Project Proposal

Automated Product Inquiry Response System for Light Recycling Program

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Section: 002

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Introduction

Background and Context

My current employer, **Product Care Association (PCA)**, is an industry-led organization dedicated to protecting the environment by providing free recycling services for post-consumer products such as paint, household hazardous waste, lights, and alarms. This project will focus specifically on **light recycling** and **developing an automated Product Inquiry Response System to improve efficiency**.

In 2022 alone, PCA successfully diverted over 10.8 million light bulbs from landfills. PCA operates across British Columbia, Manitoba, Ontario, Quebec, Nova Scotia, and Prince Edward Island, offering free recycling programs for various lighting products.

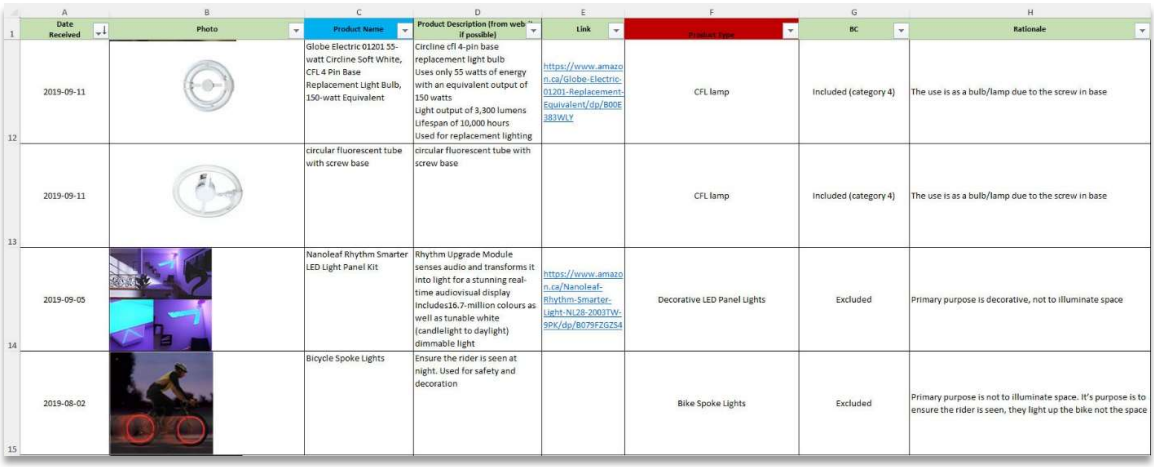
Problem Statement

Before accepting a product, PCA members (recycling centers, bottle depots, and retail stores such as Home Depot, Canadian Tire, and Save-On-Foods) must determine whether the product is included in PCA's light recycling program. This requires consulting the **Product Catalogue** or referring to **historical product inquiries stored in Excel sheets**.

The existing manual process is inefficient due to:

- **Repetitive inquiries from different members.**
- **Time-consuming manual searches through the Product Catalogue and past inquiries.**
- **Inconsistent decision-making, as different staff members handle inquiries.**

A screenshot of past product inquiries stored in Excel sheet:



	A	B	C	D	E	F	G	H
1	Date Received	Photo	Product Name	Product Description (from web if possible)	Link	Product Type	BC	Rationale
12	2019-09-11		Globe Electric 01201 55-watt Circline Soft White, CFL 4 Pin Base Replacement Light Bulb, 150-watt Equivalent	Circline cfl 4-pin base replacement light bulb Uses only 55 watts of energy with an equivalent output of 150 watts Light output of 3,300 lumens Lifespan of 10,000 hours Used for replacement lighting	https://www.amazon.ca/Globe-Electric-01201-Replacement-Equivalent/dp/B00E383WLY	CFL lamp	Included (category 4)	The use is as a bulb/lamp due to the screw in base
13	2019-09-11		circular fluorescent tube with screw base	circular fluorescent tube with screw base		CFL lamp	Included (category 4)	The use is as a bulb/lamp due to the screw in base
14	2019-09-05		Nanoleaf Rhythm Smarter LED Light Panel Kit	Rhythm Upgrade Module senses audio and transforms it into light for a stunning real-time audiovisual display Includes16.7-million colours as well as tunable white (candlelight to daylight) dimmable light	https://www.amazon.ca/Nanoleaf-Rhythm-Smarter-Light-NL28-2003TW-9PK/dp/B079FZGZS4	Decorative LED Panel Lights	Excluded	Primary purpose is decorative, not to illuminate space
15	2019-08-02		Bicycle Spoke Lights	Ensure the rider is seen at night. Used for safety and decoration		Bike Spoke Lights	Excluded	Primary purpose is not to illuminate space. It's purpose is to ensure the rider is seen, they light up the bike not the space

