Non-contact assessment of the food quality using optical imaging methods

Kamran, Faisal; Andersen, Peter E.; Jørgensen, Thomas Martini

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Non-contact assessment of the food quality using optical imaging methods

Faisal Kamran
Advisors: Peter E. Andersen and Thomas Martini Jørgensen
DTU Fotonik – Department of Photonics Engineering,
Technical University of Denmark, Frederiksbergvej 399, 4000 Roskilde, Denmark

Motivation: for the project rise from many folds of reasons. The ability to measure the quality of the food products is a key parameter for the food industry for many reasons. Firstly they need to sort out the raw material needed for the products, secondly it is important to maintain a uniform high quality product with minimum waste and thirdly, the most important requirement is, development and production of food products with required chemical, physical, sensory or health related properties. Accurate and efficient testing is essential for ensuring the quality and safety of the food we eat, and optical imaging methods have potential to provide the solution.

Challenge: is to relate relevant food quality characteristics to optical properties of food material. Central hypothesis is that a relation can be established between the wavelength dependent laser light scattering (optical properties), resulting from size and density distribution of scatterers, and the chemical and physical properties such as concentration and rheology parameters.

Transport regime:
1: Single scatterer. 2: No or reduced absorption. 3: No multiple scattering effects. 4: \( \mu_s \) and \( g \) calculation

Transport reduced / diffused regime:
1: Multiple scattering effects. 2: Absorption. 3: \( \mu_s \) and \( \mu_s' = \mu_s(1-g) \) calculations. 4: Separate testing for \( \mu_s \) and \( g \).

Methods of investigation include:
1) Confocal Microscopy (rCSLM)
2) Optical Coherence Tomography (OCT)
3) Optical Coherence Microscopy (OCM)

Fig 1: (Top)The reflectance signal decay shown as a function of depth of scanning following R(z)=\( \rho \times \exp(-\mu z) \). (Bottom) Grid showing mapping of \( \rho \) and \( \mu_s \) in to \( \mu_s \) and \( g \) for excised murine skin samples.[1]

Fig 2: Oblique incidence Reflectometry showing center shift of diffuse reflectance profile and calculations of \( \mu_s \) and \( \mu_s' \).[3]

Fig 3: Wavelength dependent behavior of \( \mu_s' \) in accordance with Mie Theory of light scattering.[4]

Comments: Various techniques are available for measuring different optical properties. Depending upon the physical parameters of the sample, appropriate method can be selected to determine the relevant optical properties. Measuring \( \mu_s \) and \( g \) is more difficult but if the effect of physical changes in the sample can be investigated clearly by these properties, method that can operate in transport regime will be more appropriate for measurements. For example food or skin samples can be investigated for changes in \( \mu_s \) & \( g \) using rCSLM non-invasively. Measuring \( \mu_s \) or \( g \), however, using diffused reflectometry will require the sample to be investigated invasively using collimated transmission or integrating sphere method. Hence, the choice of method is dependent on sample under investigation and whether the process needs to be non-invasive.

References:

Take Home Message: This PhD thesis is part of the CiFQ project and will contribute with model based approach towards establishment of a link between optical properties and physical parameters, which will improve the new data driven design methodology, by refining the research, resulting in a series of in-line and in process active illumination and computer vision based measurement systems for food quality analysis.