

# FlexoPlate Manager Optimizing Plate Usage through Similarity Detection

Group ID : R25 - 082



# SUPERVISOR DETAILS

## SUPERVISOR

Ms Uthpala Samarakoon

## CO-SUPERVISOR

Ms Dushanthi Kuruppu

# INTRODUCTION



Revolutionizing Flexo Printing:  
Harnessing AI to Reduce Waste,  
Cut Costs, and Optimize Plate  
Reuse.



Flexographic printing is essential in packaging, but manual plate reuse is inefficient and costly. This research leverages AI for artwork similarity detection and automated plate tracking to reduce waste, cut costs, and improve efficiency [1]



# WHAT IS THE ARTWORK?

**CUSTOMER PROOF APPROVAL - FO/PP/09/02**

**PRINTCARE**  
Printcare PLC  
77, Nangamugoda Road,  
Kelaniya, Sri Lanka.  
Tel: +94 (0) 11 4829292  
Fax: +94 (0) 11 2912790  
Email: printcare@printcare.lk  
www.printcare.lk

PLEASE CHECK CAREFULLY  
THIS PROOF should be signed and APPROVED prior to printing. Please check carefully all type, illustrations, position and then mark corrections clearly.  
This proof is supplied for your protection and confirmation of your requirements prior to print.  
Have checked this proof and understand that PrintCare (pvt) ltd accepts no responsibility for any errors not MARKED hereon

Client: \_\_\_\_\_ Job No: \_\_\_\_\_  
Description: \_\_\_\_\_  
☐ OK TO PROOF AS PRINT VISUAL  
☐ CORRECTIONS REQUIRED THEN OK TO PROOF  
☐ REPROOF AFTER CORRECTION  
☐ OK TO PRINT AS PRODUCTION

Clients: \_\_\_\_\_ Date: \_\_\_\_\_  
Signature: \_\_\_\_\_  
Have checked this proof and understand that PrintCare (pvt) ltd accepts no responsibility for any errors not MARKED hereon

TYPE: Perfecta  
SIZE (MM): 28 x 32  
CUSTOMER :  
FLAVOUR: Great Value 3-5min T  
ITEM CODE:  
JOB NO.:  
P/P NO: 018624V1  
DATE: 28/06/2023  
COLOURS : 02  
285 C ■

THIS PRINTOUT IS ONLY FOR VISUALISING NOT FOR MATCHING COLOURS CUSTOMER FILE

OUR FILE Front & Back

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

**CUSTOMER PROOF APPROVAL - FO/PP/09/02**

**PRINTCARE**  
Printcare PLC  
77, Nangamugoda Road,  
Kelaniya, Sri Lanka.  
Tel: +94 (0) 11 4829292  
Fax: +94 (0) 11 2912790  
Email: printcare@printcare.lk  
www.printcare.lk

PLEASE CHECK CAREFULLY  
THIS PROOF should be signed and APPROVED prior to printing. Please check carefully all type, illustrations, position and then mark corrections clearly.  
This proof is supplied for your protection and confirmation of your requirements prior to print.  
Have checked this proof and understand that PrintCare (pvt) ltd accepts no responsibility for any errors not MARKED hereon

Client: \_\_\_\_\_ Job No: \_\_\_\_\_  
Description: \_\_\_\_\_  
☐ OK TO PROOF AS PRINT VISUAL  
☐ CORRECTIONS REQUIRED THEN OK TO PROOF  
☐ REPROOF AFTER CORRECTION  
☐ OK TO PRINT AS PRODUCTION

Clients: \_\_\_\_\_ Date: \_\_\_\_\_  
Signature: \_\_\_\_\_  
Have checked this proof and understand that PrintCare (pvt) ltd accepts no responsibility for any errors not MARKED hereon

TYPE: C2000  
SIZE (MM): 57 x 135.46  
CUSTOMER :  
FLAVOUR: GreatValue Decaffeinated Green Tea E  
ITEM CODE:  
JOB NO.:  
P/P NO: 019913V1  
DATE : 20/02/2025  
COLOURS : 03  
151 C ■  
285 C ■  
Black ■

THIS PRINTOUT IS ONLY FOR VISUALISING NOT FOR MATCHING COLOURS CUSTOMER FILE

OUR FILE

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

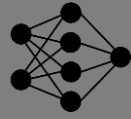
Great Value  
Steep 3-5 minutes

Great Value  
Steep 3-5 minutes

The number of polymer plates used for printing should be determined by the colors in the artwork.

# OBJECTIVES

Harnessing AI to revolutionize flexo printing—minimizing waste, lowering costs, and enhancing efficiency.



## AI-Based Artwork Similarity Detection



## Automated Plate Tracking



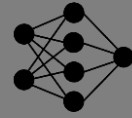
## Cost & Waste Reduction



## Operational Efficiency

# OBJECTIVES

Harnessing AI to revolutionize flexo printing—minimizing waste, lowering costs, and enhancing efficiency.



