BSc. Software/Multimedia Year 3

IPCV - Image Processing and Computer Vision

Intelligent Bread Identification and Handling Evaluator

A02 - Home Assignment

Assignment Guidelines

This assignment is a **home assignment** that is to be completed by end of **10th April 2025.**

Some parts of the assignment require a certain amount of **research** to be completed successfully. It is entirely your responsibility to do so.

Assignments without a proper bibliography will not be accepted.

The College operates a cheating/**plagiarism policy** and any copied work will be penalized according to this policy.

All the institute procedures rules and regulations apply to this assignment.

At the end of the assignment you should submit the following in one Moodle submission:

- Document with Research tasks. (append any references at the end)
- Project Solution (zipped including source code, outputs and any data sets used)
- Unlisted Youtube or OneDrive link with short video explaining your development pipeline

Project Background

A local bakery and food retailer is seeking to introduce innovative AI solutions to streamline inventory management and customer service, with a focus on accurately identifying bread products and hygienic food handling. This system will enable faster and more efficient stock monitoring, while also providing detailed information about bread types to assist customers, and providing alerts for incorrect handling.

Bread comes in a variety of shapes, sizes, and packaging. Some bread types, such as the traditional Maltese loaf, are sold unpackaged and have distinctive features. Others, like pre-sliced packaged bread, come in labelled wrapping with brand names and specific details. Additionally, unpackaged bread often has unique characteristics, such as crust texture or flour dusting, which distinguish it from other varieties.

You have been engaged to develop an AI solution that can identify at least three types of bread, including:

1. **A large, unpackaged large Maltese loaf** (with distinctive visual features such as size and crust appearance).
2. **Another type of unpackaged bread** (e.g., baguette, ciabatta, etc.).
3. **One type of packaged bread** (e.g., pre-sliced loaf with labelled wrapping).

The AI solution should output a concise report of the detections, which includes:

1. Bread type (e.g., "Large Maltese Loaf," "Packaged White Bread").
2. Count of the same type of bread in the image.
3. An alert if a customer's hand is handling unpackaged bread from the bins containing unpackaged bread provided in the shop.

Tasks to Perform

To implement a smart system capable of evaluating bread types, you are required to:

1. Identify one unpackaged bread type (e.g., the Maltese loaf).

2. Identify and distinguish between two additional bread types, one of which must be packaged.

3. Identify if a customer has grabbed an unpackaged bread from inside a bread box, with hands rather than using the provided metal tongs.

You may use a combination of image processing techniques, texture analysis, object detection, image classification, OCR (for reading labels on packaged bread), pose estimation and tracking to accomplish the above three tasks.

Task 1 – Prepare the scenario

1. Create a new project within your Python+OpenCV environment.
2. You are free to use any distribution, but for convenience you may wish to follow the instructions to set up environments supplied at: https://vle.mcast.edu.mt/course/view.php?id=57#section-2
3. You may also use Google Colab to train and test your models. https://colab.research.google.com/

   Should you wish to use a live webcam feed, it is suggested you make use of normal Python (.py) files rather than a Jupyter notebook.

Task 2 – Transformations.

AA2.8 - Develop and test an algorithm which involves the use of geometric transformations

1. Research and write a short report on algorithms which can be used to warp, skew or distort an image to change or correct the perspective of an object in an image.
2. Implement an algorithm to:

   a. Load an image containing an object at a perspective.

EXAMPLE:

   b. Use a perspective transform to produce **three** other different perspectives of the object.

   c. Display the results.

SAMPLE OUTPUT:

KU2.7 - Discuss the effects of geometric transformations on images		
	Maximum	Awarded
Report on geometric transformations which transform perspective of an object.	5	
Total	5	

AA2.8 - Develop and test an algorithm which involves the use of geometric transformations		
	Maximum	Awarded
Load image and display	1	
Perform perspective transforms	3	
Correct output results	3	
Total	7	

Task 3 – Research Pose estimation and Human Activity Recognition

KU 3.1 Discuss the relevance of edge-finding and feature-finding algorithms

3. Investigate algorithms that perform:
    i.   Pose estimation
    ii. Human Activity Recognition

    Research, identify, compare and evaluate algorithms for each of the above detection methods. Include references and submit relevant literature with your submission.

KU3.1 - Discuss the relevance of edge-finding and feature-finding algorithms		
	Maximum	Awarded
Pose estimation	2	
Human Activity Recognition	3	
Total	5	

Task 4 – Create a working AI bread identifier

SE4.1 -Evaluate and research possible scenarios for the application of object detection and tracking algorithms
SE3.3 - Compare algorithms that can be used for feature / corner detection
SE4.2 - Combine algorithms in order to create a working object recognition application

Implement a smart system capable of evaluating bread types. You are required to:

1. Create a custom dataset to identify three types of bread according to the following

   guidelines:

   a. the **Maltese loaf**.

   b. **two additional bread types**, one of which can be packaged.

2. Train a model able to identify with acceptable performance the three types of bread.

3. Research, identify and explain a relevant technique for identifying the human hand.

4. Implement a function to recognise a human hand in a video frame or sequence of frames.

5. Identify if a customer has touched/grabbed an unpackaged bread from inside a bread box, with hands rather than using the provided metal tongs.

You may use any combination of image processing techniques, texture analysis, object detection, instance segmentation, pose estimation and activity recognition and/or tracking to accomplish the above tasks.

6. Write a short report detailing the following:

   a. A diagram to document your bread identifier solution pipeline, documenting development phases from dataset creation, training, and inferencing/evaluation.
   a. Model training and validation metrics. (e.g. confusion matrices, accuracy/recall/precision graphs.)
   b. Sample outputs for each of the 3 classes.

7. Sample outputs or video showing an alert when a person handles bread from a box/shelf by hand.

8. Record a video in which you explain your development pipeline (Dataset creation, model training, inference and testing phases). Upload as unlisted Youtube or OneDrive and include link in your report document.

SE4.1 -Evaluate and research possible scenarios for the application of object detection and tracking algorithms		
	Maximum	Awarded
Explanation of your chosen method to identify human hand	4	
Development and implementation of human hand detection	6	
Total	10	

SE3.3 - Compare algorithms that can be used for feature / corner detection		
	Maximum	Awarded
Custom dataset creation for a relevant machine learning algorithm	6	
Training and saving a model to recognise 3 types of bread	2	
Evaluation metrics reporting	2	
Total	10	

SE4.2 - Combine algorithms in order to create a working object recognition application		
	Maximum	Awarded
Product identification	3	
Product handled with hands alerts	3	
Pipeline diagram and video explaining chosen algorithm	4	
Total	10	