# Computer Vision-based planogram matching in retail businesses

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## Introduction

Effectively managing the arrangement of products on shop shelves is crucial in the retail industry, as it directly impacts sales and customer experience. When shelves are empty, products are low in stock, or misplaced, it becomes difficult for customers to find and purchase what they need. This not only leads to dissatisfied shoppers but also significant loss of sales. Research shows that when faced with out-of-stock situations, 21-43% of customers buy the item elsewhere, and 7-25% of customers don't purchase it at all [1].

To address this issue, retailers employ planogram matching, a process that compares the actual placement of products on shelves with predetermined planograms. This ensures compliance with merchandising strategies.

A planogram typically includes detailed information about the quantity, location, and positioning of each product or stock keeping unit (SKU) within a specific area of the store. It provides guidelines for product placement based on factors such as product category, brand, size, shape, and promotional considerations.

Traditionally, planogram matching has been a manual and time-consuming task performed by employees. However, advancements in computer vision technology have led to automation, enhancing efficiency, accuracy, and cost-effectiveness. For instance, employees can capture shelf images, which are then automatically compared with corresponding planograms, reducing human errors [2], [3]. Some companies [4]–[6] provide a service using robots to navigate aisles and perform planogram compliance automatically, although this method can be expensive.

This study will focus on utilising computer vision techniques for planogram and shelf image analysis. The proposed method can be applied in various applications, such as using mobile devices to capture images and compare them with a web application, or deploying robots to automate planogram compliance.

The literature presents several computer vision and pattern recognition-based methods to address planogram compliance and object detection from shelf images. Laitala et al. [7] combines a Gaussian Layer Network product proposal generator and Domain Invariant Hierarchical Embedding (DIHE) for classification, utilising RANSAC pose estimation for planogram compliance evaluation.

Liu et al. [8] suggest using method involves partitioning the input image, detecting repeated products in each region, merging them to estimate the product layout, and comparing it against the expected layout in the planogram. This approach employs a divide and conquer strategy to improve speed.

Saqlain et al. [9] put forward a technique named Hyb-SMPC, comprising of two components: an object detection module that identifies detailed retail products using a one-stage deep learning detector, and a planogram compliance module. The numerical examination reveals that the suggested method attained an accuracy of up to 99% on the given retail dataset, while the qualitative assessment shows an improvement in sales and customer satisfaction levels.

In addition, Chong et al. [10] have explored different types of training images to determine the most suitable for classifying products on retail shelves. Accurate classification of these products enhances inventory management performed by robots.

Another proposed method by Tonioni and Di Stefano [11] involves three steps: object detection using generalized Hough transform and local feature extraction from the shelf image, sub-graph matching to compare the reference planogram with actual item placements, and an iterative approach to locate undetected objects.

Lastly, Erkin Yücel and Ünsalan [12] suggest using local feature extraction and implicit shape model formation for object detection, followed by sequence alignment using the modified Needleman-Wunsch algorithm for planogram compliance control.

The following sections delve into the study's aims and objectives, provides an overview of the progress made thus far, and outlines the project plan.

# Aim and Objectives

## Aim

This research aims to revolutionise planogram matching in the retail industry through the power of computer vision. By automating the process, improving efficiency and accuracy, and providing actionable insights, we aspire to empower retailers to optimize their retail space, drive sales, and deliver exceptional customer experiences.

## Objectives

This study will primarily address four key objectives:

1. Gather the dataset of shelf images, corresponding planograms, and product images .
2. Utilise object detection techniques to automatically detect products within the shelf images.
3. Compare the detected products with the generated planograms.
4. Analyze and present insightful information from the results, such as identifying missing products on the shelf and labeling areas that correspond to the planogram.

# Overview of Progress

A comprehensive review of the literature has been conducted, initially casting a wide net to explore various applications of object detection, particularly in the retail environment, as well as planogram compliance through the use of computer vision techniques.

The project also includes the preparation of the dataset. The Grozi-3.2K dataset, sourced from George and Floerkemeier [13], is explored. This dataset consists of 8,350 training images of grocery products, categorized into 80 hierarchical classes, along with 680 annotated test images of supermarket shelves. Fig. 1 provides visual examples of the sample training images while Fig. 2 provides an example of the testing images.


Fig. 1. Training images from Grozi-3.2K dataset under class cereal (left) and biscuit (right)


Fig 2. A testing image from Grozi-3.2K dataset

Furthermore, the manually created annotation package by Tonioni and Di Stefano [11] is utilised alongside the dataset. This package includes annotations for each test image, which specify the bounding box of each individual product instance, as well as the graph structure representing the ideal planogram for that particular scene. Visual depictions of the sample images, annotated with the package, are presented in Fig. 3. Additionally, Fig. 4 illustrates a visual representation of the ideal planogram for the scene.

