CMSC 190 SPECIAL PROBLEM

Peanut Mold Detection Via Marker-based Watershed Segmentation and An Artificial Neural Network With Feedforward Backpropagation

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Peanuts

Arachis Hypogaea

MAJOR FIELD CROP

47 million metric tons produced
worldwide in 2020

AS FOOD

inexpensive and **high protein** energy food

healthy alternative feed for livestock

HEALTH RISKS

prone to mold contamination
which may carry carcinogenic substance
called **Aflatoxin**

Problem Statement

In **humid environments** with warm, tropical temperatures, **mold-infected peanuts** are more likely to be contaminated with **aflatoxins**. Aflatoxins have been found to be **highly carcinogenic**, posing a risk to humans and livestock. Before reaching manufacturers and consumers of peanut products, **peanuts should be inspected and segregated effectively**.

This study seeks to develop a **computer vision system** as an approach to **peanut mold detection**.

Objectives

- To build an artificial neural network model for detecting early onset of peanut mold contamination

- Create a computer vision system capable of detecting mold infection in peanuts with cost-efficient and readily-available tools such as open-source software, consumer-grade smartphone camera, and LED lighting.

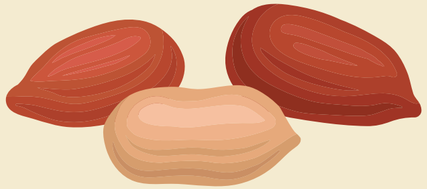
Significance of the Study

At present, peanut quality is mostly graded via **manual** inspection and **biochemical** testing.

Manual inspection of peanut seeds is **laborious** and biochemical inspection requires **expensive equipment** and a precise process that can only be performed by experts.

To keep up with the demand for peanut production, processing, and export, it is imperative to come up with an **effective and low-cost solution to detect peanut mold contamination.**

Scope and Limitations



Involves peanut seeds only
(removed from shells)

Exposed to mold infection within at least
7 days

Supplied from local market in Tayabas, Quezon, imported from India (Runner and Java variety)

Related Literatures

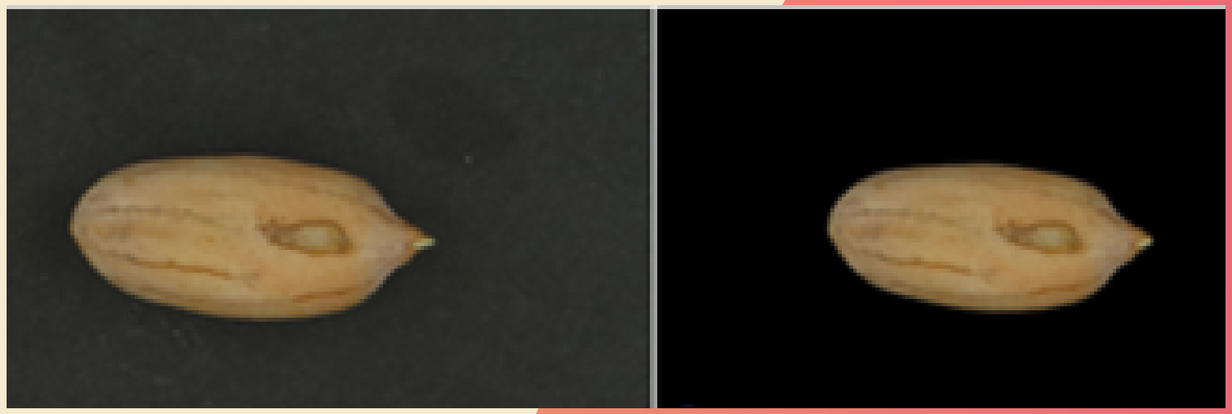
Related Studies

Suyantohadi and Masitoh (2016)

created a computer vision detecting peanut molds via **K-Means Clustering** using **Average RGB** values on peanut kernel images inspected under **UV light**

Ziyaee, et al. (2021)

compared different machine learning techniques in peanut mold detection and reported an **accuracy of 99%** using **ANN,** inspected with **LED** and **UV lighting**.



