National Institute of Technology Rourkela

Defence Seminar

Seminar Title	: Development of AI-enabled Multifunctional Optical Devices for Process Monitoring Applications
Speaker	: Deblu Sahu (Rollno : 519bm1005)
Supervisor	: Kunal Pal
Venue	: Seminar Room, BM Department.
Date and Time	: 17 Oct 2025 (05:30 PM)
Abstract	: Ensuring food safety and quality is critical for achieving the Sustainable Development Goals (SDGs) set by the United Nations, particularly SDG-2 (zero hunger) and SDG-12 (responsible consumption and production). Although reliable, traditional food quality assessment methods are often laborious, time-consuming, and unsuitable for real-time monitoring. The present work aimed at developing AI-enabled multifunctional optical devices that are affordable, portable, and capable of real-time, noninvasive monitoring of food quality and spoilage. A reflectance-based multimode colorimeter was first developed for real-time monitoring of fat crystallization processes in oleogels, demonstrating a strong correlation with conventional differential scanning calorimetry data. By upgrading its functionality, a colorimeter-cum-spectrometer imaging system was developed by integrating an artificial neural network to predict reflectance spectra from RGB values. Based on microbial evaluation through Total Plate Count, the collected color and spectral data were categorized into two datasets: a two-class distribution (D1: Fresh and Spoiled) and a three-class distribution (D2: Fresh, Marginally Fresh, and Spoiled). Machine learning (ML) models, particularly Support Vector Machine (SVM), achieved an F1 score of 0.9584 (D1) and 0.9086 (D2). Further, a digital imaging-based deep learning (DL) framework was proposed to enhance early spoilage detection using a custom 2D-CNN model and transfer learning architectures (ResNet-50, VGG16, VGG19, InceptionV3). The custom 2D-CNN model exhibited the highest F1 score of 0.9156 (D1) and 0.9025 (D2). Furthermore, the device was upgraded to a filter-free snapshot hyperspectral (HS) imaging system. Herein, a novel HS image generation algorithm was proposed that helped to eliminate the expensive tunable filters and translational stage employed in conventional HS systems. Among all the DL models, 2D-CNN (F1 score: 0.9728) and InceptionV3 (F1 score: 0.9775) achieved the best testing performance for the D1 and D2 categories, respectively, under autoselected wavelengths. Finally, all the best-performing models were integrated into a unified graphical user interface (GUI). During real-time testing with HS images as input, the 2D-CNN model (D1) and the InceptionV3 model (D2) demonstrated excellent performance. Future work will be emphasized on validation across diverse foods, real-world deployment, and explainable AI integration.