Problem: Finding a chemical source in flowing fluids using microrobotics

Description. A chemical source is introduced in a flowing fluid. The source may be stationary, or it might be carried by the fluid and move relative to it. The task is to find a strategy for a population of small autonomous robots to detect the source and for (some) robots to converge onto the source.

The robots are assumed to have sensors for the concentration of the chemical. The location of the robots and the underlying velocity field are assumed to be known. The robots are assumed to be faster than the target. However the maximal velocity that the robots can achieve relative to the fluid may occasionally be less than the velocity of the underlying current. Additionally, due to possible energy limitations, robot locomotion could be optimally guided by the current flow.

The problem should be considered for physical quantities that are relevant for real world situations, for example, for miniature robots flowing through human bloodstream, and other multi-robot engeneering applications. Due to the complexity of the system, one should begin analyzing the problem in two-dimensions with later adaptations to a full three dimensional model.

The strategy should be robust to robot failure and to noise in measurements of all quantities in the system. It should also be flexible so that modified tasks can be considered (such as multiple chemical sources, complex domain geometries, floating obstacles and slowly varying underlying flow). In addition one may consider the case that the flow is not known, but that it needs to be detected using that the robot positions are. One could also discuss engeneering trade-offs deriving from variants to the chosen chemical detection and robot locomotion and communication strategies.

While considering this problem it would be useful to estimate the magnitude of each physical effect (and the typical speeds, forces and timescales involved) so as to determine the most important factors in the given system.