Methodology

Activity Diagram

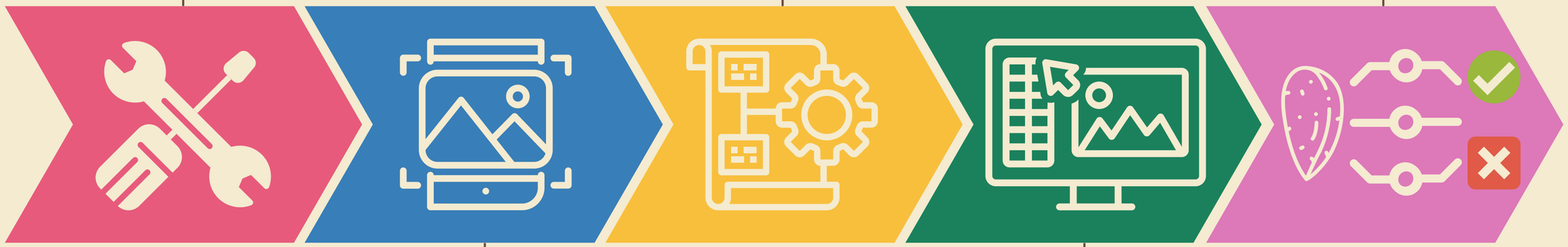
Imaging Setup

Image Acquisition

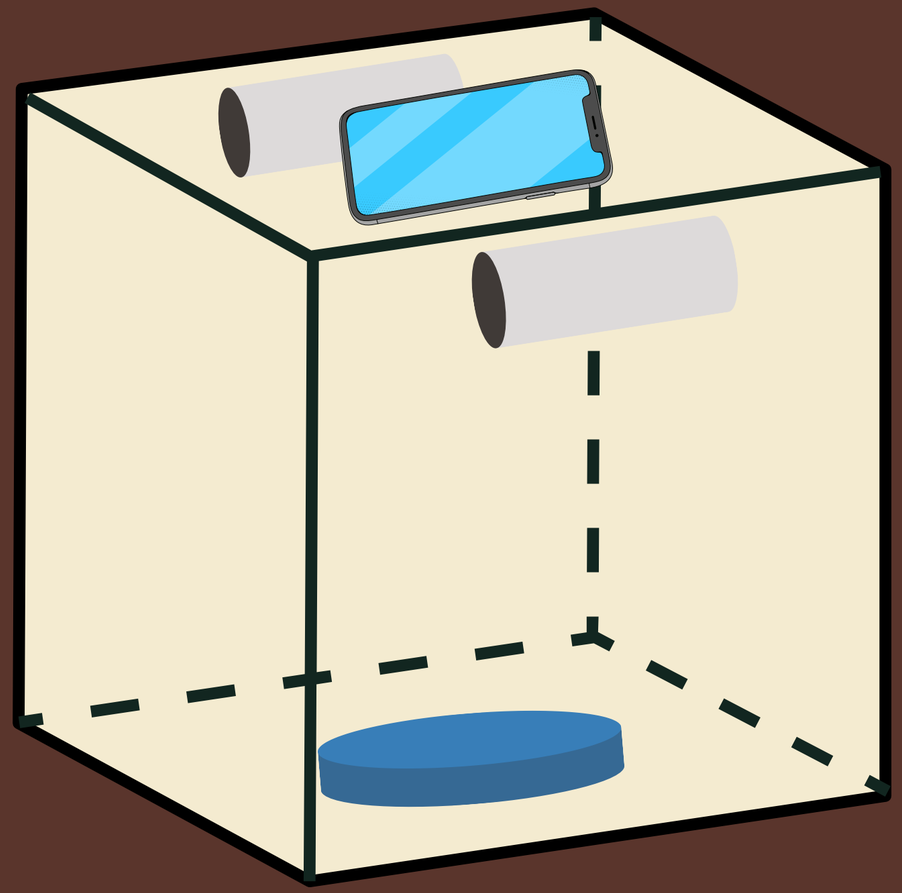
Image Segmentation

Feature Extraction and Selection

Peanut Mold Detection

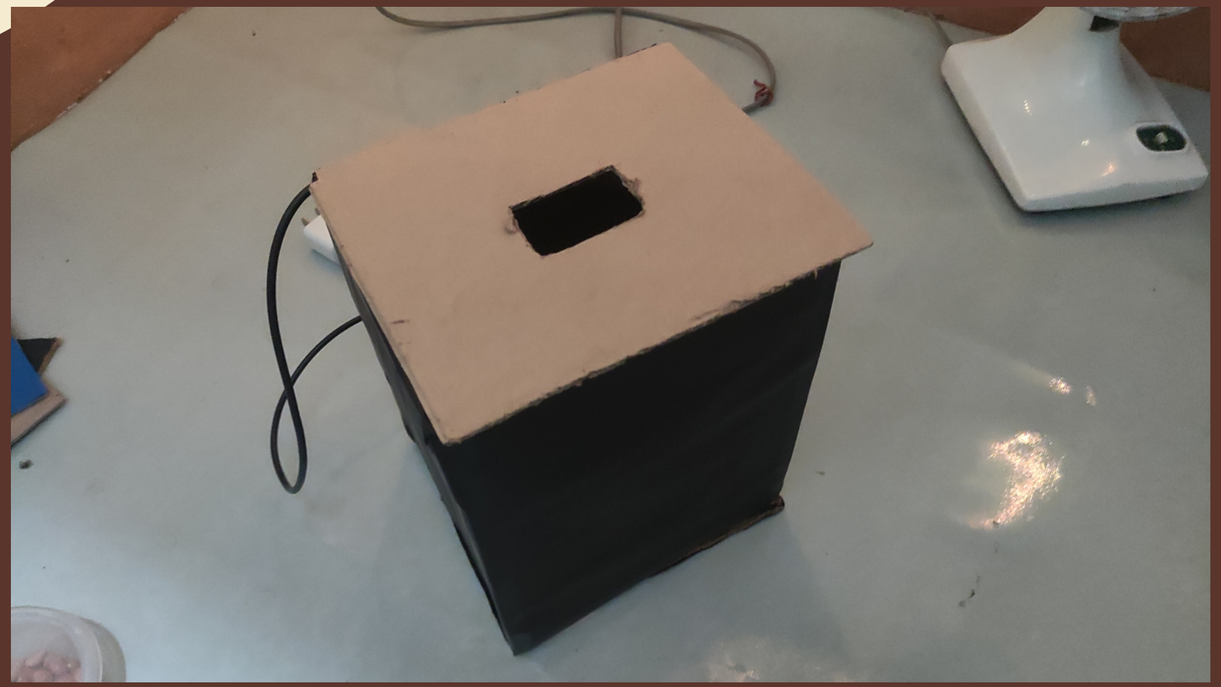


Imaging Setup Plan



- Container box
- LED lights
- Smartphone camera
- Object Container

Actual Imaging Setup



Actual Imaging Setup

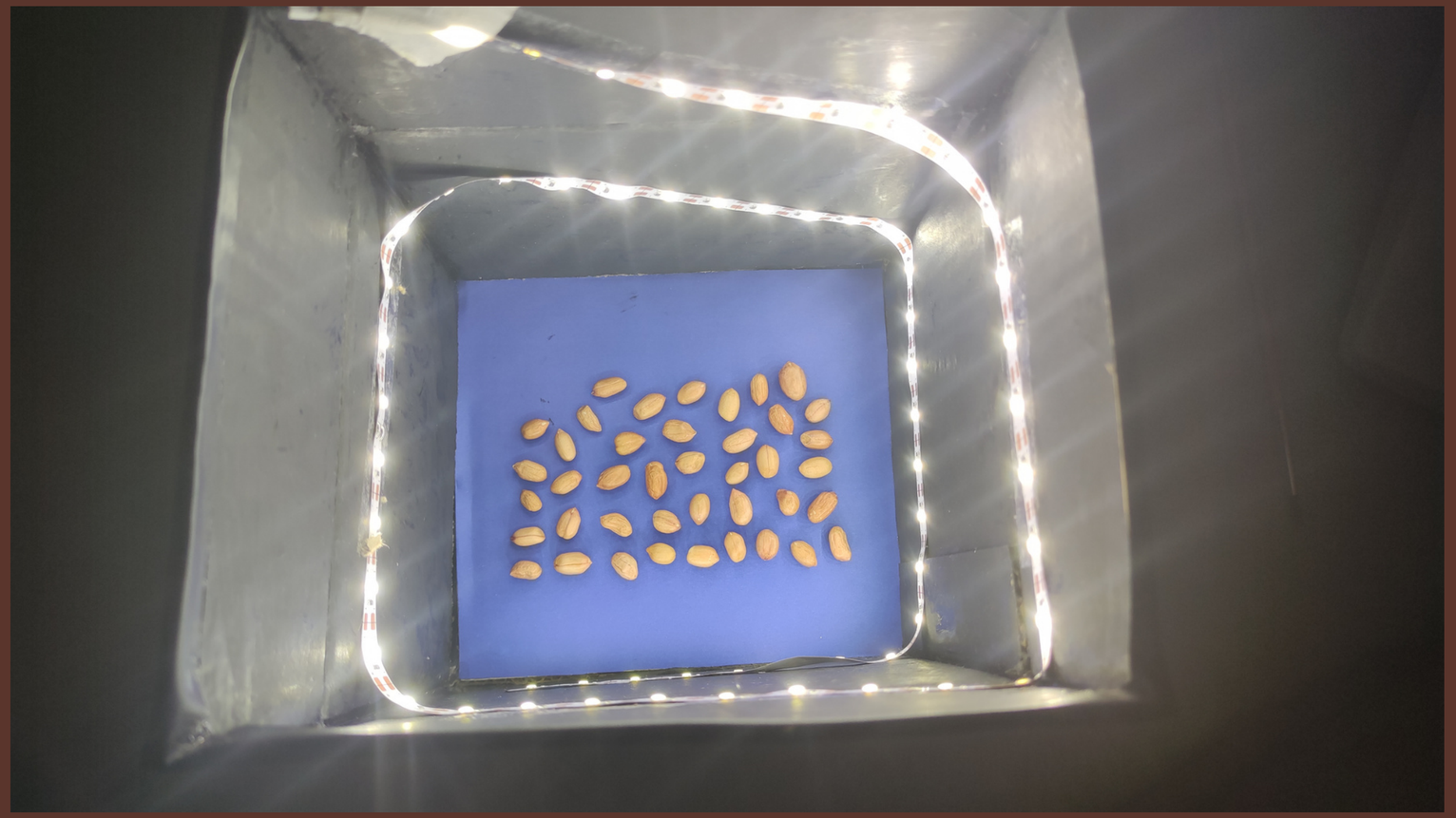
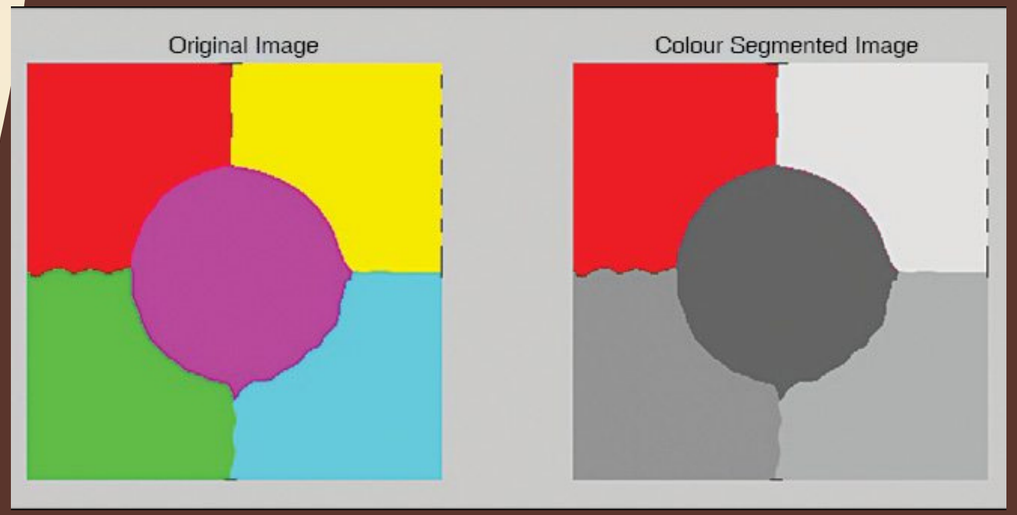


