University of Basel
Department of Biomedical Engineering

University of Basel, Department of Biomedical Engineering, Hegenheimermattweg 167c, 4123 Allschwil

Master of Science – Biomedical Engineering
Thesis Proposal

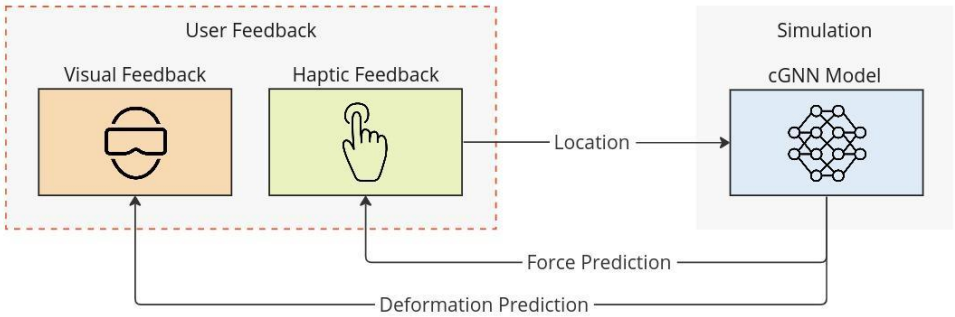
Human-in-the-loop soft tissue palpation simulation based on graph neural-networks

Context

In the scope of ongoing research, we are developing a soft tissue palpation simulator with a conditional graph neural network (cGNN) model that predicts both surface deformation and reaction force based on the pose of the probing tool. The force prediction is intended to realize haptic force feedback using a human-machine interaction haptic device. The cGNN model takes initial or deformed surface points and a virtual probing tool as input. The current method using a full set of points (1024) can simulate single output in 0.112 s (<10Hz). Using fewer points is possible, which accelerates the simulation time, but some interpolation of points is needed to visualize the surface smoothly. Haptic force feedback devices are typically controlled on kHz clock rates. An interactive soft tissue palpation simulation will require a careful compromise of limitations or interpolation in the spatial and temporal domains.

Task description

The goal of this project is to develop a software pipeline for using our trained cGNN model to be used with a haptic force feedback device for simulating soft tissue deformation and visualizing the deformed output. The project focus is on transferring the model outputs and rendering them (haptically and visually) for the user using state-of-the-art techniques. This first implementation can be used as an experimental test bed to investigate different compromising of spatial and temporal interpolation.



System overview with user and simulation environment.

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Work packages
- Literature research on state-of-the-art haptic and visual rendering methods
- Define and implement a pipeline to transfer torch-based deep-learning model into required formats
- Test the working principle on a haptic device
- Visualize the deformed surface
- Create a first prototype implementation to test different compromises between spatial and temporal interpolation

Nature of the Thesis
Experimental: 40%
Programming: 40%
Documentation: 20%

Specific Requirements
- Background in biomedical engineering, computer science, robotics, physics, mech./elec. engineering or related expertise
- Programming experience (Python and C++)

Group Leader / Supervisor
Madina Kojanazarova
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Collaborators
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