

A Sentiment-Enhanced AI Framework for Intelligent E-Commerce Recommendations

Course: CIS 731
Description: Term Project
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Professor: Dr. William Hsu

Presented By



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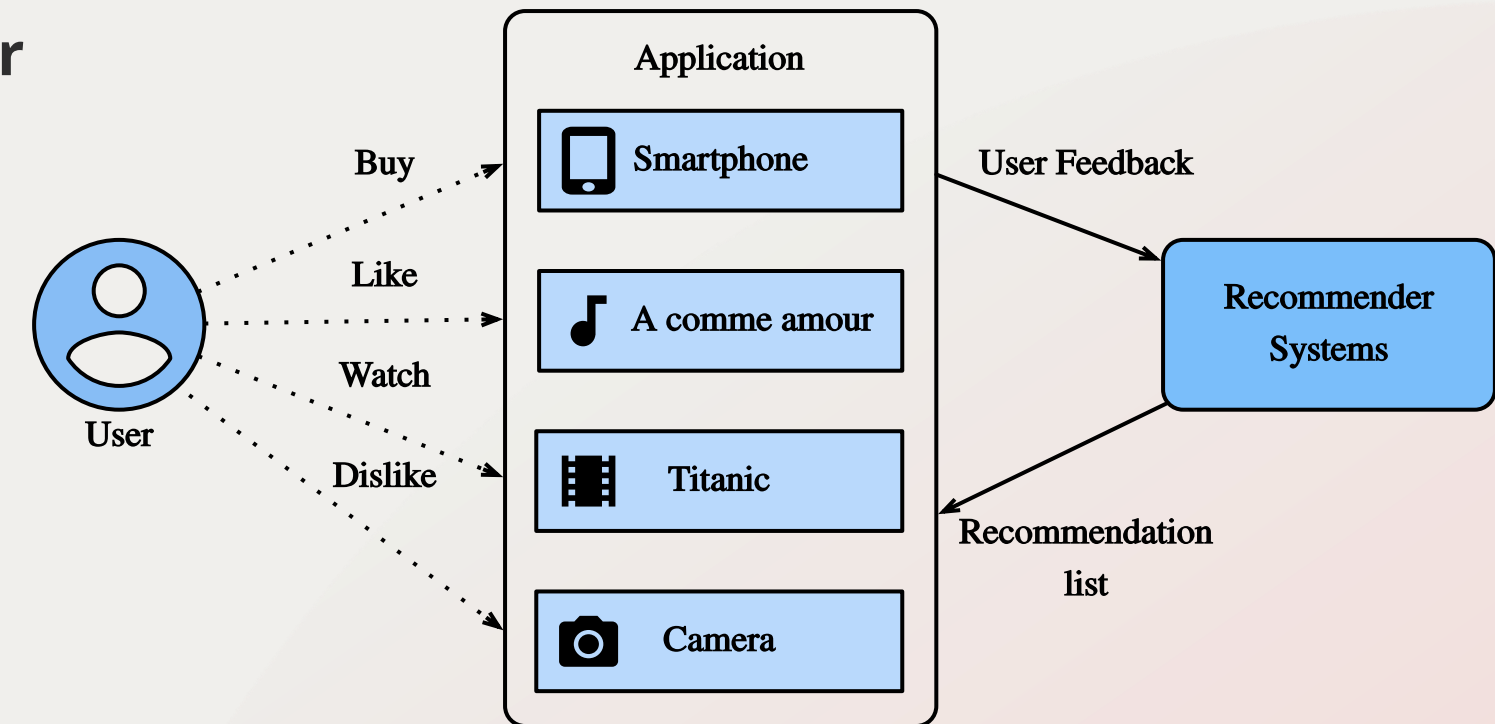
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Project Problem and Motivation

In the world of e-commerce, recommending the right products to customers is essential for creating a smooth and satisfying shopping experience. However, many traditional recommendation systems fail to address an important aspect of consumer behavior which is emotion (Zhang et al., 2022).

