Food Quality assessment using MSI and RGB Systems

Short introduction about the work

Food safety and quality are a major concern at present. A non-destructive and fast methods are an essential factor to maintain superior food qualities with the consumer demands to maintain the quality of the life. Therefore, assessment of food quality is a major concern in today's food industry to be aware of public health concerns and customer satisfaction. Hence food research extended to different areas such as turmeric, tea, meat, oil, and fish.

Turmeric: Turmeric (Curcuma longa) is a popular spice in traditional cuisine and now is globally available. As in the case of many widespread spices, turmeric powder is often adulterated using various additives and colorants.

Tea: Black tea is known to be one of the most popular beverages enjoyed by two-thirds of the world's population. With the increasing consumption of tea, quality control of tea becomes more and more important nowadays. Sugar adulteration is one such major issue faced by the tea industry.

Meat: The visual appearance, textural patterns, and colour of fresh meat are the main criteria used by the customers when choosing high-quality meat products.

Oil: Coconut oil is known for its wide range of uses. To get the best profits with this high demand, some people tend to adulterate coconut oil with palm oil and repeatedly used coconut oil leading to many health issues.

Fish: Fish is a staple food around the globe, and its quality is heavily dependent on freshness. Generally, visual inspection of a fish sample is the customary practice for quality assessment which is susceptible to variability in accuracy and efficiency while potentially compromising safety.

Through these researches, to assess turmeric, tea, and meat quality, reflectance-based nine multi-spectral images were used with wavelengths ranging from 405nm to 950nm.
To assess the oil quality, transmittance-based nine multi-spectral images were used.
An automated fish grading platform was developed using RGB captured from a smartphone camera.

Key results

1. For the turmeric, the variation of the Bhattacharyya distance with the adulteration level was modelled by a second-order polynomial function with an R^2 value of 0.9911 (B = 0.001007p 2+0.02077p). By using the calibrated model, the adulteration level of each validation sample was predicted with an accuracy of R^2 = 0.9816.
2. The trained model accuracy was checked for original MSI data, PCA data, and FDA data with tea samples. The highest accuracy was 77.567% was obtained from the original data. FFNN was trained for original nine-dimensional data. Testing accuracy

was obtained using the trained model. FFNN gave the maximum testing accuracy of 82.6% for the median filter size of 80x80 pixel^2.

3. For the analysis, 121 pixels from each of the multispectral images were selected randomly on the area of the meat piece. The nature of the multispectral image dataset, intensity values of all the pixels were plotted against the spectral bands for different storage times. Variation of microbial count (Colony Forming Units per gram - CFU/g) for storage time of 0 hrs, 4 hrs, 8 hrs, 24 hrs, 28 hrs, 48 hrs, 54 hrs, 72 hrs, 76 hrs, and 96 hrs.
4. Detection of adulteration of coconut oil using palm oil: The error between the actual adulteration level and the estimated adulteration level is very low with a mean squared error (MSE) of 0.0029. Reheating of Coconut oil: For 20 trials the model showed an average accuracy of 98.5%.
5. The network was trained from scratch and optimized for fast-response time and accuracy to classify fish according to quality grade. The model accuracy was validated by several performance measures (accuracy 0.98, precision 0.98, and recall 0.98).

Beneficiaries of the research (optional)

Sellers, consumers, industry partners, responsible government authorities, and persons who are engaged in research and development purposes.

Outcome and/or Output of the research

Publications: Journals and Conference Papers

1. Wele Gedara Chaminda Bandara, Gode Withanage Kasun Prabhath, Dissanayake Walawwe Sahan Chinthana Bandara Dissanayake, Vijitha Rohana Herath, Gunawath Mudiyanselage Roshan Indika Godaliyadda, Mervyn Parakrama Bandara Ekanayake, Dhanushika Demini, Terrence Madhujith, "**Validation of multispectral imaging for the detection of selected adulterants in turmeric samples**", Journal of Food Engineering, Volume 266, Article 109700, February 2020.

   ISSN 0260-8774,
   https://doi.org/10.1016/j.jfoodeng.2019.109700.

2. W.A.N.D.Wickramasinghe, E.M.S.L.B. Ekanayake, M.A.C.S. Wijedasa, A.D. Wijesinghe, T. Madhujith, M.P.B. Ekanayake, G.M.R.I. Godaliyadda and H.M.V.R. Herath, "**Validation of Multispectral Imaging for the Detection of Sugar Adulteration in Black Tea**" Accepted paper in IEEE International Conference on Information and Automation for Sustainability 2021(ICIAFS2021).
3. M.A.C.S.Wijedasa , A.D.Wijesinghe , E.M.S.L.B.Ekanayake , W.A.N.D.Wickramasinghe , H.M.H.K.Weerasooriya , D.Y.L.Ranasinghe , M.P.B.Ekanayake , H.M.V.R.Herath , G.M.R.I. Godaliyadda, T.Madhujith, "**Multispectral Imaging System to Estimate Sugar Adulteration Level of Black Tea**" Accepted paper in IEEE conference. (ICIIS 2021).

4. W.G.C. Bandara, G.W.K. Prabhath, D.W.S.C. B. Dissanayake, V.R. Herath, G.M.R.I. Godaliyadda, M.P. Ekanayake, S. Vithana, D. Demini, and T. Madhujith, "**A multispectral imaging system to assess meat quality**," in 2018 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Colombo, Sri Lanka, Dec. 2018, pp. 1–6.

5. H.M.H.K. Weerasooriya, H.M.S. Lakmal, D.Y.L. Ranasinghe, W.G.C. Bandara, H.M.V.R. Herath, G.M.R.I. Godaliyadda, M.P.B. Ekanayake, and T.Madujith, "**Transmittance Multispectral Imaging for Edible Oil Quality Assessment**," in Imaging and Applied Optics Congress, OSA Technical Digest (Optical Society of America, 2020), paper JW5C.8., Vancouver, Canada, June 2020.

6. J.M.V.D.B Jayasundara, R.M.L.S Ramanayake, H.M.N.B. Senarath, H.M.S Lakmal, G.M.R.I Godaliyadda, H.M.V.R. Herath, M.P.B. Ekanayake, " **Multispectral imaging for automated fish quality grading**" in proceedings of 15th IEEE International Conference on Industrial and Information Systems (ICIIS-2020), IIT Ropar, India, November 2020.

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