## AI-Based Artwork Similarity Detection



## Automated Plate Tracking



## Cost & Waste Reduction



## Operational Efficiency

# DEEP LEARNING ARCHITECTURE

## OCR-Based Specification Extraction - Duty: Extract technical

```
import pytesseract
import re

def extract_specifications(image):
    # Multiple OCR configurations for accuracy
    text = pytesseract.image_to_string(image, config='--psm 6')

    # Extract PP number using regex
    pp_pattern = r'P/P\s+NO\s*[:\-\]\s*{([A-Z]\d+[-_]\d{4}[-_][A-Z]\d+)'
    pp_number = re.search(pp_pattern, text)

    # Extract dimensions
    size_pattern = r'SIZE\s*\((MM)\)\s*[:\-\]\s*(\d+\.?\d*)\s*x\s*(\d+\.?\d*)'
    dimensions = re.search(size_pattern, text)

    # Extract color count
    color_pattern = r'COLOURS?\s*[:\-\]\s*(\d+)'
    colors = re.search(color_pattern, text)

    return {
        'pp_number': pp_number.group(1) if pp_number else None,
        'width': float(dimensions.group(1)) if dimensions else None,
        'height': float(dimensions.group(2)) if dimensions else None,
        'colors': int(colors.group(1)) if colors else None
    }
```

- pytesseract.image\_to\_string: Reads text from image using OCR
- Regex patterns (pp\_pattern, size\_pattern, color\_pattern): Extract industry-specific info.
- Returns structured dictionary (pp\_number, width, height, colors).
- **Why important?** This captures *exact technical details* that a CNN cannot recognize (e.g., plate numbers).



# CNN-Based Visual Analysis

**Duty:** Extract deep visual features (logos, patterns, designs).

```
def extract_visual_features(image):  
    # Load pre-trained VGG16 model  
    model = VGG16(weights='imagenet', include_top=False, pooling='avg')  
  
    # Preprocess image  
    image_224 = cv2.resize(image, (224, 224))  
    image_array = np.expand_dims(image_224, axis=0)  
  
    # Extract CNN features  
    cnn_features = model.predict(image_array, verbose=0).flatten()  
  
    # Traditional CV features  
    gray = cv2.cvtColor(image, cv2.COLOR_BGR2GRAY)  
    hsv = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)  
    hist_h = cv2.calcHist([hsv], [0], None, [50], [0, 180])  
    hist_s = cv2.calcHist([hsv], [1], None, [50], [0, 256])  
    edges = cv2.Canny(gray, 50, 150)  
    edge_density = np.sum(edges > 0) / edges.size  
  
    # Combine deep + traditional features  
    combined_features = np.concatenate([  
        cnn_features,  
        hist_h.flatten(),  
        hist_s.flatten(),  
        [edge_density]  
    ])
```

- VGG16: Pre-trained CNN extracts **design patterns**.
- hist\_h & hist\_s: Color histograms (hue & saturation info).
- edge\_density: Captures **line/outline details**.
- np.concatenate: Combines deep learning features + classic computer vision features.
- **Why important?** Captures what OCR misses — logos, fonts, layouts, background graphics.

# Dual-Approach Similarity Calculation

Duty: Combine OCR and visual features into one **similarity score**.

```
def calculate_similarity(new_artwork, database_artwork):  
    # Approach 1: OCR similarity  
    ocr_sim = calculate_ocr_similarity(  
        new_artwork['specs'],  
        database_artwork['specs']  
    )  
  
    # Approach 2: Visual similarity  
    visual_sim = cosine_similarity(  
        [new_artwork['visual_features']],  
        [database_artwork['visual_features']]  
    )[0][0]  
  
    # Weighted combination  
    overall_similarity = (ocr_sim * 0.4) + (visual_sim * 0.6)  
  
    return {  
        'overall': overall_similarity,  
        'ocr': ocr_sim,  
        'visual': visual_sim  
    }
```

```
def calculate_ocr_similarity(specs1, specs2):  
    score = 0.0  
  
    # PP number exact match  
    if specs1['pp_number'] == specs2['pp_number']:  
        score += 0.5  
  
    # Size similarity (±2mm tolerance)  
    if specs1['width'] and specs2['width']:  
        if abs(specs1['width'] - specs2['width']) <= 2 and abs(specs1['height'] - specs2['height']) <= 2:  
            score += 0.4  
  
    # Color similarity  
    if specs1['colors'] == specs2['colors']:  
        score += 0.1  
  
    return score
```

- calculate\_ocr\_similarity: Matches PP number, size, and colors.
- cosine\_similarity: Compares deep visual features numerically.
- Weighted average → **60% visual + 40% OCR**.

# Training & Database Building

**Duty:** Process dataset → store OCR + visual features → build database.

```
def train_dual_approach_model(artwork_dataset):
    artwork_database = []

    for image_path in artwork_dataset:
        image = cv2.imread(image_path)

        # Extract both feature sets
        ocr_specs = extract_specifications(image)
        visual_features = extract_visual_features(image)

        artwork_record = {
            'filename': os.path.basename(image_path),
            'ocr_specs': ocr_specs,
            'visual_features': visual_features
        }

        artwork_database.append(artwork_record)

    # Build searchable matrix
    visual_matrix = np.array([art['visual_features'] for art in artwork_database])

    return artwork_database, visual_matrix
```

- Loops over dataset → extracts OCR & CNN features.
- Saves each record with filename + features
- Builds visual\_matrix (used for fast similarity search with cosine/FAISS).
- **Why important?** Turns raw dataset into **structured searchable index**.

# Finding Similar Artworks

**Duty:** Query new artwork → find closest matches.

```
def find_similar_artworks(new_artwork, database, top_k=10):
    similarities = []

    for db_artwork in database:
        sim_score = calculate_similarity(new_artwork, db_artwork)
        similarities.append((db_artwork, sim_score))

    # Sort by highest overall similarity
    similarities.sort(key=lambda x: x[1]['overall'], reverse=True)

    return similarities[:top_k]
```

- Compares new artwork against entire database.
- Uses dual-approach similarity.
- Returns **top K similar artworks** ranked by similarity.
- **Why important?** Suggests which **polymer plates can be reused**.