Image Acquisition

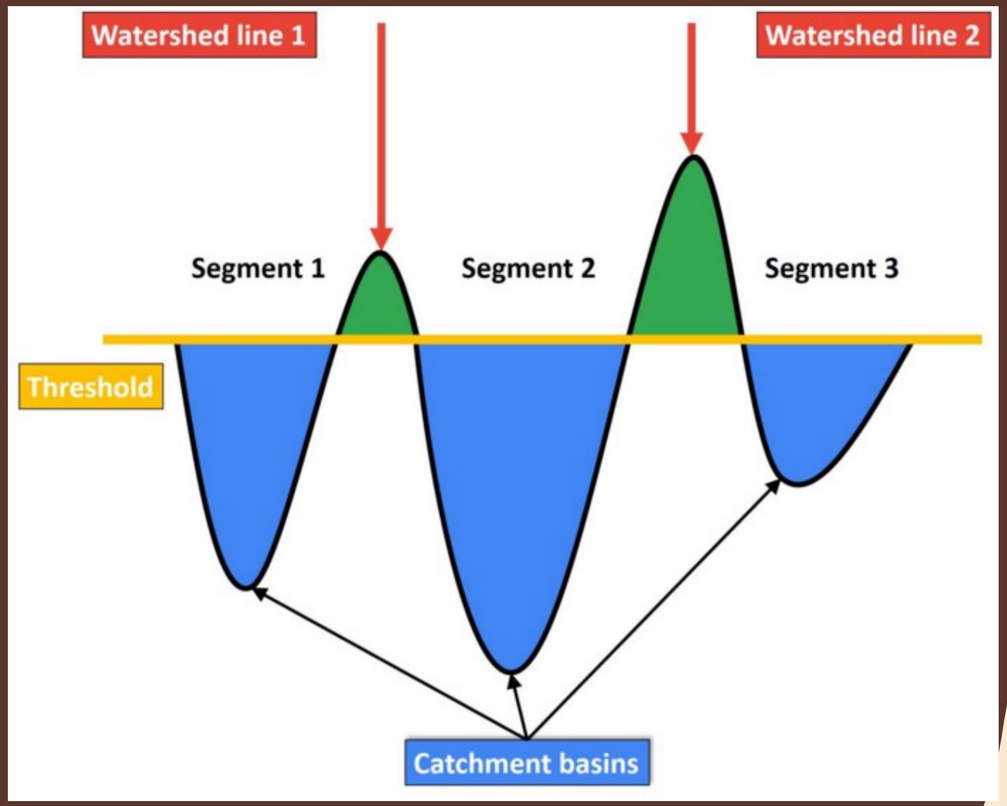
Non-contaminated

Mold-contaminated

Image Segmentation



Color Segmenetation



Marker-based Watershed Segmenetation

Image Segmentation

Non-Contaminated

Color Segmentation

Marker-based Watershed Segmentation

Image Segmentation

Mold-Contaminated

Color Segmentation

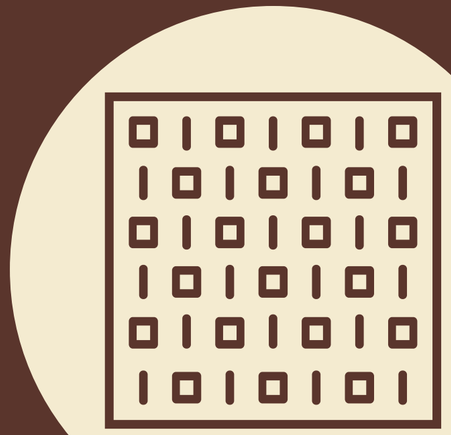
Marker-based Watershed Segmentation

Feature Extraction

Color Spaces:
RGB, HSV,
Grayscale

1) Red		
2) Green		
3) Blue		
4) Hue	$60(G-B)/(V-min(R,G,B))$	if $V=R$
	$120+60(B-R)/(V-min(R,G,B))$	if $V=G$
	$240+60(B-R)/(V-min(R,G,B))$	if $V=B$
	0	if $R=G=B$
5) Saturation	$\frac{V-min(R,G,B)}{V}$	if $V \neq 0$
	0	otherwise
6) Value	*max*(R,G,B)	

