***Abstract***

The primary handling of food with robots calls for the development of new manipulation devices, especially when products are easily damaged and have a wide range of shapes and textures. These difficulties are even greater in the agricultural industry because the quality of the products is also checked during the manual handling process. This PhD dissertation provides solutions to these issues and helps to further introduce robotics into the handling of food.

Several methods for handling food are included and analyzed, and specific solutions are proposed and then validated with prototypes. The research focuses on devices capable of adapting themselves to the shapes of the products without increasing the complexity of the mechanism. After analyzing several different solutions, the method chosen involves the use of under-actuated mechanisms, compliant mechanisms and fingers with pads filled with granular fluids. These fluids can behave as quasi-liquids or quasi-solids due to the jamming transition, which provides a soft initial grasp and can support high stresses during fast movements performed by the robot.

The additive manufacturing process provides an opportunity to develop robot grippers that are lighter, simpler, more flexible and cheaper. By using this process elastic mechanisms are manufactured in a single part, which are equivalent to mechanisms with several rigid parts connected by joints. Laser sintering is employed to produce pneumatic actuators, with different types of motions, based on the elastic properties of the materials used in this manufacturing process. As a result, the systems can be simplified to achieve grippers, with several fingers, that are produced as a single part.

In order to estimate the freshness and quality of agricultural products while they are being grasped, accelerometers are added to the fingers of several grippers. Accelerometers are economical and act as intrinsic tactile sensors. They can be easily embedded, thereby reducing the risk of getting damaged due to contact with the product, and allow each of the grasping phases to be identified. To achieve good performance of the accelerometers, a specific process is defined for the robot gripper, which touches the products a few times. In addition, several gripper prototypes are manufactured with diverse under-actuated mechanisms, jamming systems, and a new program that processes the signals from the accelerometers using different procedures in order to obtain parameters that can be used to estimate the quality of products. These parameters are correlated with data from destructive tests that are commonly used as a reference. The best performance of the accelerometers is achieved when the finger employs a granular fluid, a correlation coefficient of 0.937 being accomplished for the ripeness of mangoes and 0.872 for the firmness of eggplants.