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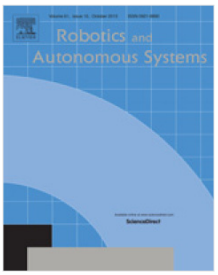

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Uriel Martinez-Hernandez, Tony J. Dodd, Mat Evans, Tony J. Prescott, Nathan F. Lepora

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Active sensorimotor control for tactile exploration

Uriel Martinez-Hernandez[a,b,*], Tony J. Dodd[a,b], Mat Evans[b], Tony J. Prescott[b], Nathan F. Lepora[c,d]

[a] *Department of Automatic Control and Systems Engineering, The University of Sheffield, Sheffield, UK*
[b] *Sheffield Robotics Lab, The University of Sheffield, Sheffield, UK*
[c] *Department of Engineering Mathematics, The University of Bristol, Bristol, UK*
[d] *Bristol Robotics Lab, The University of Bristol, Bristol, UK*

Abstract

In this paper, we present a novel and robust Bayesian approach for autonomous active exploration of unknown objects using tactile perception and sensorimotor control. Despite recent advances in tactile sensing, robust active exploration remains a challenging problem, which is a major hurdle to the practical deployment of tactile sensors in robots. Our proposed approach is based on a Bayesian perception method that actively controls the sensor with local small repositioning movements to reduce perception uncertainty, followed by explorative movements based on the outcome of each perceptual decision making step. Two sensorimotor control strategies are proposed for improving the accuracy and speed of the active exploration that weight the evidence from previous exploratory steps through either a weighted prior or weighted posterior. The methods are validated both off-line and in real-time on a contour following exploratory procedure. Results clearly demonstrate improvements in both accuracy and exploration time when using the proposed active methods compared to passive perception. Our work demonstrates that active perception has the potential to enable robots to perform robust autonomous tactile exploration in natural environments.

Keywords: Active tactile sensing, Bayesian perception, sensorimotor control, tactile exploration

1. Introduction

Humans purposefully move their hands and fingers to enhance the perceptual characteristics of objects being touched, which is known as active exploration [1, 2, 3]. Different exploratory procedures (EPs) are performed according to the type of information that is desired – for instance, pressure, contour following and sliding are used for extracting hardness, shape and texture [4, 5]. Motivated by this, recent advances in tactile sensing technology have improved the capability of robots to interact with their surrounding environment. In particular, robots equipped with biomimetic fingertip sensors are able to detect, explore and manipulate objects [6, 7]. However, despite these advances in tactile sensing technology, robust computational methods for real-time active control of biomimetic sensors during an autonomous exploratory procedure have not been developed.

This paper presents a novel and robust Bayesian approach for actively controlling a biomimetic fingertip during autonomous exploration of an unknown object. We consider a task of actively exploring object contours with two types of movement: 1) local repositioning to improve perception (fingertip position normal to contour), and 2) movements to accomplish the exploration task (edge orientation to move tangentially along the contour). We utilise a computational method for estimation of position and edge orientation based on Bayesian optimal decision making that reduces the uncertainty of the measurements from the tactile sensor. This method improves tactile perception by accumulating

*Corresponding author