

Enhance the professionalism of
LLM answers through keyword-
based labeled database

(RAG with Gemini)

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Introduction

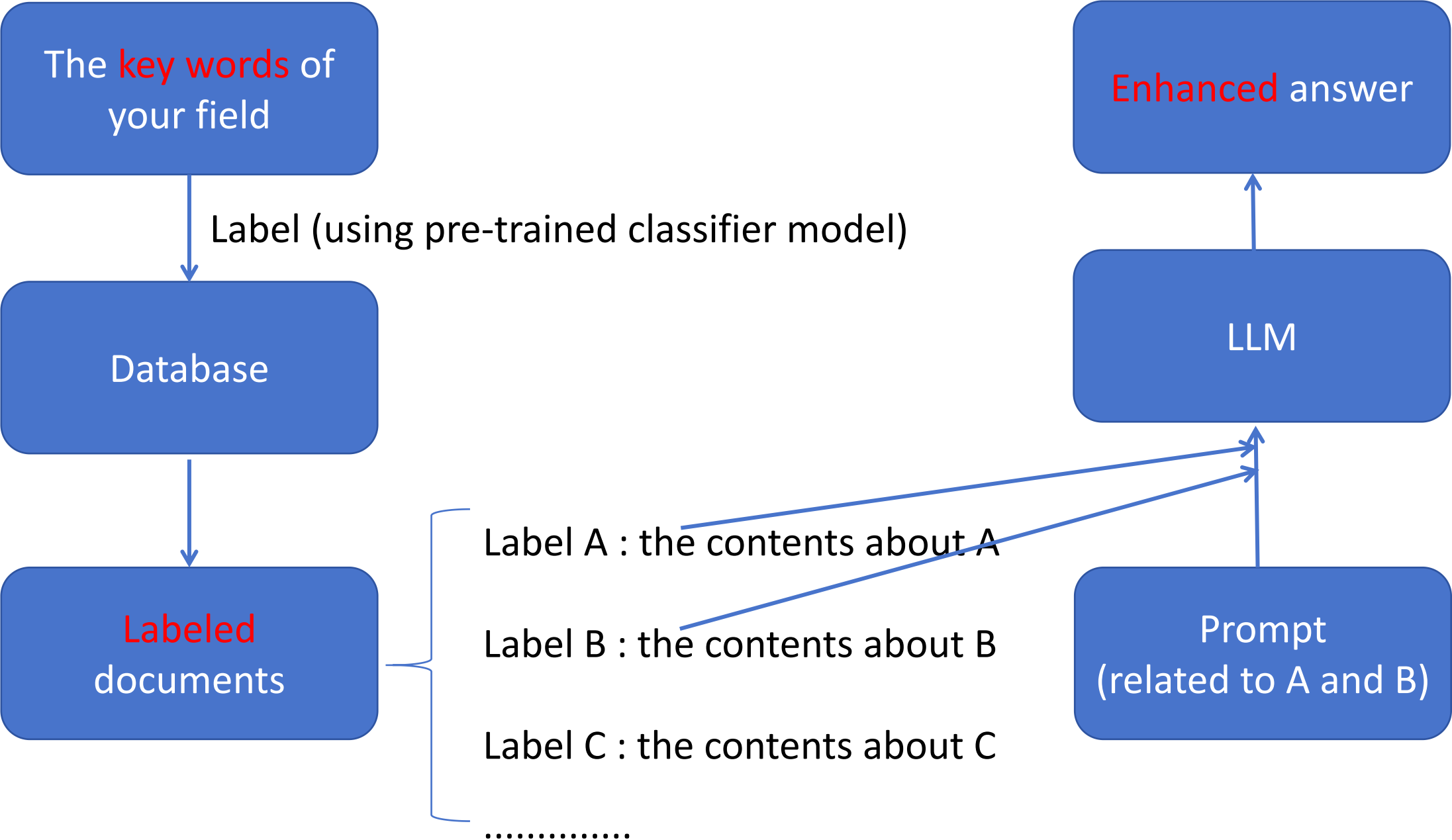
The latest progress about magnetostriction, today (2024/11/15)



As of November 15, 2024, the latest research on **magnetostriction** focuses on several key directions, including the development of new materials, performance optimization, fundamental mechanism studies, and expanded applications. While I cannot access up-to-date databases like Google Scholar or arXiv, I can summarize the current trends and research topics in the field. Below are some of the research directions and possible paper content reflecting the latest progress in magnetostriction research in 2024:

Commercial LLM models **typically cannot access certain databases** in areas of interest to us, or may be **slow to update**, which can **lead to a decrease in the accuracy or specialization of the responses.**

Method (Flowchart)



Pre-trained models used in this work

LLM :

Gemini-1.5-flash

Classifier model :

Zero-shot classification model using Natural Language Inference (NLI) based on the Bidirectional and Auto-Regressive Transformers (BART) :
pipeline('zero-shot-classification', model='*facebook/bart-large-mnli*')

Results (Examples)

Prompt : "What is the magnetostriction, and what are the typical materials"

Database : <https://en.wikipedia.org/wiki/Magnetostriction>

With RAG

Magnetostriction is the property of magnetic materials that causes them to change their shape or dimensions when exposed to a magnetic field. This change in shape is known as magnetostrictive strain.