An extract from the Product Catalogue:

Light Recycling Product Guide

British Columbia

British Columbia | Manitoba | Quebec | Prince Edward Island | Policies | Contact

CATEGORY	DESCRIPTION	EHF
1. Fluorescent tubes measuring less than or equal to 2 ft	Includes all diameters and light outputs, shaped fluorescent tubes, and UV-A and UV-B tubes. 	
2. Fluorescent tubes measuring greater than 2 ft and up to or equal to 4 ft		
3. Fluorescent tubes measuring greater than 4 ft		
4. Compact Fluorescent Lights (CFL)/ Screw-In Induction Lamps	Fluorescent bulbs that are typically similar in size and intended to replace an incandescent (traditional) light bulb, including pin-type sockets, covered CFLs and various output wattages. Includes screw-in induction lamps. 	
5. Light Emitting Diodes	Solid-state lamps used for specialty purposes and conventional lighting applications. 	
6. High Intensity Discharge (HID), Special Purpose and Other	Includes all HID technologies, such as High Pressure Sodium, Low Pressure Sodium (HPS), Mercury Vapour and Metal Halide, as well as UV-C / Germicidal lamps and tubes, Tubular Induction lamps (circular, square, U etc.), UHP replacement lamps (projector etc.), Neon replacement lamps, etc. 	

Research Significance

This project will enhance PCA's operational efficiency by developing a web portal that integrates a Machine Learning (ML) model to automate product inquiries. The system will:

1. Accept inquiries containing a **product name, description, and image**.
2. Match inquiries against **PCA's Product Catalogue and historical data**.
3. Provide automated responses, including:
    - **Product Category**
    - **Recycling Program Inclusion/Exclusion Status**

Hypotheses and Assumptions

- A hybrid NLP + CV ML model will accurately match product inquiries to existing data.
- Automating inquiries will reduce response time by at least 50%.
- Sufficient historical data exists for effective model training.
- Product images in inquiries will be of reasonable quality for analysis.

Potential Benefits

This research will have multiple benefits for Product Care Association (PCA):

- **Operational Efficiency**: Automating the product inquiry response system will reduce manual workload, freeing up staff to focus on more strategic tasks.
- **Faster Response Times**: Members will receive near-instantaneous responses, improving service levels and satisfaction.
- **Consistency in Decision-Making**: Machine learning will ensure consistent and accurate classification of product inquiries, minimizing human errors.
- **Scalability**: The system can be expanded to support other recyclable product categories beyond light products.
- **Cost Savings**: Automating inquiries will reduce operational costs related to manual processing and staff workload.
- **Pioneering AI Implementation**: This project sets a precedent for PCA's first ML-driven operational system, paving the way for future AI adoption.

Proposed Research Project

Research Design and Objectives

The project involves designing, developing, and deploying a web-based Automated Product Inquiry Response System with an integrated ML model. The objectives are:

1. Develop a **web portal** where PCA members can submit inquiries.
2. Build an **ML model** capable of classifying inquiries based on text and image data.
3. Automate responses by identifying product categories and recycling eligibility.

