Title Development of technology for orienting apples for automated on-line inspection

Author Priya Narayanan, Uri Tasch, Alan M. Lefcourt, Rouben Rostamian and Marc Zupan

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Abstract

Inspection using machine vision offers the potential for improved food safety and quality. However, effectiveness of fruit inspection has been limited by the difficulty of appropriately orienting fruit for imaging. Commercial orientation systems have had limited impact due to mechanical complexity, cost, error, or some combination thereof. Preliminary tests demonstrated that apples could be oriented by rolling them down a track consisting of two parallel rails. After traversing a short distance, the apples generally moved to an orientation where the stem/calyx axis was perpendicular to the direction of travel and parallel to the plane of the track. The ultimate goal of the current research is to develop a technology using the observed orientation phenomena that could be used in a commercial system for orienting apples. Three different approaches are taken. First, a stability analysis is performed to determine whether this orientation phenomenon can be explained in terms of the inertial characteristics of axially symmetric objects. Rotation of a free body around an axis of axial symmetry is found to be stable, while rotation around an axis perpendicular to this symmetric axis is not. Furthermore, comparisons of action values for two different mathematical models of apples indicate that inertial characteristics can be used to orient apples. Second, experiments are performed to empirically test the orientation phenomena. Apples are rolled down two test tracks each consisting of two parallel wooden rails with three initial orientations of the stem/calyx axis: perpendicular, parallel, or at 45° to the rails. Apples started in a perpendicular position are de facto oriented. Apples started at 45° almost instantly become oriented. For the parallel condition, orientation is delayed and is successful in only about half of trials. Potential methods to improve the performance for the parallel loading condition are discussed. Third, a dynamic model of the orientation process using rigid body dynamics is developed. This model is created using multi-body dynamic modeling software and takes into account inertial properties of the fruit and nature of contact (friction stiffness). An investigation of the orientation phenomena is first performed using a simulated dynamic model of a rolling ball with a non-uniform mass distribution. The simulations showed that the ball always has the tendency to re-orient itself such that it rotated about the maximum moment of inertia. Experiments are performed and tentative argument is presented toward explaining the behavior. Overall, this research demonstrates that an orientation system based on use of an inclined track potentially is commercially viable.