Feature Extraction

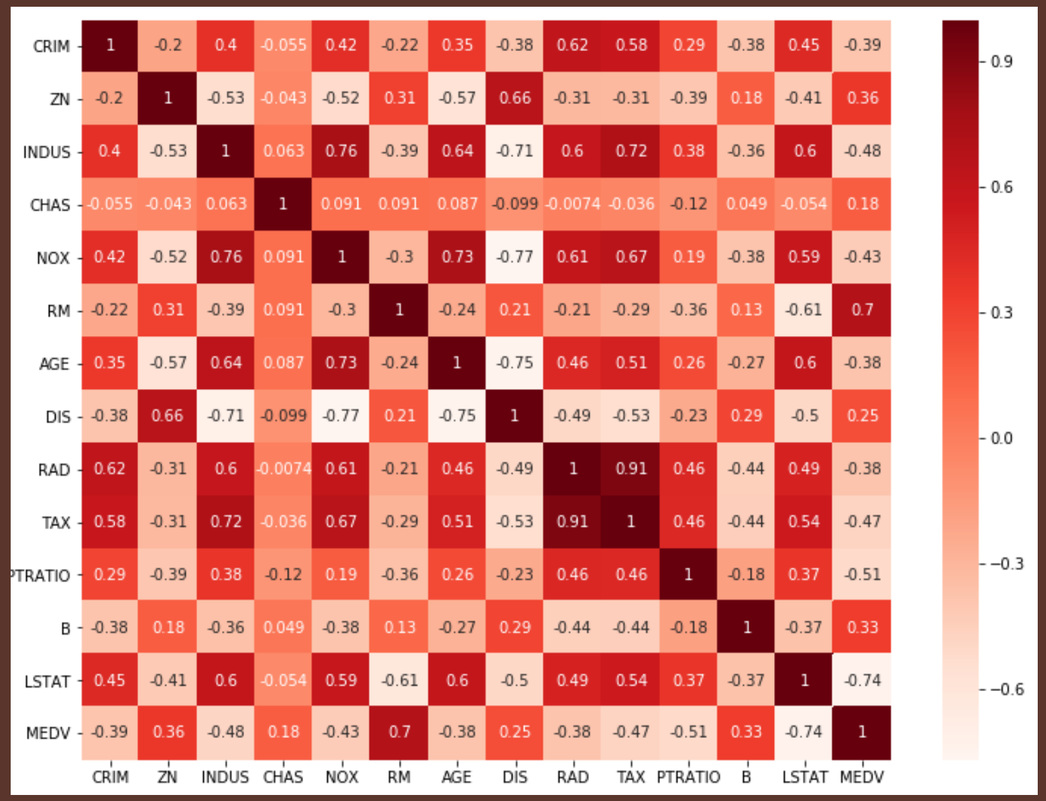


Texture Features: Gray Level Co-occurrence Matrix

1) Contrast	$\sum_{i,j=0}^{levels-1} Pij(i-j)^2$
2) Dissimilarity	$\sum_{i,j=0}^{levels-1} Pij\|i-j\|$
3) Homogeneity	$\sum_{i,j=0}^{levels-1} \frac{Pij}{i+(i-j)^2}$
4) Angular Second Moment	$\sum_{i,j=0}^{levels-1} P_{ij}^2$
5) Energy	$\sqrt{\sum_{i,j=0}^{levels-1} P_{ij}^2}$
6) Correlation	$\sum_{i,j=0}^{levels-1} \left[\frac{(i-\mu i)(j-\mu j)}{\sqrt{(\sigma_i^2)(\sigma_j^2)}}\right]$

Feature Selection

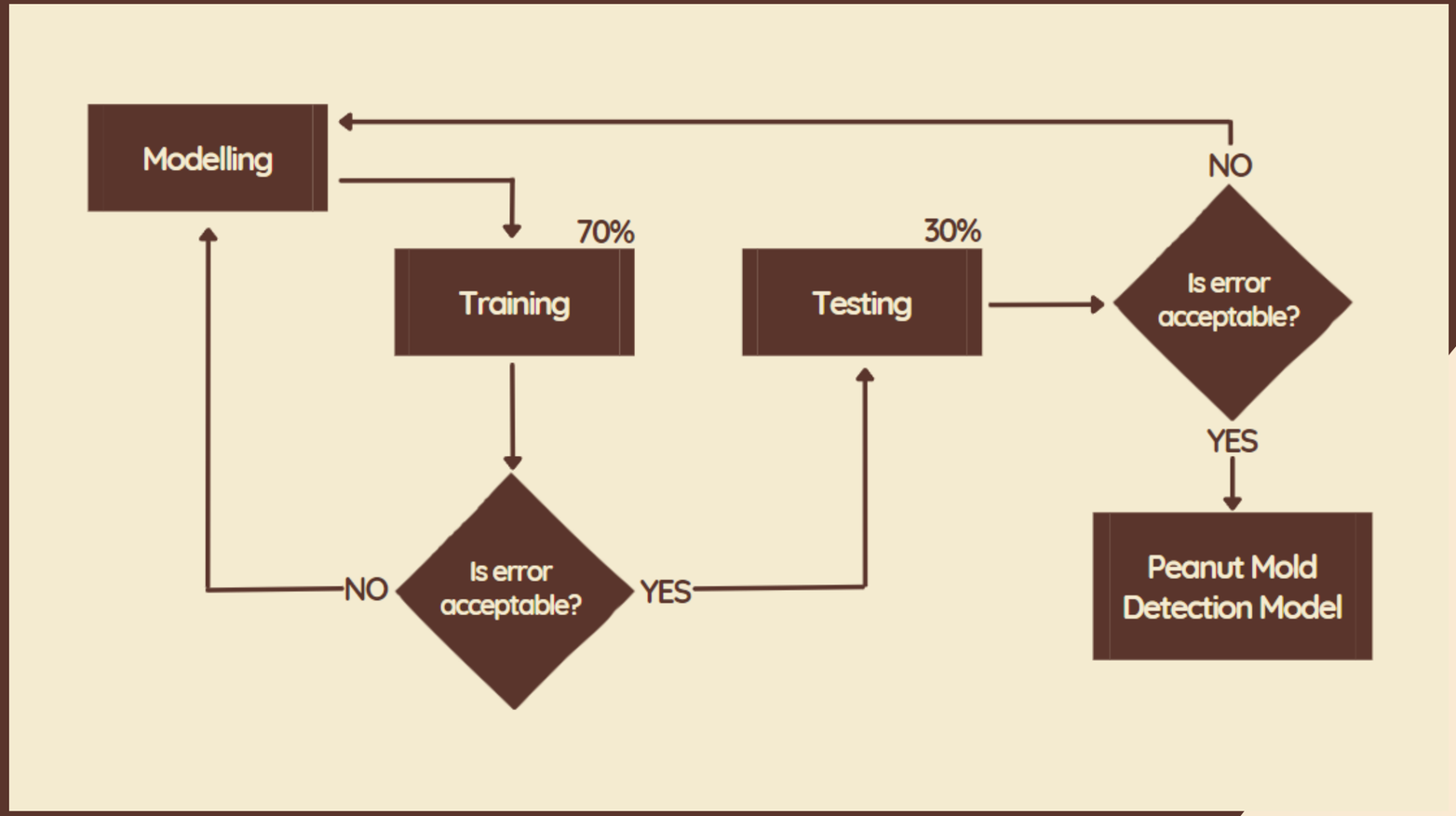
Correlation-based Feature Selection



(Sample Only)

