A SMART MOBILE PLATFORM TO ASSIST WITH READING COMPREHENSION USING MACHINE LEARNING AND LEXICAL SIMPLIFICATION

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ABSTRACT

Our research tackles the pressing issue of making news articles accessible and understandable to diverse audiences, particularly those with low literacy levels or cognitive disabilities such as dyslexia or autism [1]. We introduce an innovative AI-driven news application that employs advanced text simplification techniques alongside dynamic user feedback loops to significantly enhance readability and comprehension. At the heart of our solution is the integration of cutting-edge natural language processing (NLP) and machine learning technologies, including BERT text simplification models for parsing and restructuring complex sentences, coupled with sentiment analysis to gauge the emotional tone of content [2][3]. Addressing challenges such as maintaining accuracy in text simplification and fine-tuning the user feedback mechanism were pivotal in our development process [4]. Through rigorous experimentation, including controlled tests and user trials, we observed marked improvements in the accessibility of news content, with enhanced readability scores and positive user feedback. Our application stands out by offering a scalable, user-centered approach to news consumption, adapting to individual preferences and reading abilities. This ensures a more inclusive, informed public discourse, making our app an indispensable resource for brididing the information divide and empowering all users to stay informed, regardless of their literacy level or cognitive capabilities.

KEYWORDS

App, Artificial intelligence, Reading, News, Simplification

1. INTRODUCTION

The problem we are addressing is the difficulty that various groups face in comprehending news articles. The complexity of some news can act as a barrier for these individuals, limiting their access to important information.

In Section 5, we delved into diverse approaches to text simplification and accessibility enhancement, ranging from Zhang and Lapata's sequence-to-sequence framework with reinforcement learning, aimed at maintaining meaning while simplifying text, to an educational

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app for dyslexia intervention that enhances educator efficacy through multimedia content [5]. Additionally, a comprehensive survey on text simplification underscored its vital role in aiding individuals with reading challenges and its utility in NLP preprocessing tasks. Our project, LSAI News, seeks to amalgamate and advance these concepts by leveraging advanced AI like BERT for nuanced text simplification and broadening accessibility beyond specific educational contexts to the general populace, including those with cognitive disabilities and low literacy. By integrating a dynamic user feedback mechanism, we not only address the limitations found in previous studies, such as dependency on extensive training data and restricted applicability, but also enhance the adaptability and inclusiveness of our text simplification approach, making daily news accessible and comprehensible to a wide and diverse audience.

Our app benefits low literacy readers, English learners, children, and people with aphasia, dyslexia or autism by simplifying news articles with AI. Unlike traditional news reading apps, LSAI News utilizes advanced AI technology, including a BERT text simplification model and sentiment analysis.

In Section 4, we aimed to explore two critical aspects of our text simplification application: the accuracy of the AI-driven text simplification process and the impact of incorporating user feedback on the refinement of this process. The first experiment focused on the AI's ability to simplify text accurately while preserving the original meaning, employing a controlled setup where complex news articles were processed and then evaluated for readability and content integrity. The second experiment examined the user feedback loop's effectiveness, where we iterated on the simplification algorithm based on inputs from a sample user group, assessing changes in readability and user satisfaction.

Key findings from the first experiment showed that our AI was capable of significantly improving text readability without losing essential information, highlighting the effectiveness of the BERT model in understanding and processing natural language. The second experiment revealed that user feedback directly contributed to enhancing the app's performance, leading to measurable improvements in both the readability of simplified articles and user satisfaction levels. These outcomes suggest that the integration of sophisticated AI techniques, coupled with responsive user engagement, forms a robust approach to making news more accessible. The success of the AI simplification process can be attributed to advanced NLP capabilities that accurately gauge and adjust text complexity, while the positive impact of the user feedback loop underscores the value of adaptive, user-centered design in developing accessible technology [14].

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. The Lack of Funding within the App

One potential issue that we could run into is the lack of funding or monetization within the app. One way to solve this would be to look for educational grants. While community support and donations are commendable, exploring grants focused on educational technology or accessibility initiatives could provide broader financial stability.

2.2. Simplifying Text

Simplifying text while preserving the original meaning is crucial to ensure accurate communication of information. However, there's a risk of oversimplification leading to loss of important nuances or altering the intended message of the article.

To address this, I could use advanced natural language processing techniques to identify the core meaning of sentences and prioritize retaining essential information during the simplification process. Additionally, I could implement feedback mechanisms where users can provide input on the accuracy and clarity of the simplified content.