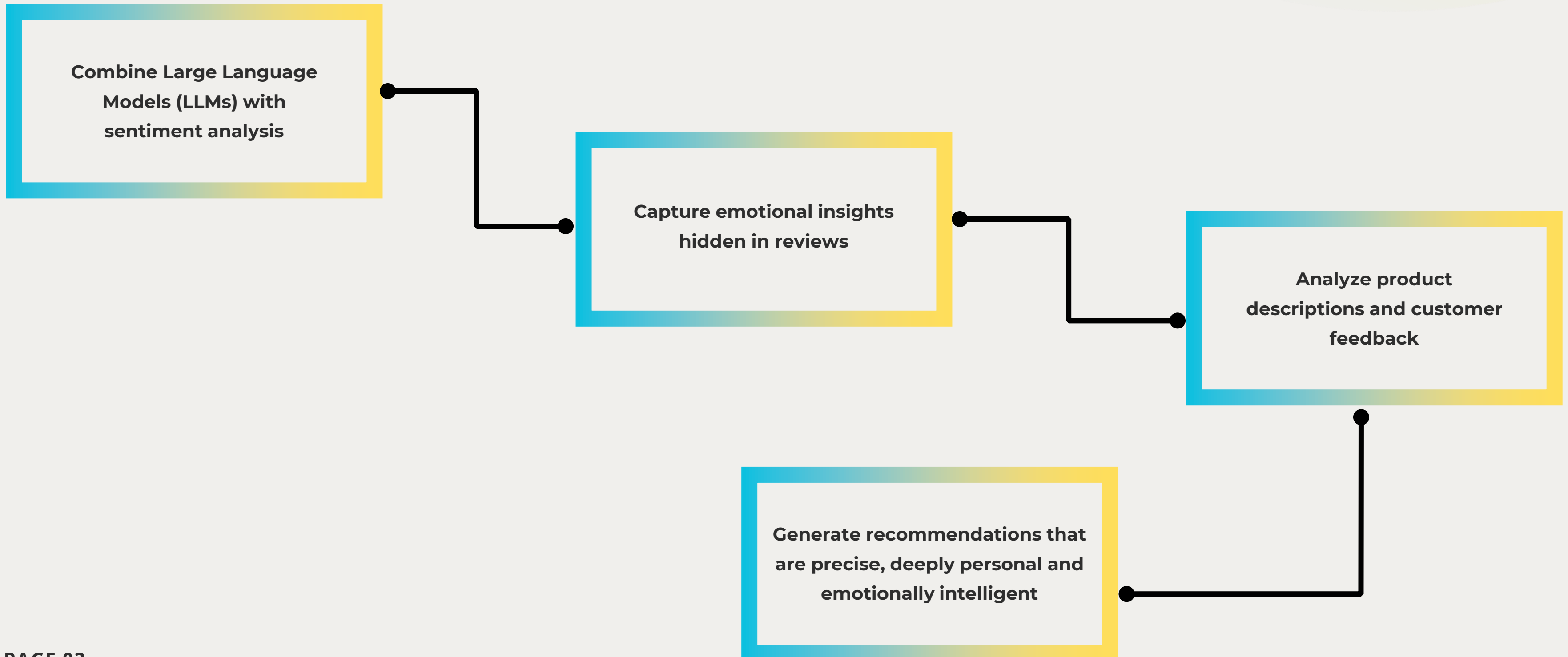
Key Limitations of Traditional Systems:

- ✦ Focus only on:
 - Past user actions
 - Product attributes
- ✦ Miss critical emotional context of user experiences
- ✦ Unable to understand why customers like or dislike products



Project Objective

Core Goal: Creating a recommendation system that goes beyond simply tracking user behavior



Methodology - Dataset

Dataset: Amazon-Reviews-2023 from Hugging Face (McAuley-Lab, 2023)

● Millions of user reviews across multiple product categories

● Includes detailed:

- Product descriptions
- Customer feedback
- Emotional context

● Data Split:

- 72% Training data
- 18.6% Testing data
- 9.4% Validation data

This is a large-scale **Amazon Reviews** dataset, collected in 2023 by [McAuley Lab](#), and it includes rich features such as:

1. **User Reviews** (*ratings, text, helpfulness votes, etc.*);
2. **Item Metadata** (*descriptions, price, raw image, etc.*);
3. **Links** (*user-item / bought together graphs*).

```
DatasetDict({
  train: Dataset({
    features: ['text', 'label', 'label_text'],
    num_rows: 8544
  })
  validation: Dataset({
    features: ['text', 'label', 'label_text'],
    num_rows: 1101
  })
  test: Dataset({
    features: ['text', 'label', 'label_text'],
    num_rows: 2210
  })
})
```

