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Transmittance Multispectral Imaging for Edible Oil Quality Assessment

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Outline of the Presentation

- Overview of the Edible (Coconut) Oil Adulteration and Existing Detection Methods.
- Multispectral Imaging for Food Quality Analysis.
- Proposed Multispectral Imaging System.
- Sample Preparation.
- Proposed Image Processing Algorithm.
- Results, Discussion and Conclusion.

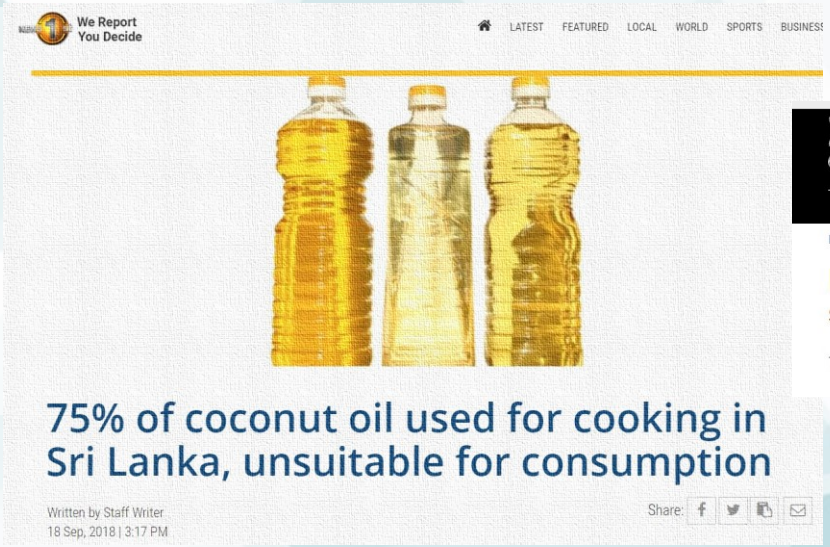
Overview of the Edible (Coconut) Oil Adulteration

Coconut Oil is Mainly Used

- As a Cooking/ Frying oil
- For Skincare and Haircare products
- To produce Pharmaceuticals
- Industrial products such as Detergents and Emulsions

Coconut Oil is Commonly Adulterated Using

- Palm Oil
- Argemone Oil
- Cottonseed Oil
- Second grade coconut oil
- Used Coconut oil



Source : https://www.newsfirst.lk/2018/09/18/75-of-coconut-oil-used-for-cooking-in-sri-lanka-unsuitable-for-consumption/

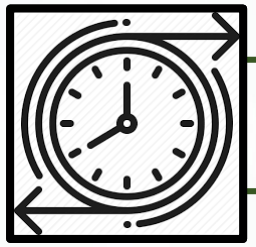
Source : http://www.dailynews.lk/2017/07/13/business/121777/hazardous-trans-fat-found-adulterated-coconut-oil-sold-market

Detection Methods

Conventional Detection Methods

- Fourier Transform Mid Infrared (FT-MIR) Spectroscopy
- Colour Tests such as Sodium azide, Hexabromide
- Differential Scanning Calorimetry (DSC)

Disadvantages of Conventional Detection Methods



Time Consuming

Need human inspection

Destructive

Highly Laborious

Multispectral Imaging for Food Quality Analysis

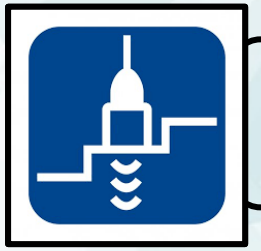
Multispectral Imaging is used to

- Detect Adulteration Levels of Spices.
- Detect Contamination of Meat.
- Grade Fish Harvest.

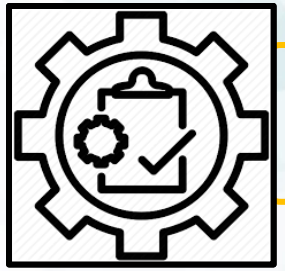
Advantages of Multispectral in Food Quality Analysis