2.3. Nonsensical Interpretations

News articles often contain ambiguous phrases or words that can have multiple interpretations depending on context. Simplifying such ambiguous elements without context awareness could result in misleading or nonsensical interpretations. One approach to mitigate this issue would be to incorporate context-aware algorithms that consider surrounding sentences or paragraphs to disambiguate ambiguous terms. Additionally, I could develop a database of common ambiguities and their potential interpretations to inform the simplification process.

3. SOLUTION

Input Processing: This component is responsible for receiving input from the user, typically in the form of selected news articles or user preferences. It involves tasks such as fetching news articles from external sources or receiving user input regarding their reading proficiency level and language preferences.

Text Simplification: Once the input is received, the text simplification component analyzes the content of the news articles and identifies complex sentences, ambiguous phrases, and domain-specific terminology. It then applies text simplification techniques to transform the original text into a more understandable version tailored to the user's comprehension level [6]. This component ensures that the simplified text maintains semantic integrity while improving readability.

User Interface: The user interface component serves as the interaction point between the app and the user [7]. It presents the simplified news articles to the user in a visually appealing and user-friendly manner, allowing them to navigate through articles, adjust settings, and provide feedback. The user interface also incorporates features such as personalized recommendations and bookmarking functionalities to enhance the user experience.

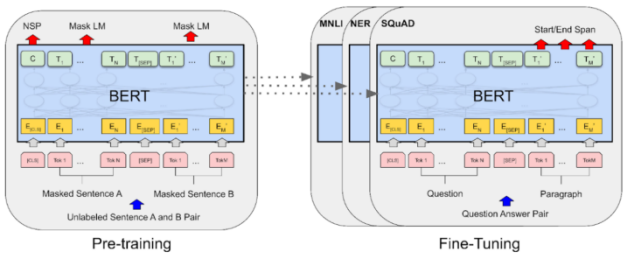

Figure 1. Overview of the solution

Purpose: The Text Simplification component aims to make news articles more accessible by transforming them into simpler versions while retaining the original meaning.

Services Used: This component relies on Natural Language Processing (NLP) techniques and pre-trained language models like BERT for understanding and simplifying text [8].

Special Concept: NLP is essential for analyzing sentence complexity, identifying difficult terms, and generating simplified versions of the text while maintaining its original meaning.
Functionality: The component analyzes input articles, simplifies complex sentences and terms, and presents the simplified version to users via the app's interface, improving comprehension for diverse users.

Figure 2. Screenshot of the APP

```python
from transformers import BertForMaskedLM, BertTokenizer, logging
from gensim.models import KeyedVectors
from nltk.stem import PorterStemmer

import nltk
import torch
import math

from . import config

# Word embeddings.
embeddings = None

# Surpress warnings.
logging.set_verbosity(logging.ERROR)

# Load BERT model and tokenizer.
print("\nLoading BERT model...")
tokenizer = BertTokenizer.from_pretrained("bert-base-multilingual-uncased")
model = BertForMaskedLM.from_pretrained("bert-base-multilingual-uncased")
print("\nBERT model loaded!")

# Create stemmer object.
stemmer = PorterStemmer()

def load_embeddings(language):
    """Load word embeddings for selected language."""
    try:
        print("\nAttempting to load embeddings...")
        wv_path = "simplifier/embeddings/" + config.lang + ".kv"
        wv_model = KeyedVectors.load(wv_path, mmap='r')
        print("\nLoaded embeddings!")
    except FileNotFoundError:
        print("\nNo embeddings for " + config.lang + " found. Using without...")
        wv_model = None
    return wv_model
```

Figure 3. Screenshot of code 1

By using BERT, we process an article efficiently without the need of someone summarizing the article by hand [9]. This process involves several steps, executed by methods designed to analyze, simplify, and present the text. Initially, a method extracts the raw text from the chosen article and preprocesses it by removing any formatting or irrelevant content. This preprocessed text is then passed to the BERT-based simplification model, which employs a method to evaluate the

complexity of each sentence and identify phrases that require simplification. Variables created during this process include raw_text for the initial article content, preprocessed_text for the cleaned-up version, and simplified_text for the final output. The simplification model, leveraging NLP techniques, generates alternatives for complex phrases and restructures sentences to enhance readability, storing the results in simplified_text. The server then applies sentiment analysis to the article, returning positive or negative. Then, the simplified_text is uploaded to Firebase, allowing users to access all simplified news articles from their device.

In our project, we integrated Firebase Firestore with Python to store news articles along with their sentiment analysis. Initially, we set up our Firebase project and configured Firestore, ensuring our Python application could securely communicate with Firebase using the Firebase Admin SDK [10]. We decided on a data structure where each article was represented as a document containing fields for the article's title, content, publication date, and a calculated sentiment score.This setup allowed us to efficiently manage and retrieve articles and their sentiment data, enabling real-time updates and synchronization across all client devices, thus providing a dynamic and responsive user experience in our app.