Embedding and Sentiment Analysis

✿ Embedding Generation:

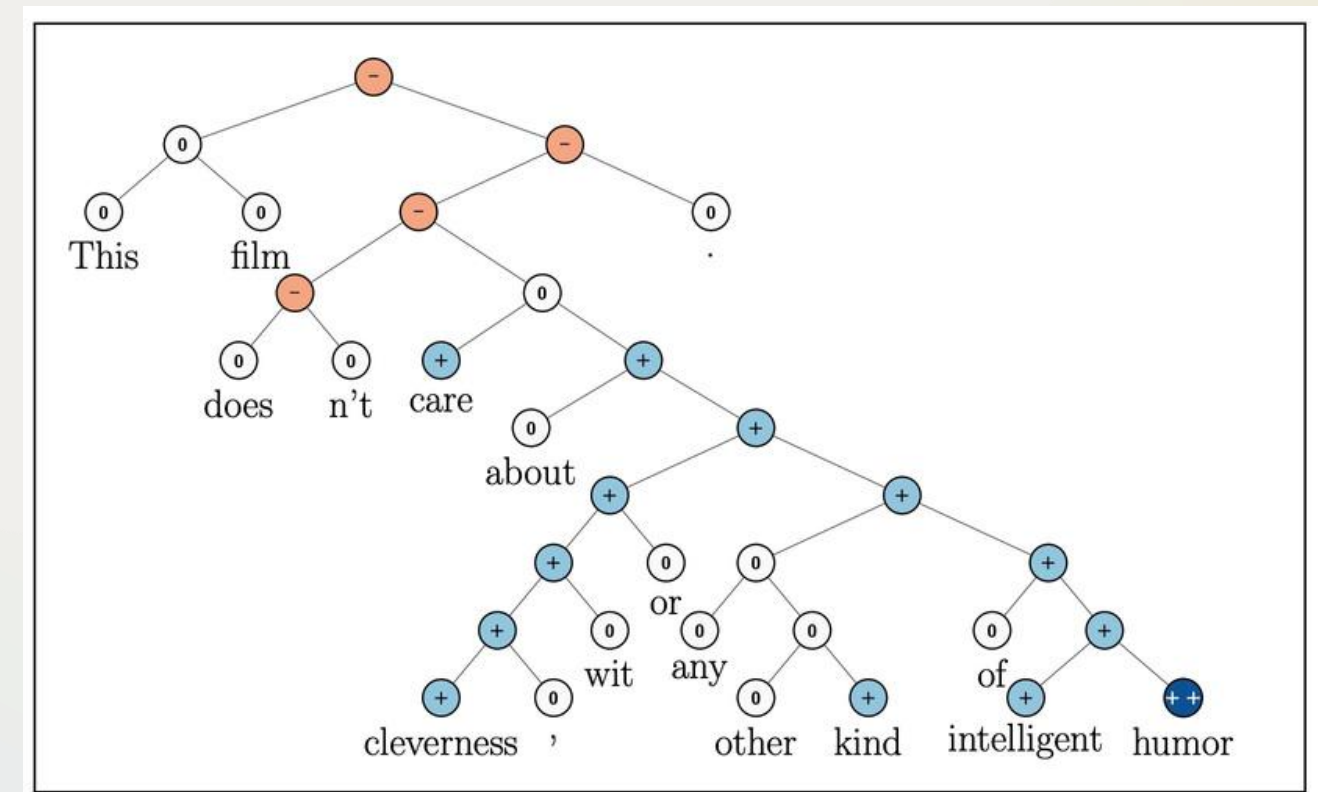
- Model: **all-MiniLM-L6-v2 SentenceTransformer (Devlin et al., 2019)**
- Converts product descriptions to semantic vectors
- Extracts key product attributes:
 - Product type
 - Functionality
 - Usage characteristics

all-MiniLM-L6-v2

This is a [sentence-transformers](#) model: It maps sentences & paragraphs to a 384 dimensional dense vector space and can be used for tasks like clustering or semantic search.

