ON-THE-GO SENSING TECHNIQUES FOR SUGAR DETERMINATION OF SUGARBEET IN THE FIELD

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Introduction:

The advancement of sensing and sensor technologies has enabled us to improve upon the previously developed sugar content determination system for sugarbeet. The more reliable and efficient components have greatly improved the accuracy of the sensing system and have made the system one step closer to the ultimate on-the-go concept.

Currently, to determine sugarbeet sugar content from a farm, a sample of beets must be taken from a producers truck when it is being dumped at the piling station. A sugar sensor will allow sugarbeet coops to take multiple samples from a truckload and analyze them immediately without having to send them to a lab for analysis. It would allow more samples per truckload and every truck could easily be sampled providing more accurate results. As soon as a beet is sampled, the sugar content would be recorded in a computer and the beet could be dumped in the pile. This would eliminate a significant amount of time and effort of analyzing sugarbeets at a lab.

Literature Review:

Near-infrared (NIR) technology has been used as a quick, reliable and non-destructive means of determining different amounts (protein, oil, starch, moisture, carbohydrates, sucrose) of a variety of food and agricultural products. For these measurements, generally, a laboratory scale NIR spectroscope in reflectance or transmission has been used.

NIR instruments have been used for numerous food processing applications and for quality control in sugar factories. These instruments can provide real time measurement of sugarbeets sugar in the field and at piling stations.

Calibration is a critical component of a NIR analysis system. Statistical techniques have been used to develop the calibration model for NIR analysis. Statistical techniques have some limitations which is easily handled by "Neural Networks". Neural networks process the information in a parallel and distributed form, similar to that of a human. Also, neural networks are more fault tolerant and robust with the capability to learn from its own error. Neural networks have been used for several agricultural applications, ranging from disease prediction and weather forecasting to farm management and quality control operations. Thus, neural network techniques will be suitable for developing an on-line calibration model for an NIR based analysis system.

Objective:

The objective of this research is to further develop an on-the-go sensor for the determination of sugar content of sugarbeets in the field during harvest.

Procedure:

A new integrated system was used to acquire the NIR reflectance (absolute) signal of sugarbeet samples. The system is consisting of a PC-based fiber optic spectral meter along with the sensor head, a tungsten halogen lamp, and a sample holder. Initially, experiments were conducted to optimize different optical configurations for signal acquisition.

Before acquisition of the signal, a thin cross section of the beet is cut out from the beet as shown in figure 1. The sample is mounted on the sample holder. Using the adjustable arm of the sample holder, the appropriate distance between the sample surface and light box is set. The NIR signals were acquired for a total of 617 randomly selected sugarbeet samples. The NIR signals are further processed using different statistical techniques. The processed signal generated representative spectral signature consisting of 121 discrete data points. These 121 data points were provided as input to SAS procedures to predict sugar content. Before the sensor can be used in the field, a correction factor will need to be determined to adjust for the difference in sugar content between the crown of the beet and where the samples were taken. A sensor is also needed to tell the sugar sensor when it is over a beet and to take a reading.

Results:

A total of 490 samples were used for training the prediction model. The highest accuracy in the training set is 99.99% with an average accuracy of 96.8%. The highest accuracy in predicting sugar content among 127 test data was 99.98% with an average accuracy of 95.1%. The maximum error is 5.63 (percent of sugar content) and the minimum error is .0032 (percent of sugar content) for the test data. The average error is 0.022 (percent of sugar content).

Further analysis has shown that there were 3 outlier points exists among all 617 samples and they are part of the test data set. The average accuracy was increased from 95.1% to 95.6% with the inclusion of the outlier points with an average error of 0.05 and MSEP (Mean Standard Error of prediction) of 0.85.

Figure 3 shows the predicted versus actual sugar content for the test data (outlier points removed) and a regression line that is fitted through these points. It shows a promising prediction accuracy with an r-value of almost 0.9. Our developed statistical model has predicted sugar content with high accuracy. Figure 2 is a picture of the test instrument

Conclusion:

From this study, it was concluded that the modified portable NIR sensor could predict sugar content of the sugarbeet with very high accuracy. And the rugged design of the integrated system has paved the way for the on-the-go sensor development for predicting of sugar content during harvest time.

Future Work:

Further research in development of the calibration and validation model is required to improve performance.

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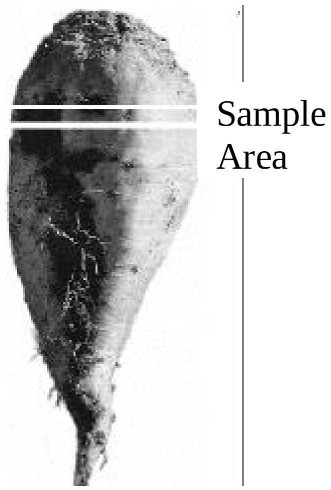

Figure 1. Area for Obtaining Sugarbeet Samples for analysis

Figure 2. NIR Sugarbeet Sugar Sensor

Figure 3. Performance of a Validation Model to Predict Sugar Content of Sugarbeet (Test Data = 124)