Modernizing FAQ Search with NLP: A Comparative Performance Assessment of Lexical and Semantic Models

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ABSTRACT

With the exponential growth of online support portals and digital helpdesks, Frequently Asked Questions (FAQ) systems have become essential to reducing customer support load and improving user experience. Traditional information-retrieval approaches such as TF-IDF and BM25 rely heavily on lexical overlap and therefore perform poorly when users phrase questions differently, use synonyms, or switch between languages. To overcome these limitations, this research explores a semantic FAQ retrieval model based on Sentence-BERT (SBERT), which generates dense sentence embeddings to capture contextual meaning. The study compares SBERT against a classical TF-IDF baseline using retrieval metrics such as Recall@K, Mean Average Precision (MAP@K), and Mean Reciprocal Rank (MRR). Anticipated results indicate a significant improvement in ranking quality, especially in paraphrased and user-style queries. The paper also discusses computational efficiency, memory requirements, and applicability in real-world deployments. This work highlights how semantic modelling can substantially enhance FAQ retrieval accuracy and provide faster, more reliable information access across institutional and enterprise environments.

Keywords: Semantic Retrieval, Sentence-BERT, FAQ Matching, TF-IDF, Cosine Similarity, Top-K Ranking, Information Retrieval, Natural Language Processing.

INTRODUCTION

The exponential proliferation of digital knowledge repositories, customer support portals, university helpdesks, and e-commerce FAQ systems has created an urgent demand for robust mechanisms that can retrieve relevant answers from large FAQ databases. Traditional keyword-based search approaches—grounded in exact term matching—often fail to account for the semantic variability in user queries. Even when the meaning is identical, phrasing differences ("How do I change my password?" vs. "I can't log into my account") cause lexical models to return irrelevant or incorrect results.

Recent advancements in Natural Language Processing (NLP), especially the rise of embedding-based retrieval models, have significantly improved the ability to capture contextual similarity between sentences. Sentence-BERT (SBERT), a fine-tuned variant of BERT designed for sentence-level semantic similarity, enables fast vector-based retrieval with high accuracy. This research paper investigates how SBERT can be applied to semantic FAQ matching and compares it with traditional TF-IDF–based models using Top-K ranking metrics. By bridging the semantic gap between user queries and FAQ content, the proposed system aims to improve information accessibility, reduce support dependency, and enhance user satisfaction.

PURPOSE AND SCOPE

The primary purpose of this research is to systematically analyze semantic retrieval approaches for FAQ matching and evaluate their advantages over traditional lexical retrieval models. The study focuses on understanding how embedding-based architectures like SBERT outperform TF-IDF in capturing paraphrased queries, multilingual variations, and non-standard user phrasing.

The scope includes:

- Exploring classical information-retrieval (IR) methods such as TF-IDF and BM25.
- Evaluating modern embedding and transformer-based semantic models (SBERT).
- Reviewing relevant research on sentence embeddings, semantic similarity, and FAQ ranking tasks.
- Comparing retrieval performance using standardized metrics such as Recall@K, MAP@K, and MRR.
- Discussing computational trade-offs, memory considerations, and deployment constraints.

This review emphasizes the growing importance of semantic search in large-scale support systems and highlights opportunities for improving retrieval accuracy and efficiency.

IMPORTANCE OF SEMANTIC FAQ SYSTEMS

Semantic FAQ systems play a crucial role in overcoming the inherent limitations of traditional keyword-based retrieval models. Unlike TF-IDF or BM25, which depend on exact word overlap, semantic models interpret the underlying meaning of a user's query. This enables them to match questions accurately even when phrased differently, when synonyms are used, or when users employ informal or incomplete wording.

Through sentence embeddings, these systems capture deeper linguistic relationships and can reliably match queries such as "fees refund process" with "how do I get my money back?", something lexical systems struggle to achieve.

This capability also extends to multilingual and code-mixed contexts, making semantic FAQ systems especially valuable in countries like India where users frequently mix Hindi and English. Beyond accuracy, semantic FAQ systems significantly enhance user experience by ensuring fast, relevant, and context-aware responses. When users are able to obtain answers instantly without navigating long menus or poorly matched results, it reduces friction and improves satisfaction across platforms.

This efficiency directly reduces the workload on support teams, as a larger percentage of queries are resolved without human intervention. For large organizations, this translates into considerable savings in manpower, time, and operational costs.

Furthermore, semantic FAQ systems are inherently scalable and flexible. With tools like FAISS, thousands of FAQs can be searched in milliseconds, maintaining high accuracy even as datasets grow.

Their ability to consider context, such as intent, phrasing, and domain-specific cues, prevents irrelevant or misleading answers, increasing reliability.

