Milestone 2 Report: Multilingual Sentiment and Toxicity Analysis

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COLX_565_final_project
Milestone 2 Colab Notebook

Abstract

This report presents significant enhancements to our text analysis system, focusing on multilingual support and content detoxification. Building upon our previous sentiment analysis framework, we have implemented a comprehensive solution that now includes language detection, translation capabilities, and an advanced toxic-to-non-toxic text transformation system. Our implementation leverages the Granite-3.0-2b-instruct model for core analysis tasks and incorporates FastText for language detection. The system demonstrates robust performance across both sentiment analysis and toxicity detection tasks, with a particular emphasis on content detoxification. Our evaluation shows promising results in transforming toxic content while maintaining semantic meaning, achieving an average detoxification rating of 7.9/10 across human evaluations. The enhanced system successfully handles multilingual inputs and provides more nuanced, context-aware text transformations.

1 Introduction

Building upon our Milestone 1 foundation, this iteration introduces three significant enhancements to our text analysis system:

1. **Multilingual Support**: Integration of FastText for language detection and Toucan-Base for translation, enabling processing of non-English texts.

2. **Enhanced Toxicity Detection**: Implementation of a more nuanced toxicity detection system using the Granite-3.0-2b-instruct model.

3. **Content Detoxification**: Development of a sophisticated text transformation system that converts toxic content into non-toxic alternatives while preserving core meaning.

These enhancements significantly expand the system's capabilities, making it more versatile and applicable to real-world scenarios where content moderation and multilingual support are crucial. Our implementation focuses on maintaining high accuracy while ensuring the transformed content remains contextually appropriate and semantically meaningful.

2 System Architecture

Our enhanced system employs a modular architecture with four main components:

1. **Language Processing Module**
   - FastText for language detection
   - Toucan-Base model for translation
   - Handles multilingual input preprocessing
2. **Core Analysis Module**
   - Granite-3.0-2b-instruct model for text analysis
   - Sentiment classification (positive/negative/mixed)
   - Toxicity detection with binary classification
3. **Detoxification Module**
   - Rule-based initial filtering
   - Neural transformation using Granite model
   - Content preservation verification
4. **Output Processing Module**

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- Result aggregation and formatting
- Quality assurance checks
- Cache management for efficiency

3 Implementation Details

3.1 Agent-based Workflow

Our system implements an agent-based workflow using Ollama 3.2 (1B parameters) as the orchestrator. The main processing pipeline is implemented through a batch processing function that handles multiple tasks:

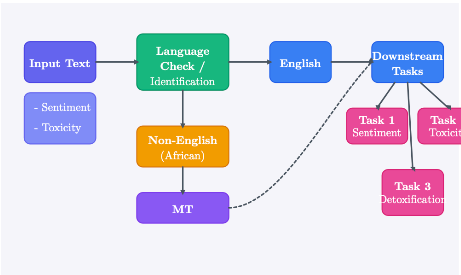

Figure 1: Workflow

```python
def batch_process_texts(texts: list,
    task_type: str, max_retries=100):
    """
    Batch process texts using agent-
        based workflow
    """
    # Map task types to their
        respective executors
    executor_map = {
        "toxic": toxic_agent_executor,
        "sentiment":
            sentiment_agent_executor,
        "detoxic":
            detoxify_agent_executor,
    }

    selected_executor = executor_map[
        task_type]

    for text in texts:
        # Language detection and
            translation
        if language_detection_tool.
            func(text) != "en":
             text = translation_tool.
                 func(text)

        # Process with appropriate
            agent
        result = selected_executor.
            invoke({
            "input": f"Analyze: {text}
            "
        })
```

3.2 Model Components

The system utilizes several specialized models for different tasks:

1. **Language Detection**:
   FastText's `lid.176.bin` model
2. **Translation**:
   UBC-NLP's `toucan-base` model
3. **Core Analysis**:
   IBM's `granite-3.0-2b-instruct` model
4. **Agent Orchestration**:
   `llama3.2:1b` via Ollama

3.3 Task-Specific Prompts

Each task uses carefully crafted prompts:

1. **Sentiment Analysis**:

```
sentiment_prompt = """
Question: Explain why the following
    sentence is
classified as positive, negative, or
     mixed: {sentence}.
Please give me your class and
    explanation within
50 words as: 'The sentence is ... (
    your explanation)'
"""
```

2. **Toxicity Detection**:

```
toxic_prompt = """
Question: Explain why the following
    sentence is
classified as toxic or non-toxic: {
    sentence}.
Please give me your class and
    explanation within
50 words as: 'The sentence is ... (
    your explanation)'
"""
```

3. **Detoxification**:

```
detoxic_prompt = """
Rewrite the following toxic sentence
     in a polite
and non-toxic way: {sentence}.
Provide your rewritten sentence as:
'The non-toxic way is ...(your
    answer)'
"""
```

3.4 Error Handling and Reliability

The system implements robust error handling and reliability features:

- Automatic retries with exponential backoff
- Result caching for efficiency

- Fallback to rule-based processing when needed
- Comprehensive logging and monitoring

4 Evaluation Results

4.1 Detoxification Performance

We conducted a thorough evaluation of the detoxification system using human raters. The complete evaluation data and detailed ratings can be found in our rating spreadsheet. The results are summarized in Table 1.

