BiGS: BioTac Grasp Stability Dataset

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I. Introduction

Autonomous grasping of unknown objects is a fundamental requirement for robots performing manipulation tasks in real world environments. Even though there has been a lot of progress in the area of grasping, it is still considered an open challenge and even the state-of-the-art grasping methods may result in failures [1]. A reliable prediction of grasp stability helps to avoid such failures and provides an option to re-grasp the object safely. Since the majority of grasping failures happen at the contact points, which are occluded for vision systems, tactile feedback plays a major role for predicting grasp stability.

The human-inspired biomimmetic tactile sensor (BioTac) [2] is equipped with a 19-electrode array and a hydro-acoustic sensor surrounded by silicon skin inflated with incompressible and conductive liquid. This design provides rich tactile feedback similar to the slowly-adapting and fast-adapting afferents present in the human skin [3].

Latest developments in classification algorithms [4] allow us to explore the potential of large amounts of data from these sensors. Our goal is to provide a publicly accessible grasp-stability dataset collected using the BioTacs and, thus, enable further development of algorithms capable of reliable grasp stability prediction.

II. Dataset description

Our dataset was collected using the Barrett WAM^{TM} Arm manipulator and the Barrett hand equipped with three BioTac sensors. For the data collection, we use a cylindrical object, depicted in Fig. 1, whose initial position is known. We track the markers attached to the object and calculate its position using a VICON motion-tracking system. In addition, we introduce a bowl that is firmly attached to the table. The bowl is used to bring the object up right if it falls out of the gripper during the extensive shaking motions that are performed in the course of each trial. This simple modification enables us to fully automate the data collection process and let the robot run for more than 20 hours without human supervision.

The experiment proceeds as follows. The robot reaches for the object to perform a randomly generated top grasp. After approaching and grasping the object using the force grip controller described in [5], the robot lifts the object up and performs a range of extensive shaking motions in all directions to ensure that the grasp is stable. If the object is still in the hand after the shaking motion, we consider it to be a successful grasp. The wrist-mounted force-torque sensor is used to determine if the object is still in the hand at the end of the experiment. We collected 1000 grasps, out of which 46% resulted in failures and 54% succeeded. Each of the samples contains 10 seconds of temporal grasping data (from the moment the fingers start to close until when the object is lifted up) sampled at 300Hz frequency.

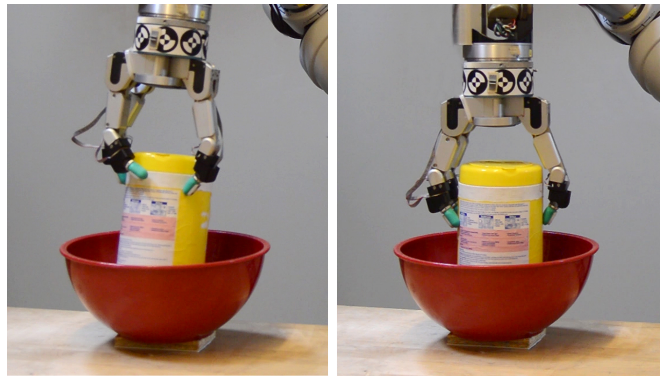

Fig. 1: Experimental setup used for collecting the grasp stability dataset. Left: an unsuccessful grasp attempt, right: a successful grasp.

The dataset consists of the following sensory and robot state information: raw BioTac electrode values, BioTac pressure sensor values, robot's joint angles, endeffector pose, object pose obtained from the VICON system, robot's hand force-torque sensor values, finger strain gauges and finger joint angles. More information about the included modalities, the data format and the experiments will be available on the dataset website[1].

In our work, we use the collected data set to learn a grasp stability predictor. While processing the temporal tactile data, it is important to take advantage of the spatial and temporal aspects of the information extracted from the BioTac. In order to do so, we employ spatio-temporal hierarchical matching pursuit (ST-HMP) [4] that constructs a spatio-temporal pyramid of the tactile signal. The extracted features can be used later to learn a grasp stability classifier.

We believe that the collected dataset can be of importance to the robotics community and we plan to extend it even further to incorporate other manipulation tasks that use the BioTac tactile sensors.

III. Acknowledgements

BioTac sensors used in this research were kindly provided by SynTouch LLC.

[1] `http://bigs.robotics.usc.edu`

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