Experiment-5 Report

STUDY ON BRIX VALUE OF FRUIT USING IoT & INTERACTANCE SPECTROSCOPY

CPS Lab

(CH5425)

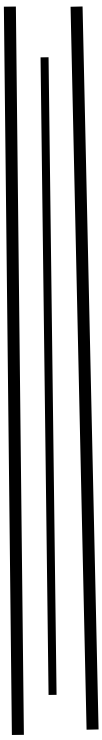
M. Tech in Cyber-Physical Systems, IIT Madras

Chennai, India, 600036

Submitted By:

Group-2

(KRISHNA SH TELI- GE22M018, BHUVANESH P- MM19B027, SAI KIRAN- ME19B132)



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Aim

The Aim of the experiment is to find the Brix value of the given fruit sample using Interactance Spectroscopy principle to collect the data and then estimating the brix value using the regression machine learning model over the collected data.

Introduction

Interactance spectroscopy is a non-destructive analytical technique used to investigate the properties of a material or a sample by measuring the intensity of light reflected from or transmitted through the sample. In interactance spectroscopy, a beam of light is directed onto the surface of the sample, and the reflected or transmitted light is analysed using a spectrometer. The resulting spectra provide information about the electronic, vibrational, or other physical properties of the material, including its composition, structure, and optical properties.

In this experiment, we have used interactance spectroscopy to study the Brix value of fruits by measuring the intensity of light reflected or transmitted through the fruit. Brix value is a measure of the sugar content of a fruit or vegetable, which is important for determining the fruit's quality and ripeness.

To measure the Brix value of a fruit , we built up an IoT device which send a beam of light onto the surface of the fruit, and the reflected or transmitted light is read and stored. Thus, the process repeated to collected the various samples from three different parts of a fruit for three different wavelength sources. The resulting spectrum is used to determine brix value of fruit based on the absorption of light at specific wavelengths.

The Brix value can also be determined by comparing the reflectance or transmittance spectrum of the fruit to a reference spectrum obtained from a fruit with a known Brix value. The difference between the two spectra can be used to calculate the Brix value of the fruit being tested

Underlying Principle

The underlying principles are interactance spectroscopy based on which an IoT device is built to read the intensity value of reflected light from the surface of fruits and then using Beer Lambert's principle, the absorption of the fruit is calculated.

$$Absorption = -\log\left(\frac{I_{in}}{I_o}\right)$$

Procedure

- First Build up a model using the regression data provided. There are about 400 files having 18 wavelength value corresponding to different varieties of apples. To build a model, we need to take

average of vales in each file mapped with the corresponding brix value of the fruit. Few files are redundant with no corresponding brix vales which can be removed.

- Wavelength values needs to be normalized with a reference value which was provided in a different file. The reference values also need to be averaged before using.
- The we should calculate absorbance by taking negative logarithm of it

$$Absorbance = -\log\left(\frac{I_i}{I_0}\right)$$

- Ultimately the data the need to be feed into the model is the absorbance corresponding to the 18 wavelengths and the corresponding brix values of different apples.
- After building the regression model, the corresponding RMSE and R-square should be calculated for reporting.
- Then for calculating the measuring the wavelength, a sensor board equipped with 3 LEDs (these serve as the source for the UV, visible and IR wavelengths) which is connected with an audrino board. The code for operation needs to be uploaded to the board.
- Then we need to write another code to get the data collected by the sensors using the pyserial module.
- The data collected will be in the form of bits which needs to be converted back. The collected data should be saved in the form of a csv file. We need about 20-25 readings of wavelength in the csv file.
- The data again needs to be averaged out. The after calculating the absorbance corresponding to 18 wavelengths, the data is fed into the model which gives the Brix value.
- The data needs to be collected for 2 different at 3 spots each

Outcomes

The following the specification of the build regression model.

OLS Regression Results

Dep. Variable:	new	R-squared:	0.418
Model:	OLS	Adj. R-squared:	0.377
Method:	Least Squares	F-statistic:	10.30
Date:	Sun, 12 Mar 2023	Prob (F-statistic):	1.18e-21
Time:	16:55:56	Log-Likelihood:	-528.49
No. Observations:	277	AIC:	1095.
Df Residuals:	258	BIC:	1164.
Df Model:	18		
Covariance Type:	nonrobust		

	coef	std err	t	P>|t|	[0.025	0.975]
const	9.8456	1.384	7.113	0.000	7.120	12.572
410 nm	-1.0923	0.598	-1.827	0.069	-2.270	0.085
435 nm	3.3410	1.327	2.517	0.012	0.727	5.955
460 nm	-0.9899	0.660	-1.500	0.135	-2.290	0.310
485 nm	-3.2629	1.089	-2.997	0.003	-5.407	-1.119
510 nm	0.8724	1.210	0.721	0.472	-1.511	3.256
535 nm	-0.8160	0.782	-1.044	0.297	-2.355	0.723
560 nm	1.8965	1.045	1.814	0.071	-0.162	3.955
585 nm	0.2000	1.260	0.159	0.874	-2.282	2.682
610 nm	0.3783	0.872	0.434	0.665	-1.339	2.096
645 nm	1.7249	1.388	1.243	0.215	-1.009	4.458
680 nm	-2.7771	0.831	-3.341	0.001	-4.414	-1.140
705 nm	-4.5766	2.053	-2.229	0.027	-8.619	-0.534
730 nm	-3.5998	4.283	-0.840	0.401	-12.034	4.835
760 nm	6.2468	5.962	1.048	0.296	-5.494	17.987
810 nm	0.7175	3.847	0.187	0.852	-6.857	8.292
860 nm	-1.1885	2.698	-0.441	0.660	-6.500	4.124
900 nm	-9.1310	4.029	-2.266	0.024	-17.065	-1.197
940 nm	10.0326	4.064	2.469	0.014	2.030	18.035

Omnibus:	24.408	Durbin-Watson:	2.124
Prob(Omnibus):	0.000	Jarque-Bera (JB):	49.940
Skew:	0.457	Prob(JB):	1.43e-11
Kurtosis:	4.868	Cond. No.	591.

The following table shows the estimated brix for the different samples.

Apple Sample	Brix Value
Apple 1 – Sample 1	12.87361896
Apple 1 – Sample 2	14.42900778
Apple 1 – Sample 3	12.57259733
Apple 2 – Sample 1	15.26317029
Apple 2 – Sample 2	14.50660869
Apple 2 – Sample 3	13.13188387

Observation and Results

Based on the prior provided data, a regression model is built and different samples of three different fruits for three wavelengths are collected using IoT device. It can be very well observed that the RMS of the model is low hence we can assume that the model may not be well fit in this scenario. However, we applied it and have got some interesting result. The brix value of the fruits has been found out approximately 13.5.

Inference

As suggested before, the regression model was pretty bad with very low fit to the data. The Brix values of the fruits was observed to be very high, some even going past 15 which is a little higher than usual. This maybe as a result of the in proper model in use. With more relevant data, perhaps the model accuracy can be improved along with the Brix values estimated.