

Using Retrieval Augmented Generation (RAG) and Ontologies to build an Assistant for Dental Clinicians

Michael DeBellis & Nivedita Dutta, mdebellsf@gmail.com niveditadgp@gmail.com

<https://www.michaeldebellis.com/blog>

FOIS 2024: Workshop on Convergence of LLMs and Ontologies

15, July 2024



The problem: Provide Timely Information to Dental Clinicians

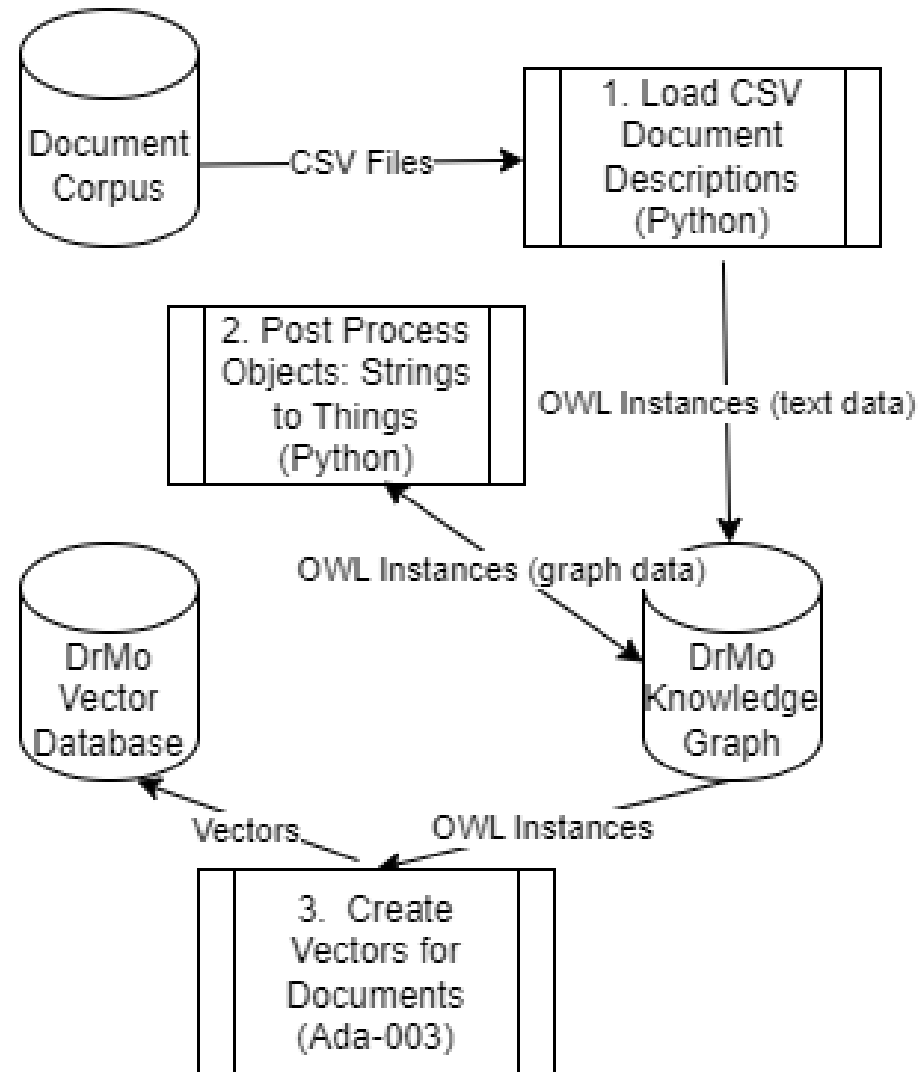
- This is the problem that inspired Dr. Dutta to develop an ontology on Dental Materials and Products
- She presented the first version: Dental Restorative Materials Ontology (DrMo) at FOIS 2023
- Next step: use ontology for a Semantic Search tool to help clinicians. Collected corpus of journal articles and manufacturer publications.
- As we evaluated alternative designs, two problems seemed most difficult:
 - How to model the meaning of the text in the corpus
 - Providing a user interface that was intuitive for clinicians
- I asked colleagues at AllegroGraph if they had any ideas



