THE UNIVERSITY OF BUCKINGHAM
SCHOOL OF COMPUTING

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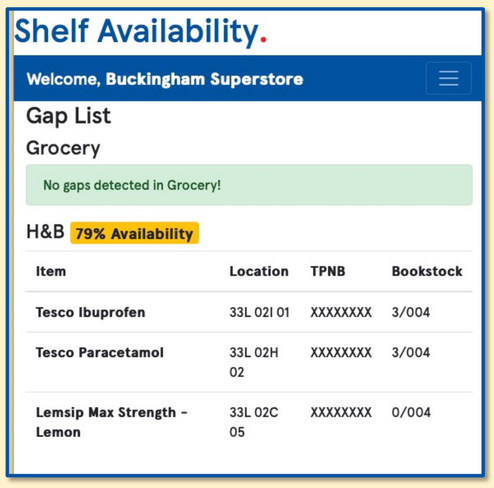
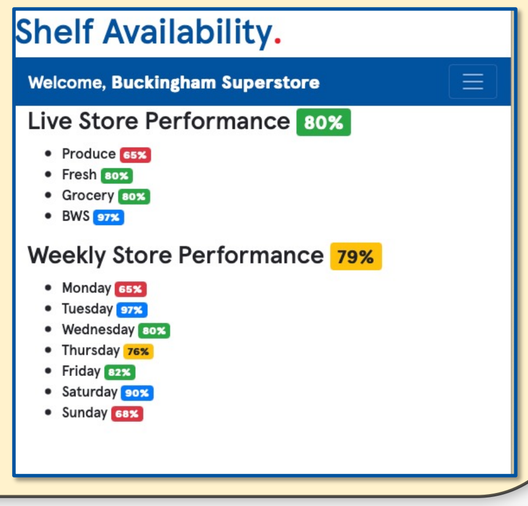
Automatic Detection of Empty Supermarket Shelves

Introduction and Objectives

- Lack of availability is a major irritant at Tesco supermarkets
- My project aims to make store operations more efficient and increase availability
- Uses a fixed camera, image processing/deep learning is used to detect the location of gaps
- This data is presented through a web app on colleague PDAs

Suggested Final Web App Layout





Process

Capture Image
- Pre-determined intervals, more often for more important lines etc

→ **Check that there is no person**
- To comply with GDPR and to ensure data is not false, deleting image if a person is detected

→ **Detect Gaps**
- Using traditional image processing, deep learning or combination of both

→ **Detect Shelves/Product Boundaries**
- Using traditional image processing, deep learning or combination of both

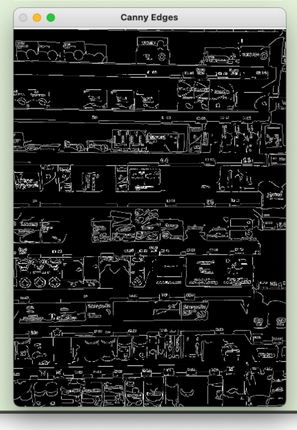
→ **Place gaps into product grid**
- Find the mid point of each detected gap, find which shelf and position it corresponds to

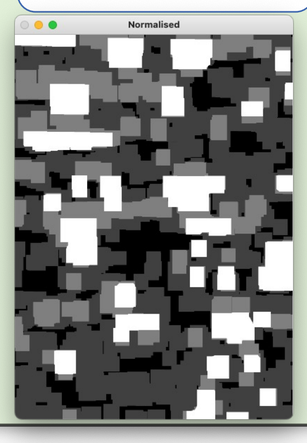
→ **Lookup gap location to determine missing product**
- Lookup the Shelf/Side/Mod/Shelf/Position from database, display in web app

Gap Detection Method 1: Traditional Image Processing

Import Image → Convert to Greyscale → Histogram Equalisation/ Bilateral Filter → Canny Edge Detection → Laplacian Filter, Erosion & Dilation → Normalisation & Contours Drawn

- Canny Edge detection is applied once histogram is equalised/bilateral filter applied
  - Sobel was also explored but Canny gave the clearest edges
- Laplacian filter applied to make edges stronger
- Erosion/Dilation used to close up edges
- Values then normalised
- Contours drawn around the voids



