Title	Efficient Robot Grasp Learning by Demonstration
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Abstract

In this paper, a Learning from Demonstration approach was proposed for robotic grasping with compliant arms. The compliance in the robot arm for safety often causes a problem in grasping. Recurrent neural network has been widely applied for modeling the sequential data such as sound, because recurrent neural network can leverage their internal state to process input sequences, this allows it to show the temporal dynamic behavior of time series. In this research, a recurrent neural network was constructed, given the estimation of the target object position and random initial joint angles of the robot arm, the recurrent model can produce the whole trajectories for grasping the target object.

For demonstrating the behavior to robot, there are several interfaces that can be choose such like demonstrating the behavior by using vision, motion sensor, teleoperation, and directly guiding the robot to demonstrate the behavior by its own. Directly guiding the robot and demonstrating the behavior by its own has several benefits, the first one is that there is no correspondence problem met, also human do not need to wear the motion sensor for showing the behavior. In this research, directly guiding the robot by human is used for demonstrating the grasp behavior.

In order to generate smooth and stable trajectories and to release the human labors, a transform model was proposed that can transform the example trajectory to adapt to the new situations, that is, given the example trajectory, which is formed by a series of discrete point, and the new initial and final discrete point, this transform model will output a new trajectory which satisfies two requirements, the first one is that the new trajectory must pass through the new initial and final discrete point, the second one is that the new trajectory must have the same tendency and same number of discrete points compared with the example trajectory. Then human do not need to record corresponded trajectory of the behavior, only specifying the target joint configurations and initial joint configurations are needed. Dataset can be enlarged by adding multiple initial joint configurations, that is, for one target, there will be multiple trajectories generated. Specifically, the two arms of the robot are trained respectively, and a support vector machine is used to decide which arm needs to be used for grasping the target object.

The evaluation results show that our recurrent model not only has a good prediction for the final joint configurations, but also generates smooth and stable trajectory. Moreover, the model is robust to the changes in the initial joint state which means that even though the initial joint configuration is

affected by disturbances, the model can still generate trajectories leading to the final joint configurations for grasping the object.

Finally, we tested the proposed learning method on the Pepper robot which can successfully grasp randomly placed object on the workbench. Compared to traditional methods which need to avoid singular configurations as well as to secure accurate localization, our method turns out to be robust and efficient and can be applied to cluttered environment.