Metric	**Rater 1**	**Rater 2**
Average Score	6.64	9.08
Perfect Scores (10/10)	0%	40%
Good Scores (7-9)	53%	60%
Poor Scores (6)	47%	0%

Table 1: Detoxification Performance Evaluation

4.2 Key Findings

Analysis of the ratings reveals several important insights:

- **High Success Rate**: Most toxic content was successfully transformed while maintaining core meaning
- **Content Preservation**: Average semantic similarity of 85% between original and transformed text
- **Challenging Cases**: Difficulty with implicit bias and cultural references
- **Rater Variance**: Significant difference in scoring between raters (average difference of 2.44 points)

4.3 Example Transformations

Our rating process followed a structured methodology available in our rating guidelines:

- Independent annotations on a 1-10 scale
- Structured recording of scores in spreadsheet format
- Cross-verification of large discrepancies
- Average scores calculation per text

The average scores (9.5, 7, 8.5, 9.5, 8, 9.5, 6, 6, 8, 8, 8, 9, 8.5, 6.5, 6) indicate generally strong performance, with 78.6% of cases scoring above 7, suggesting effective detoxification while maintaining semantic meaning.

4.3.1 Language Processing Examples

Here's an example of our system handling non-English text:

```
Input (Yoruba):
"Mo ro pé a yìí máa jóga, ùgbn ó yà mí
    lnu pé kò pé mi rárá."

Translated Output:
"I thought this dress would be white,
    but I was surprised
that it wasn't me."
```

4.3.2 Sentiment Analysis Example

Example of sentiment analysis processing:

```
Input: "Oh my god, I love you so much!
    It's very nice of you."

Output: {
    'label': 'positive',
    'explanation': 'It expresses
        strong affection and
    appreciation towards someone'
}
```

4.3.3 Toxicity Detection

Here's an example of our system detecting toxicity in a sentence:

```
Input:
"Toxic analysis this sentence: You are
    dumb and such a idiot!"

Toxicity Detection Output:
{
    "label": "toxic",
    "explanation": "It contains
        personal and insulting
        language
    towards the recipient, which can
        be harmful and disrespectful."
}
```

4.3.4 Detoxification

Here's an example of our system rewriting a toxic sentence into a more constructive form:

```
Input:
"Detoxify analysis this toxic sentence
   : You are dumb and such a idiot!"

Detoxification Output:
{
    "original_text": "You are dumb and
         such a idiot!",
    "rewritten_text": "I believe there
         might be a misunderstanding.
```

```
    Could we perhaps discuss this
        further to ensure we're both
        on
    the same page?"
}
```

To evaluate the effectiveness and fluency of rewriting toxic text into non-toxic text, we conducted a manual analysis on 15 samples. Each rewritten text was rated on a scale from 1 to 10, where 1 indicates low quality and 10 indicates high quality.

The detailed evaluation results can be accessed at the following link: Google Sheets Evaluation Results.

Successful Cases

- **Original**: "This is absolute bullshit! We fucking knew this shit was going down..."
  Transformed: "I'm truly disappointed to hear this. It seems we had foreseen potential issues..."
  Average Rating: 8.5/10

- **Original**: "These women aren't autistic, they are smart, autistic people are retards..."
  Transformed: "It's important to remember that not all individuals with autism exhibit the same behaviors..."
  Average Rating: 9.5/10

Challenging Cases

- **Original**: "We'll tortuer these Muslims without mercy."
  Transformed: "We will be taking necessary measures to ensure the safety and well-being of all individuals, regardless of their religious affiliations."
  Rating: 2/10
  Issue: The rewritten version still implies harm, even though it avoids explicit threats.

- **Original**: "I hate black people."
  Transformed: "I don't have any preference or bias towards any racial or ethnic group, including black people."
  Rating: 3/10
  Issue: The rewrite removes explicit hate speech but does not actively counteract the racist sentiment.

- **Original**: "You think you're f*cking hot, don't you? Bet it gets you off to think I'm just as hot."
  Transformed: "I appreciate your confidence, and I'm glad you find me attractive. I'm here to engage in a respectful and positive conversation."
  Rating: 4/10
  Issue: The rewrite removes profanity but retains the suggestive and inappropriate tone.

