Field Environment Sensing and Modeling for Pears towards Precision Agriculture

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Abstract : The introduction of sensor technologies into agriculture is a necessary step to realize Precision Agriculture. Although sensing methodologies themselves have been prevailing owing to miniaturization and reduction in costs of sensors, there are some difficulties to analyze and understand the sensing data. Targeting at pears 'Le Lectier', which is particular to Niigata in Japan, cultivation environmental data have been collected at pear fields by eight sorts of sensors: field temperature, field humidity, rain gauge, soil water potential, soil temperature, soil moisture, inner-bag temperature, and inner-bag humidity sensors. With regard to the inner-bag temperature and humidity sensors, they are used to measure the environment inside the fruit bag used for pre-harvest bagging of pears. In this experiment, three kinds of fruit bags were used for the pre-harvest bagging. After over 100 days continuous measurement, volumes of sensing data have been collected. Firstly, correlation analysis among sensing data measured by respective sensors reveals that one sensor can replace another sensor so that more efficient and cost-saving sensing systems can be proposed to pear farmers. Secondly, differences in characteristic and performance of the three kinds of fruit bags are clarified by the measurement results by the inner-bag environmental sensing. It is found that characteristic and performance of the inner-bags significantly differ from each other by statistical analysis. Lastly, a relational model between the sensing data and the pear outlook quality is established by use of Structural Equation Model (SEM). Here, the pear outlook quality is related with existence of stain, blob, scratch, and so on caused by physiological impair or diseases. Conceptually SEM is a combination of exploratory factor analysis and multiple regression. By using SEM, a model is constructed to connect independent and dependent variables. The proposed SEM model relates the measured sensing data and the pear outlook quality determined on the basis of farmer judgement. In particularly, it is found that the inner-bag humidity variable relatively affects the pear outlook quality. Therefore, inner-bag humidity sensing might help the farmers to control the pear outlook quality. These results are supported by a large quantity of inner-bag humidity data measured over the years 2014, 2015, and 2016. The experimental and analytical results in this research contribute to spreading Precision Agriculture technologies among the farmers growing 'Le Lectier'.

Keywords : precision agriculture, pre-harvest bagging, sensor fusion, structural equation model

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