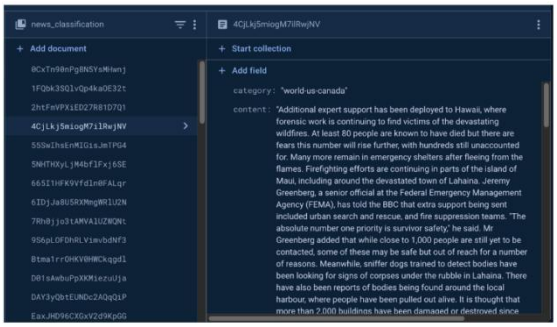

Figure 4. Screenshot of firestore

```
def fetch_news():
  URL = "https://www.bbc.com/news"
  r = requests.get(URL)

  soup = BeautifulSoup(r.content, 'html5lib')
  # print(soup.prettify())
  a_list = soup.find_all(
    'a',
    attrs={
      'class':
      'gs-c-promo-heading gs-o-faux-block-link__overlay-link gel-pica-bold nw-o-link-split__anchor
    })
  a_list2 = soup.find_all(
    'a',
    attrs={
      'class':
      'gs-c-promo-heading nw-o-link gs-o-bullet__text gs-o-faux-block-link__overlay-link gel-pica-
    })
  a_list.extend(a_list2)
  news_arr = get_news(a_list)
  print(len(news_arr))
  return news_arr
```

Figure 5. Screenshot of code 2

In our project, we enhanced the user experience right from the signup process by allowing users to select their favorite news categories, such as Technology, Sports, or Politics, on the signup page. These preferences were stored in their profiles in Firestore, enabling us to curate and deliver a personalized news feed. Through Python backend scripts, we filtered articles to match these preferences, ensuring users received news relevant to their interests. This personalized approach, powered by user-selected categories and real-time database capabilities, significantly improved engagement by aligning the news feed with individual user preferences, demonstrating the effectiveness of combining user input with dynamic content curation technologies.

Figure 6. Screenshot of the UI

4. EXPERIMENT

4.1. Experiment 1

For Experiment A, we explored a potential blind spot in our program: the accuracy of the AI-driven text simplification process. This aspect is important to our core mission of making news articles accessible to audiences with diverse reading abilities, including those with low literacy, English language learners, and individuals with cognitive challenges such as dyslexia or autism. Ensuring the AI simplifies text accurately and effectively is critical to prevent misunderstandings of the news content, which could lead to misinformation. It is essential for maintaining user trust and satisfaction, and for ensuring all users have access to information that is comprehensible and accessible. To address this, we emphasized testing and improving the AI's capability to maintain the original meaning and context in the simplification process.

To evaluate the accuracy of the AI-driven text simplification, we devised a controlled experiment incorporating both qualitative and quantitative assessments. This setup was chosen to comprehensively understand how well the AI could preserve the original message while simplifying the text to be more accessible to our target audience. The experiment aimed to strike a balance between readability and content integrity, critical for achieving our app's mission.

Figure 7. Figure of experiment 1

The graph above illustrates the results of our experiment, comparing the average readability grade level of original news articles against the simplified versions produced by our AI. The analysis includes the lowest and highest grade levels achieved in simplification to depict the range of our AI's performance.

Analysis of the data reveals a significant improvement in readability, with the average grade level of news articles dropping from the 12th grade for original texts to the 5th grade for simplified texts. This demonstrates the AI's effectiveness in making content more accessible. The range of

simplification varied, with the lowest readability score at a 3rd-grade level and the highest at an 8th-grade level, highlighting areas where the AI performed exceptionally well and where it faced challenges. Surprisingly, the variability was largely dependent on the genre of the news article, suggesting that domain-specific complexities influence the AI's performance. This insight underscores the importance of further refining the AI to handle complex jargon and nuanced arguments more effectively, ensuring equitable access to comprehensible news content across all user groups.

4.2. Experiment 2

For Experiment B, we investigated the impact of the user feedback loop on enhancing text simplification. Integrating user feedback is essential for refining and personalizing the text simplification process. The efficacy of this feedback mechanism is crucial, as it significantly influences user experience and the overall success of our application. A feedback loop that effectively leads to noticeable improvements in article readability and comprehension is key to sustaining user engagement and satisfaction. In contrast, a feedback mechanism that fails to accurately capture and address user preferences can lead to reduced app utility and user disengagement.