# System Evaluation

**Duty:** Measure system accuracy (validation for research).

```
def evaluate_system_performance(test_dataset, ground_truth):
    correct_predictions = 0
    total_predictions = len(test_dataset)

    for test_artwork in test_dataset:
        similar_artworks = find_similar_artworks(test_artwork, database)

        # Top result check
        if similar_artworks[0][0]['filename'] in ground_truth[test_artwork['filename']]:
            correct_predictions += 1

    accuracy = correct_predictions / total_predictions
    return {
        'accuracy': accuracy
    }
```

- Compares system's top prediction with **ground truth labels**.
- Calculates accuracy (later can add precision/recall/F1).
- **Why important?** Provides **scientific validation** for research panel.



# Proof of Completion

```
create_upload_interface()

ARTWORK UPLOAD INTERFACE

Tea Artwork Similarity Finder
Instructions: Upload any tea artwork image to find all similar artworks from the same brand/range with P/P numbers.

Upload Artwork (P/P)
Find Similar Art.

Processing uploaded file: 1494_A2V2024054676-A2V0640-Our Finest-English Breakfast-Ima C28 Env-mall-01.jpg
Analyzing uploaded artwork...
Detected Brand/Folder: Our Finest-Envelopes
Found 7 artworks in the same range

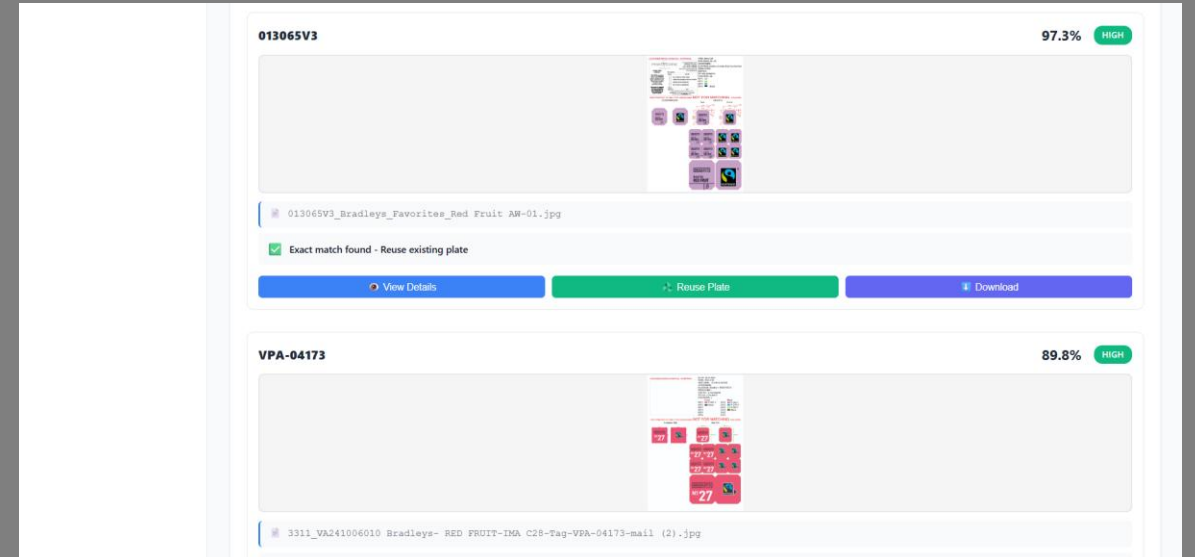
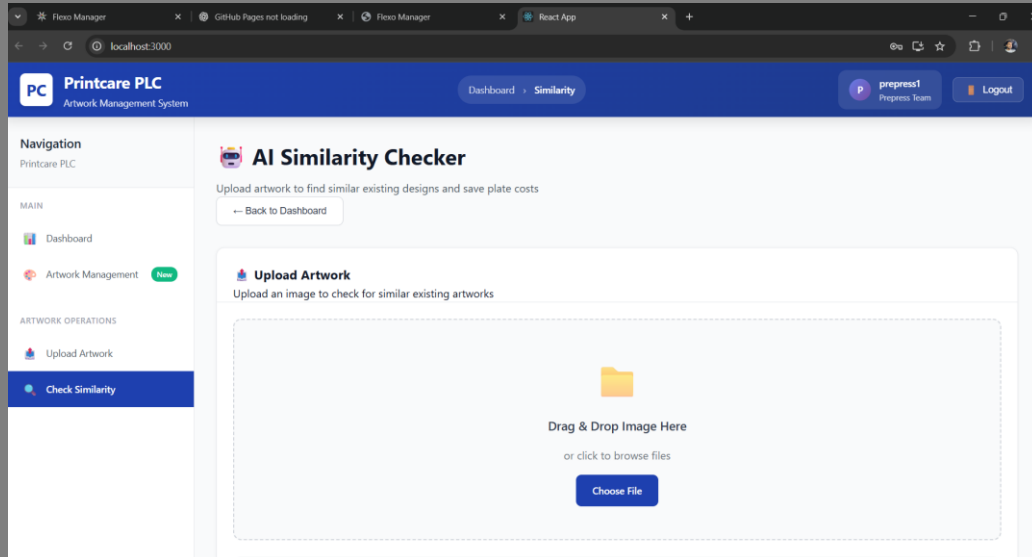
SIMILARITY RESULTS
Folder/Brand: Our Finest-Envelopes
Found: 7 similar artworks

ARTWORK LIST:
1. P/P No: A2V-0640-V2 | Score: 100.0 % | File: 1494_A2V2024054676-A2V0640-Our Finest-En
2. P/P No: A2V-0639-V2 | Score: 97.8 % | File: 1497_A2V2024054675-A2V0639-Our Finest-Le
3. P/P No: A2V-0636-V2 | Score: 97.4 % | File: 1493_A2V2024054672-A2V0636-Our Finest-Ea
4. P/P No: A2V-0636-V2 | Score: 97.4 % | File: 1493_A2V2024054672-A2V0636-Our Finest-Ea
5. P/P No: A2V-0634-V2 | Score: 97.3 % | File: 1498_A2V2024054678-A2V0634-Our Finest-Mi
6. P/P No: A2V-0637-V2 | Score: 96.3 % | File: 1496_A2V2024054673-A2V0637-Our Finest-Le
7. P/P No: A2V-0637-V2 | Score: 96.3 % | File: 1496_A2V2024054673-A2V0637-Our Finest-Le
```