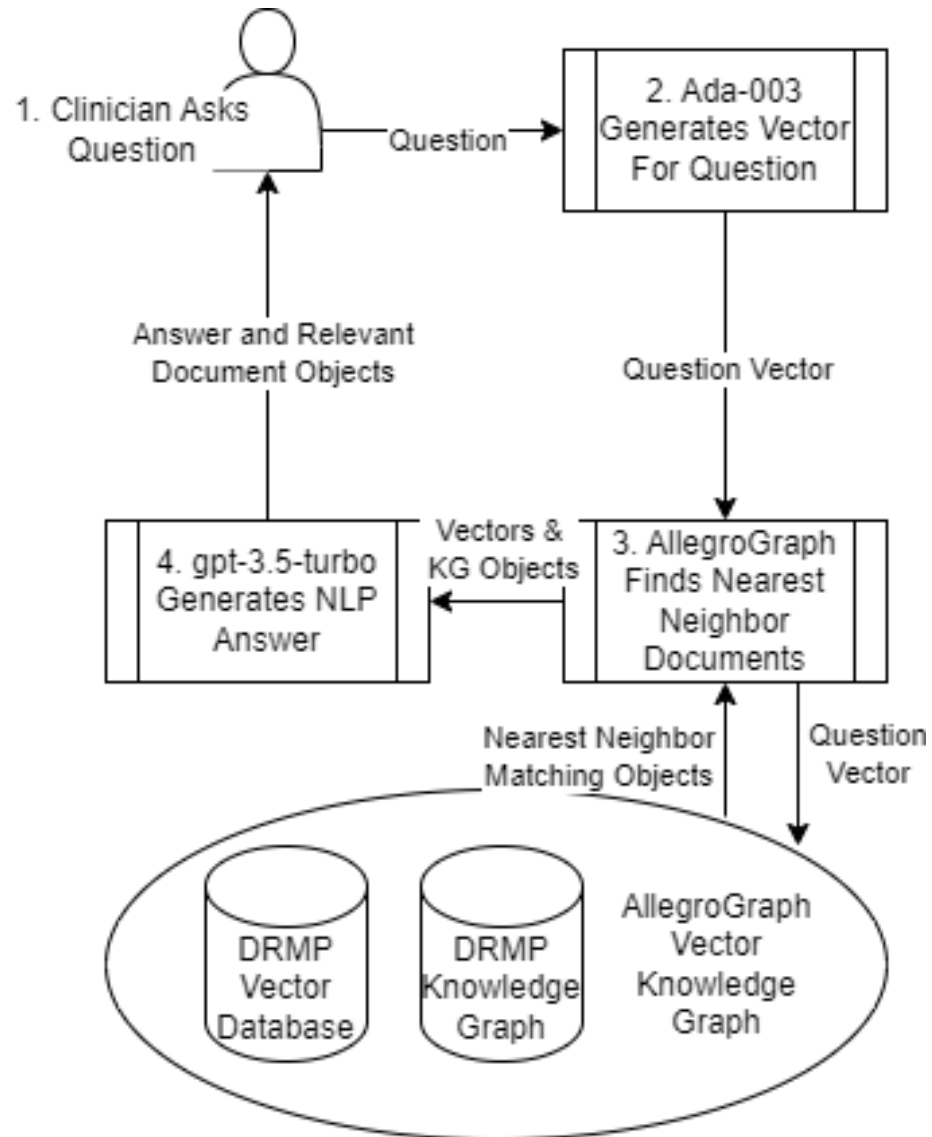
Solution: New Version of AllegroGraph integrated with ChatGPT

- Why not just use ChatGPT?
 - Hallucinations
 - Black-Box Reasoning
- RAG solves LLM issues by replacing broad but shallow knowledge of ChatGPT with narrow and deep knowledge base of domain specific documents.
- RAG Solved both our design problems
 - Meaning captured by vector embedding.
 - Intuitive user interface via ChatGPT's NLP capability.

Data Pipeline: Creating the RAG Knowledge Base from Document Corpus



Run Time Architecture



Example: GPT Answer Doesn't Reflect Latest Research

Open AI Gpt 3.5



Does study evidence support positive outcome of rapid high-intensity light-curing on polymerization shrinkage properties of resin-based composite?



