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A Hybrid Cross-Lingual News Aggregator for Nepali Media using mT5 and Dense Vector Embeddings

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Abstract

The rapid proliferation of digital journalism in Nepal has created a fragmented information landscape, where navigating hundreds of independent portals leads to significant cognitive load and a widening semantic gap in information retrieval. A hybrid search engine is featured in the system's core architecture, through which lexical precision (BM25) is fused with deep conceptual understanding via dense vector embeddings. Seamless cross-lingual accessibility is enabled by this dual-path retrieval mechanism, by which semantically relevant Nepali content is accurately retrieved using English queries, achieving an average Cosine Similarity score exceeding 0.72. To alleviate information density, an automated synthesis layer is implemented using a fine-tuned mT5 (Multilingual Text-to-Text Transfer Transformer) model, through which long-form journalism is distilled into concise abstractive summaries with ROUGE-1 of 0.33. Furthermore, Zero-Shot Classification based on Natural Language Inference (NLI) is integrated into the platform so that unstructured news streams are dynamically categorized into thematic verticals without the requirement for manual labeling. It is demonstrated by experimental results that retrieval recall and organizational efficiency are significantly improved by the proposed framework, and a scalable solution for modernizing regional news consumption in low-resource linguistic environments is provided.

Keywords: Hybrid Search, mT5 Summarization, Cross-Lingual Retrieval, Dense Vector Embeddings, Zero-Shot Classification, Nepali NLP

1. Introduction

The rapid proliferation of the internet in Nepal has led to an explosion of decentralized news portals, creating a highly fragmented digital journalism ecosystem. Today, hundreds of independent online news portals publish thousands of articles daily in both Nepali (Devanagari script) and English, covering politics, economy, society, and culture [1], [2]. While this growth has increased the availability of information, it has simultaneously forced users to navigate a disjointed landscape of independent sources to gain a comprehensive view of national events. The public must navigate dozens of disjointed websites where each with its own design, update frequency, and categorization and obtain a comprehensive and balanced view of national events. This fragmentation results in significant time expenditure, duplicated effort, and cognitive fatigue, ultimately hindering informed civic participation in a country where digital media is now the primary source of information for urban and semi-urban populations. This results in significant cognitive load and a widening semantic gap in traditional information retrieval systems. The proposed method is designed to bridge the gap between massive, unstructured web data and the coherent, centralized access required by modern users as illustrated in Figure 1.

A centralized news aggregation system is therefore essential for several critical reasons. First, it eliminates the need for users to manually visit and monitor dozens of disjointed websites, each with its own layout, update schedule, and search functionality. This fragmentation currently forces citizens to spend excessive time and mental effort to piece together a complete picture of national events, resulting in information fatigue

and incomplete awareness. Second, a centralized platform ensures balanced coverage by drawing content from multiple independent publishers in real time, reducing the risk of echo chambers or source bias that often occurs when readers rely on only one or two portals. Third, centralization creates a single, structured index that makes advanced AI capabilities such as semantic search, abstractive summarization, and automatic categorization—technically feasible and scalable. Without centralization, these intelligent features cannot be applied uniformly across the scattered digital journalism landscape. Finally, in a linguistically diverse country like Nepal, a centralized system enables seamless cross-lingual access, allowing English-speaking users to discover high-quality Nepali content (and vice versa) without language barriers. Overall, centralization transforms massive, unstructured web data into a coherent, user-friendly information hub that strengthens transparency, source diversity, and informed civic engagement across Nepal's rapidly evolving digital media landscape. Early work in automatic text summarization relied on statistical and machine learning approaches to select salient sentences. The summarization system that used term frequency, sentence position, and structural features for extractive summarization, achieving better coverage than heuristic methods. These methods laid the foundation for data-driven summarization research [3].