✿ Sentiment Analysis:

- Model: **SST5 pre-trained model**
- Sentiment Categories:
 - Very Negative
 - Negative
 - Neutral
 - Positive
 - Very Positive
- Assigns emotional scores to products based on reviews



Sentiment Treebank

Recommendation Engine Architecture

Key Technologies:

- Llama 3 (Language Model)
 - Generates initial product suggestions
 - Identifies complex product connections
- FAISS (Facebook AI Similarity Search) (Johnson & Wichern, 2019)
 - Efficient product embedding comparison
 - Quick retrieval of relevant products



Recommendation Process:

- Generate initial suggestions using Llama 3
- Filter and refine using FAISS
- Prioritize products with positive sentiment
- Ensure emotional and functional relevance

facebookresearch/ faiss



A library for efficient similarity search and clustering of dense vectors.

166
Contributors

4k
Used by

222
Discussions

32k
Stars

4k
Forks

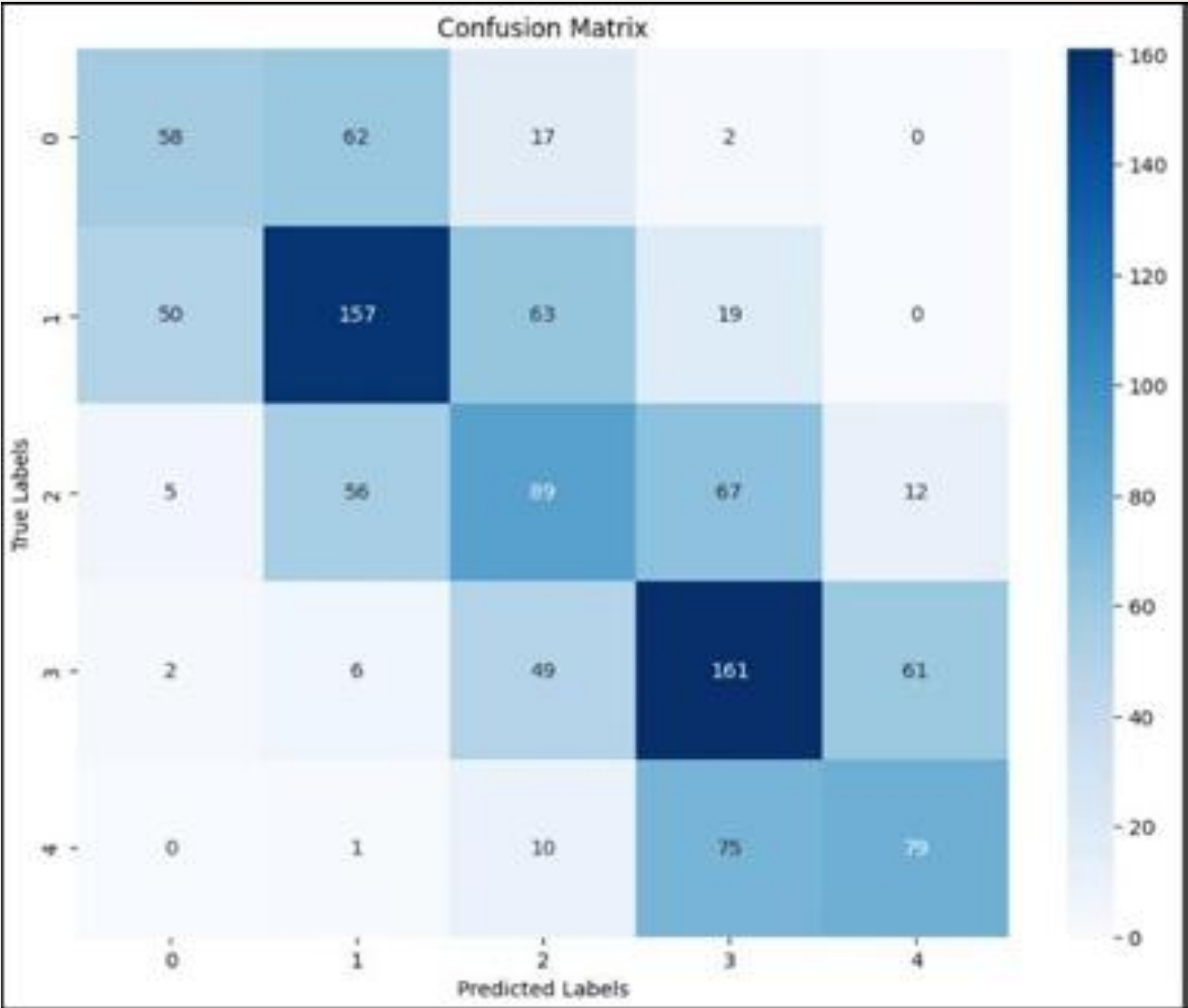


Performance Metrics

**Sentiment Classification Results for
DistilBERT(Devlin et al., 2019):**
Precision: 0.4948 (49.48%)
Recall: 0.4941 (49.41%)
F1-Score: 0.4930 (49.30%)

