Abstract of Thesis
Potato Shape Grading using Depth Imaging

By

Su Qinghua

Potato is one of most important crop around the world with a harvested area of 19 million hectares in total. However, with vulnerability to damage on surface, and widely appearance diversity in shape and size makes the potato crop a hard one to grade in postharvest process. Normal potatoes with regular-shaped are always preferable in market because the deformity ones cause a plenty of losses while peeling and subsequent processing. Good appearance, size and uniform shape will always be import factors which are preferred by buyers and will have a better sales appeal with higher price. Therefore, grading and sorting processes will ensure that the products meet defined grade and quality requirements for sellers and provide an expected level of quality for customers. Since grading mainly done by experienced workers who work along the conveyor systems, certain labor-related problems, including rising labor costs, production waste because of inconsistent sorting and grading and human errors, are plaguing the potato-packaging industry. Besides the inconsistency and subjectivity, the manual process is very tedious, laborious, costly, and is easily influenced by surrounding environments. Even many researches had been conducted by previous researches, most of the researches are based 2D shape data without considering of 3D space analysis. Thus, a potato shape grading system which based on depth imaging technology was investigated: a machine vision system installed with a depth camera, in order to help farmers grade potato shapes. To build up the system, we studied the depth camera system settings and Application Programming Interfaces of Standard Development Kits as the first step. After that, the machine vision system was able to capture the depth images by enable the depth video stream. Depth images were obtained with different camera heights and the best quality images were captured while camera set 60 cm above the ground. Then, machine vision system was used to predict physical features by extracting potato 3D shape data. Experiment result indicated

that potato length, width and thickness were predicted with 2.5%, 3.5% and 4.4% for mean percentage errors while 2.3 mm, 2.1 mm and 2.4 mm for mean absolute errors. With three different mass prediction models, 93%, 73% and 90% samples could be grouped into correct size based on Chinese Official Grades and Specifications of Potatoes by volume intensity, area intensity and linear regression, respectively. With further study, an algorithm was also proposed for surface shape defects detection in 3D space, including bent shape, bump and hollow. In addition, a virtual reality potato model with RGB and 3D shape data was created for redisplaying sample appearance with virtual reality technology. As the experimental results shown, 88% potatoes with surface shape defects were classified into different defect groups as manually. Besides that, the 3D potato model generation was successful based on Point Cloud Library and OpenGL library, the sample surface 3D shape and color could be displayed with zoom in/out and 360° rotation in vertical and horizontal direction for simulating in-hand examination experience. To automatically classify potato quality based on mass and shape, another application that combined our machine vision system and machine learning technology for potato quality grading was developed. Since depth images provided potato 3D shape data, a softmax regression model and a convolutional neural network model were developed to automatically grading samples into corresponding size and shape group, respectively. Experiment result indicated that softmax regression model was sensitive for size detection but low sensitivity for appearance classification. Therefore, only 67% potatoes grouped into correct mass and shape groups as manually. The convolutional neural network model, which improved softmax regression model by adding three convolutional neural network layers, showed higher accuracy. Totally 86% samples classified into correct size and appearance groups as manually. In conclusion, depth imaging is an effective method for future non-destructive post-harvesting grading, especially for products which size, shape, and surface condition are important quality factors. This technology also shows promising future for reducing postharvest loss which relates to sample shapes.