Deep learning hyperspectral imaging: a rapid and reliable alternative to conventional techniques in the testing of food quality and safety

Naillah Gul[1], Khalid Muzaffar[2], Syed Zubair Ahmad Shah[1,*], Assif Assad[1], Hilal A Makroo[2], B.N.Dar[2,*]

[1]*Department of Computer Science and Engineering, Islamic University of Science and Technology, Kashmir, India-192122;*
[2]*Department of Food Technology, Islamic University of Science and Technology, Kashmir, India-192122*

***Correspondence Authors**: B.N. Dar, Department of Food Technology, Islamic University of Science and Technology, Kashmir, India-192122. Email: darnabi@gmail.com; Syed Zubair Ahmad Shah, Department of Computer Science and Engineering, Islamic University of Science and Technology, Kashmir, India-192122. Email: zubair.shah@islamicuniversity.edu.in

Received: 3 October 2023; Accepted: 31 December 2023; Published: 27 February 2024

REVIEW

Abstract

Food quality and safety are a great public concern; outbreaks of food-borne illnesses can lead to different health problems. Consequently, rapid and non-destructive artificial intelligence approaches are required for sensing the safety situation of foods. As a promising technology, deep learning for hyperspectral imaging (HSI) has the potential for rapid food safety and quality evaluation and control. Spectral signatures of food substances are sensitive to water content variation, the extent of hydrogen bonding, geographical origin, harvesting time and the variety of food under study. Deep learning models have shown great potential in addressing the challenge of sensitivity of spectral signatures of food substances. After discussing the basics of HSI, this review provides a detailed study of various deep-learning algorithms that have been put to use via HSI in the determination of sensory and physicochemical properties, adulteration and microbiological contamination of food products. The existing literature includes HSI for evaluating quality attributes and safety of different food categories like fruits, vegetables, cereals, milk and meat. This paper presents a practical framework for deep learning-based food quality assessment using hyperspectral imagery. We demonstrate its versatility across diverse food quality domains and provide a concise step-by-step guide for researchers. It has been predicted that deep learning for HSI can be considered a reliable alternative technique to conventional methods in realising rapid and accurate inspection, for testing food quality and safety.

Keywords: hyperspectral image analysis; spectroscopy; neural net; deep learning; image classification; food technology

Introduction

Hyperspectral imaging (HSI) is a non-destructive and non-polluting imaging technique that combines spectroscopic technique and imaging technique to be collectively called 'Imaging Spectroscopy' (Jia *et al.*, 2020). In a traditional colour image, each pixel is categorised into three colour channels (Red, Green and Blue). However, each pixel in HSI is categorised by many continuous bands; the number of bands depends on the spectral resolution of the hyperspectral camera. Traditional RGB cameras mimic the recognition capability of the human eye on the basis of the shape and colour of the imaged object. Sun is the ultimate source of all electromagnetic radiation reaching the earth. Out of the total radiation illuminating the scene, human eyes and traditional cameras are sensitive to the visible (VIS) bands of the electromagnetic spectrum. To visualise scenes outside the VIS band, the technique of spectroscopy has been used and has proved useful in eliminating the limitation of the human eye and

ISSN 1757-837X online, DOI 10.15586/qas.v16i1.1392