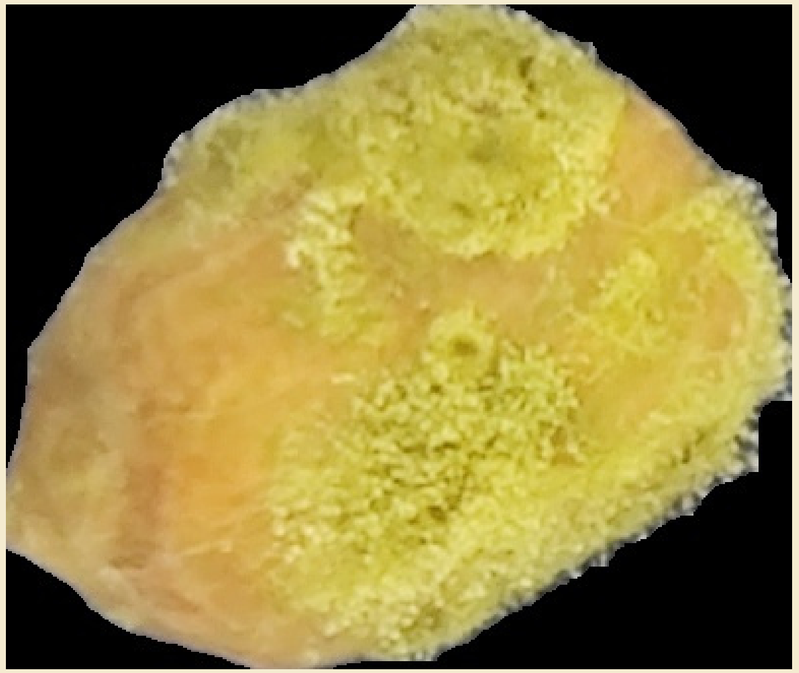
Peanut Mold Detection

Feedforward
Backpropagation
Neural Network



Results and Discussion

Molds Present in the Samples



Aspergillus parasiticus / flavus

Aspergillus glaucus

Aspergillus niger

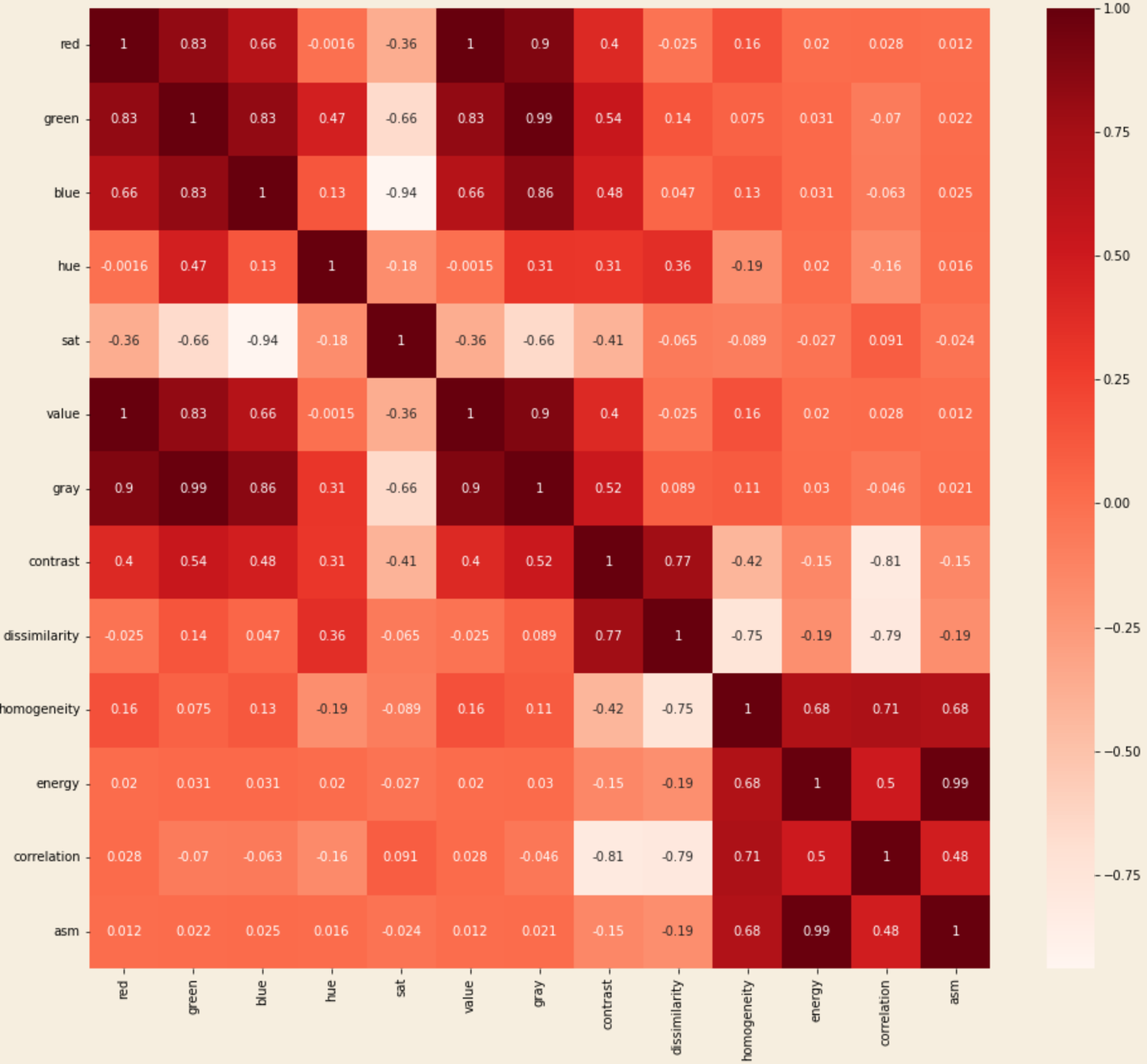
Molds Present in the Samples

Alternaria

Curvularia

Fusarium

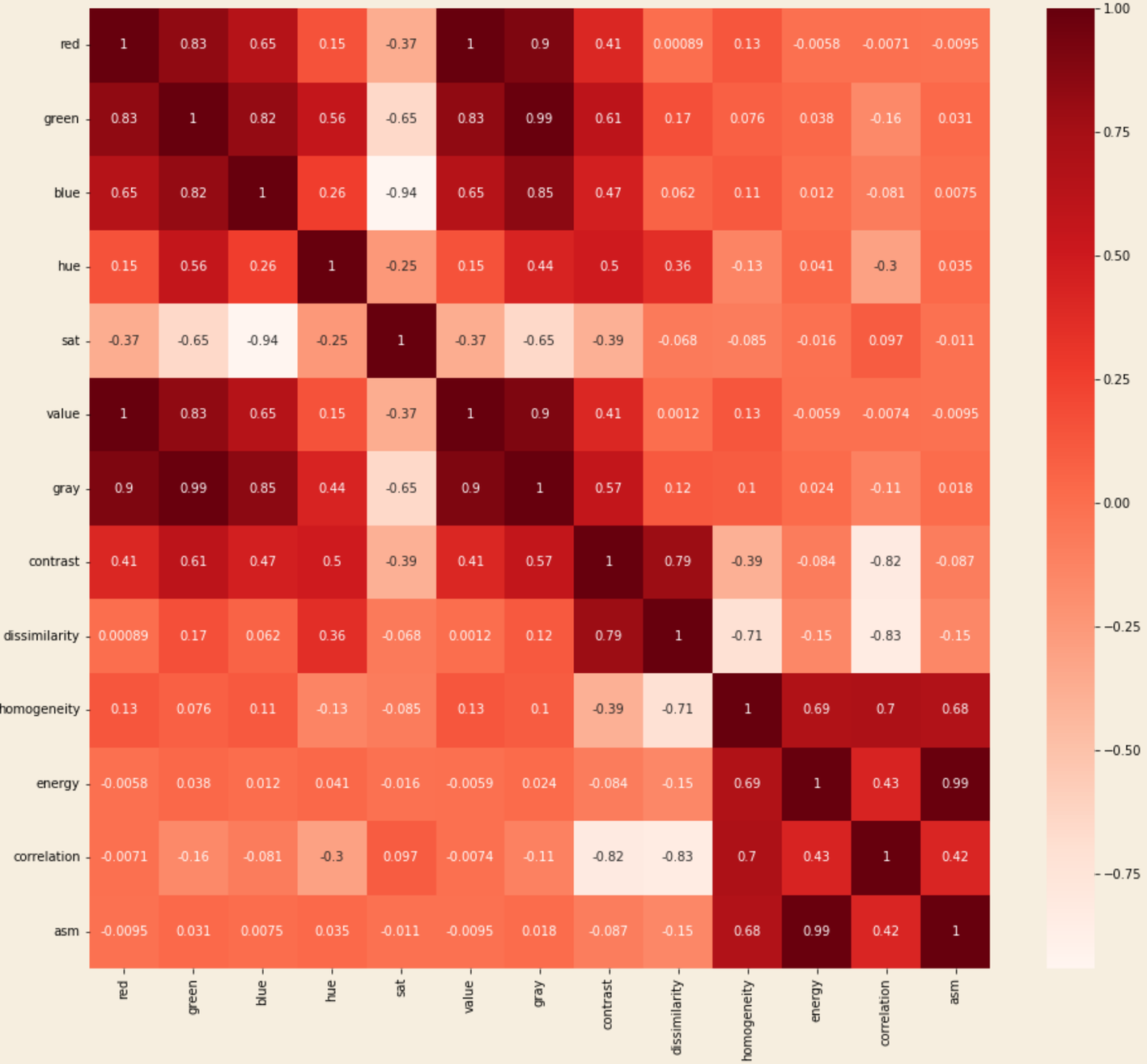
Rhizopus



Removed Features

Color Segmentation

- Red
- Green
- Energy



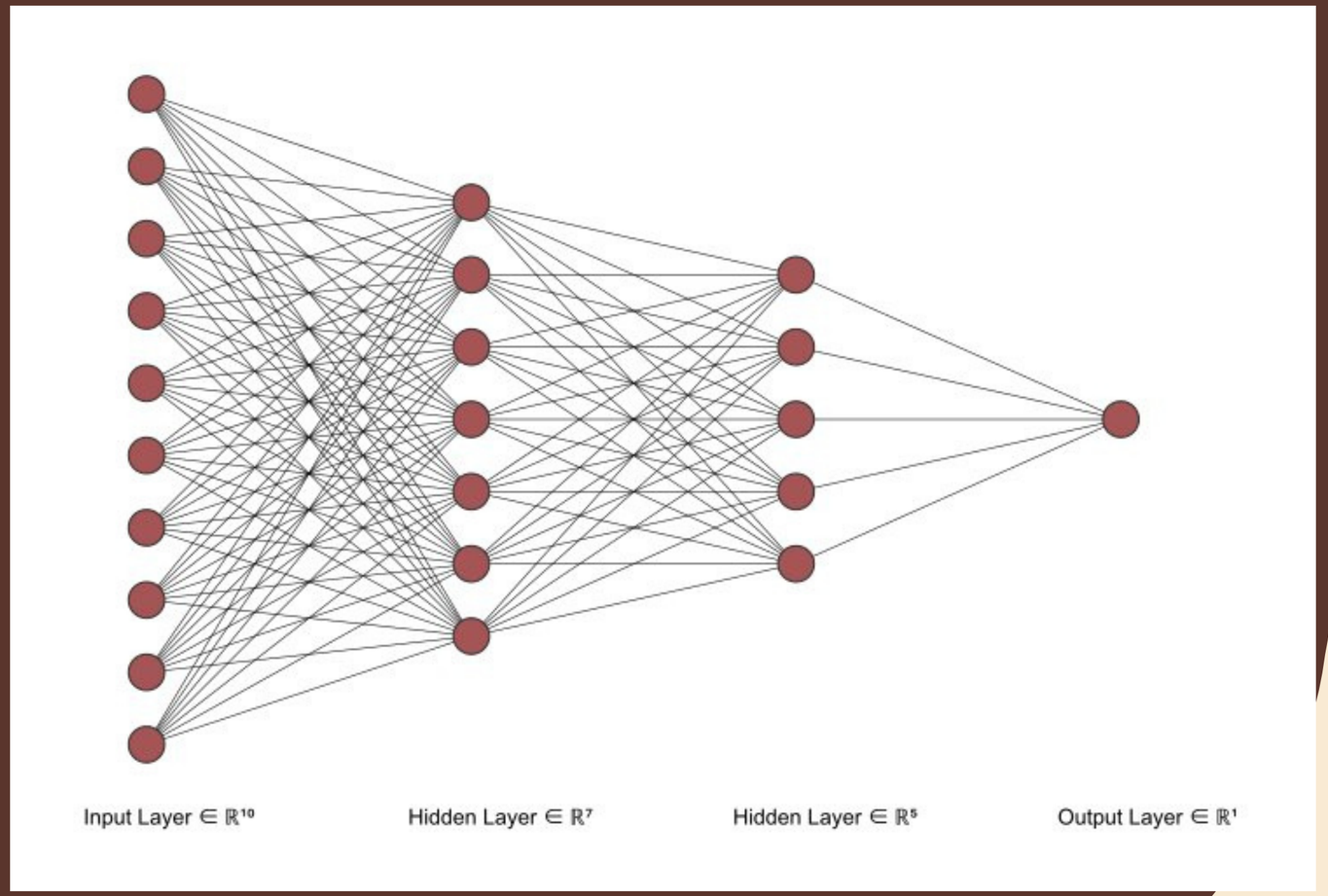
Removed Features

Marker-based Watershed Segmentation

