Development of an Optical Smart Portable Instrument for Fruit Quality

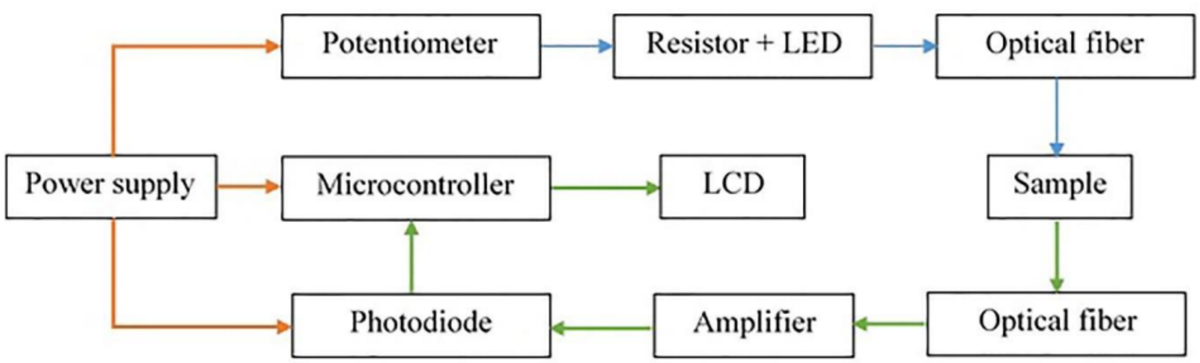
Literature Review 02(Conference,2019)

Link-https://ieeexplore.ieee.org/document/9149737

Summary:

The aim of this paper was to design and develop a new portable optical device for non-destructive determination of apple ripeness using moisture content, SSC, pH and firmness as quality indices.The desired qualities considered here as goals for development of the dedicated instrument included: low weight, small size, low cost, easy to use, rapid response and high accuracy. The device is envisioned to have the means to emit light at certain wavelengths, receive the reflected light, condition the received signals, and process the data for fruit classification.

Methodology:



Before evaluation of the instrument, a simple setup including an Arduino, the selected LEDs and photodiodes, resistors and potentiometers was developed to make sure that the LEDs emit waves in the desired ranges of this study and, these waves are detectable by the photodiodes. The instrument was equipped with a SD memory card to save the collected data. An experimental procedure was implemented for calibration and evaluation of the device, using 140 samples (70 ripe and 70 unripe apples). Apple samples were procured from an orchard in Damavand area of Tehran province, Iran, during the harvest season. Orchard owners/operators normally use visual and tactile senses to determine ripe and unripe apples. In addition to that, in this experiment, for ensuring the correct selection of ripe and unripe apples, in each visit, 15 apples were randomly harvested from trees and their pH, SSC, firmness and moisture content were determined using conventional methods. The values were then used for sorting the samples into ripe and unripe groups by comparing the obtained values to the ranges reported in the literature. These samples were transferred to the laboratory for evaluation of the developed instrument. Acquired reflectance signals saved on the memory card were analyzed using the decision tree method for classification utilizing Matlab 2017a software. Due to the simple and programmable rules of the decision tree method for uploading in the microcontroller, this method was selected for data classification with maximum number of 4 splits, split criterion of Gini's diversity index, and hangout algorithm for validation of the results. Performance of the developed decision tree models including fine tree, medium tree and coarse tree were compared using accuracy, confusion matrix, and Receiver Operating Characteristic (ROC) curve of the models. The model with high accuracy, large area under the ROC curve and higher numbers of correctly classified samples in the confusion matrix was selected as the best classification model.

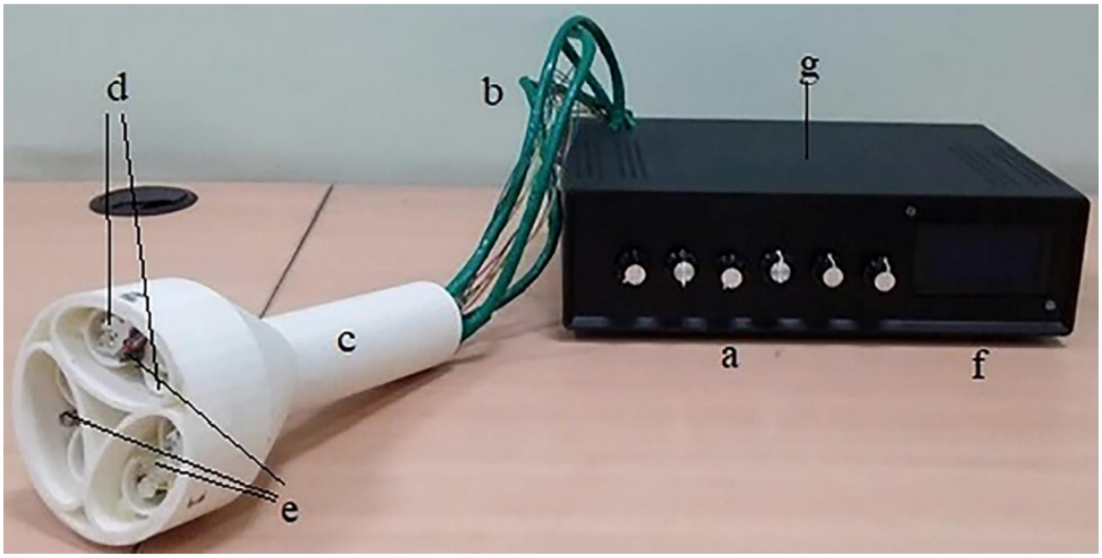


Figure 3. Prototype of the instrument developed for non-destructive estimation of fruit ripeness. a) LEDs' Potentiometers, b) optical fibers, c) WTM, d) wave emitters, e) wave receivers, f) LCD, g) instrument's box