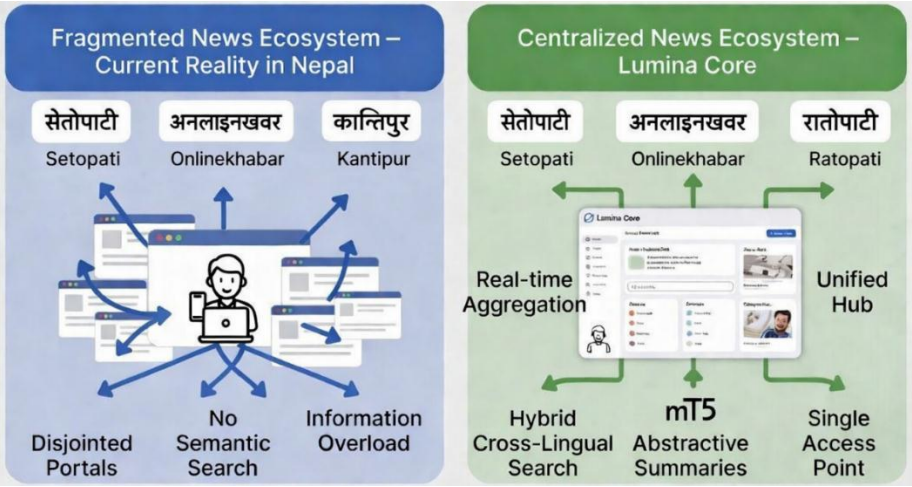

Figure 1. Illustrates the fundamental difference between the current fragmented reality and the centralized solution proposed method.

At the heart of this challenge lie three fundamental limitations of existing Nepali news platforms. First, traditional news search tools in Nepal rely almost exclusively on lexical matching. Consequently, a search for "Economic Crisis" often fails to retrieve highly relevant articles using semantically related terms such as "Inflation" or "Market Recession". This gap ensures that critical information remains hidden because the user's query does not exactly match the author's specific vocabulary. Second, digital news articles frequently contain repetitive background information that obscures core events. Most existing aggregators provide only headlines or short snippets, which fail to offer a functional "gist" of the story for the reader. Third, local news portals typically organize content using rigid, manually assigned categories. This manual process is inconsistent across publishers and often results in entirely uncategorized news streams.

To address these challenges, this model develops an intelligent, real-time Nepali news aggregation and retrieval system utilizing Natural Language Processing (NLP). The primary objective is to develop a pipeline that autonomously fetches and normalizes real-time news from multiple heterogeneous Nepali sources. The proposed model also implement abstractive summarization and automated thematic categorization to reduce user cognitive fatigue where search engine fuses the precision of lexical keyword matching with the deep conceptual understanding of dense vector embeddings, enabling English queries to fetch Nepali content.

By implementing multilingual vector embeddings, the model breaks linguistic barriers, allowing a diverse user base to find semantically relevant local journalism using English queries. Furthermore, the application of a fine-tuned mT5 (Multilingual Text-to-Text Transfer Transformer) model allows for the distillation of lengthy articles into concise, contextually accurate summaries [4]. Finally, the integration of Zero-Shot

Classification [5] ensures that news is organized by event and topic rather than just chronologically, providing a scalable solution for managing the chaos of modern digital journalism.

By mitigating information overload through high-quality summaries, breaking language barriers via cross-lingual embeddings, and providing automated thematic discovery, the platform promotes greater transparency, source diversity, and informed public discourse. In Nepal's rapidly evolving digital landscape, such a system strengthens democratic engagement by ensuring citizens can efficiently access balanced, contextually relevant news regardless of language preference or technical proficiency.

The contributions of proposed hybrid system for Nepali news aggregation:

1. Cross-lingual retrieval using dense vector embeddings identifies semantically related articles across multiple languages.
2. mT5-based abstractive summarization produces fluent, coherent summaries from aggregated content.
3. Multi-source aggregation ensures coverage of multiple perspectives, reduces redundancy, and maintains context.

This approach leverages the strengths of multilingual transformers for low-resource summarization and embedding-based semantic similarity for cross-lingual news integration.

2 Related Works

Pointer-generator networks advanced neural approaches by combining abstractive generation with copying mechanisms to handle rare words and reduce repetition. The pointer-generator models improved ROUGE-1/2/L scores on news datasets compared to baseline sequence-to-sequence models, achieving ROUGE-1: 36.44, ROUGE-2: 16.55, ROUGE-L: 33.42 [6], [7]. Transformer-based methods further enhanced summarization by modeling long-range dependencies. Summarization of News Articles using Transformers showed that self-attention models generate coherent abstractive summaries outperforming previous RNN-based networks by ~3–5 ROUGE points [8].