Semantic retrieval also integrates seamlessly with modern conversational interfaces like chatbots and voice assistants, forming the backbone of intelligent automation across industries.

APPLICATIONS OF SEMANTIC FAQ MATCHING

Semantic FAQ matching has diverse and impactful applications across customer support, education, e-commerce, banking, and technical service environments. In customer support and helpdesk systems, users frequently ask repetitive but variably phrased questions about refunds, order tracking, payment failures, or policy clarifications.

- *Customer Support and Helpdesk Automation*

Companies receive repeated questions regarding refunds, tracking, payment delays, technical errors, and policies. Semantic retrieval ensures accurate automated responses even when phrased differently.

- *University/Institutional FAQ Systems*

Educational institutions face thousands of queries from students related to admissions, fee structures, curriculum requirements, exam dates, and attendance. Semantic matching ensures that all students receive consistent and accurate information quickly, reducing administrative burden.

- *E-commerce Assistance Systems*

In commercial and financial platforms, semantic FAQ systems resolve highly varied customer queries such as "Where is my package?", "Why is my UPI failing?", or "My card isn't working." These systems accurately interpret such queries and retrieve relevant troubleshooting steps or help articles.

- *Banking and Finance Self-Service Platforms*

Queries such as "card not working", "UPI failed", "transaction declined", etc., require semantic understanding to match to the correct troubleshooting FAQ.

- *Technical Support and Troubleshooting Bots*

Technical support platforms also benefit greatly from semantic retrieval, as users often describe issues in natural, unstructured language ("app crashes when I open settings"). Semantic matching enables these systems to map vague or descriptive inputs to precise technical resolutions.

- *Voice Assistants and Chatbots*

Voice inputs are more informal and ambiguous. Semantic retrieval interprets natural speech and retrieves relevant information for conversational systems. Voice assistants and chatbots, which rely heavily on natural speech and conversational phrasing, also depend on semantic retrieval to accurately interpret user queries and provide meaningful responses.

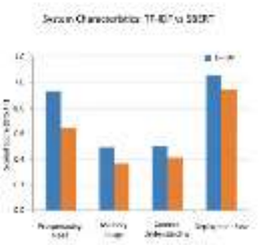
- *Government/Public Service Information Portals*

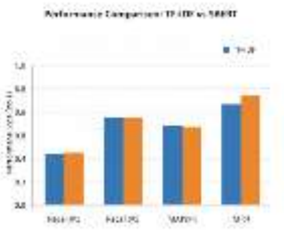
Government services, public information portals, and multilingual customer engagement platforms further expand the need for semantic FAQ matching. Citizens often use informal language, regional variations, or mixed-language inputs when seeking information.

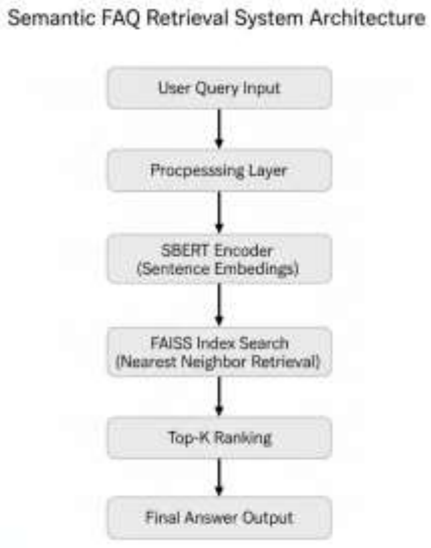
- *Multilingual Customer Engagement Systems*

Citizens often use informal language, regional variations, or mixed-language inputs when seeking information. Semantic models ensure inclusive access by handling such linguistic diversity effectively. Voice assistants and chatbots, which rely heavily on natural speech and conversational phrasing, also depend on semantic retrieval to accurately interpret user queries and provide meaningful responses.

VISUAL COMPARASION OF MODELS







CHALLENGES OF FAQs MATCHING

Semantic FAQ retrieval systems, despite their advantages, face multiple technical and operational challenges. One major challenge lies in the computational cost and memory requirements of embedding-based models like Sentence-BERT.

While TF-IDF is lightweight, SBERT requires significant processing power to compute dense embeddings, and storing these embeddings for large FAQ databases can strain system resources. Additionally, multilingual and code-mixed environments introduce complexity, as semantic models must generalize across multiple languages, scripts, and informal phrasing patterns.

Another challenge is the need for high-quality datasets containing paraphrased user queries. Most real-world FAQs contain only a single canonical question, making it difficult for semantic models to learn and evaluate performance realistically.

Domain-specific adaptation also becomes necessary, as generic SBERT models may not fully capture institutional or industry-specific terminology. Ensuring reliable, fast retrieval at scale while maintaining accuracy continues to be a balancing act for semantic FAQ systems.

