling.

READING REFERENCE/S

S. H. Strogatz, From Kuramoto to Crawford: exploring the onset of synchronization in populations of coupled oscillators, Physica D, 2000.
J. A. Acebrón et al., The Kuramoto model: A simple paradigm for synchronization phenomena, Reviews of Modern Physics, 2005.
J. Canizo, J. Carrillo and J. Rosado, Collective Behavior of Animals: Swarming and Complex Patterns, 2010.