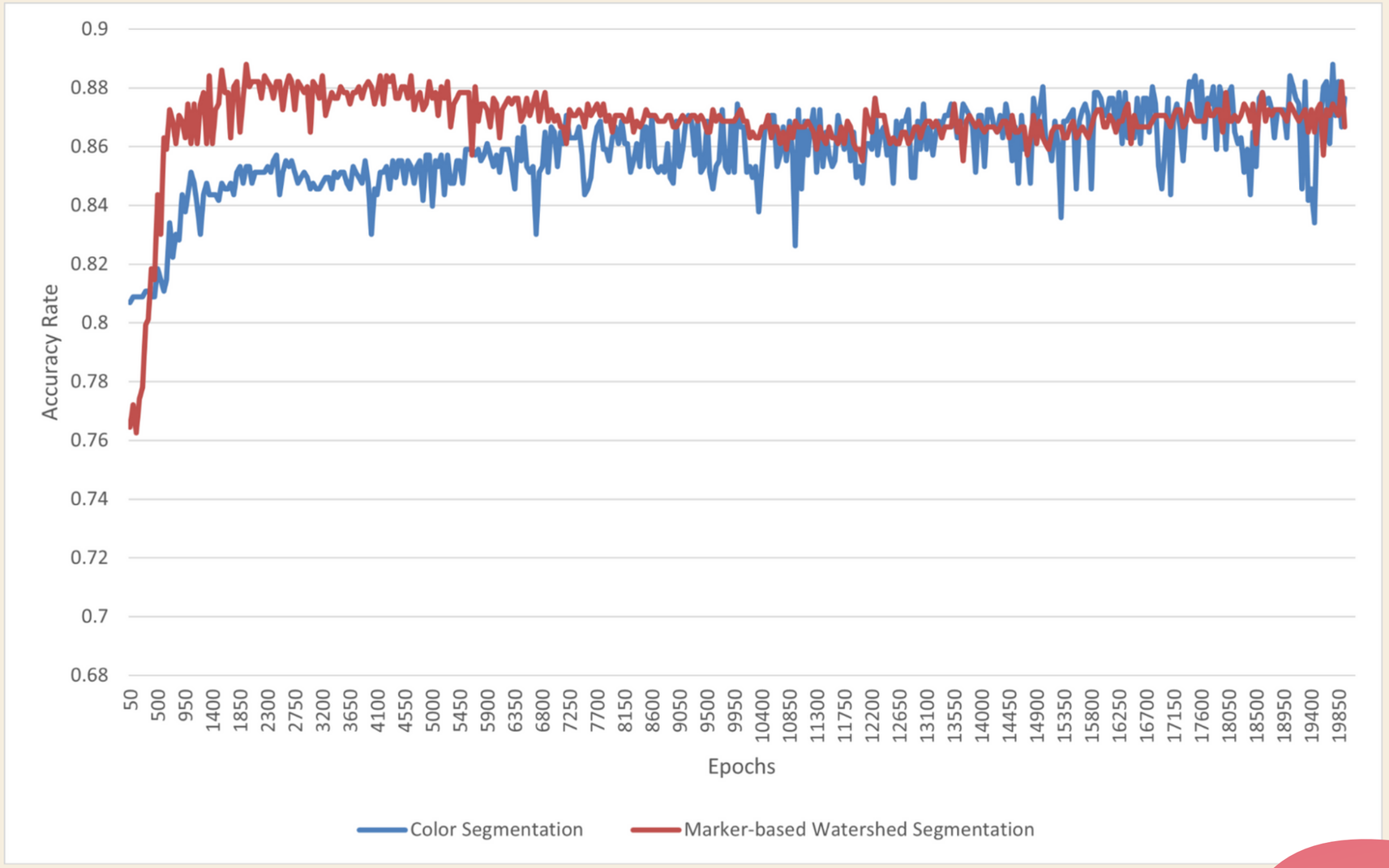
- Value
- Green
- Energy

Peanut Mold Detection

Feedforward
Backpropagation
Neural Network



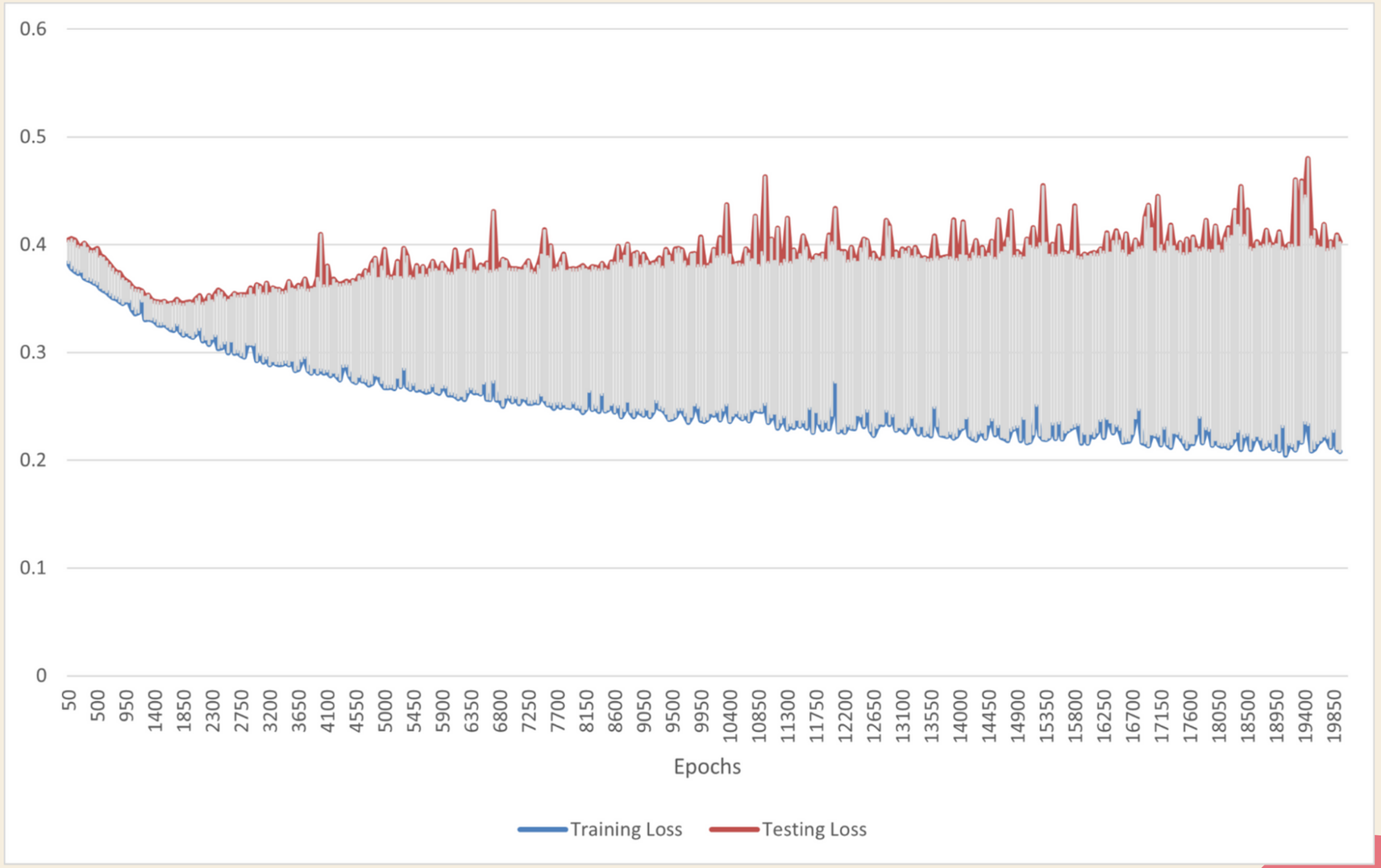
ANN: Accuracy Rate



Color Segmentation vs Watershed Segmentation

Peak Accuracy: 88.80%

ANN: Error Rate / Log Loss

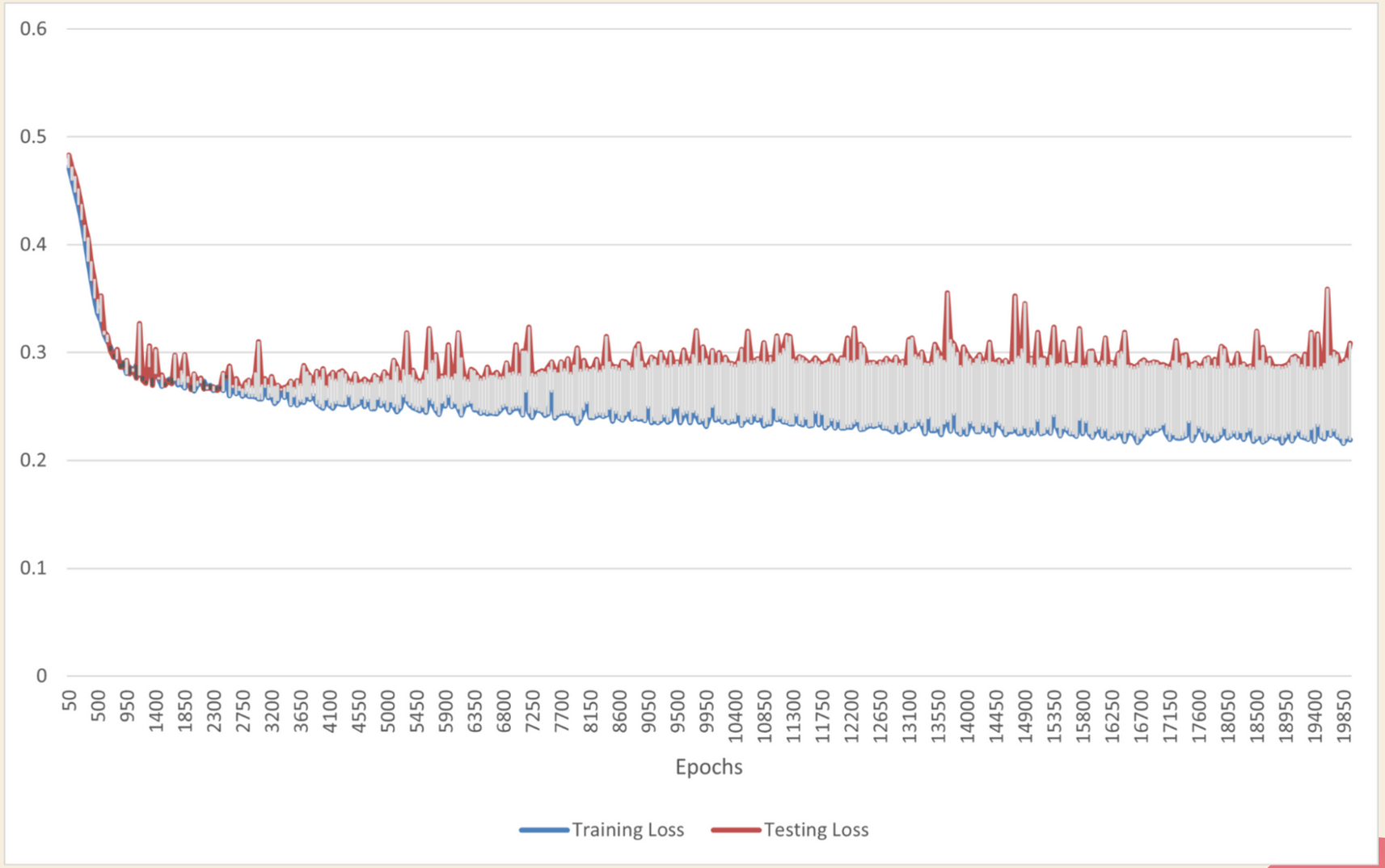


Color Segmentation

Min. Loss: 34.5%

Iterations: 1650

ANN: Error Rate / Log Loss



Marker-based Watershed Segmentation

Min. Loss: 26.5%

Iterations: 2400

ANN: Performance Comparision

