NIRMA UNIVERSITY
INSTITUTE OF TECHNOLOGY
NAAC ACCREDITED 'A' GRADE

IMAGE PROCESSING PROJECT

Fried Potato Wafer Batch Quality Inspection using Image Processing

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Abstract

Acrylamide is a chemical that forms in carbohydrate-rich foods, like potato wafers, when subjected to high-temperature cooking processes such as frying and baking. This compound has been linked to potential health risks, including neurotoxicity and cancer, raising significant food safety concerns. Traditional methods to detect acrylamide levels rely on chemical analyses, which are often complex, time-consuming, and costly. This project introduces an innovative, non-invasive approach using image processing to detect acrylamide in potato wafers. The method offers a rapid, efficient, and affordable solution for food quality assessment, aiming to enhance consumer health protection.

Introduction

- Acrylamide, a potentially harmful chemical linked to neurotoxicity and cancer, forms in certain carbohydrate-rich foods, such as potato wafers, during high-temperature cooking processes like frying and baking. Due to health concerns, monitoring acrylamide levels in food products has become essential to ensure consumer safety and meet regulatory standards. Traditional detection methods for acrylamide are complex, costly, and time-consuming, requiring specialized chemical analysis equipment.

- This project proposes an innovative, image processing-based approach to detect acrylamide levels in potato wafers, offering a rapid, non-invasive, and cost-effective solution. Image processing techniques have shown promise in food quality assessments, as they enable quick, visual analysis of food products. By examining color and textural variations in wafer images, this method can identify markers associated with high or low acrylamide levels without complex lab procedures.

- The project will involve developing a machine learning model or a threshold-based color analysis system trained on a dataset of potato wafer images. By detecting specific visual markers correlated with acrylamide formation, the model aims to provide accurate predictions validated against known acrylamide concentrations. This tool is intended to be practical and user-friendly, assisting food manufacturers and regulatory agencies in quality control, thus promoting safer food practices. This approach could help mitigate the risks associated with acrylamide, offering consumers safer, healthier food options.

Concepts used in this project :

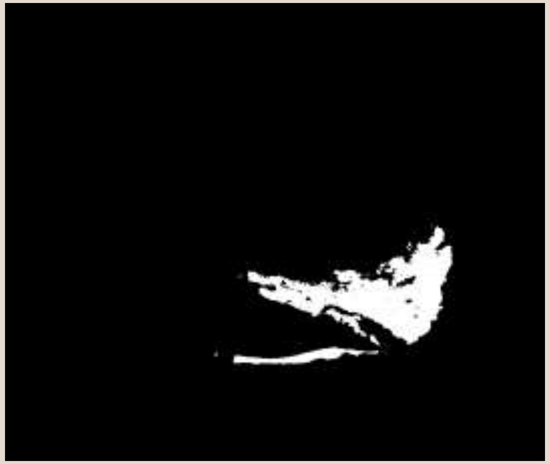
1. **GRAYSCALE CONVERSION** - SIMPLIFIES ANALYSIS BY REDUCING COLOR TO INTENSITY.
2. **GAUSSIAN SMOOTHING** - REDUCES NOISE WITH A GAUSSIAN FILTER.
3. **THRESHOLDING** - CONVERTS GRAYSCALE TO BINARY TO ISOLATE DARK SPOTS.
4. **BINARY IMAGE INVERSION** - INVERTS BINARY IMAGE FOR EASIER DEFECT COUNTING.
5. **PIXEL COUNTING** - COUNTS WHITE PIXELS TO CLASSIFY AS 'GOOD' OR 'BAD'.
6. **HISTOGRAM CALCULATION** - ANALYZES INTENSITY DISTRIBUTION IN GRAYSCALE AND BINARY IMAGES.
7. **HISTOGRAM DIFFERENCE** - QUANTIFIES DIFFERENCES TO HIGHLIGHT DEFECTS.
8. **VISUALIZATION** - DISPLAYS HISTOGRAMS AND A PIE CHART FOR CLASSIFICATION RESULTS.

Procedure

- This wafer classification algorithm categorizes potato wafers as "good" or "bad" based on detected defects, providing an efficient solution for quality control through structured image processing techniques. Starting with 100 wafer samples, it initializes a result matrix to store classifications (0 for "bad" and 1 for "good") and sets a defect threshold: any wafer with 700 or more detected "bad" spots is labeled defective.
- For each wafer, the algorithm constructs the file path, retrieves the image, and processes it. It converts the image to grayscale, simplifying data by focusing on intensity alone, and applies a Gaussian filter to reduce noise, improving accuracy in defect detection. A thresholding step then binarizes the image, turning high-intensity pixels white and low-intensity pixels black, to highlight defect regions. The image is inverted to ensure defect spots appear as white pixels, which are then counted. If the count meets or exceeds the threshold, the wafer is classified as “bad"; otherwise, it’s deemed "good.".