Similar Artworks from Our Finest-Envelopes




# Proof of Completion



# Proof of Completion

**013065V3** 97.3% **HIGH**




013065V3\_Bradleys\_Favorites\_Red Fruit AM-01.jpg


✓ Exact match found - Reuse existing plate

[View Details](#) [Reuse Plate](#) [Download](#)

**VPA-04173** 89.8% **HIGH**



3311\_VA241006010 Bradleys- RED FRUIT-IMA C28-Tag-VPA-04173-mail (2).jpg




3314\_VA241006005 Bradleys- MOROCCAN MINT-IMA C28-Tag-VPA-04168-mail (1).jpg

👉 Very similar - Consider reusing plate

[View Details](#) [Reuse Plate](#) [Download](#)

**VPA-04148** 88.7% **HIGH**



3312\_VA241005958 Bradleys- ENGLISH BLEND-IMA C28-Tag-VPA-04148-mail-01 (1).jpg

👉 Very similar - Consider reusing plate

[View Details](#) [Reuse Plate](#) [Download](#)

# Proof of Completion

3308\_VA241005943 Bradleys- EARL GREY-IMA C28-Envelopes-VPA-04133-mail-01 (1).jpg

✓ Exact match found - Reuse existing plate

[View Details](#) [Reuse Plate](#) [Download](#)

**VPA-04134** 92.5% HIGH

3628\_VA241005944 Bradleys- CAMOMILE-IMA C28-Envelopes-VPA-04134-mail-01 (2).jpg

✓ Exact match found - Reuse existing plate

[View Details](#) [Reuse Plate](#) [Download](#)

**VPA-04144** 96.1% HIGH

3310\_VA241005954 Bradleys- RED FRUIT-IMA C28-Envelopes-VPA-04144-mail-01 (1).jpg

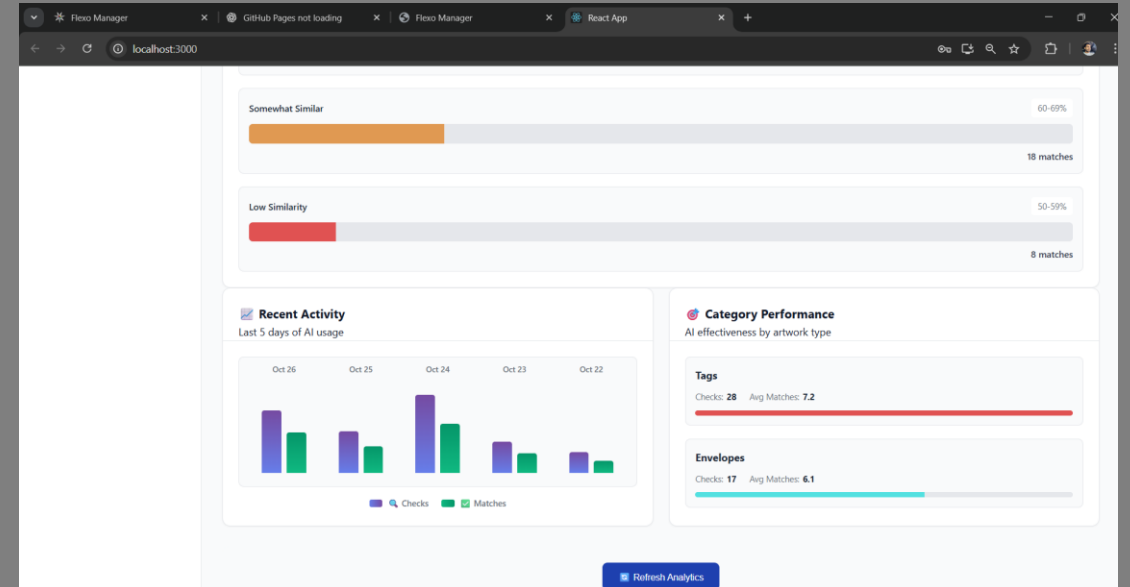
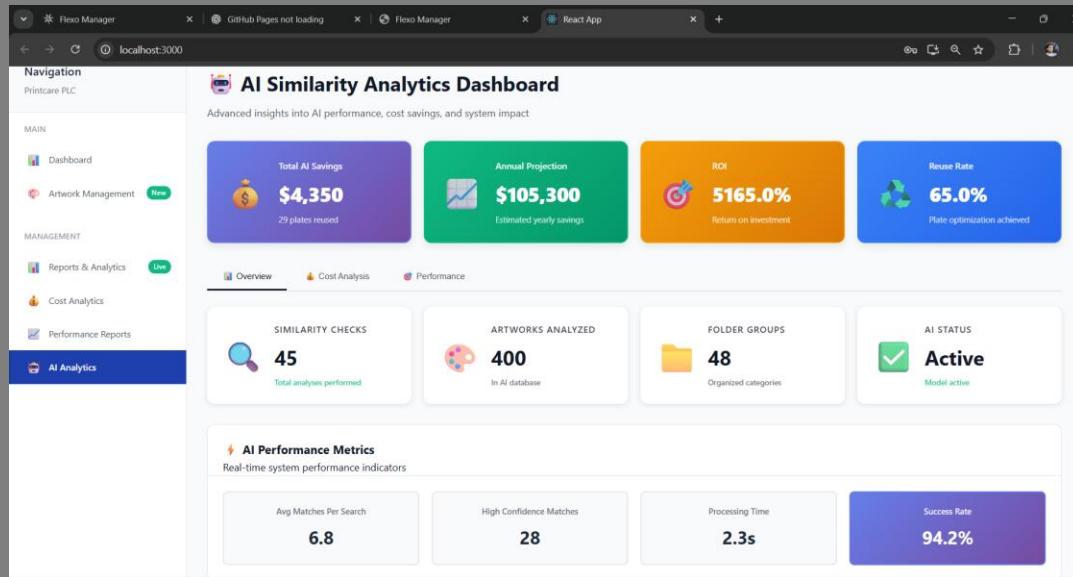
✓ Exact match found - Reuse existing plate