Segmentation Method	Minimum Loss (%)	No. of Iterations at Minimum Loss	Accuracy at Minimum Loss (%)	Peak Accuracy (%)	No. of Iterations at Peak Accuracy	Loss at Peak Accuracy (%)
Color Segmentation	34.50	1650	84.56	88.80	19800	39.63
Marker-based Watershed Segmentation	26.50	2400	88.03	88.80	2000	26.57

ANN: Validation of Results

Color Segmentation

		Predicted	
		Non-Contaminated	Mold-Contaminated
Actual	Non-Contaminated	768	118
	Mold-Contaminated	125	714

$$Accuracy = \frac{768 + 714}{768 + 118 + 125 + 714} \times 100\,\% = 85.91\,\%$$

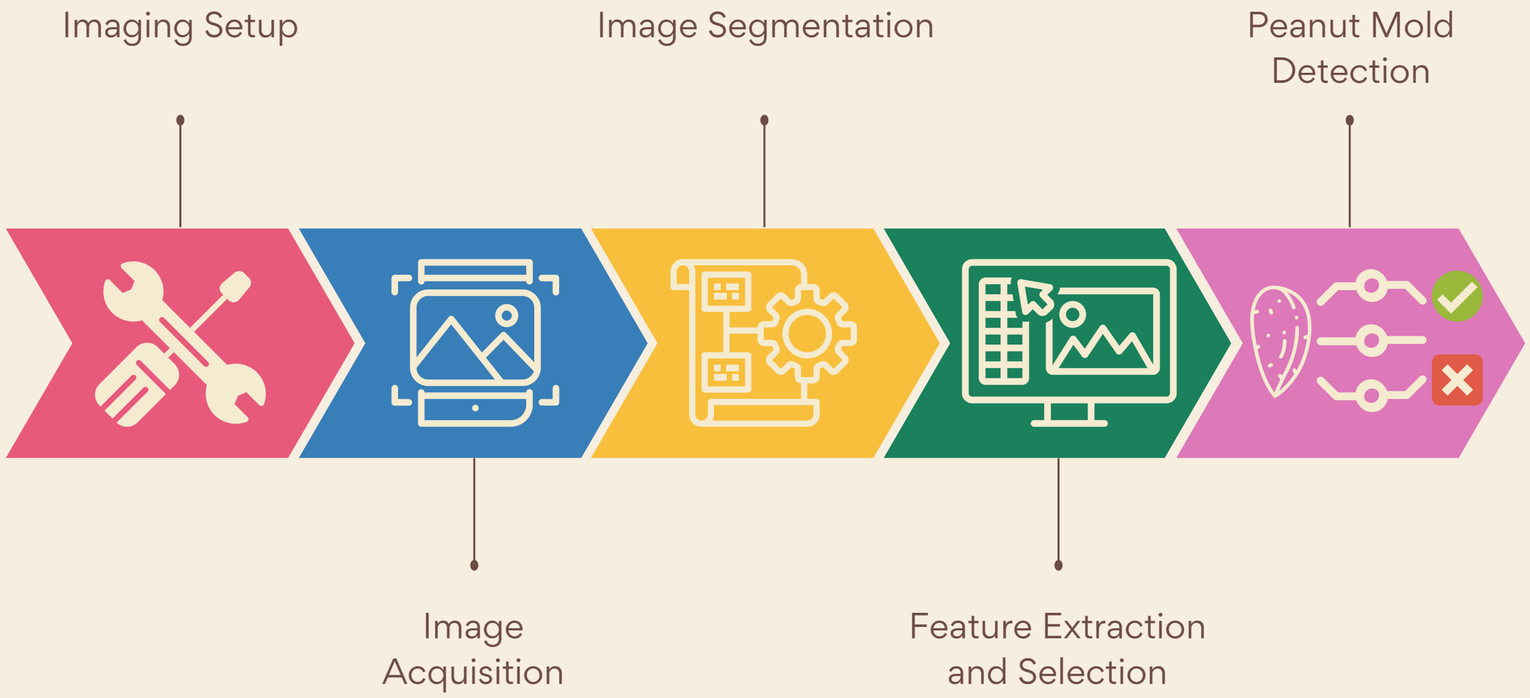
ANN: Validation of Results

