Software Requirements Specification

for

Product Review and Visual Categorization Using Deep Learning

Prepared by

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1. Introduction

1.1 Document Purpose

The purpose of this document is to outline the development of a system that utilizes deep learning techniques for product review analysis and visual categorization. This system aims to enhance e-commerce platforms by automatically analyzing customer reviews and categorizing product images, thereby improving product recommendations and search functionality.

1.2 Document conventions

This document uses the following conventions:

- CNN: Convolutional Neural Network
- NLP: Natural Language Processing
- API: Application Programming Interface
- ML: Machine Learning

1.3 Intended Audience

This project is a prototype for an advanced product review and categorization system and it is restricted within the college premises. This has been implemented under the guidance of college professors. The primary audience for this document includes:

- Data scientists and machine learning engineers
- E-commerce platform developers
- Product managers in the retail tech industry
- Academic researchers in the fields of computer vision and natural language processing

1.4 Project Scope

The purpose of the Product Review and Visual Categorization system using Deep Learning is to revolutionize how e-commerce platforms handle product information and customer feedback. The system aims to:

- Analyze textual product reviews using natural language processing techniques to extract sentiment, key features, and overall product quality.
- Categorize product images using convolutional neural networks to improve search accuracy and automate product tagging.
- Combine text and image analysis to provide comprehensive product insights.
- Develop an API that can be integrated into existing e-commerce platforms.
- Create a user-friendly interface for demonstrating the system's capabilities.

By leveraging state-of-the-art deep learning models, we hope to significantly enhance the accuracy of product categorization and the depth of insights gleaned from customer reviews, ultimately improving the shopping experience for consumers and the efficiency of product management for retailers.

2. Overall Description

2.1 Product Perspective

The Product Review and Visual Categorization system using Deep Learning is designed to process and analyse the following information:

- Product details: Includes product ID, name, description, category, brand, and pricing information.

- Review data: Comprises review text, rating, reviewer ID, review date, and helpful votes.

- Image data: Contains product images, image metadata, and associated product IDs.

- User information: Includes user ID, username, and review history (for personalized recommendations).

2.2 Product Features

The major features of the Product Review and Visual Categorization system are shown in the following component diagram:
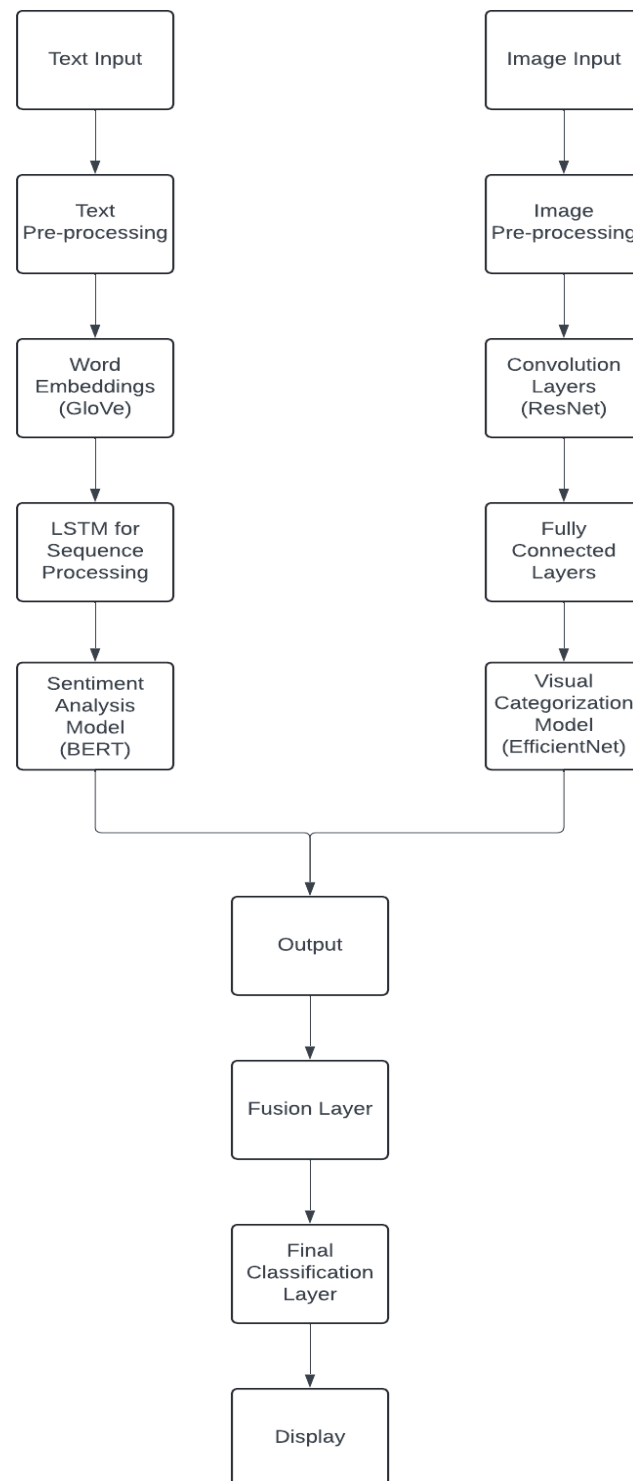
```
   Text Input                          Image Input
       |                                    |
       v                                    v
     Text                               Image
  Pre-processing                    Pre-processing
       |                                    |
       v                                    v
     Word                            Convolution
  Embeddings                           Layers
    (GloVe)                           (ResNet)
       |                                    |
       v                                    v
   LSTM for                            Fully
   Sequence                          Connected
  Processing                          Layers
       |                                    |
       v                                    v
   Sentiment                           Visual
   Analysis                         Categorization
    Model                               Model
    (BERT)                          (EfficientNet)
       |                                    |
       +------------------+-----------------+
                          |
                          v
                       Output
                          |
                          v
                   Fusion Layer
                          |
                          v
                      Final
                  Classification
                      Layer
                          |
                          v
                      Display
```