[View Details](#) [Reuse Plate](#) [Download](#)

**VPA-04143** 94.0% HIGH

3626\_VA241005953 Bradleys- TROPICAL FRUIT-IMA C28-Envelopes-VPA-04143-mail-01 (1).jpg

# Proof of Completion





# Key Technologies Summary

Component	Technology	Purpose
OCR Engine	Pytesseract	Text extraction from images
CNN Model	VGG16 (TensorFlow/Keras)	Deep visual feature extraction
Pattern Matching	Regex	Industry-specific text patterns
Similarity Calculation	Cosine Similarity (Scikit-learn)	Feature vector comparison
Image Processing	OpenCV	Traditional computer vision

# Key Points

## Dual-Approach Concept

**Approach 1:** OCR extracts exact specifications (PP numbers, dimensions, colors)

**Approach 2:** CNN analyzes visual patterns and design elements

## Integration Strategy

Weighted combination: 60% visual + 40% OCR

Handles both quantitative specs and qualitative design similarity

Multi-modal feature fusion

## Core Technologies

**TensorFlow/Keras VGG16:** Pre-trained CNN for visual analysis

**Pytesseract:** Multi-configuration OCR engine

**OpenCV:** Traditional computer vision features

**Scikit-learn:** Cosine similarity calculations

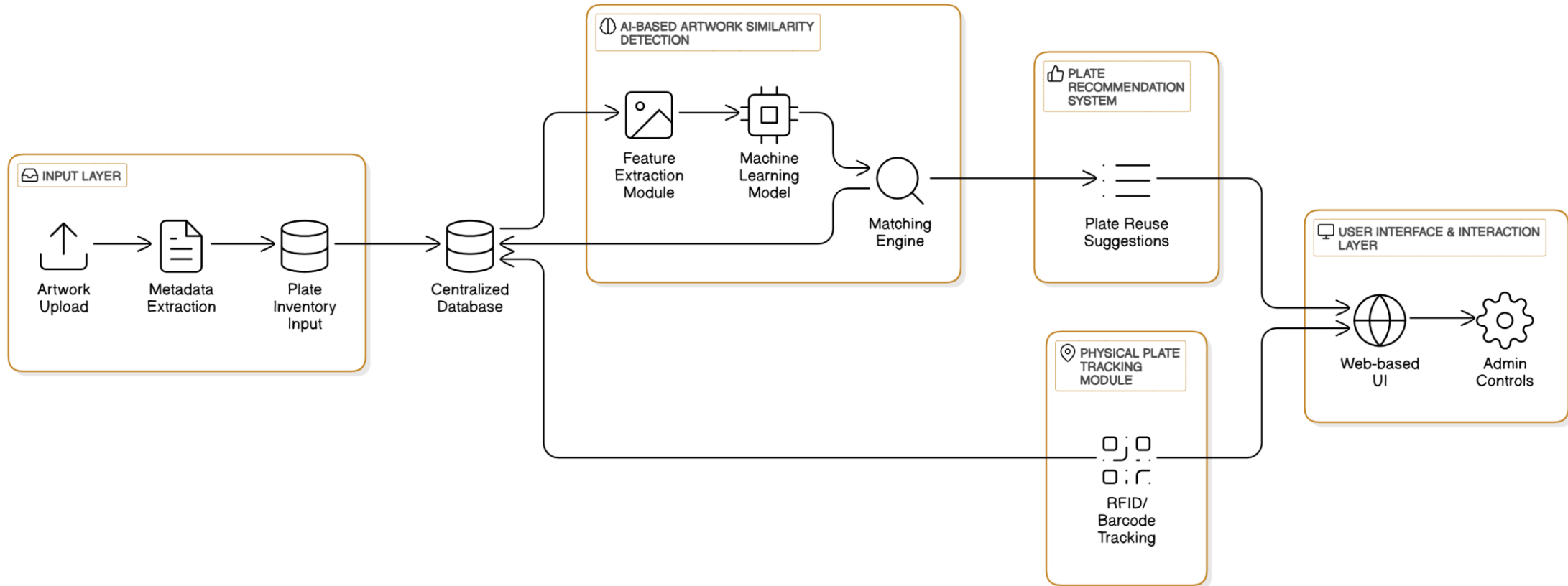
## Research Innovation

First dual-approach system for flexographic printing

Combines deep learning with industrial pattern recognition

Scalable for manufacturing databases

# OVERALL SYSTEM DIAGRAM



# COMMERCIALIZATION PLAN

## Basic Plan Free

- ✓ Limited artwork similarity detection for up to 5 artwork uploads per month
- ✓ Basic plate tracking with manual entry
- ✓ View basic plate reuse suggestions without history tracking

**Small businesses exploring AI for plate reuse.  
Individual operators seeking basic tracking tools.**

## Premium Plan (\$15/month)

- ✓ Unlimited artwork similarity detection using AI-powered analysis
- ✓ Automated plate tracking with barcode/RFID integration
- ✓ Advanced plate reuse recommendations with location and usage history
- ✓ AI-driven pattern recognition for better matching accuracy

