Comparison of methods for online inspection of apple internal quality

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Abstract
Various methods for online quality inspection using X-ray (CT) are available. Here, two novel methods are compared. The first approach uses 3D vision in combination with deformable shape models to normalize X-ray radiographs for the sample shape, revealing internal properties and/or defects. The second approach reconstructs the sample based on limited data obtained by combining the translational movement of the sample on the conveyor belt with a limited sample rotation. Both methods have advantages and disadvantages and a choice between them should be motivated by application-specific requirements.

Keywords: X-ray, inspection, online, agrofood

1. Materials and Methods

1.1. Dataset

62 'Braeburn' apples *(Malus × domestica* Borkh.) were stored at Braeburn browning disorder (BBD) [1] inducing conditions (1 °C, 1% O_2, 7% CO_2) for eight months, scanned in a Philips AEA Tomohawk X-ray CT system and were subsequently destructively evaluated on the presence of disorders. The reconstructed CT scans were used to simulate the setups described in sections 1.2 and 1.3.

1.2. Multisensor inspection

A 3D vision system and radiograph linescanner are installed on a conveyor. A statistical shape model [2] is fitted to the pointcloud generated by the 3D vision system using a decoupled iterative closest point alignment [3] and least squares fit. This reference shape is voxelized according to [4] and a radiograph is simulated using the ASTRA toolbox [5], [6]. This simulated radiograph is subtracted from the measured radiograph, resulting in a residual image from which a set of features is calculated which are classified by a naïve Bayesian algorithm as containing disorders or not. An flowchart of this method is shown in Figure 1.

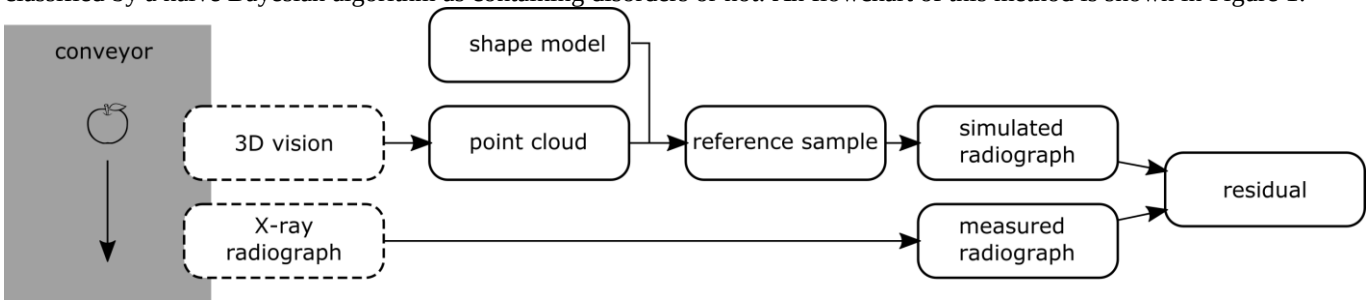

Figure 1: Flowchart of the multisensor inspection method

1.3. Reconstruction from limited data

The translational movement of a sample on a conveyor belt passing between an X-ray source and detector, combined with a limited rotation of the sample (see Figure 2) is used to obtain projections from a sufficient angular range to allow for SIRT-based reconstruction. Classic, defect-specific image processing methods are developed to grade the inspected samples based on these reconstructions.

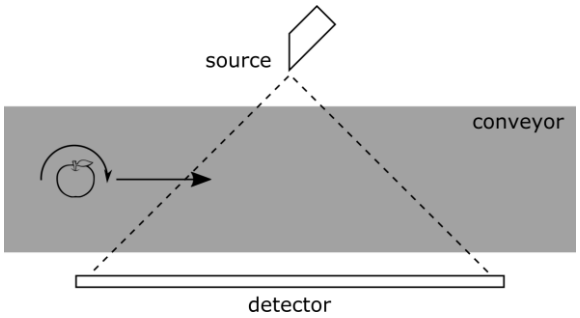

Figure 2: Obtaining projections by using the translation between source and detector and a small rotation of the sample.

2. Results and discussion

Both methods can accurately detect the disorder but some differences are worth noting. The multisensor approach only detects the presence of a defect or disorder but is less suited for quantification of the defect. It is fast and cheap though, and since it detects deviations from an ideal, it is more flexible with regard to the types of defects it can detect. The reconstruction-based method is more expensive, since it requires a large area X-ray detector and appropriate hardware to rotate samples in a controlled way. However, the reconstruction allows for a more detailed analysis and quantification of internal properties. Image processing methods have to be developed for every type of defect however, making it less flexible. Based on these results it can be concluded that both methods have advantages and disadvantages and a selection should be based on a detailed analysis of application-specific requirements.

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