Robot Learns to Perform Electrical Impedance Measurements from Demonstration

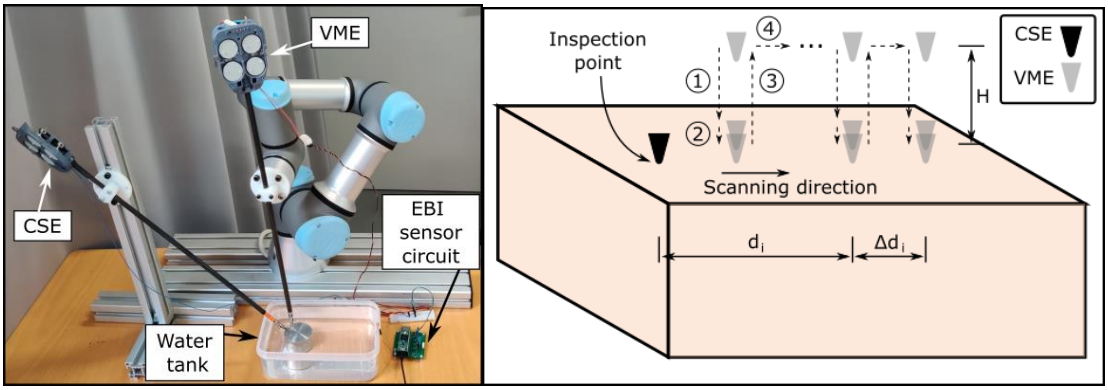
This project aims to teach the robot to perform an electrical impedance measurement procedure autonomously given a set of manual demonstrations. This project includes two parts: Learning from Demonstration (trajectory) and electrical impedance sensing.

The goal for Learning from Demonstration part is to collect a demonstration of a probing movement, encode this using Dynamic Movement Primitives and execute the trajectory on the robot, such that the same DMP can be generalized to multiple probing locations. We recommend that you make use of the UR RTDE (Real-Time Data Exchange) library to communicate with the robot, both to read data from it, as well as to send commands. You should do the following:

- You should first make a script that records a demonstration by putting the robot in *freedrive*, reading the necessary data from it, and writing it to a CSV file.
- You should use the above script to record a probing motion, using kinesthetic teaching to show the robot the trajectory. Consider that you can always perform the demonstration much slower, and then speed it up using DMP time-modulation (I.e. changing the time constant, τ).
- The CSV file of the demonstration should then be imported by the DMP class (as provided in the course exercise) and encoded. You should plot the trajectory and test generalization of the start and endpoints to different probing locations in simulation.
- You should write an additional script that steps through the DMP in a real-time loop and sends each trajectory point to the robot. For this, you can make use of the *servoL* (for position setpoints) or *speedL* (for velocity setpoints) commands in the UR RTDE interface.

For the task of electrical impedance sensing, you will need to collect the data on a water tank with & without an emersed metal object, and calculate the conductivity σ(d). d represents the distance between current source electrode (CSE) and voltage measurement electrode (VME). To achieve this target, you need to inject excitation current through CSE (the position of its tip is marked as A), and measure the electric potential through VME from at least 2 positions (the tip position is marked as M and N respectively). Then you can compute the material conductivity with the following equation. Please try to measure multiple d, and see how the conductivity changes σ with d and frequency in two conditions.

$$\sigma_a = \frac{I}{2\pi V_{MN}}\left(\frac{1}{|AM|} - \frac{1}{|AN|}\right)$$



After the Learning from Demonstration and Electrical Impedance Sensing parts are completed, you should integrate them together such that your main program script can correctly execute a sequence of DMP trajectories for each probing point, while performing the electrical impedance measurements at those points based on keyboard input.