**Mid-sized businesses aiming for automated plate optimization.  
Production managers needing detailed tracking and reports. Agency FB**

## Enterprise Plan (\$150/month)

- ✓ All features from the Premium Plan
- ✓ Multi-user access for up to 20 users
- ✓ Centralized dashboard for managing multiple printing jobs and plate inventories
- ✓ Integration support for existing ERP or production systems
- ✓ Custom AI model training for industry-specific artwork styles

**Large companies managing high-volume artwork and plates.  
Corporations needing multi-user access and system integration.**



**IT21291500 | Premajayantha W.H.S.I.**

**Specialization: Information technology**



# INTRODUCTION

- Flexographic printing is essential in packaging, but manual plate reuse is inefficient and costly [2]
- Relies on operator experience, causing inconsistencies and unnecessary plate creation.
- Loss of knowledge when experienced operators leave or resign, creating a knowledge gap
- Time-consuming training for new operators, leading to further inefficiencies.
- High potential for mistakes, increasing material waste, production costs, and environmental impact.

# CHALLENGES

- Polymer plates used in flexo printing are not environmentally friendly and contribute to waste
- Storage challenges—large amounts of plates require significant space to store properly.
- Tracking difficulty—managing and locating specific plates in a large inventory is time-consuming
- Job setup delays—finding the correct plates when loading a job into the machine can be complex.
- Duplicate plates issue—if multiple plates exist for the same design, identifying the correct one is difficult.

# RESEARCH GAP

Component	[3]	[4]	[5]	[6]	Proposed System
AI-Based Artwork Similarity Detection					
Automated Plate Tracking (RFID/Barcode)					
Centralized Database for Plate Reuse					
Real-Time Plate Reuse Recommendation					
Knowledge Retention Without Operator Dependency					
Cost & Waste Reduction in Flexo Printing					

[3] 2022 - Study on AI applications in packaging industry automation.

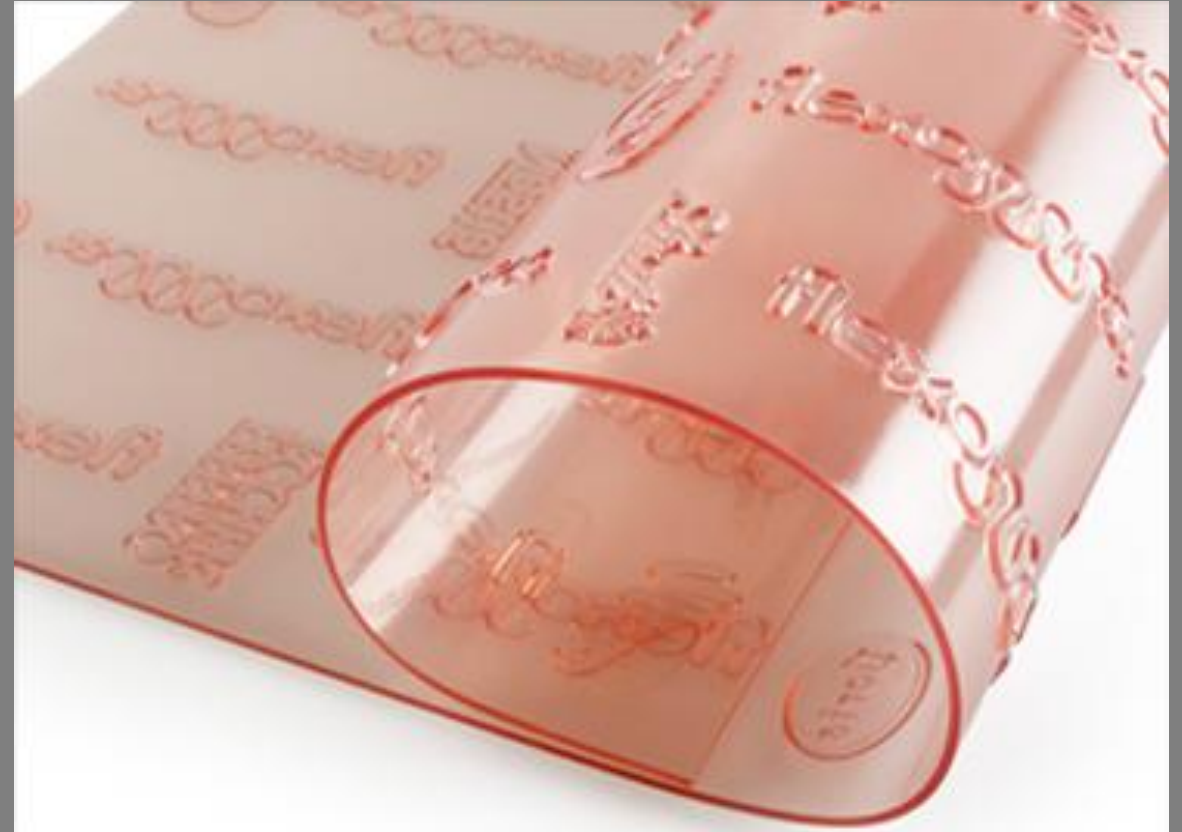
[4] 2023 - Review of plate management challenges in flexographic printing.

[5] 2021 - Analysis of cost and material waste in flexo printing operations.

[6] 2024 - RFID and barcode tracking systems in industrial printing.

# RESEARCH PROBLEM

How can we leverage AI-driven artwork similarity detection and automated plate tracking to optimize polymer plate reuse in flexographic printing, reducing material waste, production costs, and operational inefficiencies while improving sustainability?