Methodology and Justification

The solution will be implemented in two phases:

1. Machine Learning Model Development

- **Text Processing**: Utilize BERT-based sentence embeddings for product name/description matching. BERT (Bidirectional Encoder Representations from Transformers) is chosen because it provides context-aware representations of text, making it ideal for comparing product descriptions.
- **Image Processing**: Use CNN models (ResNet50/EfficientNet) for product image matching. Convolutional Neural Networks (CNNs) are well-suited for image classification tasks, and ResNet50/EfficientNet offer state-of-the-art feature extraction capabilities.
- **Decision Making**: Combine text & image similarity scores using an ensemble model to increase accuracy. This approach ensures that both textual and visual data contribute to classification decisions, leading to more robust results.

2. Web Portal Development

- **Frontend**: Flask + Bootstrap (or React). Flask is chosen for simplicity and flexibility, while Bootstrap or React provides a responsive and dynamic UI.
- **Backend**: Flask + Azure SQL Database. Flask is lightweight and easy to integrate with machine learning models, and Azure SQL ensures secure, scalable storage for inquiry and product data.

- **Data Storage**: Azure Blob Storage (for images), Azure Table Storage (for text data). These Microsoft Azure solutions provide scalable, cost-effective storage options for handling large volumes of product information.
- **ML Serving**: Flask API or Azure Machine Learning. Hosting the ML model via Flask API ensures easy deployment, while Azure ML provides cloud-based scalability.
- **Search & Retrieval**: FAISS or Azure Cognitive Search. FAISS (Facebook AI Similarity Search) enables fast similarity search for large datasets, while Azure Cognitive Search provides an enterprise-grade alternative within the Microsoft ecosystem.

My employer's technology stack is built on **Microsoft solutions**, so I will primarily leverage Microsoft tools and services to ensure seamless integration, compatibility, and smooth deployment within the existing ecosystem.

Data Collection & Analysis

- **Product Catalogue (PDF Extraction)**: Use PyMuPDF & Tesseract OCR to extract structured data. PyMuPDF enables PDF parsing, while Tesseract OCR is essential for extracting text from scanned documents. *(sample size = around 100)*
- **Historical Inquiry Data (Excel Processing)**: Pre-process using Pandas & NLP techniques. Pandas provides powerful data manipulation capabilities, while NLP techniques help clean and normalize text data. *(sample size = around 500)*
- **ML Training & Testing**: Train on historical data, validate against real-world inquiries. Ensuring a well-balanced training dataset improves model generalization.

Technologies Used

Component	Technology Stack
Frontend	Flask + Bootstrap (or React) for UI
Backend	Flask + Azure SQL Database for scalable data storage
Programming Language	Python
Data Storage	Azure Blob Storage (images) & Azure Table Storage (text data)
ML Model Hosting	Flask API or Azure Machine Learning for deployment
Search & Retrieval	FAISS (fast similarity search) or Azure Cognitive Search