As of my last update, I don't have access to specific clinical trial reports or studies on the performance of a "Universal Simplified Adhesive System" in composite restorations after a 36-month period. Clinical trial data on dental materials and techniques are continually being generated and published in scientific journals, and it's essential to consult the latest literature for up-to-date information on specific products or techniques.

However, clinical trials evaluating the long-term performance of adhesive systems and composite restorations are common in dental research. These studies typically assess parameters such as restoration retention, marginal integrity, secondary caries incidence, color stability, and patient satisfaction over extended periods.

If you're interested in finding clinical trial reports on a specific adhesive system or composite restoration material after a 36-month period, I recommend searching scientific databases such as PubMed, Google Scholar, or dental journals' websites using relevant keywords. Additionally, you can check with dental manufacturers or professional dental organizations for any published studies or clinical data related to the product in question.

Example: RAG

- has latest information
- provides references

Dental Materials and Products Portal

Enter question here:

Does study evidence support positive outcome of rapid high-intensity light-curing on polymerization shrinkage properties of resin-based composite?

Answer:

"Study evidence supports that high-intensity light-curing can lead to faster development of shrinkage forces in the early stage of polymerization, with material-dependent shrinkage behavior. Shrinkage force kinetics are more affected by high-intensity curing compared to absolute values of shrinkage. Composites designed for high-intensity curing show comparable shrinkage parameters."

[View answer graph in Gruff](#)

Supporting Documents:

"Objectives To compare the effect of high-intensity (3s with 3440mW/cm²) and conventional (10s with 1340mW/cm²) light-curing on shrinkage properties and degree of conversion of conventional and bulk-fill resin composites, including two composites specifically designed for high-intensity curing. Methods Real-time linear shrinkage and shrinkage force of 1.5 mm thick composite specimens were measured for 15 min after the start of light-curing using custom-made devices. From the shrinkage force data, maximum shrinkage force rate and time to achieve maximum shrinkage force rate were determined. Degree of conversion was measured using Fourier transform infrared spectrometry. Results Flowable composites showed significantly higher linear shrinkage compared to sculptable composites (1.93–2.91 % vs. 1.15–1.54 %), as well

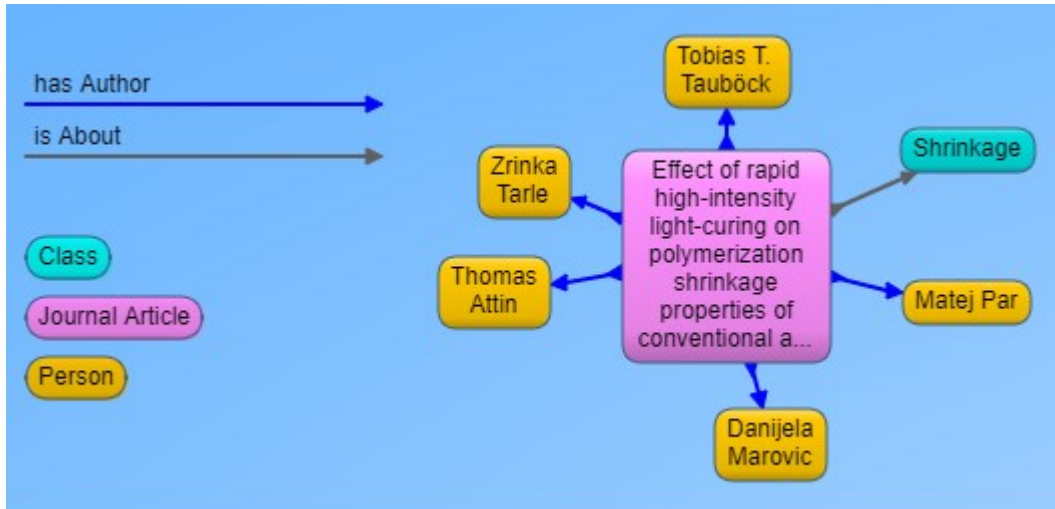
Under the hood: SPARQL Query Generated Every Time User Asks a Question

Streamlit.io Python Servlet makes this easy. Define a template query then fill in the template with the user question