# OBJECTIVES

- ➔ **AI-Driven Artwork Similarity Detection**  
Automates plate reuse identification, reducing manual effort and costs.
- ➔ **Automated Knowledge Retention**  
Eliminates reliance on operator memory, ensuring consistent plate management even if experienced staff leave.
- ➔ **Efficient Plate Reuse & Waste Reduction**  
Identifies reusable plates to minimize material waste and unnecessary plate creation.



- ➔ **Real-Time Plate Tracking**  
Uses RFID/barcodes to track plate location and history, improving inventory management.
- ➔ **Faster Onboarding & Reduced Training Time**  
User-friendly system helps new operators adapt quickly, reducing disruptions.
- ➔ **Sustainability & Cost Savings**  
Optimizes resources, cutting costs while supporting eco-friendly practices in flexo printing.

# TECHNOLOGIES

TensorFlow



React



Python



Open CV



git

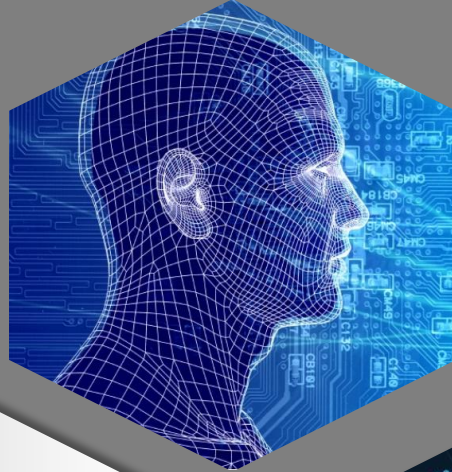


GitHub



mongoDB GridFS

Machine Learning



Automation & Tracking



Image Processing



KEY PILLARS

# FUNCTIONAL REQUIREMENTS

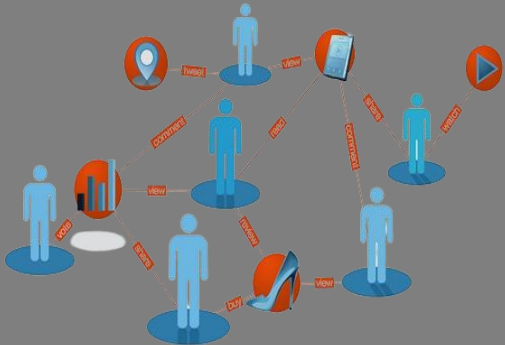
Data Collection and Processing

AI-Powered Artwork Similarity Detection

Adaptive Plate Identification & Tracking

Interactive Plate Selection & Recommendation System

User Interface & Experience



# NON-FUNCTIONAL REQUIREMENTS



Performance

