Project Report

IMAGE ANALYSIS OF PLANT BASED MEAT PRODUCTS

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1 Introduction

In our study on food texture and color assessment for plant-based meat products, we recognized that traditional methods for texture analysis using specialized instruments can be prohibitively expensive and time-consuming for routine quality assurance and for distinguishing new products. Additionally, food color and texture assessment involves complex processes such as colorimetry, spectrometry, microscopy, and image processing.

(a) Normal Image (b) 3D Scanned Image (c) SEM Image

Figure 1: Different Types of Image of Plant Based Meat Products

To address these challenges, we developed a methodology that combines experimental techniques for developing food textures and colors with image analysis techniques. Specifically, we utilized computer vision techniques to assess the texture and color properties of plant-based meat products.

Our approach demonstrates the usefulness of computer vision in assessing plant-based meat products and provides an efficient and cost-effective alternative to traditional methods for texture and color analysis.

By utilizing image analysis techniques, we were able to accurately and efficiently assess color properties of plant-based meat products, which could have important implications for the food industry in terms of quality control and product development.

2 Dataset Collection

The dataset comprises a collection of images representing different classes of plant-based meat product patties. Two different sources were used to obtain these patties: **1. the IITGn Food Lab product** (referred to as the "**Inhouse product**") and **2. the commercial Tata product**.

(a) Commercial Air Fried (b) Degraded Product (c) IITGn Food Lab. Unbaked

Figure 2: Examples of various types of patties used in the dataset collection.

In order to explore the effect of degradation on patty quality and color, the IITGn Food lab products were stored for 15 days in normal cold conditions before being cooked, resulting in the creation of an additional patty class.

Two distinct cooking methods,**1. Air frying** and **2. Deep Frying**, were employed to prepare the patties. The patties were cooked for a standardized duration, with an additional duration used to create overcooked patties as per the patty type and cooking method.

(a) (b) (c) (d)

Figure 3: Commercial Air Fried Patty in Different Backgrounds.

In total, **14 different classes** were generated based on the different types of patties and cooking methods. To improve the quality of the classification model, **four patties** were used **in each class**, resulting in a larger number of data points. The development and cooking of the patties were carried out by Preeti Dhiman and IITGn Food Lab.

The dataset comprises a **total of 10,900 images**, with approximately **800 images captured in each class**. The images were captured using a mobile phone camera, with different lighting conditions and settings. Additionally, various backgrounds were utilized to minimize background noise and bias. We can observe the differences in background

Commercial Tata Product	**IITGn Food Lab Product**	**IITGn Food Lab Product. Degraded 15 Days and Starch Coated**

• Unbaked
• Deep Fried
  – Normal Cooked
  – Over Cooked, 4 min extra
• Air Fried
  – Normal Cooked
  – Over Cooked, 10 min extra
	• Unbaked
	• Deep Fried
	  – Normal Cooked
	  – Over Cooked, 2 min extra
	• Air Fried
	  – Normal Cooked
	  – Over Cooked, 20 min extra
		• Deep Fried
		  – Normal Cooked
		  – Over Cooked, 2 min extra
		• Air Fried
		  – Normal Cooked
		  – Over Cooked, 12 min extra

Table 1: Dataset Class Description

appearance between commercially produced air-fried and normal cooked products in Figure 3.

We originally captured a large number of high-resolution images, which had to be resized to facilitate their use in training the model. The dataset is available for access at this link.

3 Methodology

Our approach relied on images of different food products in the category of plant based meat analogous. Our project was focused on classifying images of plant-based meat analogous products using deep learning techniques. To achieve this, we followed a three-stage approach, which involved pre-processing the images, selecting an appropriate model, and training and fine-tuning the model.

In the first stage, we used the Lanczos re-sampling technique to resize the images, which helped to standardize the size and resolution of the images. This ensured that the images were suitable for analysis and could be fed into our model without any issues.