Fig. Architecture Diagram

2.3 User Classes and Characteristics

The system will support two types of user privileges: Consumer and Administrator.

Consumers will be able to:

- Search for products using text or image queries

- View summarized product reviews and sentiment analysis

- Receive personalized product recommendations

Administrators will have access to all consumer functions, plus:

- Upload new product data (text and images)

- View detailed analytics on product performance and review trends

Manage system settings and model parameters

2.4 Operating Environment

The operating environment for the Product Review and Visual Categorization system is as follows:

- Cloud-based distributed computing environment (e.g., AWS, Google Cloud)

- Container orchestration using Kubernetes

- Operating System: Linux

- Deep Learning Framework: PyTorch or TensorFlow

- Database: MongoDB for unstructured data, PostgreSQL for structured data

- API Platform: Flask or FastAPI

- Frontend: React.js

2.5 Design and Implementation Constraints

1. The system must be scalable to handle millions of products and reviews.

2. Real-time processing capabilities for instant product categorization and review analysis.

3. Compliance with data privacy regulations (e.g., GDPR, CCPA) for user review data.

4. Integration capabilities with existing e-commerce platforms through RESTful APIs.

5. Regular model retraining to adapt to changing product trends and language patterns.

2.6 Assumptions and Dependencies

Let's assume this Product Review and Visual Categorization system is used in the following applications:

- An e-commerce platform looking to automate product categorization and enhance search functionality.
- A market research firm analyzing consumer sentiment and product trends across multiple online retailers.

The system depends on:

- Availability of large, diverse datasets of product reviews and images for training the deep learning models.
- Access to high-performance GPU clusters for model training and inference.
- Continuous feed of new product data and reviews to keep the system up-to-date.
- Integration with existing product databases and e-commerce systems for seamless data flow.

3. External interface requirements

3.1 User Interfaces

The Product Review and Visual Categorization system will have two primary user interfaces:

1. Consumer Interface:

   - Web-based responsive design for desktop and mobile devices
   - Clean, minimalist layout with intuitive navigation
   - Search bar supporting both text and image inputs
   - Product listing pages with filter and sort options
   - Product detail pages showing summarized reviews and sentiment analysis
   - Visual cues for sentiment (e.g., color-coded ratings, emoji representations)

2. Administrator Interface:

   - Dashboard layout with key metrics and data visualizations
   - Upload interface for new product data and images
   - Configuration panels for adjusting model parameters and system settings
   - Detailed analytics views with interactive charts and graphs

3.2 Hardware Interfaces

The system will primarily interface with the following hardware components:

- Servers: High-performance CPU and GPU clusters for model training and inference
- Storage: SSD arrays for fast data access and processing
- Network: High-bandwidth network interfaces for data transfer and API communication

- Client Devices: Various end-user devices (desktops, laptops, smartphones, tablets) for accessing the web interface

3.3 Software Interfaces

The Product Review and Visual Categorization system will interface with the following software components:

