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The ability to accurately control the position of an autonomous surface vehicle (ASV) inside a nuclear storage pond has many potential applications such as monitoring, sensing and removing contaminants from the pond's wall, tasks that because of elevated radiation dose rates are often dangerous or prohibitive for humans. Unfortunately, there is still no general method that allow ASVs to traverse the pond within a few centimetre stand-off distance of the wall and maintaining its course while cleaning or collecting radiological data. The majority of the literature in this field describes localisation, mapping and control techniques relevant to open-water environments and doesn't consider operations near the boundary, where disturbances and reaction forces are significant, translating in to poor control of the vehicle. The few centimetres stand-off distance is required due to detection of alpha particles for instance, of which detection can happen only at very short distances or due to cleaning equipment that needs to maintain that distance in order to effectively clean the wall.

The current ASV utilised in this work is the MALLARD (sMALL Autonomous Robotic Duck) that took part in the IAEA's Robotics Challenge in summer 2017. MALLARD carries two sensors: LiDAR used for localisation and map building and an IMU designated to provide orientation of the robot. MALLARD builds its map and navigates the pond according to LiDAR's laser beam reflected from the boundary wall. When the vehicle is in motion, the roll and pitch of the entire platform causes inaccuracies to be introduced into the LiDAR measurements. This is particularly the case in outdoor nuclear storage ponds, such as Sellafield's legacy ponds. When the vehicle rolls, the laser beam is no longer horizontal thus providing inaccurate distance reading to the boundary. This can have significant impact on position accuracy. To compensate for this error, the IMU would be used to detect roll (or pitch) angle and together with LiDAR measurement the correct distance could be calculated. Additionally, to improve MALLARD's localisation, the Kalman filter with IMU as an input would be used to correct LiDAR's measurements. Other AI techniques such as particle filter will also be used as localisation methods.

With improved localisation in place, the challenge for Mallard will be to precisely traverse the pond's wall in order to carry out various tasks from collecting radiological measurements to cleaning materials from the walls. The required stand-off distance is 2cm thus local navigation and precise actuation is mandatory to collect radiological data and compensate for reaction forces coming from cleaning tool. For these reasons the robotic arm is being placed on top of the MALLARD. The robotic arm's end-effector would provide very fine tracking of the stand-off distance, where MALLARD's thrusters and arm's actuators would cooperate in unison to achieve this goal. The aim is to distribute the control actions among thrusters and actuators such that the end effector would be found with desired, 2cm stand-off distance from the wall, while the robot is traversing the pond. It will be achieved by employing appropriate control allocation algorithm and optimisation technique. This a novel approach, where coarse thruster and fine actuator control are merged together, to form controller capable of the precise set-point tracking.