Virtual fixture – team 5

The concept of virtual fixtures involves controlling a system at a high level by applying additional rules to the robotic kinetic and dynamic models (1). This allows users to generate desired behavior for the robot, simulating interactions in a virtual world, limiting certain changes in robot configurations while facilitating others. In the field of medical robotics, virtual fixtures offer potential benefits such as restricting robot movement near vital organs, facilitating specific directions and procedures, or enhancing surgeon sensations (2).

Our project aims to develop and test virtual fixtures on a planar robot with three degrees of freedom. This will be achieved through the development of a robust force control system and the simulation of various objects and control rules across different areas in the robot's workspace. Users will be able to move the robot's end effectors in different directions, and different control rules will be applied based on specific coordinates to simulate different environments. This aim could be achieved by fulfilling the following objectives:

1. Develop a closed-loop force control system for each motor that can accurately generate the desired force input from users. The system should rapidly converge to a stable desired value, minimizing steady-state error.
2. Design a force control system for the end effector by controlling the forces exerted by each motor. Joint torques will be calculated to achieve the desired force at the end effector in the x-y coordinate plane to get the desired dynamic behavior.
3. Create a virtual environment for simulating different objects. The objects and conditions in the environment should be editable, allowing for flexibility in the simulation.
4. Develop various control models to handle different obstacles in different areas. Examples include, but are not limited to:
   1. Hard object: The end effector will stop upon collision with this object.
   2. Damp-spring system: The end effector will exhibit dampened spring-like behavior when encountering this environment.
   3. Non-Newtonian fluid: The end effector will behave as if interacting with a non-Newtonian fluid.
   4. Facilitating area: Movements along specific paths will be easier to execute.

1. Bowyer SA, Davies BL, Baena FRy. Active Constraints/Virtual Fixtures: A Survey. IEEE Transactions on Robotics. 2014;30(1):138-57.

2. Lin HC, Mills K, Kazanzides P, Hager GD, Marayong P, Okamura AM, et al., editors. Portability and applicability of virtual fixtures across medical and manufacturing tasks. Proceedings 2006 IEEE International Conference on Robotics and Automation, 2006 ICRA 2006; 2006 15-19 May 2006.