1. Databases:
   - MongoDB (v5.0+) for storing unstructured data (reviews, product descriptions)
   - PostgreSQL (v14+) for structured data (user info, product metadata)
2. Deep Learning Frameworks:
   - PyTorch (v1.10+) or TensorFlow (v2.7+) for model development and inference
3. Web Framework:
   - FastAPI (v0.75+) for building the RESTful API
4. Frontend Framework:
   - React.js (v17+) for building the user interface
5. Container Orchestration:
   - Kubernetes (v1.23+) for managing containerized applications
6. Cloud Services:
   - AWS S3 or Google Cloud Storage for storing and serving product images
   - AWS SageMaker or Google Cloud AI Platform for model deployment and scaling
7. Message Queue:
   - Apache Kafka (v3.0+) for handling real-time data streams

Data sharing between components will primarily occur through RESTful API calls and message queues. All inter-component communication will be encrypted.

3.4 Communication Interfaces

The system will utilize the following communication interfaces:

1. HTTP/HTTPS:

    *   RESTful API for client-server communication

    *   WebSocket for real-time updates in the admin dashboard

2. TCP/IP:

    *   For database connections and inter-service communication

3. SMTP:

    *   For sending email notifications to administrators

4. OAuth 2.0:

    *   For user authentication and authorization

5. GraphQL:

    *   For efficient data querying and aggregation

All external communications will use TLS 1.3 for encryption. API rate limiting will be implemented to prevent abuse. Data transfer rates will be optimized for low-latency responses, with a target of <100ms for search queries and <1s for complex analytics requests.

4 System Features

4.1 Functional Requirements

4.1.1 F1: Sentiment Analysis of Product Reviews

REQ-1: The system shall analyze the sentiment of each product review and categorize it as positive, negative, or neutral.

REQ-2: The system shall provide a sentiment score on a scale of 1-100 for each review.

REQ-3: The system shall calculate and display an overall sentiment score for each product based on all its reviews.

REQ-4: The system shall update sentiment analysis in real-time as new reviews are added

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4.1.2 F2: Visual Product Categorization

REQ-1: The system shall automatically categorize products into predefined categories and subcategories based on product images.

REQ-2: The system shall provide a confidence score for each category assignment.

REQ-3: The system shall support multi-label classification, allowing products to belong to multiple categories.

REQ-4: The system shall process and categorize new product images within 5 seconds of upload.

4.1.3 F3: Review Summarization

REQ-1: The system shall generate a concise summary (maximum 200 words) of all reviews for a given product.

REQ-2: The summary shall highlight the most frequently mentioned positive and negative aspects of the product.

REQ-3: The system shall update the summary in real-time as new reviews are added.

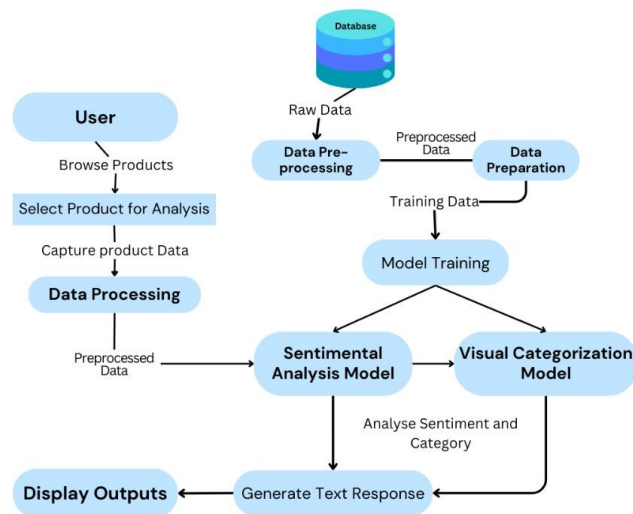REQ-4: The system shall provide links from summary points to relevant full reviews.
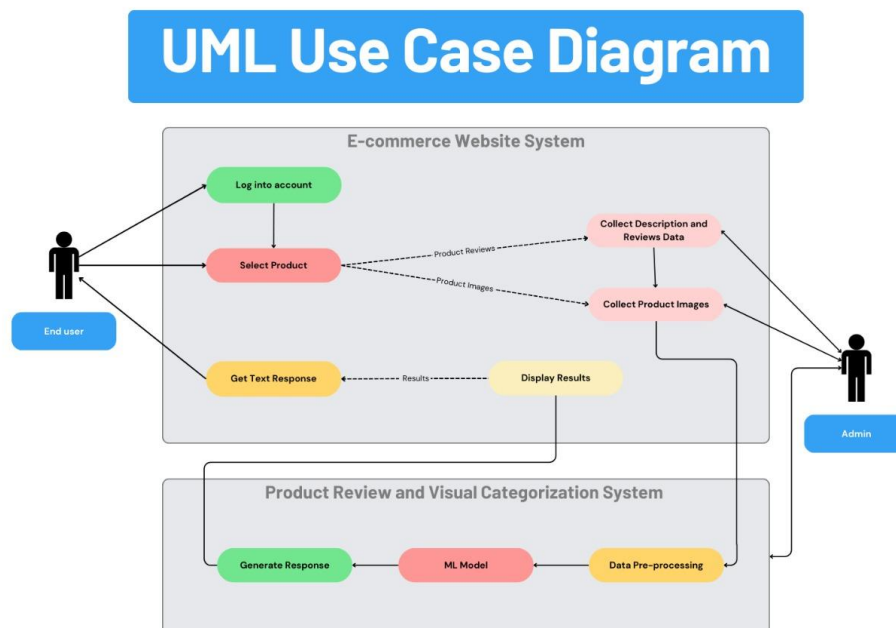
4.2   Use Case Models

