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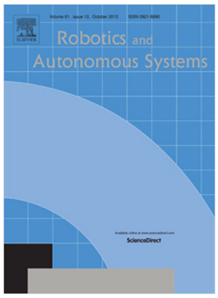

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Alex Vásquez, Véronique Perdereau

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ACCEPTED MANUSCRIPT

Proprioceptive Shape Signatures for Object Manipulation and Recognition Purposes in a Robotic Hand

Alex Vasquez[a,*], Veronique Perdereau[a,*,*]

[a]Sorbonne Universités, UPMC Univ Paris 06, CNRS, ISIR, 4 Place Jussieu, 75252 Paris, France

Abstract

Tactile information has been largely exploited for object recognition with robotic hands but very few approaches have used proprioception alone. In those that do, raw values of joint angles or torques are exploited to train learning algorithms. However, these approaches under-exploit the potential of proprioception, such as its usefulness to estimate the object pose and size. Furthermore, they focus on recognizing individual objects, which increases the amount of data needed to train the algorithms. In this paper, we present an approach based only on joint angles of a robotic hand to generate a *shape proprioceptive signature* that is invariant to the size and position of the object. Instead of recognizing a specific object from a list, object characteristics useful for its manipulation are extracted. This signature is exploited not only for shape recognition but also for pose estimation. To illustrate the scope of this method, tests are performed on primitive shapes. Results show that the signatures are invariant within large ranges of sizes and poses. Experiments on real hand were carried, and results depicted that the method works similarly in both simulated environment and real applications. A comparison between this two results is made and discussed.

Keywords:
Tactile Sensing, Multi-fingered Robotic Hand, Object Recognition and Manipulation

1. INTRODUCTION

When identifying the shape of an object, human beings make a combination of visual and tactile data mainly. All the information coming from the related senses allows us to identify lots of characteristics of the objects we manipulate with a remarkable accuracy of about the 94% and a rapidity of less than 5 seconds [1]. In an intent to reproduce such a performance with robotic manipulation systems, vision is the sense that has received most attention and has been largely exploited for object shape identification. In this sense, vision-based approaches for object shape identification perform a geometric model reconstruction (GMR). Wang et al [2] used a laser to scan the object and obtain a cloud point for 3D shape reconstruction. Jang et al. [3] used a stereo camera to get both an image that was analyzed to recognize the object and a cloud point that will be replaced with a prerecorded 3D model of the object once the object has been recognized. Furthermore, Lippierllo et al. [4] introduced a could point which adapted to the shape of the object as this was explored with a camera from different angles. Regardless the good results presented in cited works, they still present some limitations: First, online application is questionable due to the computational burn and time to complete a proper estimation of the 3D model, second, occlusion can easy occur once the object is grasped. Tactile data, on the other hand, is not subjected to occlusions and can provide data about both the shape and location of the object when the object is grasped.

Works on tactile object identification have increased over the years and the evolution of sensor technology has allowed to make good progress in that area, but there is still a lot of research to be done. In robotics, many types of sensors have been embedded on hands of manipulators to reproduce the sense of touch [5, 6, 7, 8] and most of literature in the domain mainly focuses on identifying the geometrical properties of objects using these sensors [9, 10, 11, 12]. However, according to Lederman et al. [13] when tactile object identification is to be performed, both tactile and proprioceptive information are involved. Whereas there are many methods using tactile information, proprioception is far from being exploited. Attempts to take its advantages on robots for tactile object recognition are seldom found in the literature. When found, proprioception is often combined with other sensing modes such as touch [14, 15, 16, 17], vision [18] and hearing [19]. Although proprioception is largely used by humans to perform shape identification, it has been little exploited as the only source of information by robotic systems. Furthermore, a great number of robotic hands do not have enough embedded tactile sensors to perform object recognition but they do have sensors to measure and control the joint angles of its fingers [20, 21, 22]. Thus, proprioception is their more reliable source of information for haptic shape identification.

Few studies have used proprioceptive information alone to perform object recognition and most of them use raw values as inputs to their identification algorithm. For instance, Faria

*Corresponding Author
Email addresses: vasquez@isir.upmc.fr (Alex Vasquez), veronique.perdereau@upmc.fr (Veronique Perdereau)

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