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TRAINING MACHINE LEARNING MODELS FOR ROBOT LEARNING FROM HUMAN DEMONSTRATION ON EXPERIMENTAL DATA

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Introduction. This study addresses research and analysis for the Machine learning models that will be trained to recognize patterns from human skills during contact rich tasks in order to transfer human arm trajectories and associated forces and torques to robotic arm platform. The main idea is to design a model and a single algorithm that can map movement trajectories and forces/torques from human kinematics and dynamics to robot kinematics and dynamics. The most analogous approaches for our study is robot learning from human demonstration and human robot interactions. Our goal is to address the limitation of these approaches by providing a new algorithm that can extract patterns from human multiple iterations of performance to be used to transfer these skills to teach roboitc arms. This proposed approach provides robot programming simplicity (by learning not traditional programming), generalizability (to be applicable to different robotic platforms) and scalability (scalable to different kinds of contact rich tasks).

Main part. First of all, we collected the relative dataset to peg in the hole contact rich task that contains multiple iteration of human arm that was inserting the peg in the hole while both the arm joints positions in Cartisian space and the applied forces/torques on the same Cartisian space were recorded. The dataset was recorded using Optitrack Motion Caputre System and Force/Torque API DELTA IP60 sensor for human arm joints and associated forces/torques respectively.
The data was preprocessed to remove outliers and missing data using quadratic interpolation techniques, trimmed to focus only on navicating the human hand that was hlding the peg to the hole were it should be inserted, and the insertion process for getting the most relevant features to guarantee the best approximation of training the ML model.
The data was collected from different sessions with different loactions for the peg in the hole tool and different human arm trajectories to reach it and complete the insertion to guarantee an acceptable bias and variance so that the models can be trained to accurately recognize the motion and force/torque patterns.
Three main approaches was considered to be trained on this dataset to extract the human motion and applied force patterns. The 3 approaches belong to 3 main state of the art ML models categoris: Dynamic movement primitives for imitating the human arm motion trajectories in an appropriate way to be sent as reference commands to the robotic platform, Recurrent Neural Networks models (RNN) and Time Series Transformers.

Results. Description of the practical use of research results, proposals for implementation (testing).