4.2.1 DFD Level 0 Diagram
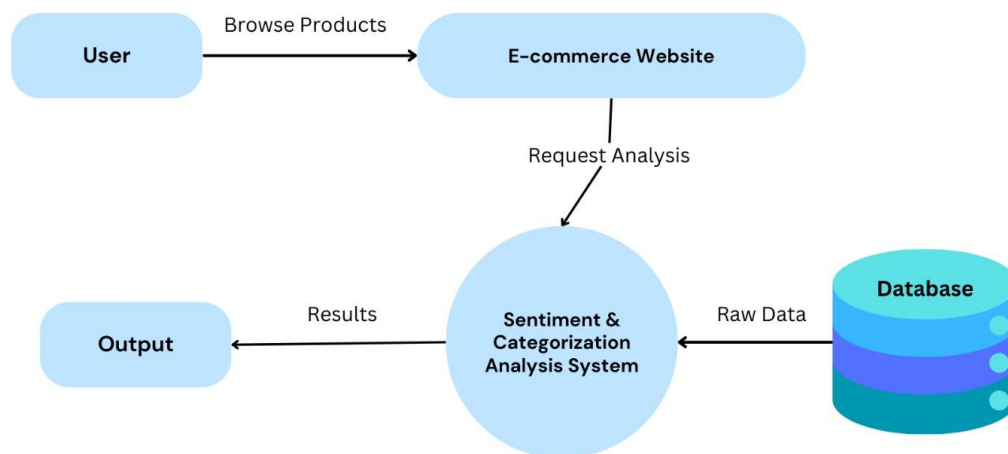
DFD Level 0

4.2.2 DFD Level 1 Diagram

DFD Level 1

4.2.3 Use Case UML Diagram

5. Other Requirements

5.1 Performance Requirements

Performance Requirement 1	The system shall process and classify a single product image within 2 seconds under normal load conditions. This response time shall be maintained for up to 100 concurrent users.
Performance Requirement 2	The text review analysis module shall process and analyze up to 1000 reviews within 5 seconds, including sentiment analysis and key phrase extraction.
Performance Requirement 3	The system shall support a minimum of 1000 simultaneous users without degradation in performance. Load testing shall be conducted regularly to ensure scalability.
Performance Requirement 4	The deep learning models shall be optimized for inference, utilizing GPU acceleration where available to maintain rapid response times.

5.2 Safety Requirements

Safety Requirement 1	The system shall implement strict data handling protocols to ensure user privacy. Product images and review text shall be anonymized and securely stored, with all personally identifiable information (PII) removed or encrypted.
Safety Requirement 2	Regular data backups shall be performed, with a recovery time objective (RTO) of 4 hours and a recovery point objective (RPO) of 1 hour to minimize data loss in case of system failures.

5.3 Security Requirements

Security Requirement 1	All data transmission between client and server shall be encrypted using TLS 1.3 or later protocols to ensure data confidentiality and integrity.
Security Requirement 2	User authentication shall be implemented using industry-standard protocols such as OAuth 2.0. Multi-factor authentication shall be available for admin accounts.
Security Requirement 3	The system shall undergo quarterly security audits and penetration testing. Any identified vulnerabilities shall be addressed within 30 days of discovery.
Security Requirement 4	Access to the system's APIs shall be controlled through API keys and rate limiting to prevent abuse and ensure fair usage

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