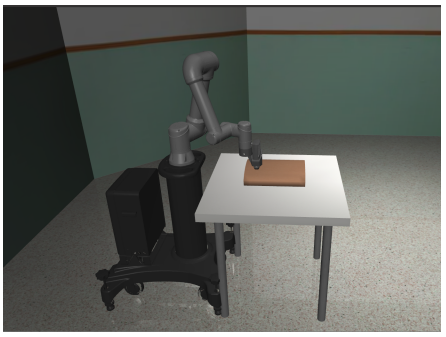
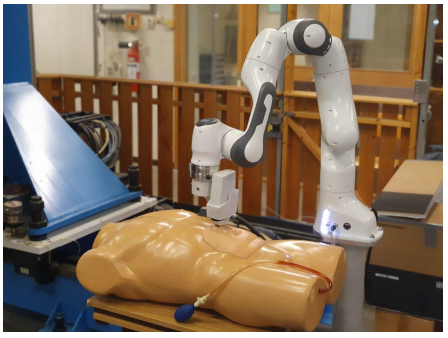
A Deep Reinforcement Learning approach for Robotic Ultrasound

Background

Robots capable of learning dexterous manipulation skills possess the potential of revolutionizing the level of automation in the healthcare sector. However, achieving human level manipulation skills with robots is a daunting task. During an ultrasound examination task, for example, the human body parts and organs might move and change shape. Both because the patient does not necessarily lie completely still, but also because of breathing motion, pulsation and the body being manipulated as part of the procedure. Deep Reinforcement Learning (Deep RL) promises to solve such complex manipulation and interaction problems through trial and error by posing this as a learning problem.



The project and thesis work will focus on developing and validating methods enabling robots to learn dynamic interaction tasks on a phantom of a human torso by combining RL with traditional robot force control methods. The final goal of the project is to achieve efficient transfer of robot motor control policies learned using simulation to a real-world robotic ultrasound examination set-up. During the first phase of the project you will also work on extending the existing robot learning simulation environment with additional functionalities of a real-time ultrasound examination procedure. Find a video of a robot performing RL in the existing robot learning framework in MuJoCo here (https://www.youtube.com/watch?v=yGMGalxWlos).



This thesis call is associated with the project, Robotics for Moving Objects (ROMO), which is a collaboration between NTNU and SINTEF. If you are motivated to develop robotic systems capable of learning and adapting for complex real-world application, here is an ideal opportunity for you. You will be working with simulation environments and lab set-up with the Frank Emika Panda robot. You will have the opportunity to work in collaboration with the multidisciplinary team composed of researchers from NTNU and SINTEF Digital and other students involved in the project. It is encouraged to write a conference paper as one of the outcomes of the thesis.

Tasks

- Extension of existing robot learning framework for ultrasound scanning in MuJoCo
  - Integrate streaming of ultrasound images.
  - Adaptive registration of medical data to the simulation environment.
  - Integration of different low-level robot force controllers.
- Deep Reinforcement learning
  - Extensive Deep RL experiments in the simulation environment to establish feasibility of the approach and to identify an optimal algorithm.
- Simulation-to-real (Sim2Real) transfer
  - Investigate limitations and possible adaptations for using the models in practice.
  - Validation of the approach through lab experiments (using Panda robot).

Qualifications

It is necessary with a basic knowledge of Python, robot control, machine learning and kinematics. Experience with C++, basic 3D modelling, reinforcement learning is an advantage.

The candidate will get access to lab and office facilities at SINTEFs group for medical technology and take part in an innovative and exciting research project. We believe that the skills acquired through this project, with its balance of practical and theoretical work of demanded expertise, will make the candidate well prepared for work within both research and industry.

Please contact Prof. Jan Tommy Gravdahl (jan.tommy.gravdahl@ntnu.no), Andreas Østvik (andreas.ostvik@sintef.no) and/or Akhil S. Anand (akhil.s.anand@ntnu.no) for further details.