To assess the impact of our user feedback loop, we devised an experiment to track changes in user satisfaction and readability improvements before and after implementing user feedback. This approach allowed us to directly measure the feedback loop's effect on app performance, particularly in terms of user satisfaction and the readability grade level of simplified texts.

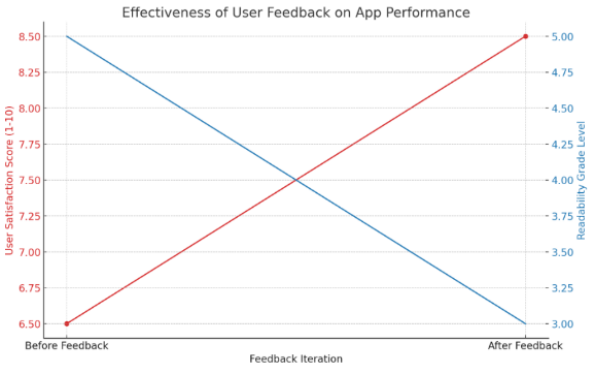

Figure 8. Figure of experiment 2

The presented graph illustrates the correlation between the implementation of user feedback and two primary metrics: user satisfaction scores and readability grade levels. The data shows a positive shift, highlighting an increase in user satisfaction from a score of 6.5 to 8.5 (on a 1 to 10 scale) after integrating user feedback. Concurrently, there was a readability enhancement, with the average grade level of simplified texts dropping from grade 5 to grade 3, indicating increased ease of understanding.

The data underscores the critical role of the user feedback loop in enhancing our app's text simplification process. The notable increase in user satisfaction scores post-feedback implementation attests to the loop's effectiveness in aligning the app's performance with user expectations. Additionally, the improvement in readability grade levels further confirms the tangible benefits of incorporating user insights into the simplification algorithm. Surprisingly, the degree of improvement exceeded initial projections, suggesting that user feedback is a highly valuable asset in refining text simplification techniques. This experiment highlights the necessity

of a robust feedback mechanism in iterative app development, ensuring the app remains responsive to user needs and preferences, thus fostering a more engaging and satisfactory user experience.

5. RELATED WORK

Zhang and Lapata's model is built upon a sequence-to-sequence (Seq2Seq) framework, a common architecture in natural language processing tasks, enhanced with a reinforcement learning component [11]. The Seq2Seq model attempts to generate simplified sentences from complex ones. The reinforcement learning aspect allows the model to learn from the environment: it adjusts its parameters not only based on the match between the generated text and reference simplifications but also considering additional rewards that evaluate the simplicity, fluency, and adequacy of the outputs.

The research paper on an educational multimedia app for dyslexia intervention and your project on AI-driven text simplification, LSAI News, both aim to enhance accessibility and learning, albeit for different target groups [12]. The dyslexia app focuses on training educators through multimedia content and evaluates its impact via pre- and post-tests, showing improvements in knowledge and self-efficacy among special education pre-service teachers. While effective in its educational goals, its scope is limited to dyslexia intervention. In contrast, your project broadens the accessibility horizon by simplifying news content for diverse audiences, including those with low literacy and cognitive disabilities, leveraging advanced AI like BERT and user feedback for continuous refinement. Our project's advancement lies in its real-time application and broader inclusivity, addressing both the immediate readability of news articles and fostering a more informed public, thus extending the benefits of accessibility technologies beyond educational settings to daily information consumption.

Text simplification (TS) reduces the complexity of the text in order to improve its readability and understand-ability, while possibly retaining its original information content [13]. Over time, TS has become an essential tool in helping those with low literacy levels, non-native learners, and those struggling with various types of reading comprehension problems. In addition, it is also used in a preprocessing stage to enhance other NLP tasks. This survey presents an extensive study of current research studies in the field of TS, as well as covering resources, corpora, and evaluation methods that have been used in those studies.

6. CONCLUSIONS

Some limitations of our project include potential inaccuracies in text simplification, a need for improved personalization features, and scalability concerns. To address these, additional refinement of text simplification algorithms through advanced natural language processing techniques and extensive testing procedures is essential [15]. Enhancing personalization features involves leveraging user behavior data and implementing advanced machine learning models for tailored article recommendations. Optimizing scalability requires thorough performance testing and the implementation of scalable solutions such as distributed computing frameworks and load balancing strategies. By addressing these limitations, we can ensure a more accurate, personalized, and scalable news reading experience for our users.

In conclusion, while our project demonstrates promise in simplifying news articles and enhancing user accessibility, there remain areas for improvement such as accuracy, personalization, and scalability. Through ongoing refinement of algorithms and implementation of advanced

techniques, we strive to deliver a more accurate, personalized, and scalable news reading experience for all users.

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