

An Integrated Deep Learning Approach for Intelligent Customer Grievance Handling

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Abstract

Effectively managing customer complaints is a critical part of running any service-oriented business. How quickly and accurately grievances are addressed can directly affect customer satisfaction and loyalty. Traditional complaint handling systems, which often rely on manual processing or rigid rule-based methods, struggle to cope with the growing number and diversity of complaints coming from multiple digital channels.

This paper proposes a **holistic framework** for automating customer grievance analysis using deep learning. The system combines multiple advanced techniques, including **multimodal inputs, multilingual and cross-lingual processing, sarcasm and mixed sentiment detection, domain-specific adaptation, customer history context, hierarchical classification, aspect-based sentiment analysis, and explainable AI**, into a single framework. By bringing these elements together, the framework aims to provide faster, more accurate, and more transparent complaint resolution, helping organizations respond efficiently to customers while building trust.

Keywords: Customer Grievance, Deep Learning, Multimodal Analysis, Sentiment Analysis, Explainable AI, Cross-Lingual NLP, Aspect-Based Sentiment

1. Introduction

Organizations today receive customer complaints through a variety of channels, including emails, chat systems, online portals, social media, and even voice messages. These complaints often come in different languages, formats, and emotional tones, which makes automated processing challenging. Traditional systems, whether manual or keyword-based, often struggle to understand the **context or the real intent behind the complaint**.

Recent advances in **deep learning and natural language processing (NLP)** allow computers to better understand text and speech in context. Modern models can pick up on subtle meanings, mixed sentiments, and domain-specific language, providing a much deeper understanding of customer grievances.

In this paper, we propose a **conceptual framework** that integrates multiple advanced techniques to handle grievances more intelligently. By combining contextual understanding, sentiment analysis, multilingual support, multimodal input processing, and explainable AI, the framework is designed to **make complaint handling faster, more accurate, and more transparent**.

2. Related Work

Early systems relied on simple rule-based methods that matched keywords to categories. While fast and simple, these systems were **rigid** and often misunderstood complaints that used different phrasing or complex language.

Machine learning models such as Naïve Bayes, Support Vector Machines, and Random Forests improved this by learning patterns from past complaints. However, they still struggled with context, sarcasm, and domain-specific terms.

Recently, deep learning techniques, especially transformer-based models, have shown strong performance in **sentiment analysis, aspect-based classification, and multilingual understanding**. Some systems also use multimodal data like text and images for complaint classification. But no single system combines **all the critical elements**—multimodality, multilingual support, sarcasm detection, domain adaptation, context, hierarchical classification, aspect-based sentiment, and explainability—into a **single unified framework**.

3. Proposed Framework

3.1 Overview

We propose a **modular, end-to-end workflow** that can process complaints in real time or in batches. The goal is to take complaints from multiple sources and turn them into actionable insights for support teams.

Workflow:

**Complaint Input → Text Pre-processing
→ Contextual Embeddings → Sarcasm &**

Mixed Sentiment Detection → Domain & Customer Context → Hierarchical Classification → Aspect-Based Sentiment & Severity → Explainable AI → Automated Routing & Escalation

3.2 Multimodal Complaint Input

The system can handle complaints that come in:

- **Text:** Emails, chat logs, social media posts
- **Audio:** Voice complaints or call recordings
- **Images:** Screenshots of receipts, error messages, or apps

By processing these different types of data together, the system gains a **richer understanding of customer issues**.

3.3 Text Pre-processing & Contextual Embeddings

Text is cleaned, normalized, and tokenized. Modern deep learning models (like multilingual BERT or XLM-R) then convert the text into embeddings that capture meaning, context, and relationships between words. Audio and image data are processed using neural networks and fused with text embeddings to provide a **complete multimodal understanding**.

3.4 Sarcasm, Irony, and Mixed Sentiment Detection

Many complaints are not straightforward— they can be sarcastic, ironic, or express mixed emotions. A dedicated module detects these subtle cues, ensuring the system doesn't misinterpret the complaint and can prioritize responses appropriately.

3.5 Domain-Specific & Customer Context

The system adapts to different industries, like telecom, banking, or healthcare, recognizing domain-specific terms. It also leverages **historical data and previous interactions** to understand the customer's context and improve complaint handling.

3.6 Hierarchical Classification & Aspect-Based Sentiment Analysis

- **Hierarchical Classification:** Complaints are first grouped into broad categories (e.g., billing, service, delivery) and then broken into subcategories (e.g., late payment, faulty product).
- **Aspect-Based Sentiment:** Each part of the complaint is analysed separately, allowing organizations to see which aspects require urgent attention.

3.7 Explainable AI Layer

The framework highlights which words, phrases, or features influenced decisions, making it easy for human reviewers to understand and trust the system. This ensures **ethical, transparent, and accountable complaint handling**.

3.8 Real-Time Routing & Escalation

Based on category, severity, and sentiment, complaints are automatically routed to the right team. Urgent issues are prioritized, ensuring **faster resolution and better customer satisfaction**.

4. Evaluation Metrics

Since the system is conceptual, evaluation is theoretical:

- **Classification Accuracy:** How many complaints are correctly categorized
- **Precision, Recall, F1-Score:** Measures of accuracy and completeness
- **Sentiment Accuracy:** How well emotions are identified, including sarcasm
- **Aspect-Level Sentiment Accuracy:** Accuracy of sentiment detection per complaint aspect
- **Real-Time Performance:** How quickly complaints are processed
- **Explainability Score:** How interpretable the system's decisions are
- **Cross-Lingual Robustness:** Accuracy across multiple languages

5. Conclusion

This paper introduces a **comprehensive framework for customer grievance analysis**, integrating eight advanced concepts into a single system. By combining **multimodal and multilingual processing, sarcasm detection, domain and customer context, hierarchical classification, aspect-based sentiment, and explainable AI**, the framework offers a solution that is **scalable, transparent, and adaptable**, addressing key limitations of existing systems.

This approach promises to **speed up complaint resolution, improve accuracy, and enhance customer trust**, making it highly relevant for modern customer service environments.

6. Future Work

1. Deploying the system in real-world environments with large-scale complaints
2. Using reinforcement learning for dynamic complaint routing
3. Improving multimodal fusion with attention-based mechanisms
4. Creating dashboards for proactive complaint monitoring
5. Developing domain-specific pre-trained models for different industries

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