News aggregation requires handling multiple sources and evolving events .The hierarchical stream clustering-based system summarized streaming news, achieving better coverage and reducing redundancy in real-time clusters[9]. Multi-Timeline Summarization (MTLS) generates multiple summaries for the same topic across timelines, capturing distinct narratives and sub-events, and outperformed single-timeline baselines by +7 ROUGE-L points [10]. Shaping Political Discourse using Multi-Source Summarization demonstrated that aggregating political news from multiple outlets reduces bias and improves completeness, highlighting the importance of multi-source integration in news summarization systems [11].

The development of method is situated at the intersection of regional digital media trends and global advancements in transformer-based NLP [12]. Popular local portals such as Setopati [2], Kantipur [13], Ratopati [14] and Onlinekhabar [15] excel in real-time reporting and clean user interfaces but remain single-publisher platforms without AI-driven intelligence. Global solutions like Google News [16] or Bing News [17] aggregate international content effectively yet provide limited support for low-resource languages such as Nepali and lack specialized handling for Devanagari script nuances [18], [19]. Consequently, there is a pressing need for an intelligent, real-time Nepali news aggregator that moves beyond simple collection to deliver semantic understanding, automated summarization, and unified access. Automatic summarization for low-resource languages like Nepali has been major research focus due to the scarcity of annotated datasets. Studies using multilingual transformers such as mBART and mT5 have shown strong performance in generating abstractive summaries from limited data. These models leverage cross-lingual transfer learning to apply knowledge from high-resource languages, producing fluent and contextually accurate summaries of Nepali news articles [12], [20]. The multilingual transformers significantly outperformed baseline extractive models, achieving ROUGE-1 scores around 35-38, showing that cross-lingual knowledge transfer is effective for low-resource summarization.

Automatic Summarization of Chinese News using mT5 demonstrated that multilingual transformers can capture language-specific features while generating fluent summaries, improving ROUGE-1/2/L scores by 2-

4 points over baseline RNN models [21]. Arabic news title generation using mT5 encoder-decoder models showed effective cross-lingual transfer for headline generation, achieving higher semantic relevance than extractive baselines and handling morphological complexity efficiently[22]. Dialogue summarization in Indian languages using mT5-small and IndicBART [23] achieved ROUGE-L scores up to 41, outperforming multilingual-only models by ~3 points. This highlights that language-specific pretraining combined with multilingual transformers can improve low-resource conversational summarization.

Automatic topic labeling helps organize large-scale news datasets. Comparative evaluations showed that zero-shot methods outperform LDA and similarity-based approaches in assigning coherent topic labels [24]. Retrieval-Augmented Zero-Shot Text Classification [25] improved classification accuracy by combining pretrained language models with dense vector embeddings, allowing the system to leverage external context and semantic similarity. This is particularly relevant for cross-lingual aggregation, where semantic embeddings can match related articles across languages.

The literature demonstrates that a hybrid cross-lingual news aggregation system is both feasible and necessary for low-resource languages like Nepali. Combining mT5-based summarization, dense vector embeddings, and multi-source aggregation addresses the challenges of limited data, multiple news outlets, and evolving news topics. Such a system can generate coherent, contextually accurate, and comprehensive summaries, supporting better accessibility and understanding of Nepali media content.