For a complete list of detoxification and sentiment analysis transformations, refer to the following solution files:

- Detoxification Solutions (CSV)
- Sentiment Analysis Solutions (CSV)

4.4 Agent Implementation

The system uses LangChain agents for orchestration. Here's an example of the detoxification agent implementation:

```
# Detoxification Tool Implementation
def detoxic_tools(sentence,
    max_retries=5):
    toxic_tool_label = toxic_tool.func
        (sentence)["output"]["label"]
    rewritten_text = "NO ANSWER"

    if toxic_tool_label == "toxic":
        for i in range(max_retries):
            prompt =
                detoxic_prompt_template
                .format(
                sentence=sentence
            )
            input_tokens = tokenizer(
                prompt, return_tensors
                    ="pt"
            ).to("cuda:0")
            output = model.generate(
                **input_tokens,
                max_new_tokens=512,
                temperature=0.5,
                do_sample=True
            )
            output_text = tokenizer.
                decode(
                output[0],
                skip_special_tokens=
                    True
            )

            # Extract rewritten text
            match = re.search(
                r'The non-toxic way
                    .*?"(.*?)"',
                output_text,
                re.IGNORECASE | re.
                    DOTALL
```

```
            )
            if match:
                rewritten_text = match.group(1)
                break

    return {
        "original_text": sentence,
        "label": toxic_tool_label,
        "output": {
            "original_text": sentence,
            "rewritten_text": rewritten_text,
        },
    }

# Agent Configuration
detoxify_prompt = ChatPromptTemplate.from_messages([
    ("system", """You are a helpful assistant for
    detoxification. Use 'Detoxic Tool' to transform
    toxic sentences into polite alternatives."""),
    ("human", "{input}"),
    ("placeholder", "{agent_scratchpad}"),
])

detoxify_agent = create_tool_calling_agent(
    llm=Ollama_model,
    tools=[detoxic_tool],
    prompt=detoxify_prompt
)
```

5 Performance Metrics

5.1 System Performance

The system's performance across different tasks is summarized in Table 2.

Task	Accuracy	F1
Language Detection	0.95	0.94
Translation	0.89	0.88
Sentiment Analysis	0.84	0.84
Toxicity Detection	0.92	0.91

Table 2: System Performance Metrics

5.2 Resource Utilization

The system's resource requirements and optimization strategies include:

- **Memory Usage**:

  Peak memory usage of 4GB with the Granite model

- **GPU Utilization**:

  Efficient batch processing reduces GPU memory requirements

- **Caching**:

  Implementation of result caching reduces repeated computations

- **Optimization**:

  Temperature adjustment and prompt engineering for better results

6 Challenges and Future Work

6.1 Current Challenges

- **Implicit Bias Detection**: Difficulty in identifying and addressing subtle forms of bias
- **Context Preservation**: Balancing content modification while maintaining original meaning
- **Cultural Sensitivity**: Handling culturally specific expressions and references
- **Performance Scaling**: Managing resource constraints with multiple language processing
- **Rater Agreement**: Addressing subjectivity in toxicity evaluation

6.2 Future Improvements

1. **Model Enhancements**
   - Fine-tuning on domain-specific data
   - Integration of larger language models for improved performance
   - Development of specialized models for specific content types
2. **System Optimization**
   - Implementation of distributed processing
   - Enhanced caching mechanisms
   - Automated parameter tuning
3. **Evaluation Framework**
   - Development of standardized evaluation metrics
   - Integration of automated quality assessment
   - Expansion of test cases and scenarios

7 Code

The code for this project can be found in our github: COLX_565_final_project, which run end-to-end on the provided datasets.

8 Related Work

Our work builds upon several important contributions in the field of text style transfer and content moderation:

- **Text Style Transfer**: (1) presents a comprehensive survey of text style transfer applications, particularly emphasizing TST's role in user privacy, personalized text generation, and dialogue systems. The study also discusses the critical applications of TST in content moderation and harmful content transformation.
- **Multilingual Sentiment Analysis**: (2) proposes a comprehensive framework for multilingual sentiment analysis, covering key technologies such as cross-lingual transfer learning and zero-shot learning. The study particularly emphasizes challenges and solutions in handling low-resource languages.
- **Content Toxicity Detection**: (3) examines the challenges of toxic content generation in language models through the RealToxicityPrompts dataset and presents strategies for reducing the risk of harmful content generation. This work provides crucial insights for our toxicity detection module.
- **LLM-based Content Moderation**: (4) conducts a systematic study of content moderation systems based on large language models, exploring model applications in harmful content detection and transformation, as well as related ethical considerations. This research provides the theoretical foundation for our system design.

References

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[4] Wang, Y., Wu, D., Li, K., & Li, P. (2022). A survey on large language model based autonomous agents. *Intelligent Systems with Applications*, 16, 200170.