End effector design of a robot arm for harvesting greenhouse tomatoes

Abstract

This dissertation focuses on developing a 3D model of an end-effector by using a software. The objective of the end-effector is to cut the stem and harvest tomatoes in a greenhouse environment without damaging the fruit. The end-effector was designed to simulate the human harvesting method for tomatoes with the use of the 3D CAD design software Solidworks®. The first phase of this project evaluated existing industry designs, a few of which were selected to draft engineering drawings for implementation. Emphasis was given on creating an original element.

During the next phase the most suitable idea was selected after recording a lot of observations. Literature review was conducted on the selected design and tests were carried both at the university and at the greenhouse. The following parameters were tested to determine the effectiveness of the end-effector: the amount the fruit moves, the fruit response to the applied gripping forces and defining the torque necessary for the fruit to twist and the stem to be mantained. Based on the results of the test it was confirmed that using a spring in the end-effector design prohibits damaging the fruit from applying a greater force than the allowable force.

It should be noted that during the design phase apart from the standardised components from industry catalogues were used in addition to the hand drawn parts. A static analysis was performed by observing the risk of failure of the critical components for high stresses. The geometry and the materials used were adapted based on the results of this static analysis. In addition after this analysis stage the movement capability of the end-effector was examined via video representation.

The last stage focused on estimating the cost of the mechanism. In order to reduce the cost and improve the end-efffector's effectiveness possible design variations were recorded. Furthermore design recommendations were introduced for further review.

The final end-effector design consist of a servomotor that linearly moves two parallel plate grippers on each side. One set of gripper plates is connected to another set with a hinge and a spring in between. The gripper plates are positioned at a small inward angle. A motor is attached to one of the plates and a small gear is concentrically positioned to it. A larger gear is connected to the smaller gear by a timing belt that is installed on the perimeter. A bearing is enclosed by the larger gear and it has a polyurethane sponge on the surface. An additional bearing with a polyurethane sponge is also attached to the other plate. The combined movement of the end-effector results on the twisting of the fruit similarly to the human harvesting method with the successful collection of the fruit maintaining the stem as instructed.