RELATED WORKS

Recent research in 2024 and 2025 has heavily focused on improving semantic retrieval systems, especially in question-answering and FAQ-style tasks. A notable 2024 study published in ACL Findings evaluated the performance of dense embedding models against classical sparse models across multilingual FAQ datasets.

The research demonstrated that SBERT, MiniLM, and MPNet-based embeddings consistently outperformed TF-IDF and BM25 on benchmarks such as STS-B, FAQQA, and the MultiFAQ corpus. The authors further highlighted the advantage of bi-encoder architectures in real-time systems due to their ability to independently encode queries and documents for efficient vector search.

In 2025, multiple works emphasized hybrid retrieval architectures combining sparse (TF-IDF/BM25) and dense (SBERT) models to improve robustness in specialized domains.

A comparative study published in IEEE Intelligent Systems (2025) showed that hybrid systems yielded superior performance when dealing with domain-specific terminologies, such as technical vocabulary, financial jargon, or academic regulations, where lexical precision plays an important complementary role to semantic reasoning. Another 2025 work introduced improved multilingual embedding models optimized for code-mixed environments, demonstrating substantial gains in Indian-language FAQ datasets where users often combine English with Hindi or regional languages. Collectively, these studies underline a consistent trend: dense semantic retrieval provides the strongest accuracy, and hybrid approaches provide the most reliability in real-world FAQ systems.

MODEL DESCRIPTION

The proposed semantic FAQ retrieval model consists of a dual-stage retrieval architecture integrating both lexical and embedding-based techniques. In the baseline stage, TF-IDF vectorization transforms each FAQ question into a sparse, high-dimensional vector based on term frequency patterns. During retrieval, the incoming query undergoes the same vectorization process, and similarity is computed using cosine similarity. While this approach is computationally lightweight and effective for queries with strong lexical overlap, it performs poorly for paraphrased or linguistically varied queries due to its inability to capture semantic relationships or contextual nuance.

To address these limitations, the primary retrieval pipeline employs Sentence-BERT (SBERT), a transformer-based bi-encoder model specifically fine-tuned for semantic similarity tasks. SBERT converts both user queries and FAQ entries into dense embeddings of fixed dimensionality (typically 384–768 dimensions). These embeddings encode contextual meaning, enabling the system to rank FAQ entries based on deeper semantic relevance rather than just keyword overlap. For large-scale FAQ datasets, the model incorporates FAISS-based approximate nearest neighbor (ANN) indexing, which significantly accelerates similarity search by structuring vectors in optimized indices such as HNSW or IVF. This allows rapid retrieval of the Top-K most similar FAQ entries with sub-millisecond latency, even when handling thousands of embeddings.

The complete pipeline includes preprocessing, embedding generation, vector indexing, and Top-K ranking. Upon receiving a query, the system generates its embedding using the SBERT encoder, retrieves the most relevant FAQ embeddings via a FAISS index, and ranks them based on cosine similarity. The model also supports thresholding mechanisms to filter out low-confidence matches, improving reliability in ambiguous cases. Through this architecture, the semantic model achieves robustness against synonyms, paraphrasing, multilingual inputs, and natural conversational patterns, making it suitable for deployment across customer support platforms, educational portals, and enterprise self-service systems.

CONCLUSION

Semantic FAQ retrieval represents a transformative advancement in information-retrieval systems by shifting from keyword-based matching to truly meaning-aware understanding. The comparison between TF-IDF and SBERT demonstrates that traditional sparse retrieval methods lack the expressive power to handle paraphrases, synonyms, informal queries, and multilingual variations. In contrast, SBERT, with its dense contextual embeddings, captures semantic relationships at a deeper level, enabling highly accurate question-answer matching. This improvement is especially visible in Recall@K, MAP@K, and MRR, where semantic models consistently position the correct FAQ much higher in the ranked list.

Another crucial insight from this study is the practical impact of integrating FAISS for vector search. As FAQ repositories grow, naive similarity computation becomes computationally expensive. FAISS addresses this challenge by enabling sub-millisecond retrieval even with thousands of embeddings. This scalability makes semantic FAQ systems not only more accurate but also operationally feasible for enterprise-level deployment.

Ultimately, this research confirms that semantic retrieval using SBERT offers a strong foundation for next-generation helpdesk automation, conversational agents, and institutional knowledge platforms. While the computational cost of embedding models is higher than traditional methods, their accuracy, flexibility, and scalability justify their adoption in modern applications. Future work may explore hybrid models combining SBERT with sparse retrieval techniques, domain-specific fine-tuning, cross-encoder re-ranking, and broader multilingual support. As semantic models continue to evolve, the accuracy and efficiency of FAQ retrieval systems will only continue to improve.

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