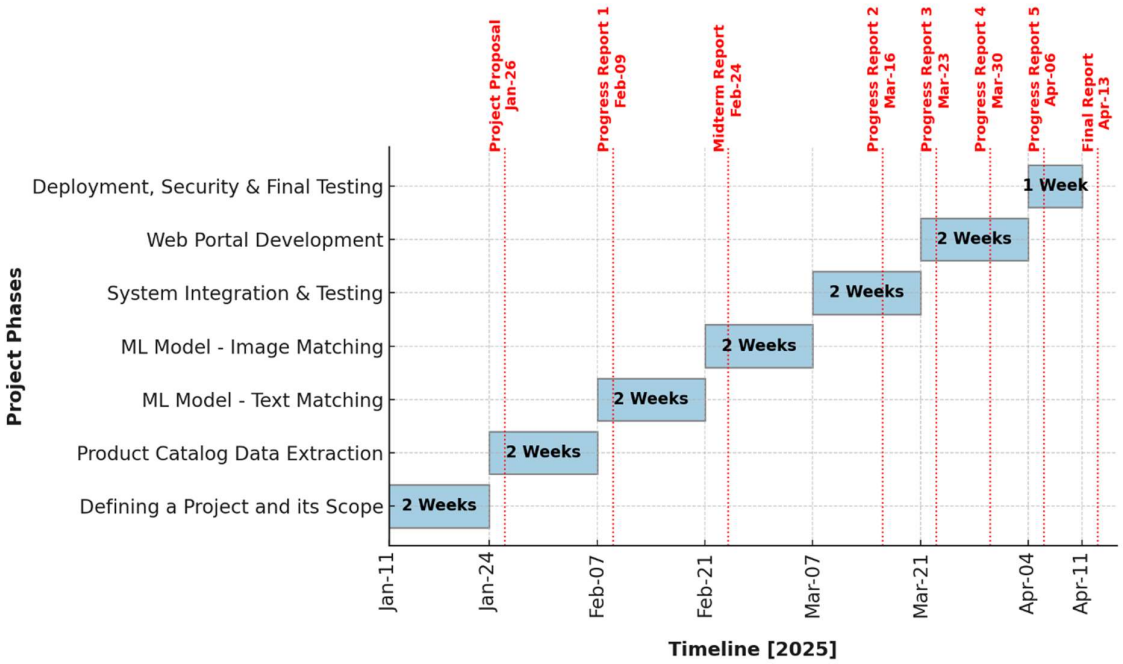
Expected Results

- Faster inquiry processing, reducing response times by 50%.
- Increased accuracy in product classification.
- Scalability, allowing PCA to extend the system to other recyclable products.

Project Planning & Timeline

Phase	Start Date	End Date	Duration (Weeks)
Defining a Project and its Scope	2025-01-11	2025-01-24	2
Product Catalog Data Extraction	2025-01-24	2025-02-07	2
ML Model - Text Matching	2025-02-07	2025-02-21	2
ML Model - Image Matching	2025-02-21	2025-03-07	2
System Integration & Testing	2025-03-07	2025-03-21	2
Web Portal Development	2025-03-21	2025-04-04	2
Deployment, Security & Final Testing	2025-04-04	2025-04-11	1

Project Gantt Chart with Check Points



Work Logs

Date	Number of Hours	Description of Work Done
Jan 13, 2025	2 hrs	Conducted initial research on PCA's operations and identified key inefficiencies in product inquiry management.
Jan 14, 2025	1 hr	Gathered and analyzed the existing product catalog and historical inquiry data to assess feasibility for ML integration.
Jan 15, 2025	2hrs	Met with the staff handling Lights Product Inquiries to review: • The product catalog and past inquiries for data understanding. • The entire process from receiving to closing an inquiry.
Jan 16, 2025	2 hrs	Researched suitable ML techniques for text and image-based product classification.
Jan 20, 2025	2 hrs	Outlined project scope, methodology, and initial timeline.
Jan 21, 2025	1 hr	Discussed project expectations and obtained consent from PCA with my manager
Jan 25, 2025	3 hrs	Drafted the initial project proposal and refined research objectives.
Jan 26, 2025	3 hrs	Finalized the initial project proposal and refined research objectives.

Acknowledgements

I would like to express my gratitude to Product Care Association (PCA) for providing the data and supporting the development of this project. I also extend my appreciation to my manager, *Luther Trammell*, for his guidance and valuable insights. Special thanks to my instructor, *Padmapriya Arasanipalai Kandhadai*, for her continuous feedback and support.

References

- PCA Official Website: https://www.productcare.org
- How are lights and light bulbs recycled: https://www.youtube.com/watch?v=KHmwDosH-FQ
- PCA Light Recycling Product Guide (Product Catalogue)
- NLP & BERT-based Text Matching: https://huggingface.co/transformers/
- Computer Vision with ResNet: https://pytorch.org/hub/pytorch_vision_resnet/
- FAISS for Similarity Search: https://faiss.ai/
- ChatGPT: OpenAI

Project Contract

This contract serves as an agreement between the student, *Namesh Mathara Arachchi Vidanalage*, and the instructor, *Padmapriya Arasanipalai Kandhadai*. The student agrees to complete the project as outlined in the proposal, adhering to the scope, methodology, and timeline.

Student Signature: Namesh _____ Date: _____26-01-2025_____