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EMG-BASED TRAJECTORY PREDICTION FOR SKILL TRANSFER IN ROBOTIC MANIPULATION

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Abstract. In this work, we are presenting a machine learning multi-model algorithm to design a policy-based learning from human demonstration. The policy input represents a state: tuple of predicted generated forces measured from human muscles using sEMG electrodes and human arm endpoint trajectory. The policy output represents encoded robot arm trajectories of position and associated force by extracting patterns from the aforementioned demonstrations (policy input).

Introduction. The need to solve manipulation tasks in multiple applications in complex environments raised the relevance of skill transfer learning techniques to teach robotic arms from human demonstration.

Main part. The problem of this study is to develop an algorithm that allows building a ploicy-based machine learning model that takes the raw recorded human arm position trajectories and the associated muscles activities as a state and outputs the appropriate robot arm trajectories and associated forces to be applied to let the robot imitate the human demonstrated manipulation skill.

Methodology: The first step of our work is data acquisition: we have two kinds of recorded data : musc;e activites data and human arm position trajectories.

1- The position data were recorded using optitrack motion capture system.
2- The muscle activites data were recorded using surface electromyugraphy electrodes (sEMG) distributed on the surface of the forearm and elbow muscles.

The sEMG data acquisition process is divided into two steps: To filter the EMG dataset using a Multi-tch filter (frequencies = 30, 49.99, 90, 60, 150 Hz), ButterWorth Bandpass filter (lp=20 Hz, hp=700 Hz), then to extract the most related features from the EMG dataset to predict the generated forces. We extracted 37 features from the dataset and computed the correlation matrix to detect the top related features: MAV(Mean Absolute Valu)e, RMS (Root Mean Square), WL(Wavelet Length), ZC (zero Crossing), SSC (Slope Sign Change), IAV (Integral Absolute Value), VAR (Variance), and WAMP (Willison Amplitude).

Second step is to build a Regression model to predict the generated muscle forces from recorded sEMG signals, then to encode the predicted force profile with the associated human arm position trajectories duning the manipulation task. The adopted regression algorithms to predict the forces from EMG data are: least square Linear Regressor, Support Vector Regressor (SVR), K nearest neighborhood regressor (KNN), XGBoost Regressor and artificial Bayesian Neural Network (BNN). We compare the results and select the best algorithm that converges arms of: Mean Absolute Error, Mean Squared Error and Coefficient of Determination.

The resulted force-position profile then will be represented as the desired trajectory to be imitated using Dynamic movement primitives algoritm (DMP) to model the output trajectory to be transferred to the robotic arm. Finally we use the Gaussian Mixture Regression model to reproduce the reference end effector wrench profile to the robot controller.

Conclusions. By building this multi-model algorithm, we present an efficient approach to teaching a collaborative robotic manipulator to achieve complex tasks by non-expert users and avoid the complexity of traditional programming.

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