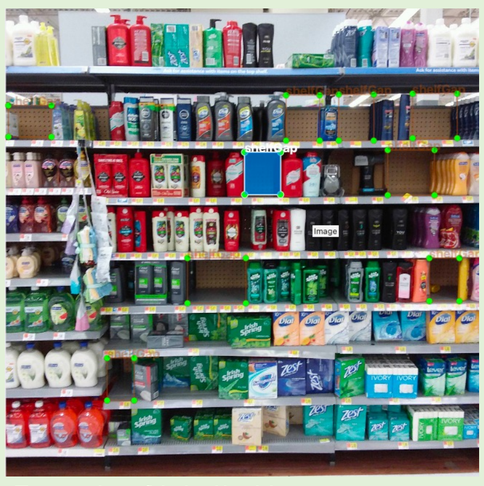


Gap Detection Method 2: YOLOv5 Deep Learning

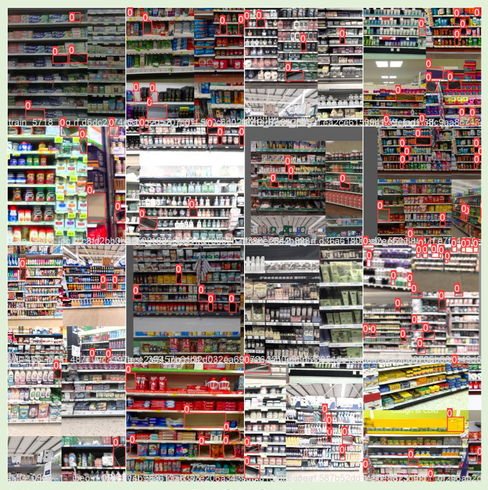
- Traditional methods weren't accurate enough.
- YOLOv5
  - separates the image into parts
  - then predicts bounding boxes/probabilities for each component.
  - Makes only one pass (You Only Look Once) [1][2]

1. Annotate Images — Using LabelImg tool
2. Preprocessing (PP)/ Augmentation (AUG) — Using Roboflow: PP: Orient, Resize, AUG: Flip, Rotate
3. Execute Training of Model

YOLO Model training process



Example of labelled image

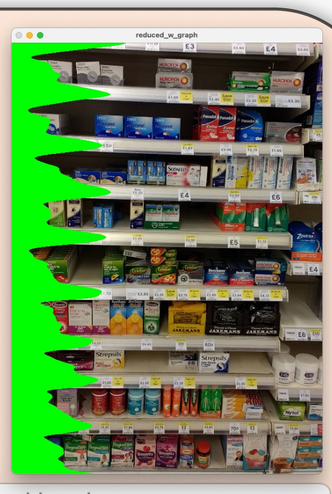


Visualisation of YOLO data

Example of detection

Product/Shelf Detection

- To correctly identify the detected gaps, I had to create a shelf 'grid'.
  - The image is converted to greyscale
  - Average values are taken going vertically/horizontally
  - The peaks of the vertical graph (green) are the locations of shelves
  - The turning points of the horizontal (blue graph are the edges of each product/gap



Problems Faced

- Messy shelves… a gap exists but a misaligned product creates false negative detections and causes shelf/product detector to be misaligned
  - Train YOLO model to include some messier shelves
  - Add minimum distance between peaks/troughs on peak detection algorithm
- Shelf detection not working properly
  - Use image transformations to make uniform lighting across image, ensure that only one shelf mod is visible, ensure that shelf image is straightened

Results

I tested my approaches by running them on a set of 18 images, where I had manually annotated where there was a gap. There were a total of 102 gaps.

Approach	False Positives	False Negatives	True Positives	Precision	Recall
Traditional	12	66	24	0.667	0.267
YOLOv5	4	3	95	0.960	0.969

References
[1]Garg, A., 2021. How to Use Yolo v5 Object Detection Algorithm for Custom Object Detection. [Online] Available at: https://www.analyticsvidhya.com/blog/2021/12/how-to-use-yolo-v5-object-detection-algorithm-for-custom-object-detection-an-example-use-case/
[2]Ultralytics, 2020. YOLOv5 Documentation. s.l.:Ultralytics.