Marker-based Watershed Segmentation

		Predicted	
		Non-Contaminated	Mold-Contaminated
Actual	Non-Contaminated	779	107
	Mold-Contaminated	77	762

$$Accuracy = \frac{779 + 762}{779 + 107 + 77 + 762} \times 100\,\% = 89.33\,\%$$

Conclusion



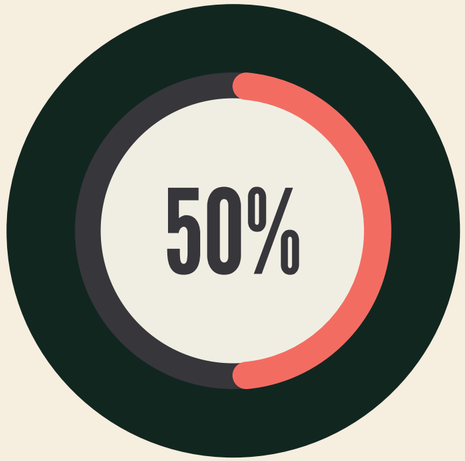
Objectives

Computer Vision System Built From Easily Accessible Tools and Materials

ANN Capable of Detecting Mold-Infected Peanut Seeds

Recommendations

Mold Identification



Level of Contamination

Other Color and Tactile Features

Better Tools and Equipment

Thank you for listening !