- After processing, the algorithm calculates the percentage of good and bad wafers in the batch and generates a pie chart, providing a quick visual overview of quality distribution. This automated approach combines grayscale conversion, filtering, thresholding, and pixel counting, offering an effective, non-subjective method to detect defects, assess wafer quality, and support consistent quality control in semiconductor manufacturing.

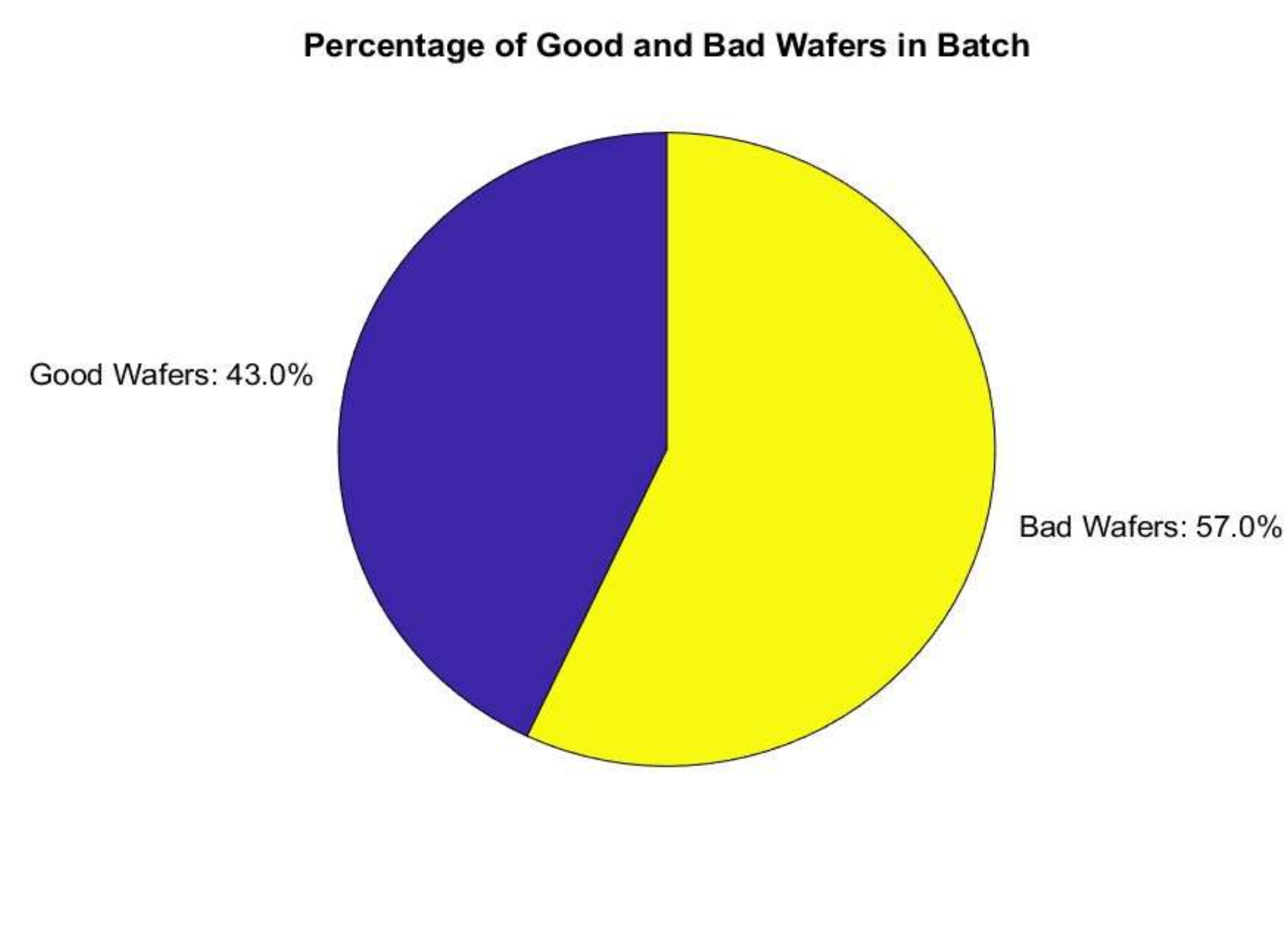
Results



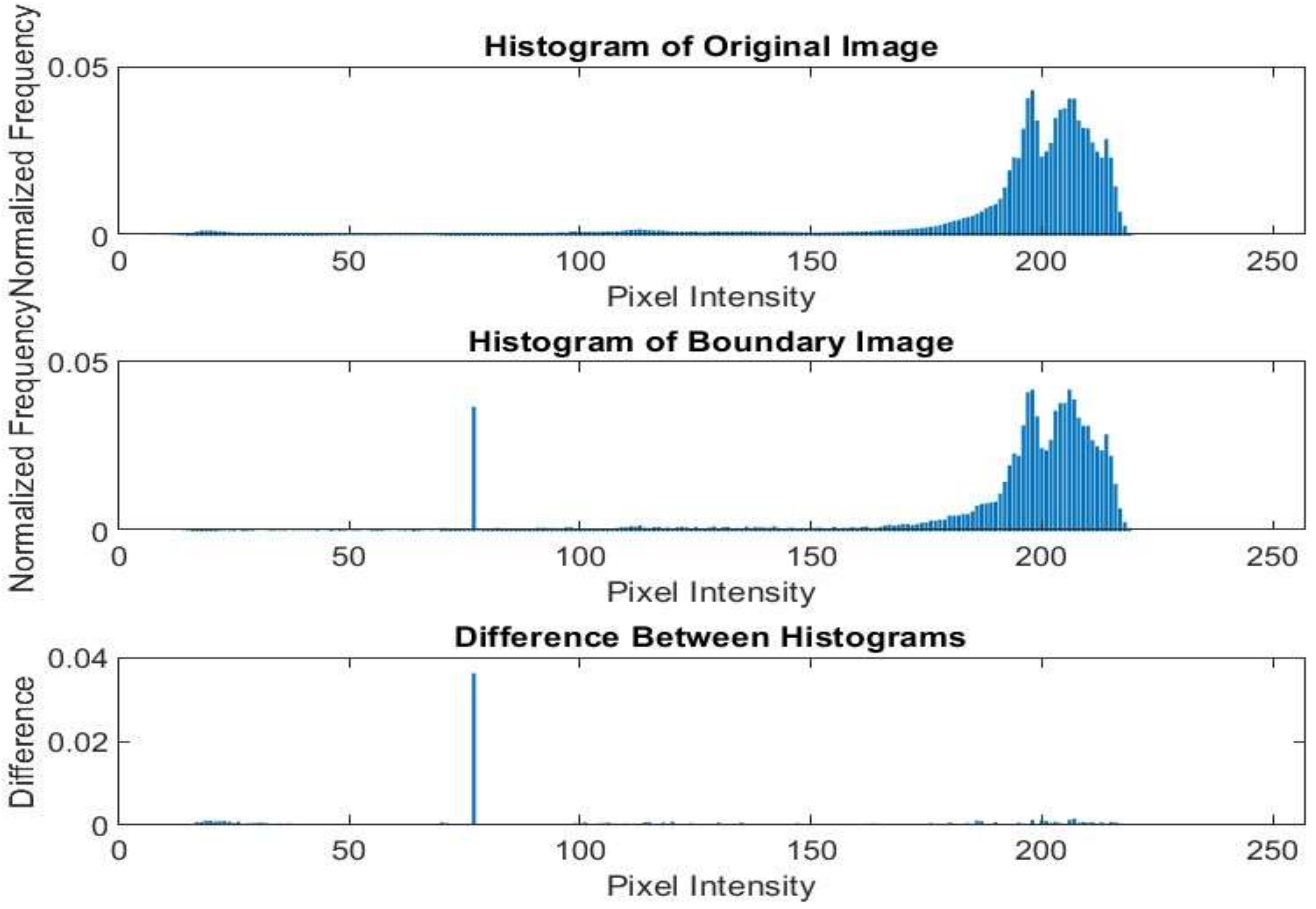
As part of the quality inspection of fired potato wafers, three processed images were generated to demonstrate the defect detection results:

1. **Original image**
2. **Threshold image :** A binarized image emphasizing the presence of dark spots, which potentially indicate defects area such as overcook or acrylamide-prone areas.
3. **Boundary image:** The final processed image with detected boundaries overlaid in red on the original image.

Matlab Simulation Results:



The presents the results of processing 100 potato chip images through the algorithm. The dataset contained an equal number of good and bad chips. While the ideal outcome would be a 50-50 split in the pie chart, the limitations of our image processing approach, which does not involve machine learning, resulted in a slightly less precise categorization.


Histogram of Original Image
Normalized Frequency
0.05
0
0
50
100
150
200
250
Pixel Intensity
Histogram of Boundary Image
Normalized Frequency
0.05
0
0
50
100
150
200
250
Pixel Intensity
Difference Between Histograms
Difference
0.04
0.02
0
0
50
100
150
200
250
Pixel Intensity

- In previous slide shown Histogram, comparing the pixel intensity distributions of the original grayscale image and the binary (thresholded) image. The gray scale histogram (`hist original`) shows overall brightness and contrast, while the binary histogram (`hist boundary`) isolates potential defect areas as white pixels. By computing the difference (`hist diff`) between these histograms, the code evaluates the effectiveness of the thresholding in identifying bad spots, helping to fine-tune defect detection and improve wafer classification accuracy.

References :

- 1. DATASET : HTTPS://WWW.KAGGLE.COM/DATASETS/CONCAPTION/PEPSICO-LAB-POTATO-QUALITY-CONTROL

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- 4. M. SONKA, V. HLAVAC, AND R. BOYLE, *IMAGE PROCESSING, ANALYSIS, AND MACHINE VISION*, 2007.

Thank You