Chemical free assessment

Environmental Friendly – No Chemical Wastes



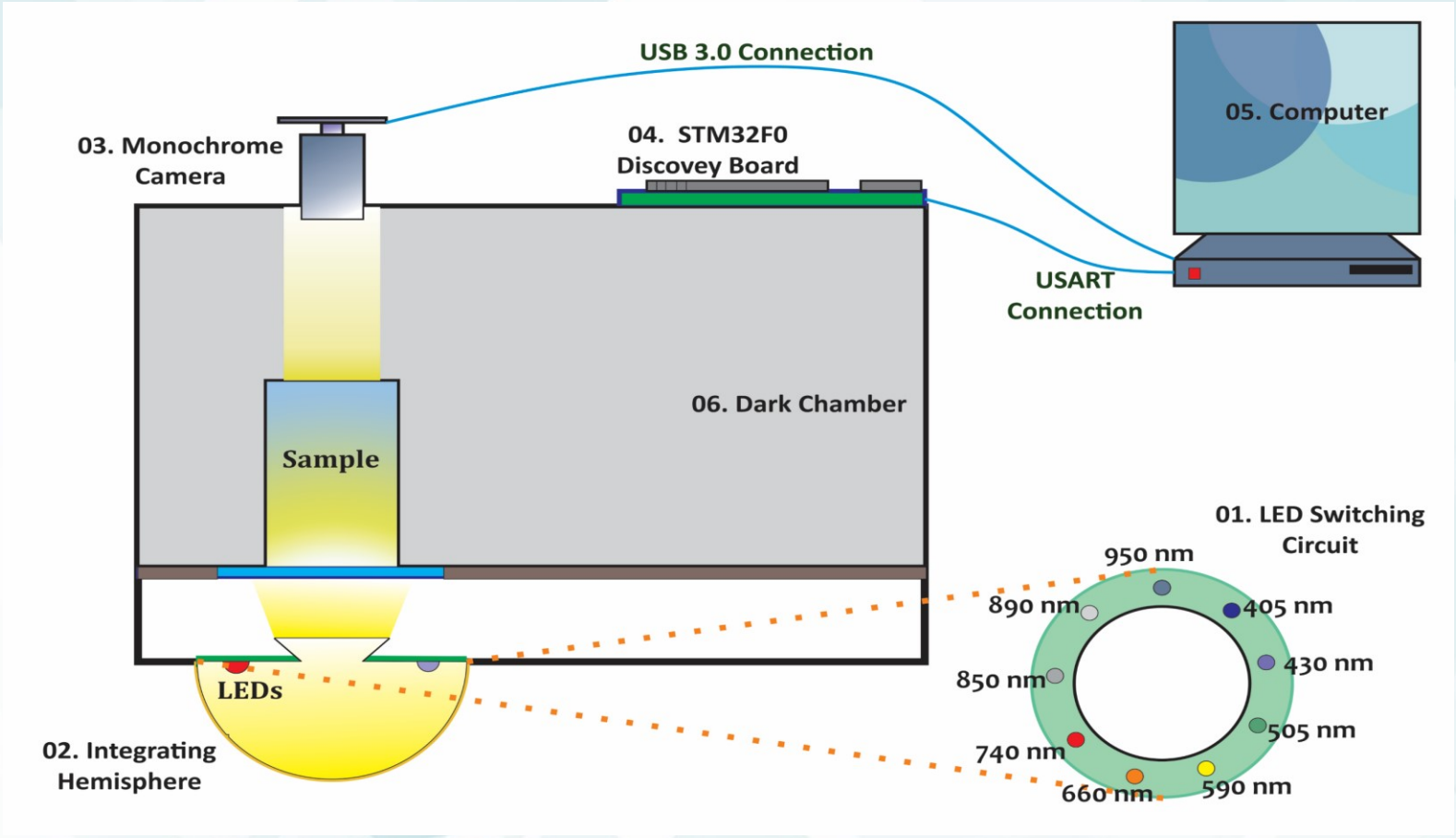
Non-destructive

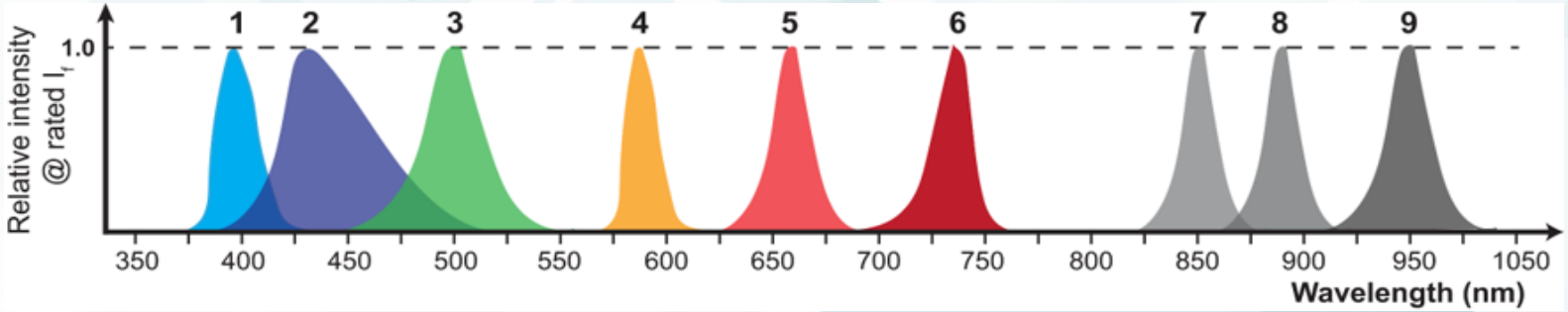


Automatable

Economical

Proposed Multispectral Imaging System





Sample Preparation

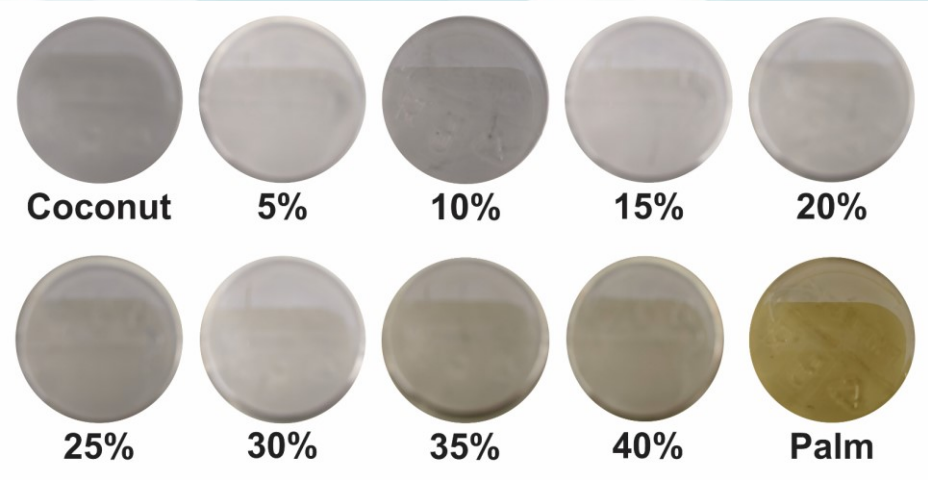
- Pure palm oil and coconut oil samples were purchased from reputed edible oil brands available in the country.

Testing Samples

Testing Samples were prepared by mixing palm oil with coconut oil at 0, 5, 10, …….,40 % ($V_{palm\ oil}/V_{total}$ %) and replicated for 15 realizations.

Validation Samples

16 samples were prepared with known adulteration levels of 2, 4, 6 ,…….36 % ($V_{palm\ oil}/V_{total}$ %) for the validation of the proposed method.



RGB Images of the Adulterated Samples of Coconut Oil with Palm Oil

Image Preprocessing

01. Dark Current Reduction

$$\boldsymbol{P[\lambda] = S[\lambda] - D}$$

where, $P[\lambda]$ is the dark current removed image at wavelength λ, $S[\lambda]$ is the raw image at wavelength λ and D is the dark current image

02. Median Filtering

$$\boldsymbol{P^*[i,j] = \frac{1}{N} \sum_{k=-w}^{w} \sum_{l=-w}^{w} P[i+k, j+l]}$$

where, $P^*[i,j]$ is the updated value of the pixel i,j after the median filtering , $P[i,j]$ is the pixel value of the dark current subtracted image at i,j , w is the suitably chosen window size and N is the number of pixels in the window.