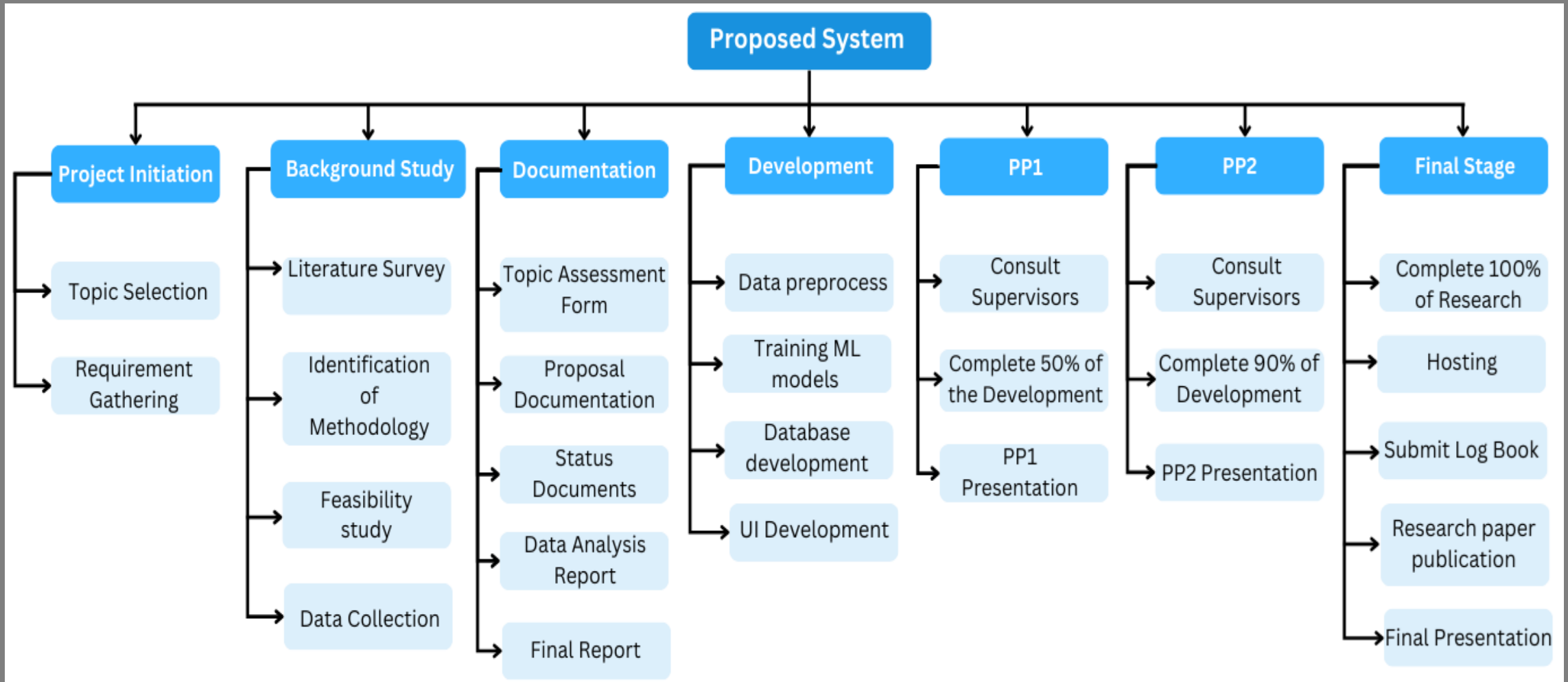
Reliability

Usability

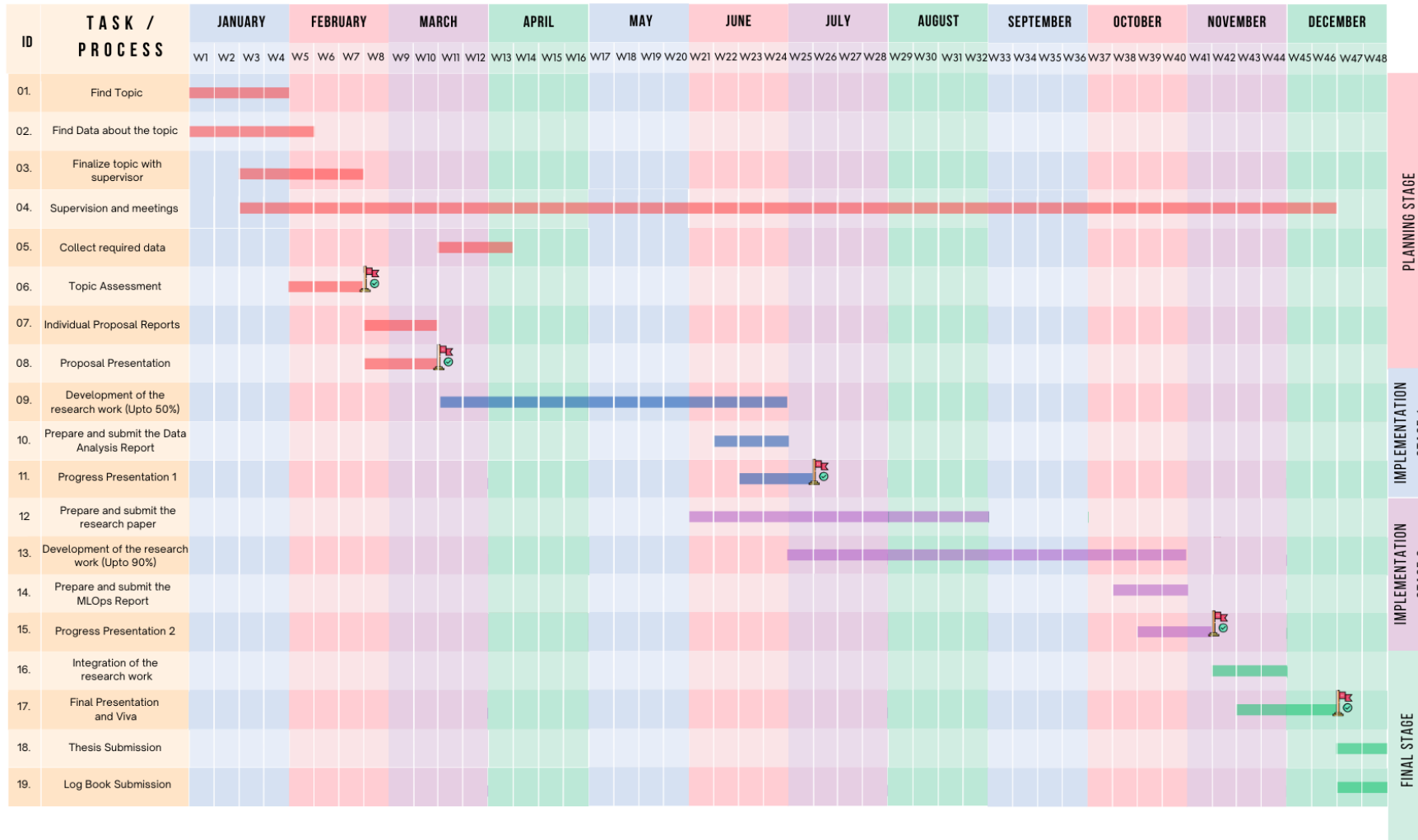
Security



# WORK BREAKDOWN CHART



# GANTT CHART



# REFERENCES

- [1] J. Smith and R. Kumar, "AI applications in packaging industry automation: A comprehensive study," *IEEE Transactions on Industrial Informatics*, vol. 18, no. 7, pp. 4561–4573, Jul. 2022.
- [2] A. Johnson and M. Lee, "Review of plate management challenges in flexographic printing," *Journal of Printing Science and Technology*, vol. 35, no. 4, pp. 215–227, 2023.
- [3] J. Smith and R. Kumar, "AI applications in packaging industry automation: A comprehensive study," *IEEE Transactions on Industrial Informatics*, vol. 18, no. 7, pp. 4561–4573, Jul. 2022.
- [4] A. Lee and M. Fernandez, "Challenges in plate management for flexographic printing: A systematic review," *Journal of Packaging Science and Technology*, vol. 12, no. 3, pp. 112–125, Mar. 2023.
- [5] K. Johnson and P. Wang, "Cost analysis and material waste reduction in flexo printing operations," *International Journal of Printing Technology*, vol. 29, no. 5, pp. 325–338, Oct. 2021.
- [6] D. Brown and L. Carter, "RFID and barcode-based tracking systems in industrial printing," *IEEE Transactions on Automation Science and Engineering*, vol. 21, no. 1, pp. 134–145, Jan. 2024.