Here are some of the typical materials used for magnetostriction:

- **Pure Elements:**
 - **Cobalt:** Exhibits the largest room-temperature magnetostriction of a pure element at 60 microstrains.
- **Alloys:**
 - **Terfenol-D (TbDyFe2):** Exhibits the highest known magnetostriction, around 2,000 microstrains in a field of 160 kA/m at room temperature. It's the most commonly used engineering magnetostrictive material.
 - **Galfenol (FexGa1-x):** Exhibits 200-400 microstrains at lower applied fields (~200 Oe) and has enhanced mechanical properties compared to Terfenol-D.
 - **Alfer (FexAl1-x):** Similar to Galfenol in terms of magnetostriction and enhanced mechanical properties.
 - **Metglas 2605SC (Fe81Si3.5B13.5C2):** An amorphous alloy known for its high saturation-magnetostriction constant (~20 microstrains) and low magnetic anisotropy field strength.
- **Ferrites:**
 - **Cobalt Ferrite (CoFe2O4):** Used for its magnetostrictive applications in sensors and actuators due to its high saturation magnetostriction (~200 ppm). It's a good substitute for Terfenol-D in the absence of rare-earth elements.

Without RAG

Magnetostriction is the phenomenon where a ferromagnetic material changes its shape in response to an applied magnetic field. This change in shape can be either a **lengthening** (positive magnetostriction) or a **shortening** (negative magnetostriction) of the material.

Here's the breakdown:

- **Ferromagnetic materials:** These materials are strongly attracted to magnets due to the alignment of their magnetic domains.
- **Magnetic domains:** These are tiny regions within the material where the magnetic moments of atoms are aligned in the same direction.
- **Applied magnetic field:** This external magnetic field influences the alignment of magnetic domains.
- **Shape change:** When the magnetic domains align, the material can slightly change its shape, either stretching or compressing.

Why does this happen?

The change in shape is due to the interaction between the magnetic moments of the atoms and the crystal structure of the material. When the magnetic moments align, they exert forces on the crystal lattice, causing it to deform.

Typical materials exhibiting magnetostriction:

- **Iron (Fe):** One of the most common and well-known magnetostrictive materials.
- **Nickel (Ni):** Another common material with significant magnetostrictive properties.
- **Cobalt (Co):** Also exhibits magnetostriction, although less than iron or nickel.
- **Terfenol-D:** A special alloy of terbium, dysprosium, and iron known for its extremely high magnetostriction.
- **Galfenol:** An alloy of gallium, iron, and a small percentage of other elements, with high magnetostriction and low cost.

Results (Examples)

Prompt = "What are the latest progresses about magnetostricton and magnetization **today**"

Database : <https://arxiv.org/list/cond-mat/new> (The latest abstracts of papers in arXiv **today**)

With RAG

The provided text discusses recent research on manipulating magnetization using surface acoustic waves (SAWs) in a bilayer heterostructure composed of a piezoelectric material and a magnetostrictive iron-gallium (Fe72Ga28) alloy. Here's a summary of the key points relevant to your query:

Key Progresses:

- **Electric Control of Magnetization Waves:** The research demonstrates the ability to control magnetization waves using electric fields. This is achieved by generating SAWs that interact with the magnetostrictive alloy, effectively tailoring the magnetic anisotropy.
- **Quantification of Magnetoelastic Coupling:** The study provides a method to quantify the magnetoelastic coupling constant in thin films using X-ray photoemission electron microscopy (XPEEM) and micromagnetic simulations. This allows for a better understanding of the interaction between SAWs and magnetization.
- **Non-Resonance Mode Generation:** The experiment reveals the generation of magnetoacoustic waves (MAWs) in a non-resonance mode. This opens possibilities for generating higher MAW amplitudes by optimizing conditions for resonance.
- **Exploring the Potential of Galfenol:** The study focuses on Fe72Ga28, a galfenol alloy known for its enhanced magnetostrictive properties. This highlights the potential of using this alloy in future magnetostrictive devices.

Without RAG

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Note: This is a brief overview, and ongoing research is constantly uncovering new advancements in magnetostriction and magnetization. You can find specific research papers and news articles on these topics through online databases like Google Scholar and scientific journals.

Gemini

Look it up
yourself!

Conclusion

This project aims to enhance the professionalism of Large Language Model (LLM) responses by using a keyword-based labeled database with Retrieval-Augmented Generation (RAG). The model used is Gemini-1.5-flash, along with a zero-shot classification model based on the BART architecture for information retrieval and classification. By incorporating domain-specific knowledge from a labeled database, LLM answers become more accurate, professional, and data-supported.

The RAG-enhanced answer not only provides detailed material information but also includes specific numerical data and technical terminology, significantly improving the quality of the response.

This approach demonstrates how integrating external databases and labeled information can enhance LLM capabilities, enabling it to generate more authoritative and professional answers in specialized fields.

THANK YOU!