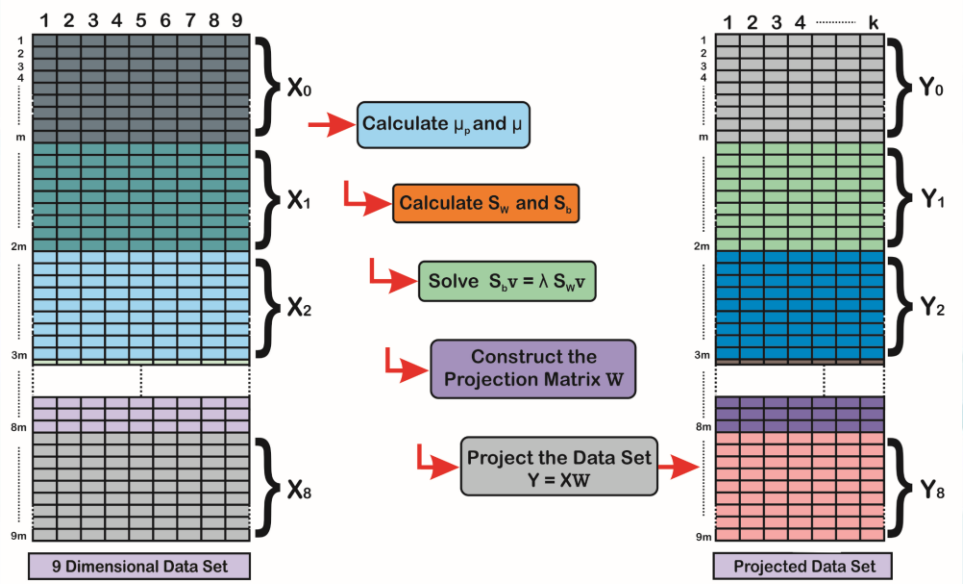
Algorithm

01. Fisher's Discriminant Analysis

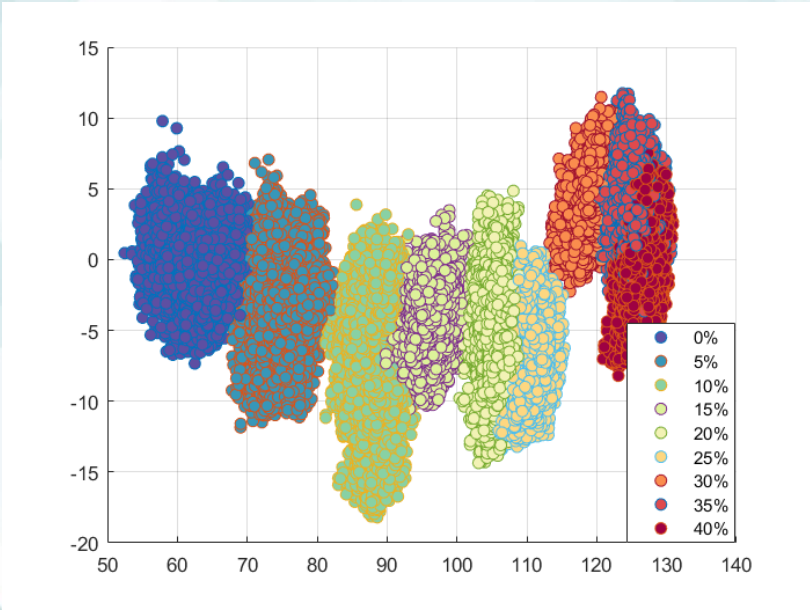
This is a dimension reduction/feature extraction method that aligns axis such that projected data are well separated by

(i) Maximizing the distance between projected class means.

(ii) Minimizing the within class variances.



Steps of FDA



Projected Dataset

Algorithm CONT.

02. Bhattacharya Distance

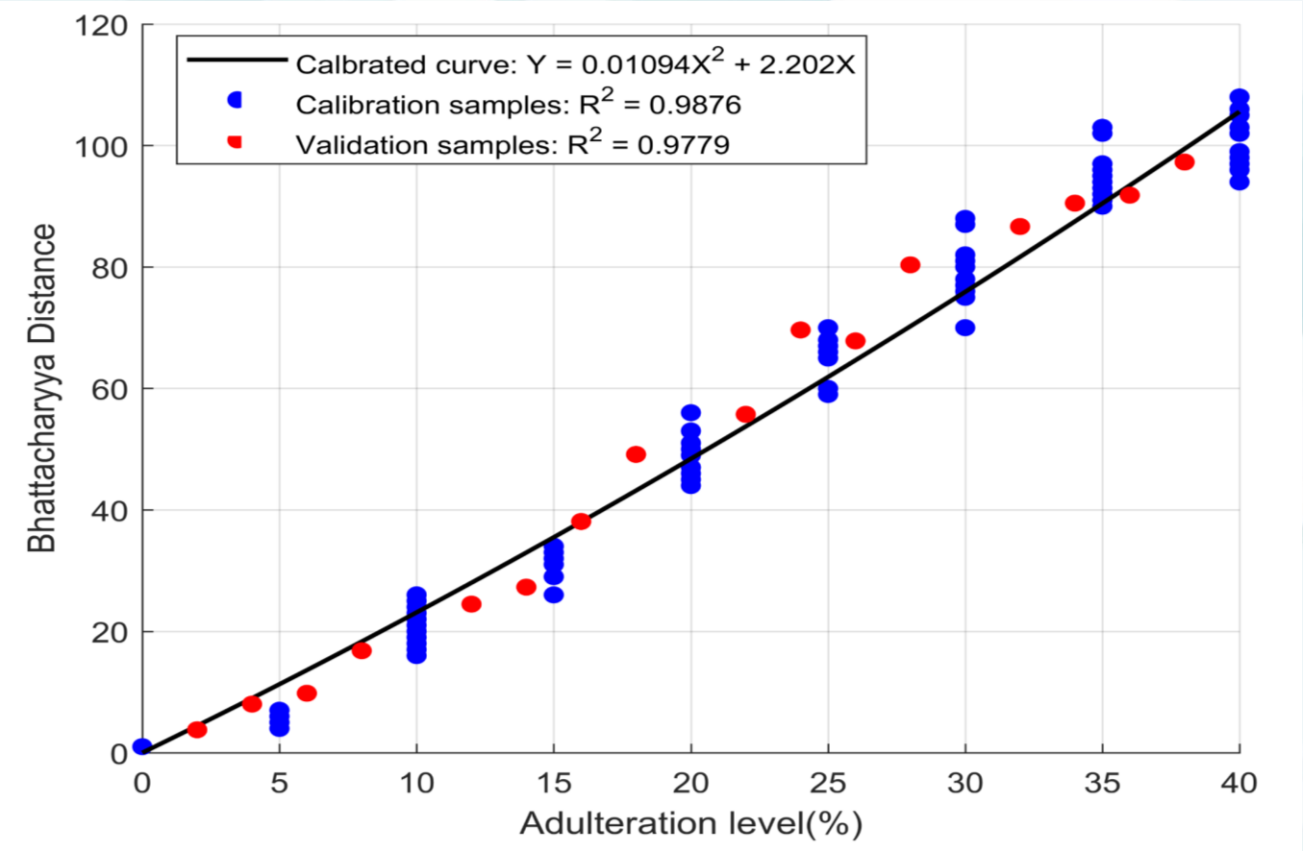
- Spectral intensity values of each adulteration level observed along the eigenvectors forms an approximate Gaussian distribution.