In the second stage, we selected the ResNet50 model, which is a deep neural network architecture that has been widely used in image classification tasks. We adopted a transfer learning technique, **where we used the pre-trained weights of the ResNet50 model on the Food101 dataset**, a large dataset containing images of food items from various categories. By using this pre-trained model as a starting point, we were able to leverage

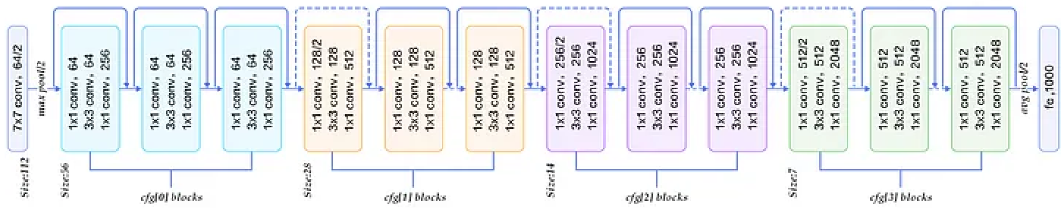

Figure 4: Architecture of the Resnet50 Model. Image Source

the knowledge that the model had learned from the Food101 dataset and apply it to our own dataset of plant-based meat analogous images.

In the third stage, **we fine-tuned the ResNet50 model with our own sampled images**, which helped to enhance the model's ability to correctly classify our images. We split our dataset into 70% for training, 15% for testing, and 15% for validation sets. This ensured that our model was trained on a diverse set of images and was not biased towards any particular set of images.

During the training process, we utilized the Cross Entropy loss function with Adam Optimizer, which is a widely used optimization algorithm that helps to improve the accuracy of the model during training. By using this loss function and optimizer, we were able to train our model to accurately classify the images of plant-based meat analogous products.

In summary, our approach involved using deep learning techniques to classify images of plant-based meat analogous products. By leveraging pre-trained models and fine-tuning them with our own data, we were able to create a model that accurately classified our images. The code we used for training our model can be found here.

(a) Train and Validation Accuracy

(b) Train and Validation Loss

Figure 5: Train and Validation Plots

4 Results

4.1 Model outcomes

Our approach for classifying images of plant-based meat analogous products achieved a high level of accuracy, with a train accuracy of 97.6%, validation accuracy of 98.56%, and test accuracy of 94.62%. These metrics indicate that our approach is effective in accurately classifying images of plant-based meat analogous products. The plots for training/validation accuracy and loss can be seen in Figure 5

4.2 Web Interface for Food Classification

Figure 6 illustrates the graphical user interface that we have designed for our application. It provides a visually appealing and intuitive way for users to interact with the food classification model. The interface offers users the ability to upload an image for classification, and view the predicted class. Our interface could be used for preliminary assessment of burger patties of unknown composition.

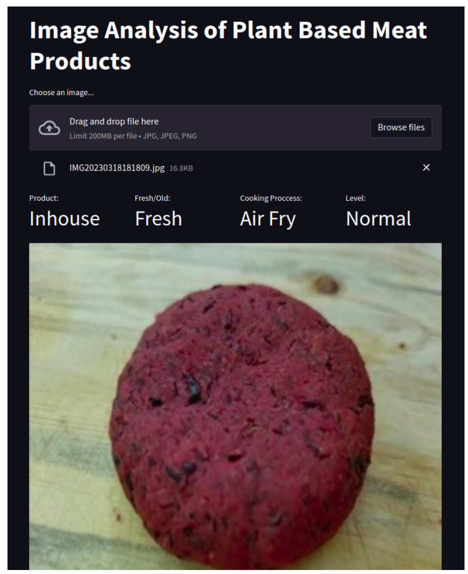

Figure 6: Web Interface Screenshot.

We have developed a web interface using the StreamLit Python module. The interface has been deployed on the StreamLit Cloud Community and can be accessed at the this link. The source code and trained model can be found on our Github repository.

The application can also be executed locally by installing the required dependencies specified in the `requirements.txt` file and running the following command in a local environment:

```
streamlit run app.py
```

Deploying the application on the StreamLit Cloud from the GitHub repository was a straightforward process. However, if the application remains inactive for five consecutive days, the aforementioned link will no longer be functional. In such a scenario, the application can be reactivated by following the instructions provided on Deploy app demo by StreamLit Community.

5 Future Work

- Compare plant-based meat products with **real meat analogues** and identify the disparities between the two.
- To enhance the quality of the products developed in IITGn Food Lab, gather **additional data from SEM images** and employ it for texture analysis.

References

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