Non-contact control of a floating object via environmental manipulation

The ability to redirect the trajectories of water-floating objects towards a predetermined location can be utilised by a number of applications, including preliminary sorting during food processing and the depollution of rivers and waterways. Doing so by actuating the water itself – using a submerged vibration source at a fixed location – would enormously simplify the required infrastructure, and eliminate the damage/hygiene concerns associated with direct-contact control methods. However, issues of underactuation, inertial effects, bifurcations, and stochasticity stand in the way of a reliable system model, necessitating the development of a non-analytic approach.

We explore the rich dynamics of a floating disc in a centrally-actuated circular container. By manipulating the disc’s environment we gain insights into the macroscopic behaviours emerging from capillary interactions between disc & fluid, as well as the potential of Bayesian optimisation and deep reinforcement learning algorithms in generating reliable trajectories. The effect of the disc’s morphology on these trajectories is examined: though significant changes cause shifts of the boundaries between behaviours, the surface flows are found to be surprisingly robust to smaller changes, enforcing the method’s feasibility for systems – such as food processing – in which morphological variations are expected.