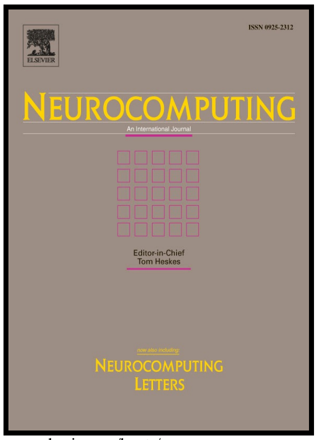
Author's Accepted Manuscript



www.elsevier.com/locate/neucom

Integration of touch attention mechanisms to improve the robotic haptic exploration of surfaces

Ricardo Martins, João Filipe Ferreira, Miguel Castelo-Branco, Jorge Dias

PII: S0925-2312(16)31218-8
DOI: http://dx.doi.org/10.1016/j.neucom.2016.10.027
Reference: NEUCOM17639

To appear in: *Neurocomputing*

Received date: 21 February 2016
Revised date: 11 July 2016
Accepted date: 17 October 2016

Integration of touch attention mechanisms to improve the robotic haptic exploration of surfaces

Ricardo Martins[a,b], João Filipe Ferreira[a], Miguel Castelo-Branco[b], Jorge Dias[a,c]

[a]*ISR-UC, Institute of Systems and Robotics*
Department of Electrical and Computer Engineering - University of Coimbra Polo II, 3030-290 Coimbra-Portugal
{rmartins, jfilipe, jorge}@isr.uc.pt
[b]*IBILI-UC, Institute for Biomedical Imaging and Life Sciences*
Faculty of Medicine, University of Coimbra, Coimbra, Portugal
mcbranco@fmed.uc.pt
[c]*Robotics Institute, Khalifa University, Abu Dhabi, UAE*

Abstract

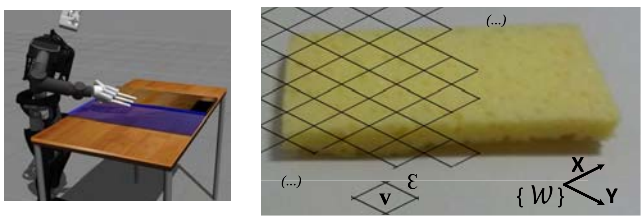
This text presents the integration of touch attention mechanisms to improve the efficiency of the action-perception loop, typically involved in active haptic exploration tasks of surfaces by robotic hands. The progressive inference of regions of the workspace that should be probed by the robotic system uses information related with haptic saliency extracted from the perceived haptic stimulus map (*exploitation*) and a "curiosity"-inducing prioritisation based on the reconstruction's inherent uncertainty and inhibition-of-return mechanisms (*exploration*), modulated by top-down influences stemming from current task objectives, updated at each exploration iteration. This work also extends the scope of the top-down modulation of information presented in a previous work, by integrating in the decision process the influence of shape cues of the current exploration path. The Bayesian framework proposed in this work was tested in a simulation environment. A scenario made of three different materials was explored autonomously by a robotic system. The experimental results show that the system was able to perform three different haptic discontinuity following tasks with a good structural accuracy, demonstrating the selectivity and generalization capability of the attention mechanisms. These experiments confirmed the fundamental contribution of the haptic saliency cues to the success and accuracy of the execution of the tasks.

Keywords: touch attention; artificial perception; Bayesian modelling; path planning; haptic exploration; probabilistic grid maps;

1. Introduction

In an attempt to capitalise on the same advantages that having hands benefit human beings, researchers have recently put a lot of effort into the development of dexterous robotic hands, due to the mechanical (high number of degrees-of-freedom) and sensory (tactile, force, torque, heat) capabilities that they provide. These devices allow robotic platforms to perform precise manipulation of objects (reaching, grasping, transportation, in-hand reorientation) [1], as well as haptic exploration of surfaces using different patterns of movements (lateral motion, press-and-release, static contact), thereby promoting the extraction and integration of different haptic properties (contours, texture, compliance, temperature) of the materials these surfaces are composed of [2].

The contributions presented in this work are related with the robotic haptic exploration of surfaces, following three essential assumptions: (1) no other type of sensors are used besides haptics (i.e. exploration is "blind"); (2) exploration paths are not predefined; (3) the surface geometry is unknown to the robot. The objectives of the exploration tasks concern haptic discontinuity/contour following. Haptic discontinuities are defined by the transition/border regions between surfaces with different haptic properties. During haptic exploration, the interaction of



(a) (b)

Figure 1: a) Results from a previous work [3], demonstrating a haptic discontinuity following task: straight line geometry. In this work, the haptic exploration tasks are more challenging: three materials and discontinuities with other geometries than straight lines. b) Illustration of a 2D isometric grid partitioning a real world workspace area. Each cell $\mathbf{v}$ has a dimension ε and is described by position (x, y) expressed in $\{\mathscr{W}\}$.