Confusion Matrix Insights:
Best Performing Class: Class 3 (161 correct predictions)
Weakest Performing Class: Class 0 (58 correct predictions)
Common Misclassifications:
Class 0 often misclassified as Class 1
Class 3 frequently confused with Class 4

```
Precision: 0.4948
Recall: 0.4941
F1-Score: 0.4930
Confusion Matrix:
[[ 58  62  17   2   0]
 [ 50 157  63  19   0]
 [  5  56  89  67  12]
 [  2   6  49 161  61]
 [  0   1  10  75  79]]
ROC-AUC: Not applicable for this task.
```



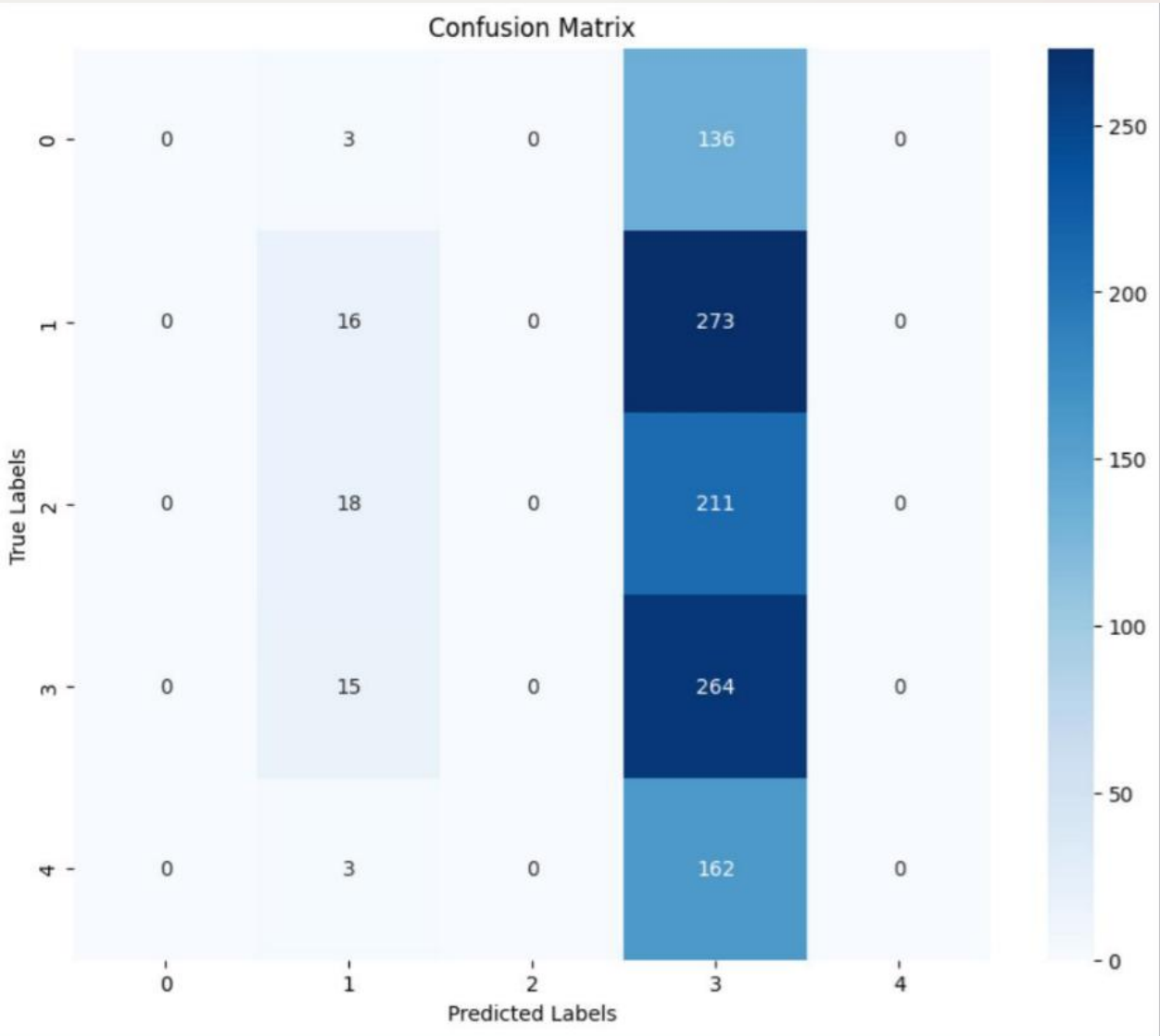
Performance Metrics

**Sentiment Classification Results for
BERT(Devlin et al., 2019):**
Precision: 0.1403 (14.03%)
Recall: 0.2543 (25.43%)
F1-Score: 0.1254 (12.54%)

Precision: 0.1403
Recall: 0.2543
F1-Score: 0.1254
Confusion Matrix:
[[0 3 0 136 0]
 [0 16 0 273 0]
 [0 18 0 211 0]
 [0 15 0 264 0]
 [0 3 0 162 0]]
ROC-AUC: Not applicable for this task.

Confusion Matrix Insights

Best Performing Class: Class 3 (Positive) with a significant bias, but with minimal correct prediction.
Weakest Performing Class: Class 3 (Positive) with only 3 correct predictions.
Common Misclassifications: The model is biased towards Class 3 (Positive), with heavy misclassifications from Class 0 (136), Class 1 (273), Class 2 (211), and Class 4 (162), all predicted as Class 3. Even Class 3 has 264 misclassifications.



Model Comparison: BERT vs. DistilBERT

BERT's Performance

Precision: 0.1403

Recall: 0.2543

F1-Score: 0.1254

Struggled with sentiment classification, biased towards neutral sentiment.



DistilBERT's Performance

Precision: 0.4948

Recall: 0.4941

F1-Score: 0.4930

Outperformed BERT with balanced predictions and better generalization.

Key Factors:

- BERT: Larger model, requires more fine-tuning and computational resources.
- DistilBERT: Smaller, faster, more efficient, and better at generalizing with fewer resources.

Recommendation Example Contin.....

Scenario: Beauty & Personal Care Products

User's Previous Purchases:
Leather Conditioner
Skin Moisturizer
Organic Hair Growth Serum

