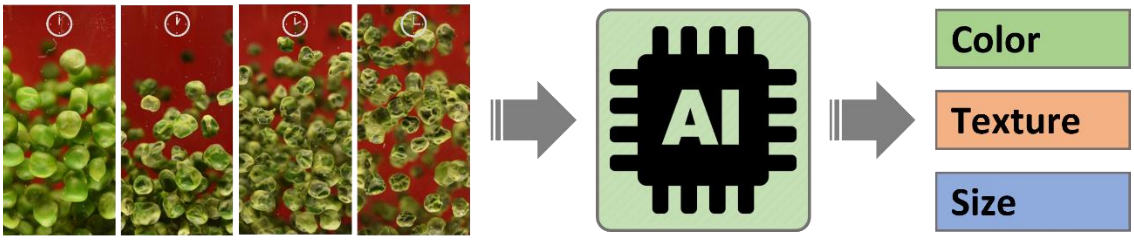

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Development of an Intelligent System to Monitor Visual Attributes of Food in Real-time during Fluidized Bed Drying

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Bioresource Engineering

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Abstract

To extend the shelf life of food, most food dryers are controlled by monitoring moisture content of the food. However, the food property that attracts consumers or dissuades them from purchasing dried products is not moisture content; it is the visual appearance. To significantly reduce food loss and waste, we need dryers that can also monitor visual appearance. Current fluidized bed dryers do not have this capability. Hence, this research was focused on developing an intelligent system to monitor the color, texture, and size of food, in real-time, during fluidized bed drying. To achieve this goal, an image acquisition system, a classical computer vision model, and two deep learning models (*"Unet-Xception"* and *"Xception")* were built. The models were trained to predict visual attributes from images of green peas captured during fluidized bed drying experiments, conducted at 50, 55, and 60^{o}C. The classical model and Unet-Xception predicted visual attributes after segmenting images of the peas, while Xception, a *"Single-Pass"* solution, by-passed the segmentation step. Segmentation by the classical model was adversely affected by overlapping peas within the image, unequal distance of the peas from the camera, and non-uniform changes in color and texture across the surface of individual peas. These challenges were overcome by Unet-Xception, resulting in an improved Mean Intersection-over-Union (MIoU) of 0.9464. Color was monitored by predicting CIE *L* a* b** values. Surface texture was measured by predicting contrast, correlation, entropy, and homogeneity Equivalent diameter, ferret diameter, filled area, perimeter, and roundness were used to monitor size. Unet-Xception and Xception significantly outperformed the classical model, while Unet-Xception produced the smoothest real-time trend. The coefficients of determination (R^2) achieved are reported in the following order: *classical model, Unet-Xception, Xception*. For the best predictors they were as follows: [0.7719, 0.8851, 0.8675] for a*, [0.8694, 0.8981, 0.9064] for *b*,* and [-0.8660, 0.8017, 0.7845] for homogeneity, along with [-1.0278, 0.7926, 0.8748] for equivalent diameter, [-1.6417, 0.8482, 0.8802] for ferret diameter, [-0.3663, 0.8391, 0.8901] for filled area, and [-1.5425, 0.825, 0.8421] for perimeter. Incorporating this novel, intelligent and adaptable system into current fluidized bed dryers could lead to consistent product quality and significant reduction in food waste and losses.

About the Candidate

Anthony Iheonye obtained a bachelor's degree in Agricultural Engineering and a master's degree in Farm Power and Machinery Engineering from the Federal University of Technology Owerri, Nigeria. He worked for many years in the agricultural industry developing improved and novel post-harvest systems. He also spent years teaching in the Department of Bioresource Engineering, at his Alma Mater. He commenced his doctoral studies in the Department of Bioresource Engineering, McGill University, under the supervision of Professor Vijaya Raghavan. Anthony's research is focused on developing intelligent food dryers that consistently produce dry food that are visually appealing and have long shelf life.