Findings:

The instrument performance was evaluated for classification of 'Golden Delicious' apples. Results showed that at different maturation times on the tree, fruits were classified correctly by 64%/66% using discriminant partial least squares and 92%/84% using plus neighboring class analysis with SECV=0.9/0.9. Moreover, for different storage conditions, the samples were correctly classified by 77%/84% and 93%/99% using discriminant partial least squares and correct plus neighboring class analysis, respectively were in the 1120-1530 nm range.

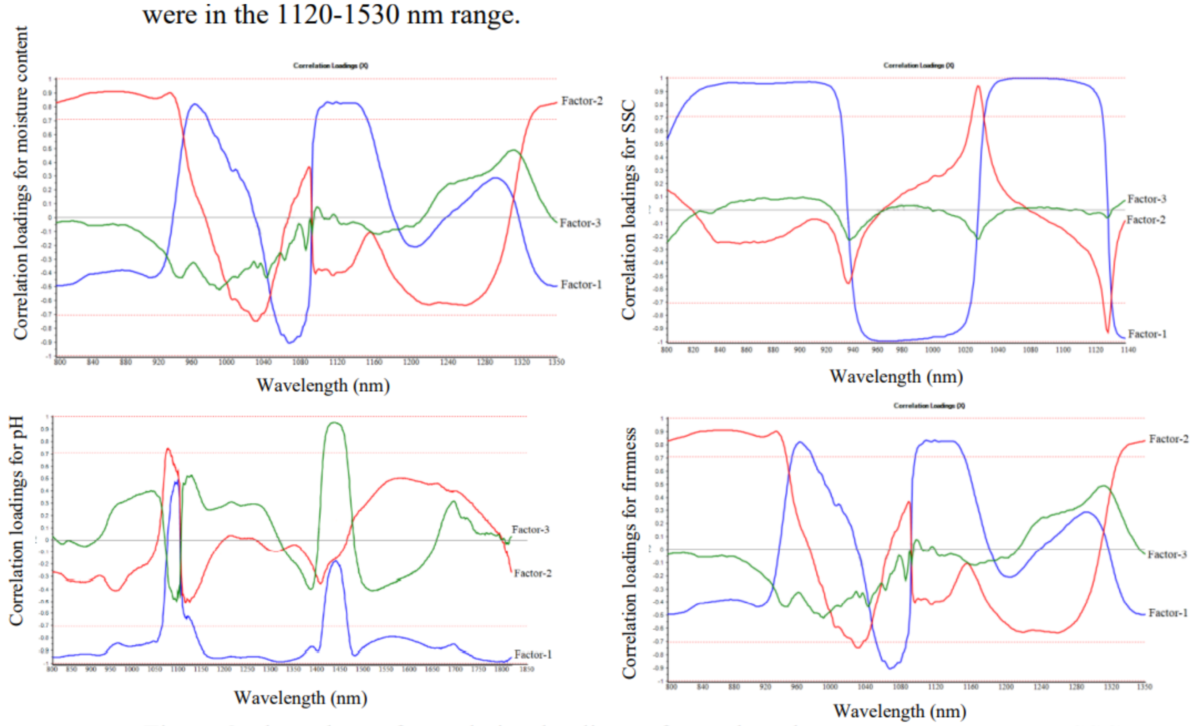


Figure 2- the values of correlation loadings of wavelengths for moisture content, SSC, pH and firmness

Analysis:

This project was undertaken to develop a portable non-destructive optical instrument for fruit classification into ripe and unripe classes. The developed prototype was tested and validated for apple ripeness detection. The decision tree method was selected to develop the model for classification of apples into ripe and unripe groups. The output results of fine, medium and coarse tree models showed that the fine tree model yielded the best performance and accuracy compared with the other models. Reasonable overall performance was obtained in correct classification of samples with an accuracy of 67.1%. The fine tree model classified 68.7% of ripe apple signals into the ripe class and grouped 56.2% of the unripe apple signals as unripe, correctly

Future work:

Different factors for reducing the performance include: limitation in the emitted wave range from each inexpensive optical source, nonlinearity effects and radiation loss in the optical fibers, low sensitivity of the optical sensors in some wavelengths, wave losses on the apple surface caused by the utilization of the designed WTM tool, and high variations in apples sizes and shapes, as well as electrical noise Increasing the accuracy of the instrument and reducing the errors is required.