- The Bhattacharya distance was calculated with respect to the dimension reduced non adulterated (0%) sample.

$$B(f_{y0}, f_{yp}) = \frac{1}{8}(\mu_{y0} - \mu_{yp})^T \left(\frac{C_{y0} - C_{yp}}{2}\right)^{-1} (\mu_{y0} - \mu_{yp}) + \frac{1}{2} ln \left[\frac{det \frac{C_{y0} - C_{yp}}{2}}{\sqrt{det(C_{y0})\ det(C_{yp})}}\right]$$

where, $B(f_{y0}, f_{yp})$ is the Bhattacharyya distance between two multivariate Gaussian distribution functions f_{y0} and f_{yp}; μ_{y0}, μ_{yp} are the mean vectors; and C_{y0}, C_{yp} are the covariance matrices of classes Y_0 and Y_P, respectively.

Results and Discussion



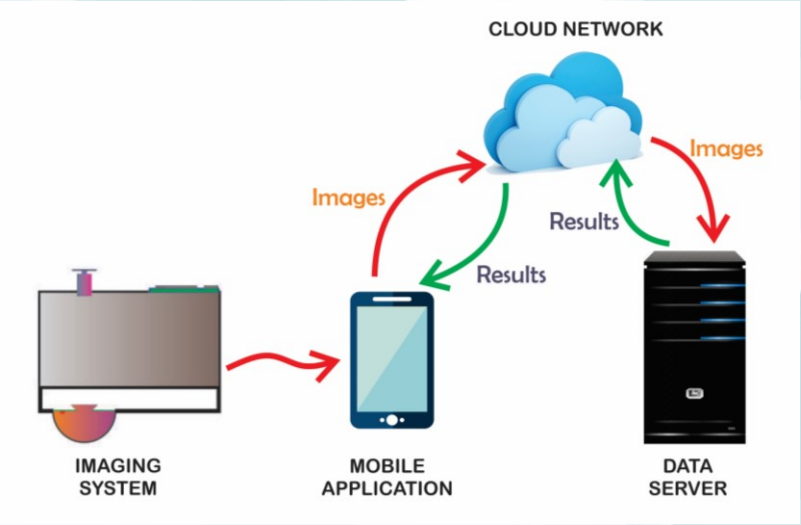
Bhattacharyya Distance vs Adulteration Level

- A functional relationship was observed, $Y = 0.01094X^2 + 2.202X$ with $R^2 = 0.9876$, where Y is the Bhattacharyya distance and X is the adulteration level as a percentage.

- Calibration model estimated adulteration levels with $R^2 = 0.9779$ for the validation samples.

Conclusion

- The developed MSI setup can be used to implement a system to detect the adulteration level of coconut oil samples with palm oil successfully.
- The multispectral imaging system and the detection process can be further developed to identify other adulterants as well as identify reused coconut oil samples.
- The proposed system can be deployed for in-situ oil quality estimation using an IoT based system with minimum human interaction and operational cost.



Proposed IoT system

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