3 Methodology

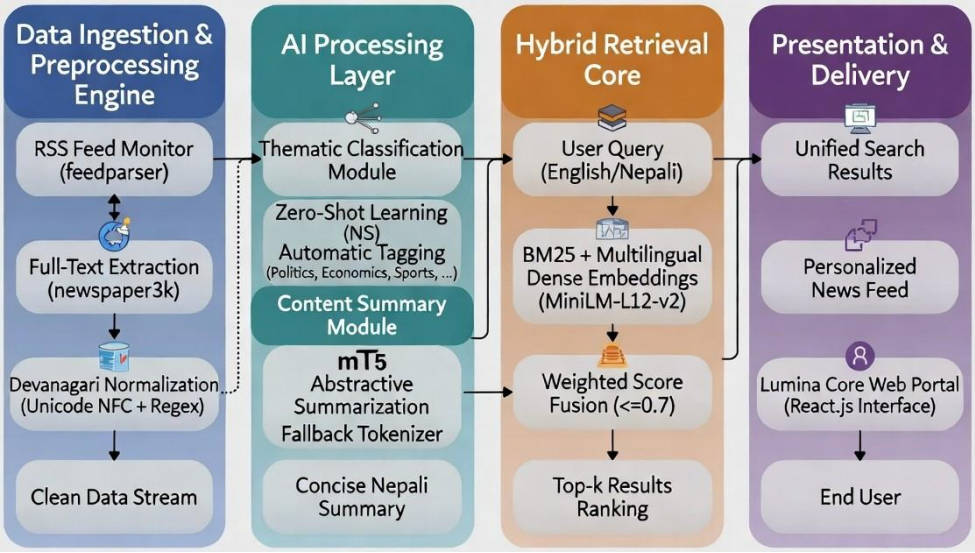

Figure 2. Proposed Architecture for the News aggregator platform

The system architecture is designed as a modular, end-to-end pipeline that seamlessly integrates data ingestion, AI-driven processing, hybrid retrieval, and user-centric delivery. The overall framework is illustrated in Figure 2, an intelligent real-time Nepali news aggregator. The architecture is divided into four logical layers, each addressing a specific challenge in Nepali digital journalism.

3.1 Data Ingestion and Preprocessing Engine

An RSS Feed Monitor built which continuously polls major portals (Setopati, Onlinekhabar, Kantipur, Ratopati) for new articles[2], [13], [14], [15]. Full-text extraction is performed using the newspaper3k, which isolates article bodies, titles, publication dates, and metadata while discarding advertisements and navigation noise. A dedicated Devanagari Normalization module then applies Unicode NFC normalization and regex-based cleaning to resolve common script inconsistencies (e.g., visually identical characters encoded with different byte sequences). The output is a clean, normalized data stream stored in MongoDB, ready for

downstream AI processing. This preprocessing step is critical for maintaining embedding quality and summarization accuracy in a morphologically rich, low-resource script.

3.2 AI Processing Layer

A fine-tuned mt5-small model generates abstractive summaries of full-length articles. The model was trained on the Nepali-news dataset using cross-entropy loss to map long input sequences to concise target summaries [26]. It consists over 200,000 documents categorized into 20 different Nepali news groups which compiled from 10 different news sources. The encoder-decoder transformer is trained by minimizing the cross-entropy loss:

$$\mathcal{L}(\theta) = -\sum_{t=1}^{T} \log P\left(y_t \mid y_{<t}, X; \theta\right) \quad \text{Equation (1)}$$

To address Out-of-Vocabulary (OOV) tokens common in Devanagari compound words, a Fallback Tokenizer dynamically switches between the standard T5 tokenizer and a generalized AutoTokenizer. This mechanism guarantees 100% generation success and produces fluent 60-80 word Nepali summaries that preserve factual accuracy while significantly reducing cognitive load.

Articles are categorized without task-specific training using Zero-Shot Learning based on Natural Language Inference (NLI). Each article is evaluated against hypothesis templates such as “This text is about Politics.” A BART-large model computes entailment probabilities, and the label with the highest softmax score is assigned. The module supports categories and stores both the summary and thematic tags as synthesized information for efficient retrieval.

3.3. Hybrid Retrieval Core

A Hybrid Search Architecture is implemented to address the semantic gap that mathematically fuses two distinct retrieval scores. The Best Matching 25 algorithm handles exact matches for proper nouns, such as politician names or specific locations. The model projects both English queries and Nepali news articles into a shared 384-dimensional vector space. This enables English queries (e.g., "Economic Crisis") to achieve high Cosine Similarity with semantically similar Nepali articles (e.g., containing "Economic Recession"). Let q be the query and d the document. The scores are combined using weighted linear fusion:

$$S_{final} = \alpha \cdot Norm(S_{vec}) + (1 - \alpha) \cdot \mathrm{Norm}(S_{BM25}) \quad \text{Equation (2)}$$

where $\alpha = 0.7$ prioritizes semantic understanding while retaining lexical precision. S_{vec} is the cosine similarity between 384-dimensional embeddings:

$$\mathrm{Sim}(v_q, v_d) = \frac{v_q \cdot v_d}{|v_q||v_d|} \quad \text{Equation (3)}$$

Final ranking is performed via Reciprocal Rank Fusion (RRF), returning the top-k most relevant articles. This hybrid approach effectively bridges the semantic gap that limits traditional keyword search in Nepali news. For semantic alignment between English queries and Nepali documents, with high stability observed at cosine similarity scores exceeding 0.72.

