Cheat Sheet: Advanced Retrievers for RAG

Estimated Reading Time: 15 minutes

Core Retrieval Concepts

What are Advanced Retrievers?

Advanced retrievers go beyond simple vector similarity search to provide more nuanced, context-aware information retrieval through:

- **Semantic Understanding**: Using embeddings for meaning and context
- **Keyword Matching**: Precise term-based search for exact specifications
- **Hierarchical Context**: Maintaining relationships between information levels
- **Multi-Query Processing**: Generating and combining results from multiple query variations
- **Fusion Techniques**: Intelligently combining results from different retrieval methods

Maximum Marginal Relevance (MMR)

Purpose: Balance relevance and diversity of retrieved results
Method: Selects documents that are highly relevant to the query AND minimally similar to previously selected documents
Benefit: Avoids redundancy and ensures comprehensive coverage of different query aspects

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LlamaIndex Retrievers

Core Index Types in LlamaIndex

VectorStoreIndex

- **Function**: Stores vector embeddings for each document chunk
- **Best suited for**: Semantic retrieval based on meaning
- **Usage**: Commonly used in LLM pipelines and RAG applications

DocumentSummaryIndex

- **Function**: Generates and stores summaries of documents at indexing time
- **Process**: Uses summaries to find and retrieve relevant documents
- **Best for**: Large documents whose meanings would be lost by chunking; large documents that cannot fit in LLM or embedding model context windows
- **Key Points**: Returns original documents, not their summaries; uses summaries instead of text chunks to enable retrieval based on the semantic meaning of the entire text

KeywordTableIndex

- **Function**: Extracts keywords from documents and maps to content chunks
- **Best for**: Exact keyword matching for rule-based or hybrid search scenarios
- **Use Case**: Applications requiring precise term matching

LlamaIndex Retriever Types

1. Vector Index Retriever

Most common retriever - uses vector embeddings to find semantically related content

- **Process**: Embeds query, compares with document embeddings using cosine similarity
- **Ideal for**: General-purpose search, RAG pipelines where semantic understanding is crucial
- **Limitation**: May miss exact keyword matches when specific terms are crucial

2. BM25 Retriever

Advanced keyword-based retrieval that improves on TF-IDF

TF-IDF Foundation:

- **Term Frequency (TF)**: How often a word appears in a document
- **Inverse Document Frequency (IDF)**: How rare a word is across all documents
- **TF-IDF Score**: TF × IDF

BM25 Improvements:

- **Term Frequency Saturation**: Reduces impact of repeated terms using saturation function
- **Document Length Normalization**: Adjusts for document length, preventing long document bias
- **Tunable Parameters**: k1≈1.2 (saturation control), b≈0.75 (length normalization)

Best for: Technical documentation, legal documents, exact terminology requirements

3. Document Summary Index Retrievers

Two Variants:

1. **DocumentSummaryIndexLLMRetriever**: Uses LLM to analyze query against summaries (intelligent but expensive)
2. **DocumentSummaryIndexEmbeddingRetriever**: Uses semantic similarity between query and summary embeddings (faster, cost-effective)

Process: Two-stage approach using summaries to filter documents, then returns full document content

4. Auto Merging Retriever

Purpose: Preserves context in long documents using hierarchical structure
Method:

- Uses hierarchical chunking (parent and child nodes)
- If enough child nodes from same parent are retrieved, returns parent node instead
- **Dual Storage**: Child chunks for precise matching, parent chunks for context

Best for: Long documents, legal papers, technical specifications needing context preservation

5. Recursive Retriever

Purpose: Follows relationships between nodes using references
Capability: Can follow references from one node to another (citations, metadata links)
Types: Supports chunk references and metadata references
Best for: Academic papers with citations, interconnected knowledge bases

6. Query Fusion Retriever

Purpose: Combines results from different retrievers and optionally generates multiple query variations

Core Capabilities:

- Multiple retriever support (combines vector-based and keyword-based methods)
- Query variation generation using LLM
- Sophisticated fusion strategies to improve recall

Three Fusion Modes:

Reciprocal Rank Fusion (RRF)

- **Most robust fusion method** - combines ranked lists using reciprocal of ranks
- **Formula**: `RRF_score(d) = Σ (1 / (rank_i(d) + k))` where k≈60
- **Best for**: Default choice for most fusion scenarios, production systems

Relative Score Fusion

- **Preserves score magnitudes** while normalizing across query variations
- **Formula**: `normalized_score = original_score / max_score`
- **Best for**: When embedding model confidence scores are meaningful

Distribution-Based Score Fusion

- **Most sophisticated** - uses statistical properties of score distributions
- **Methods**: Z-score normalization, percentile ranking
- **Best for**: Complex queries with varying score distributions

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LangChain Retrievers

LangChain Retriever Interface

Definition: "An interface that returns documents based on an unstructured query"

- More general than a vector store
- Accepts string query as input, returns list of documents as output
- Doesn't necessarily store documents - purpose is to retrieve them

LangChain Retriever Types

1. Vector Store-Backed Retriever

Foundation retriever - lightweight wrapper around vector store class
Search Types:

- **Simple Similarity Search**: Returns documents ranked by similarity (default 4 results)
- **MMR Search**: Balances relevance and diversity to avoid redundancy
- **Similarity Score Threshold**: Returns only documents above specified threshold

2. Multi-Query Retriever

Problem Addressed: "Distance-based vector database retrieval may vary with subtle changes in query wording"

Solution Process:

1. **Uses LLM to generate multiple queries** from different perspectives

2. **For each query, retrieves set of relevant documents**
3. **Takes unique union** of results for larger set of potentially relevant documents

Benefit: "By generating multiple perspectives on the same question, the MultiQueryRetriever can potentially overcome some limitations of distance-based retrieval"

3. Self-Querying Retriever

Core Capability: "Has the ability to query itself"

Process: Converts natural language query into structured query with two components:

1. **String to look up semantically**
2. **Metadata filter** to accompany it

Requirements: Documents must have rich, structured metadata with field descriptions
Best for: Applications combining semantic search with attribute filtering

Example Queries:

- "I want to watch a movie rated higher than 8.5" (filter only)
- "Has Greta Gerwig directed any movies about women" (query + filter)

4. Parent Document Retriever

Problem Solved: "Conflicting desires" when splitting documents:

- Small documents for accurate embeddings
- Large documents for context retention

Solution: "Strikes that balance by splitting and storing small chunks of data"

Process:

1. During retrieval, first fetches small chunks
2. Looks up parent IDs for those chunks
3. Returns larger documents containing the small chunks

Architecture:

- **Two splitters**: Parent (large chunks for retrieval) and child (small chunks for embeddings)
- **Dual storage**: Vector store for embeddings, document store for parent documents

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Decision Framework

Need	LlamaIndex Choice	LangChain Choice
Exact keyword matching	BM25 Retriever	Vector Store-Backed + custom keyword logic
Multi-query with fusion	Query Fusion Retriever (RRF/Relative/Distribution)	Multi-Query Retriever (union approach)
Citation following	Recursive Retriever	Not directly supported
Hierarchical context	Auto Merging Retriever	Parent Document Retriever
Simple semantic search	Vector Index Retriever	Vector Store-Backed Retriever

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