You are an AI assistant functioning as a recommendation system for an e-commerce website specializing in beauty and personal care products. The dataset contains product categories such as skincare, haircare, and grooming items, with detailed descriptions and user reviews. Be specific and limit your answers to the requested format. Recommend 5 products likely to appeal to a customer who has purchased the following items: Eye Lashes, Hand cream, and lip balm. Ensure the recommendations are diverse but relevant, spanning complementary beauty or personal care items. Express your response as a JSON object with an array of 'next_items', where each item includes: # 'title': The product name. 'category': The product category (e.g., skincare, haircare, grooming). 'description': A short description of the product. Do not include product id.



GPT4All Llama 3 8B Instruct

Based on the customer's purchase history (Eye Lashes, Hand cream, and lip balm), I've generated a set of recommendations that are diverse yet relevant to their beauty interests. Here's my response as a JSON object:

```
{
  "next_items": [
    {
      "title": "Hydrating Face Mist",
      "category": "skincare",
      "description": "A gentle, fragrant mist for the face and neck that hydrates and tones the skin while priming it for makeup application."
    },
    {
      "title": "Nourishing Shampoo Bar",
      "category": "haircare",
      "description": "A gentle, sulfate-free shampoo bar made with moisturizing ingredients to cleanse and condition hair without stripping its natural oils."
    },
    {
      "title": "Exfoliating Body Scrub",
      "category": "grooming",
      "description": "An exfoliating scrub gently removes dead skin cells while nourishing the skin with antioxidants, leaving it soft and smooth."
    },
    {
      "title": "Rejuvenating Serum for Dry Skin",
      "category": "skincare",
      "description": "A lightweight serum that deeply hydrates dry or sensitive skin using natural ingredients like hyaluronic acid, glycerin, and green tea extracts."
    },
    {
      "title": "Soft Focus Highlighting Powder",
      "category": "beauty accessories",
      "description": "A sheer highlighting powder that adds a touch of warmth to any look without looking too sparkly or shiny. Use it on cheekbones, cupid's bow, brow bone, or inner corners for a radiant glow."
    }
  ]
}
```