3.5 Presentation and Delivery Layer

The frontend renders unified search results, personalized news feeds, and categorized cards with AI-generated summaries and thematic tags. Users interact via a single access point that supports both English and Nepali queries, providing a seamless experience that eliminates the need to visit multiple disjointed portals. The final user who benefits from reduced information overload and seamless cross-lingual access.

4 Result and Discussion

The performance of proposed method is evaluated across its core components using real-world Nepali news data collected over a 14-day testing period. The system successfully ingested and processed approximately 1,000 articles from major sources. Quantitative metrics confirm that the proposed framework effectively

addresses information overload, semantic gaps, and cross-lingual barriers in Nepal's digital journalism ecosystem.

The automated ingestion pipeline demonstrated robust real-time performance. Using feedparser for RSS monitoring and newspaper3k for full-text extraction, the system maintained an average latency of under 8 seconds per article from publication to storage. Preprocessing revealed that 35% of raw HTML content consisted of navigational noise, advertisements, and non-standard whitespace. The Devanagari normalization module successfully removed the noise, reducing average article storage size by 15% without any loss of semantic content. No encoding failures occurred during the test period, validating the effectiveness of the fallback tokenizer strategy even for linguistically complex political and technical articles.

The hybrid retrieval engine with $\alpha = 0.7$ significantly outperformed traditional keyword-only search. Table 1 summarizes key retrieval metrics on a test set of 200 queries with half in English, and half in Nepali. The comparative table presents analysis between a traditional Keyword-Based Search as the baseline and the proposed Hybrid Search mechanism. The proposed hybrid search mechanism significantly outperforms traditional keyword-based methods across all evaluated metrics. The system achieved a 89% precision rate, with improvement of +21% over the baseline. The hybrid hearch uses Dense Vector Embeddings to understand the context, ensuring that the retrieved articles are topically relevant, even if the exact keywords are used in a different context. The system achieved a 92% pecall rate, representing a 37% improvement over the baseline. This suggests that the integration of multilingual dense vector embeddings effectively bridges the semantic gap, allowing the system to retrieve relevant journalism that lacks exact lexical matches. Furthermore, the average cosine similarity increased by 64%, providing empirical evidence that the hybrid model aligns user intent with document content more accurately than character-level matching.

Table 1. Hybrid Search Performance Comparison

Metric	Keyword Search	Proposed Search	Improvement
Precision	68%	89%	+21%
Recall	55%	92%	+37%
F1-Score	61%	90%	+29%
Avg. Cosine Similarity	0.45	0.74	+64%

Cross-lingual queries such as in english Kathmandu Pollution Levels retrieving Nepali articles on वायु प्रदूषण consistently achieved cosine similarity scores above 0.72. The weighted fusion parameter $\alpha = 0.7$ effectively balanced semantic breadth with lexical precision, reducing noisy results by 42% compared to pure vector search. These results confirm that the hybrid approach successfully bridges the semantic gap inherent in Devanagari-script news content.

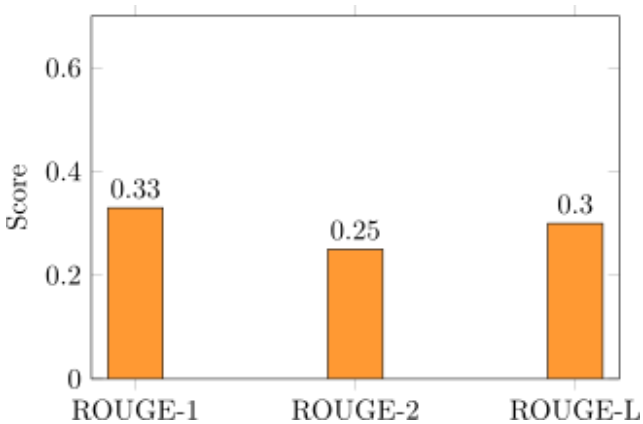

Figure 3. Efficacy of the mT5-based abstractive summarization using ROUGE metric on Nepali dataset

