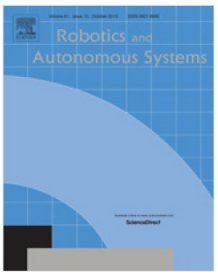

Multi-contact haptic exploration and grasping with tactile sensors

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Multi-contact haptic exploration and grasping with tactile sensors

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Abstract

Haptic exploration has received a great deal of attention of late thanks to the variety of commercially available tactile sensors. While the majority of previous works consider control of a single contact point at a time, we tackle simultaneous control of multiple contact points on several links. In addition, we use information from the existing tactile signals to increase the number of points in contact. We demonstrate the usefulness of this form of control to speed up exploration, scanning and to compliantly grasp unknown objects. Our controller requires to know only the parts of the robot on which it is desirable to make contact and does not need a model of the environment besides the robot itself. We validate the algorithm in a set of experiments using a robotic hand covered with tactile sensors and arm. In a grasping application, the active adaptation of the fingers to the shape of the object ensures that the hand encloses the object with multiple contact points. We show that this improves the robustness of the grasp compared to simple enclosing strategies. When combined with an exploration strategy, our multi-contact approach offers an efficient use of tactile sensors on the whole surface of robotic fingers, and enables the robot to perform a rapid exploration of complex, non convex shapes while maintaining low contact forces. It is robust to variation in the approach angle and to changes in the geometry and orientation of the object.

Keywords: Tactile Sensing, Haptic Exploration, Multiple Contacts, Compliant Grasping

1. Introduction

With robots moving into human-inhabited environment, haptic exploration becomes of primary importance to be able to interact with everyday objects. Other means of identification such as computer vision are limited by occlusion, illumination conditions and only provide partial information about texture and other surface properties.

In robotics, collisions are ordinarily avoided and in the cases when contact is allowed, it is usually limited to a single contact point at the end-effector. However, recent progresses in tactile sensing offer a range of research directions in robotics for allowing robots to be in contact at multiple points on the body. Moreover, thanks to advances in the design of dexterous humanoid hands that can manipulate complex shape, we can now consider manipulation that exploits the entire shape of the fingers. Such manipulation require precise control of multiple contact points along the fingers.

Most research on haptic exploration has focused on a single contact [1, 2] on the end-effector or sequences of multi contact grasps [3], much less work has been done on continuous multi contact exploration. In order to map a surface or search for an object on it, it is more efficient to keep all fingers in contact while moving than to touch sequentially several points. Increasing the number of contact points also improves the overall time for the search or the reconstruction. Keeping contact during exploration becomes particularly crucial when the mapping must be precise and when the object being scanned is moving. This allows to keep a precise estimation of the relative position between the robot and the object.

We propose an algorithm to maximize the number of points in contact when the hand is scanning or grasping an object. To this end, we project the forces/torques required for the exploration in the nullspace of the contact forces. Additionally, we control the forces at each contact point to prevent an uneven distribution of contact force. We show that this improves the robot's ability to make contact with unknown surfaces by using tactile sensors. This is crucial for tactile exploration and is very useful for grasping under uncertainty as tactile signals can guide the fingers to actively comply with the sensed shape.

2. Related work

2.1. Tactile exploration

Tactile exploration can be classified into two main categories: local and global exploration. Local exploration gathers local information about an object's surface, for instance by estimating the curvature at a given point on the surface, and matching that curvature profile to a database

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