Fig. 3. A testing image from dataset annotated with the package

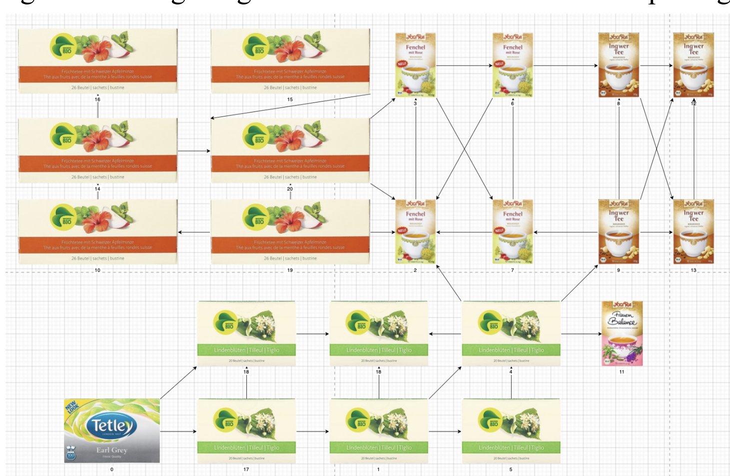

Fig 4. An ideal planogram of the scene

From now, more suitable dataset will be explored and the related works will be recreated to compare the result before moving on improving the algorithm for better result.

The proposed method is composed of four modules, forming the pipeline. The first module is responsible for object detection, detecting products from the provided shelf images. The detected products are then transformed into a graph structure using the conversion module. Subsequently, the planogram compliance module compares the generated graph with the reference planogram graph. Finally, the output display module is utilised to present the resulting information. The flowchart illustrating the proposed method can be found in Fig. 4, while Fig. 5 demonstrates the anticipated outcome.

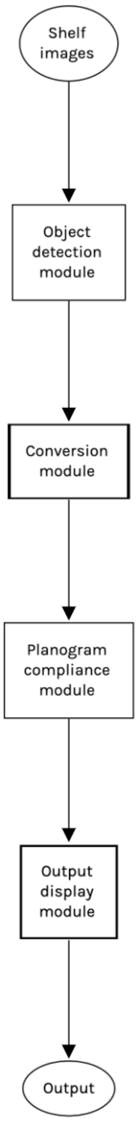


Fig 4. A flowchart of proposed method


Fig. 5. The expected output

The project utilises Google's Colab Pro Plus web IDE for coding and GitHub for version control. Google Cloud is employed for data management and storage. Since the data used is public, there is no need to worry about security and confidentiality. In fact, any trained networks produced in this project are aimed at philanthropic endeavors. Therefore, public distribution of these studies is encouraged.

# Project Plan

The duration of the project extends from April 24, 2021, to August 15, 2021. A comprehensive visual schedule can be found in Fig. 6. The intended algorithm will be created using an agile approach, incorporating frequent testing and iterations.