Recommendation Example

System Recommendations:

Hydrating Face Mist (Skincare)

Nourishing Shampoo Bar (Haircare)

Exfoliating Body Scrub (Grooming)

Rejuvenating Serum for Dry Skin (Skincare)

Soft Focus Highlighting Powder (Beauty Accessories)

```

Notebook exited: {
  "specific_recommendations": [
    {
      "parent_asin": "B00LF4P5N2",
      "title": "HSG Fashion Wigs Hair Short Blonde Girl Cute Sweet Curly Hair Wigs with Bangs Wavy Ends in 37cm 220g",
      "score": 3.0
    },
    {
      "parent_asin": "B01M0ZCEE0",
      "title": "essence extreme lasting eye pencil waterproof (03 Black Midnight Sky)",
      "score": 3.0
    },
    {
      "parent_asin": "B01M9ALSWQ",
      "title": "Roccobarocco Black by Roccobarocco Eau De Parfum Spray 3.4 oz Women",
      "score": 3.0
    },
    {
      "parent_asin": "B08B3M2V12",
      "title": "Can adjust the size,Washable Reusable Cartoon bears cotton dustproof for children Light Blue (1PCS)",
      "score": 3.0
    },
    {
      "parent_asin": "B0951VQN6B",
      "title": "Beynest 2PCS Brow Pencil Tatbrow Microblading Eyebrow Pen Natural Tattoo Eyebrow Pen\uff0cWaterproof Eyebrow Pencil for Lasting All Day Black",
      "score": 3.0
    },
    {
      "parent_asin": "B07SRWP678",
      "title": "Jaciya 15 Pack Hair Elastics Scrunchies Chiffon Hair Scrunchies Hair Bow Chiffon Ponytail Holder Bobbles Soft Elegant Elastic Hair Bands Hair Ties, 15 Colors (15 Pack Bow Scrunchies)",
      "score": 2.6666666666666665
    },
    {
      "parent_asin": "B01GIZVP2W",
      "title": "Aeeque 5pcs the Soft Flexible Silicone Wearable Nail Polish Varnish Bottle Holder Ring for Female Women Girls - Blue + Green + Hot Pink + Black + Purple",
      "score": 2.6153846153846154
    },
    {
      "parent_asin": "B07VBQHRFF",
      "title": "TOBATOPA 6 Pack Velvet Wide Headbands Knot Turban Vintage Headband with Faux Pearl Elastic Hair Hoops Hair Accessories for Women,6 Colors",
      "score": 2.6
    },
    {
      "parent_asin": "B001AWYUY4",
      "title": "Himalayan Herbal Incense - Tibetan Traditional",
      "score": 2.5
    },
    {
      "parent_asin": "B07X1R8PNX",
      "title": "4pcs Post Malone Temporary Tattoo and 2pcs Large Death Eaters Dark Mark Skull Temporary Tattoo for Costume Parties and Halloween",
      "score": 2.5
    }
  ]
}
```

Product Recommendations Output With Sentiment Score

Key Achievements

- **Developed hybrid recommendation system**
- **Successfully integrated sentiment analysis**
- **Created scalable cloud-based architecture**
- **Demonstrated potential for emotionally intelligent recommendations**
- **Balanced product features with emotional context**



Future Work



- **Improve sentiment classification accuracy**
- **Implement real-time user preference adaptation**
- **Add image and video review analysis**
- **Optimize scalability for larger product catalogs**
- **Enhance personalization techniques**
- **Explore cross-cultural sentiment analysis**

