AUTOMATED GRASPING OF REAL-WORLD OBJECTS USING VISUAL AND TACTILE INFORMATION

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ABSTRACT

This paper describes an automated grasping system for complex 2.5D real-world objects (i.e. objects with height<width). The shape of each object, along with its position and orientation, are not known by the system *a priori*. A concise 2D model of the object is first obtained using computer vision. This model, along with height information obtained using on-line tactile measurements, forms the input to the grasp planner. The planner uses the 2nd order Limited Mobility Grasping theory of Plut and Bone to generate a set of immobilizing grasps which are tolerant of robot, hand, and camera-related positioning errors. The grasps are executed using a three-fingered, nine-axis, dexterous hand. Experiments are performed on two complex shaped automotive parts. The total time for object modeling and grasp planning was under 0.9 s for both parts. The parts were successfully grasped and immobilized in all of the tests performed.

Keywords: Grasping, Manufacturing, Industrial Automation, Robot Control.

1. INTRODUCTION

An important goal in robotics research today is the ability to grasp objects whose shape is not known *a priori*. This has application in both service robotics where many unknown objects are encountered, and in the growing area of rapid response, small batch manufacturing of customized products. This requires a method for generating a model of the object online, followed by grasp planning based on this model. The most common way to gain geometric information about an unknown object is through the use of a CCD camera.

In recent years, there has been some investigation into the grasping of objects using visual information. Bendiksen and Hagar [2], Sanz *et al.* [8], and Rodrigues, Li, Lee and Rowland [7] describe the use of vision systems to grasp unknown planar objects using parallel-jaw grippers [2,8] and a single actuator three-fingered gripper [7].

Other researchers have dealt with three-dimensional objects. Taylor *et al.* [10] and Trobina and Leonardis [11] present visually guided systems that grasp arbitrarily shaped 3D objects from a pile. Davidson and Blake [4] visually plan a 2D "cage" grasp and apply it to 3D objects. All make use of simple two-fingered grippers. Bard *et al.*[1], and Stansfield [9] both present a different approach to the problem. They use a Salisbury hand, which is a three-fingered device, where each finger has three degrees of freedom. Bard *et al.* use stereo vision to obtain a 3D model of the unknown part. However, this model was found to be inadequate for successful grasping. Stansfield uses a structured lighting vision system to obtain a set of object surface points. Stansfield also makes use of grasping knowledge obtained from studying the way in which a human performs the task, in order to improve the system's performance.

The systems described above are all used to grasp relatively simple, prismatic objects. In many applications (e.g. the automotive industry), a wide variety of 2.5D objects (i.e. those with height<width) are encountered, and they tend to have complex contours which are not easily modeled.

Our objective was to create a system which can grasp real-world 2.5D objects, without any prior geometric knowledge of the object, with a bias towards the complex sheet metal parts encountered in the automotive industry. We employ a three-fingered dexterous hand whose fingertips have been specifically designed for grasping sheet metal parts. The hand has a CCD camera mounted in its palm which is used to obtain visual information about the unknown part to be grasped. The goal was to perform the task in the simplest, most effective way possible. Using a simple 2D model of the part, obtained on-line from the camera, a suitable immobilizing grasp is determined. The grasp is then extended to 2.5D using tactile information.

In this paper, our methodologies for automated object modeling and grasp planning are described first. The experimental procedure and results are then presented, and conclusions drawn.

2. OBJECT MODELING

The 2.5D object is first modeled as a 2D projection using computer vision. This process is described in section 2.1. The extension of the planned grasp to 2.5D using tactile information is described in section 3.2.