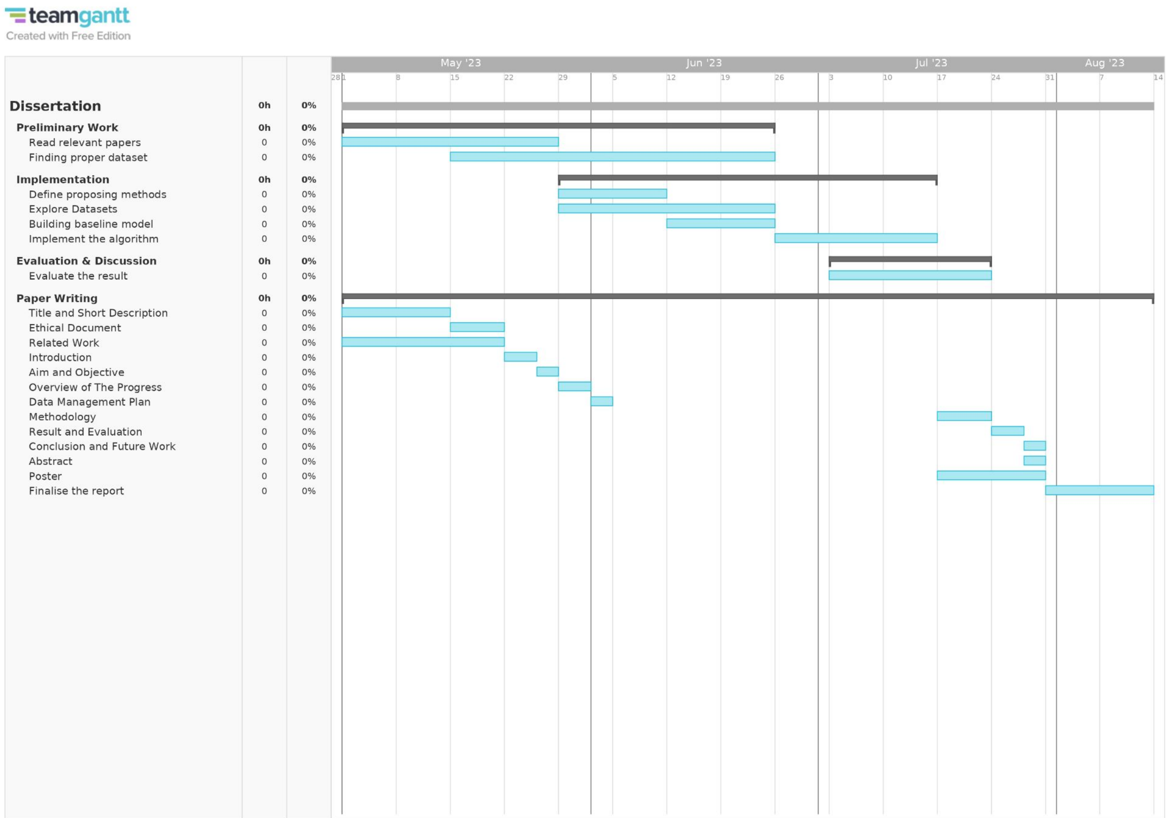


Fig. 6. Project's gantt chart

# Reference


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# Data Management Plan

**0. Proposal name**

Computer Vision-based planogram matching in retail businesses

**1. Description of the data**

**1.1 Type of study**

Studying the planogram compliance using computer vision technique in retail businesses. The datasets which we will be considering are shelf images and product images from retail stores and the annotation and matching planograms for each scene.

**1.2 Types of data**

This study uses public dataset which contains product images, shelf images, and ideal planograms for each shelf images.

**1.3 Format and scale of the data**

The dataset should contain image files such as .jpg or .png. The planograms can be provided in JSON files or any format.

**2. Data collection / generation**

**2.1 Methodologies for data collection / generation**

No new image data or annotations are intended to be gathered or produce in this project.

**2.2 Data quality and standards**

No new image data or annotations are intended to be gathered or produce in this project.

**3. Data management, documentation and curation**

**3.1 Managing, storing and curating data.**

The dataset have been downloaded and transferred to a local machine. They have also been uploaded to a Google Drive account for utilisation within the Google Colab Pro Plus environment, which offers enhanced computing capabilities. The availability of the training data publicly eliminates concerns regarding backup. However, trained networks, including architectures and weights, will be saved as files in and backed up locally along with the code in the Google Drive and project's GitHub repository.

**3.2 Metadata standards and data documentation**

Description of the trained model, architecture, and weighted will be stored and provided in the final report. The information needed for reproducibility will be upload to the project's GitHub repository.

**3.3 Data preservation strategy and standards**

The code for reproducing the project will be upload to Google Drive and GitHub repository. However, the dataset and its annotation will not be uploaded. To download the dataset and its annotation, please visit the dataset websites which will be describe in the final report and GitHub repository.

**4. Data security and confidentiality of potentially disclosive information**

**4.1 Formal information/data security standards**

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**4.2 Main risks to data security**

As the training data is publicly available, there are no security concerns related to third-party storage solutions, as highlighted by ncl.ac.uk [https://www.ncl.ac.uk/library/academics-and-researchers/research/rdm/working/]. In fact, any trained networks we develop are intended to contribute to a philanthropic cause, promoting their public distribution.

**5. Data sharing and access**

**5.1 Suitability for sharing**

The data and its corresponding annotations used in this project are openly accessible to the public and have undergone rigorous peer review. They have been extensively cited in numerous published papers, affirming their suitability for sharing.

**5.2 Discovery by potential users of the research data**

All code libraries will be hosted in the publicly available GitHub repository for the project. In the event that the project successfully achieves its objective, efforts will be made to publish the findings. Upon publication, a DOI (Digital Object Identifier) will be generated to facilitate the discoverability of the research.

**5.3 Governance of access**

The project repository will be hosted publicly on GitHub and can be supplied to any potential new user without permission.

**5.4 The study team's exclusive use of the data**

The dataset and its corresponding annotations are readily accessible as they have already been published. However, the project's methodology and code will be made available to the public upon completion of the project, scheduled for August 15, 2023.

**5.5 Restrictions or delays to sharing, with planned actions to limit such restrictions**

The GitHub repository's page will provide clear guidelines on the procedures for data sharing. As the datasets used are entirely public, confidentiality is not a concern. Any intellectual property resulting from the developed models will be freely distributed to contribute to advancements in the field. It should be noted that the author will not be held liable for any misuse of the project.

**5.6 Regulation of responsibilities of users**

External users will not be bound by data sharing agreements.

**6. Responsibilities**

Author, Panida Wiriyachaiporn, along with supervisor, Prof. Deepayan Bhowmik, are responsible for: study-wide data management, metadata creation, data security, and quality assurance of data.

**7. Relevant institutional, departmental or study policies on data sharing and data security**

| **Policy** | **URL or Reference** |
|---|---|
| Data Management Policy & Procedures | https://www.ncl.ac.uk/library/academics-and-researchers/research/rdm/ |

**8. Author of this Data Management Plan (Name)** and, if different to that of the Principal Investigator, their **telephone & email contact details**

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