Project Proposal
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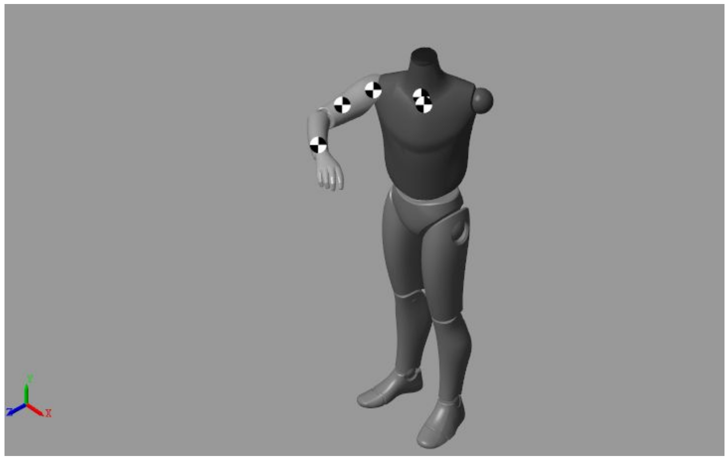
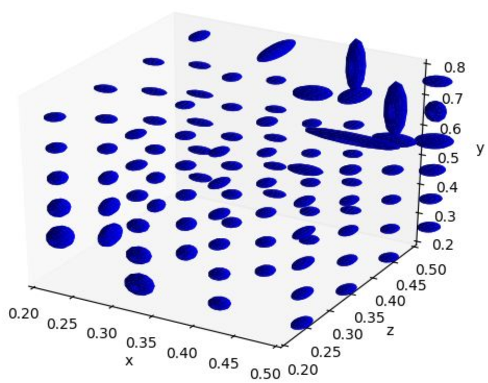
My proposed project involves developing a network capable of guessing the pose of a human body based on patterns of movement by their hand. Depending on the angles of the arm joints, the person's hand will be relatively easier to push around in some world frame directions than others. This configuration based resistance to movement of the hand is referred to as *virtual inertia*. By recording a trajectory of free movement of a person's hand (but without knowing how the rest of their body is arranged) it is possible to generate a map of the direction and magnitude of fastest acceleration for each point in space, and thus due to F=Ia, a map of virtual inertia. The problem I would be approaching for this final project would be to make predictions on human pose given a map of this virtual inertia data. I have already solved closed form equations of motion for the human arm/ torso as well as implemented a similar model in MatLab Simscape-MultiBody so I will be able to generate all required training data myself.

I have approached this problem previously from a traditional Mechanical Engineering perspective, modeling the human arm as a 6DOF rigid body pendulum. This assumes that any force exerted by the human is gaussian in nature and therefore the most significant effect of the virtual inertia of the hand in the world frame x y and z directions is due to mass of each arm segment, ignoring position dependent human strength characteristics. Reattempting this problem via Neural Network would allow the relaxation of that constraint, and allow training data in which the human is applying force in a realistic non-gaussian manner which would make data far more robust and predictions far more accurate. Because humans come in many different shapes and sizes, each simulated human used to generate maps for test data will have unique height, weight and strength characteristics.The virtual inertia map of an arm is unique to each person, so this problem is not merely fitting new test data to an existing global map (which could be accomplished without a NN) but using a network to learn patterns hidden within these maps to find the pose of a new subject who's unique height, weight and strength combination are unknown to the network and have not been encountered exactly in training data.

There are many exciting applications for this technique including collaborative material handling, virtual reality, and rehabilitative training for patients suffering from loss of motor control due to a stroke. I was originally planning on working in a group of 3 with Yanxi Piao and Amy Owens, however, I found out last night that they both have dropped this class. I was wondering if it would be possible to work alone on this project? I understand the assignment directions say groups of 2-3 but I am <u>very</u> interested in applying deep learning to this task even if it means more work for me. It would be incredibly beneficial to my research (and to this class) to be able use this problem as my final project as it would mean I would be able to spend as much time as possible working on the assignment.



Model of a human I made in MatLab Simscape-Multibody for generation of inertia ellipsoids



Example Virtual Inertia map generated with my MatLab model, visualized in with ellipsoids in MPL

Related Papers:

Harnessing RL for Neural Motion Planning
https://arxiv.org/pdf/1906.00214.pdf

Actor-Critic Network for assistive robotics- human robot "as needed" optimal control
https://www.hindawi.com/journals/mpe/2014/285248/

Noisy Networks for Exploration:
https://arxiv.org/pdf/1706.10295.pdf

Equation Identification for Extrapolation and Control:
https://www.is.mpg.de/uploads_file/attachment/attachment/494/Martius_EQL_2018.pdf

Modeling, Identification, and Compensation of Stick-Slip Friction:
https://ieeexplore.ieee.org/document/4084684

Measuring the Dynamic Impedance of the Human Arm Without a Force Sensor:
http://www.ece.ualberta.ca/~tbs/pmwiki/pdf/ICORR-2013-Dyck.pdf

Zero gravity aids in stroke recovery
https://sinaipostacutecare.com/zero-gravity-conditions-aid-in-stroke-recovery/