ABSTRACT

Current-day robotic handling applications include a wide variety of production operations, from material transfer and machine loading to assembly and inspection tasks. These industrial applications are typically confined to work in structured environments with products presenting rigid behaviour. To increase the scope of robotic handling applications to a broader range of situations will require intelligent robotic systems embodying sensing capabilities and dexterous mechanisms, able to perform complex manipulation tasks, operating in less well defined environments and dealing with products presenting variable or unknown characteristics.

This research is concerned with the enlargement of robotic handling applications by focusing on the development of robotic grippers capable of handling non-rigid products. The research began by the identification of broad categories of non-rigid products based on industrial handling requirements. A reference architecture for a handling system suitable for dealing with non-rigid products, proposing the integration of perception, grasping and manipulation functions, is then presented.

After looking at the complexities of the behaviour of non-rigid products and establishing the requirements for the development of robotics grippers, the concept of a novel modular gripper is proposed. A prototype of the gripper was then built. It is a finger-type gripper, equipped with a range of sensors to measure finger position, force and contact force, capable of implementing different grasp configurations, controlling the grasp forces and performing in-gripper manipulation. The gripper is suitable for dealing with classes of non-rigid products having bar shape, with the products presented in discrete or continuous form. The sensing systems employed, including a special built tactile sensor, and experimental results of the control strategy used, are presented.

The kinematic analysis of robotic mechanisms is reviewed and applied, together with the analysis of the workspace, to the design and choice of possible configurations for a finger and for a gripper. The kinematic model of the gripper is used for planning and simulating the manipulation of products within the gripper. The simulation results of the manipulation of a rectangular and circular shaped product are presented. A static force analysis of the manipulation is performed, enabling the identification of grasp configurations that can achieve stable grasps.

The developed gripper is used to test and to demonstrate a set of techniques and procedures that are examples of the operational functions that a robotic handling system suitable for non-rigid products must provide. The perception procedures implemented were the identification of product size, of compliance and of product profile. The experimental results showed the gripper to be fully functional and it was possible to identify, measure and control the deformation of products presenting different degrees of stiffness.