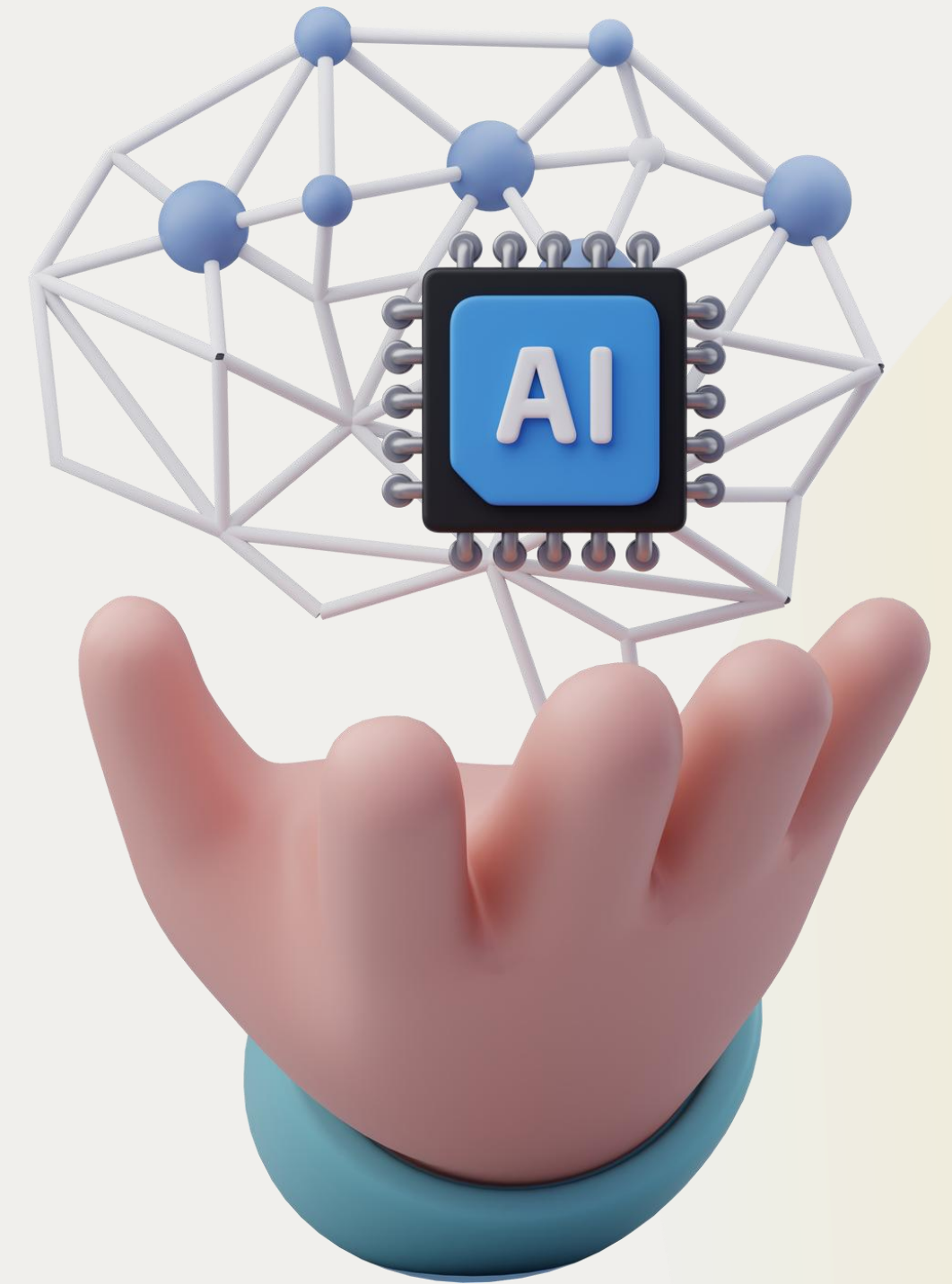
Conclusion

Key Takeaways:

- Recommendations should understand data and feelings
 - AI can capture nuanced user preferences
 - Emotional context is crucial in personalization
-

Future Direction:

- Continuous improvement of AI's emotional intelligence
- Push boundaries of personalized shopping experiences



Thank You



QUESTIONS?

References

- [1] **Devlin**, J., Chang, M. W., Lee, K., & Toutanova, K. (2019). BERT: Pre-training of deep bidirectional transformers for language understanding. Proceedings of NAACL-HLT 2019, 4171-4186.
<https://doi.org/10.18653/v1/N19-1423>
- [2] **Zhang**, Y., Wang, S., & Li, Z. (2022). A survey of sentiment analysis in e-commerce applications. International Journal of Machine Learning, 30(2), 125-140. <https://doi.org/10.1007/s10994-022-05853-0>
- [3] **McAuley-Lab**. (2023). Amazon-Reviews-2023 [Dataset]. Hugging Face. Retrieved from <https://huggingface.co/datasets/McAuley-Lab/Amazon-Reviews-2023>
- [4] **Johnson**, J., & Wichern, D. (2019). FAISS: A library for efficient similarity search and clustering of dense vectors. Journal of Machine Learning Research, 20(1), 289-296.