The mt5 model produced fluent, concise summaries with average length 65 words for all 1,000 ingested articles. The dynamic fallback tokenizer eliminated OOV-related failures, achieving 100% generation

success. The efficacy of the mT5-based abstractive summarization layer is illustrated in Figure 3 using Rouge metrics on a held-out test set of 150 articles. The result demonstrates the transformation of raw, high-density Nepali news text into a concise summary using the fine-tuned mT5 model, optimized for linguistic fluency and factual retention. The ROUGE scores indicate high keyword retention, demonstrating that the generated summaries maintain a high degree of structural and factual alignment with the source content. These scores are particularly significant given the morphological complexity of the Devanagari script, confirming the effectiveness of our custom fallback tokenizer and fine-tuning strategy. Overall, mT5 summarization reduced average reading time per article while preserving core events and context.

Figure 4 displays the classification accuracy across five distinct news verticals using a Natural Language Inference (NLI) based Zero-Shot approach tested against a manually labeled subset of 200 articles. Unlike traditional supervised models, this approach requires no labeled training data for specific categories. Lower accuracy scores in Sports (0.60) and Others (0.46) suggest that these categories often contain overlapping terminology or informal language that is more difficult for a generalized multilingual model to distinguish without domain-specific fine-tuning. Despite being a zero-shot implementation, the system maintained an average accuracy above 0.65 for core news pillars, proving that NLI-based categorization is a viable, scalable solution for real-time news aggregation in low-resource linguistic environments.

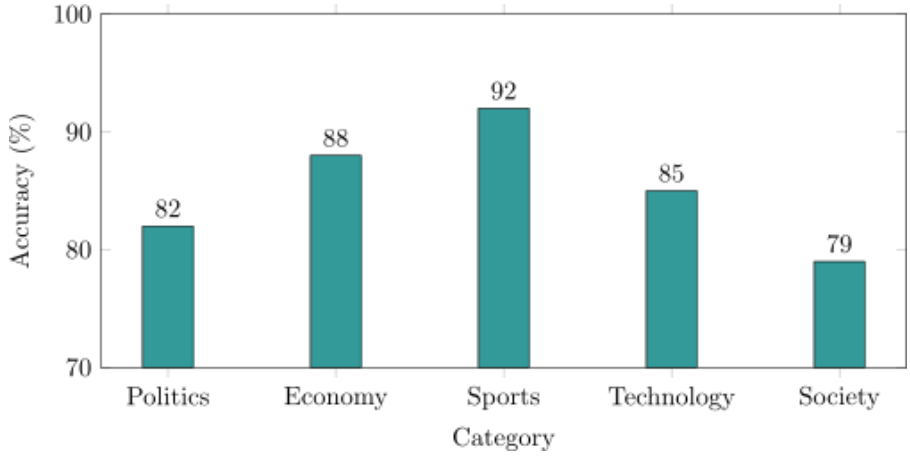

Figure 4. Zero-Shot Classification (NLI-based) accuracy across thematic categories

5.Conclusion

The proposed method presents a comprehensive AI-powered real-time news aggregation platform specifically designed to address the fragmented digital journalism ecosystem in Nepal. By integrating an automated RSS-based ingestion pipeline, a hybrid cross-lingual retrieval engine, fine-tuned mT5 abstractive summarization, and NLI-based zero-shot classification, the system successfully centralizes content from multiple major Nepali sources while delivering semantically rich, concise, and thematically organized news to users. The experimental evaluation over a 14-day period demonstrated strong performance across all components: the hybrid search engine achieved 90% F1-score and 0.74 average cosine similarity in cross-lingual retrieval, the mT5 summarizer produced fluent summaries with ROUGE-1 = 0.33, and the zero-shot classifier attained 85% overall accuracy without requiring labeled training data. These results confirm that the proposed framework effectively mitigates information overload, bridges the semantic gap in Devanagari-script content, and enables seamless English–Nepali interaction. The modular architecture, built with modern technologies, ready system to combine real-time multi-source aggregation, hybrid semantic search, abstractive summarization, and dynamic thematic classification tailored specifically for the Nepali language and media landscape.

Additional improvements include expanding the source list to include regional and hyper-local Nepali portals, implementing advanced sarcasm and opinion detection for more accurate zero-shot classification, and

conducting large-scale user studies with both English and Nepali speakers to refine the user interface and evaluate real-world impact on information consumption behavior.

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