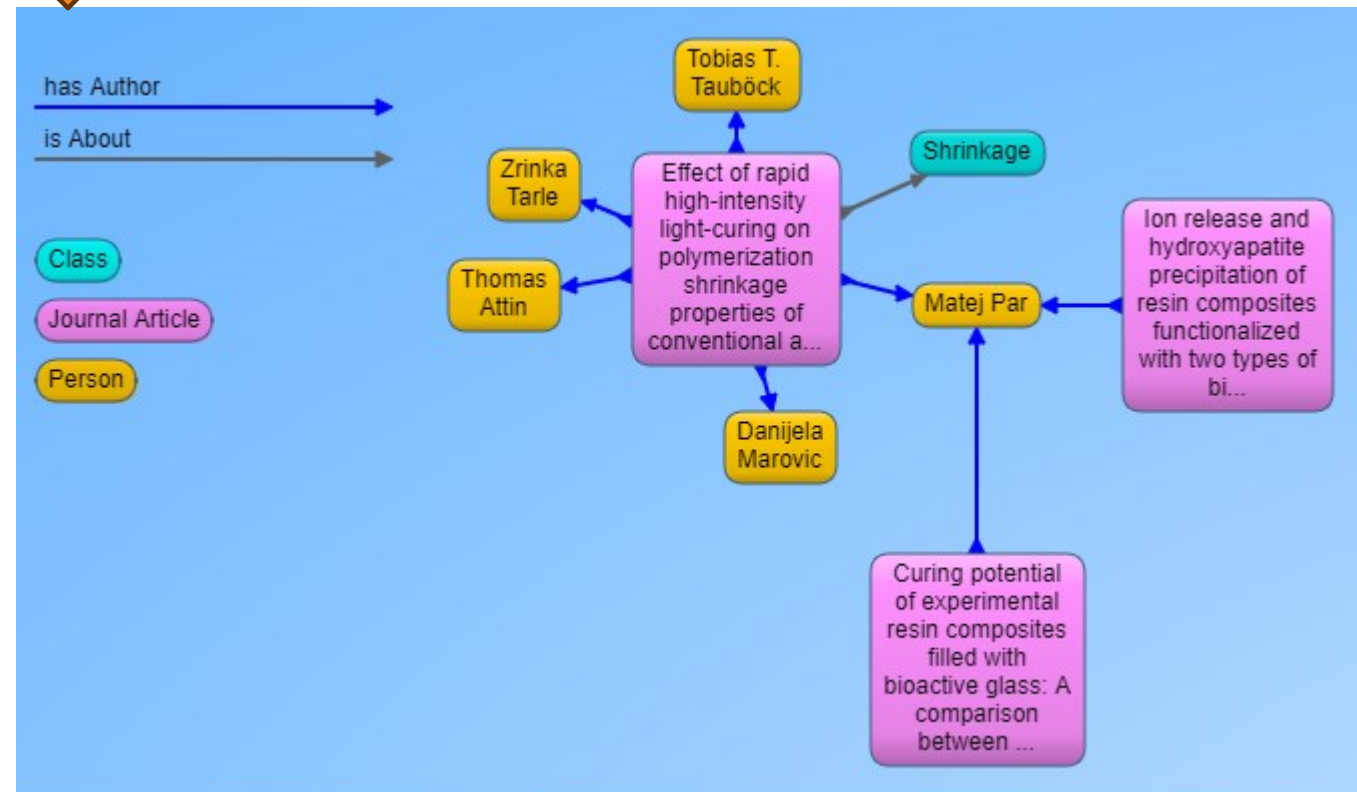
```
SELECT *  
WHERE {bind("Question ends up here" as ?query)  
      (?response ?score ?citation ?content) llm:askMyDocuments (?query "drmov" 4 0.7).  
OPTIONAL {?citation obo:IAO_0000136 ?entity1.}  
OPTIONAL {?citation drmo:hasAuthor ?cauthor.}  
OPTIONAL {?document drmo:hasSubSection ?citation;  
          drmo:hasAuthor ?dauthor;  
          obo:IAO_0000136 ?entity2.}}
```


Knowledge Graph Facilitates Further Exploration


Initial Graph




User selects "Matej Par" and displays all hasAuthor triples with that node as object





User Selects “Matej Par” and selects option to visit URL associated with node






Connecting research and researchers

Michael DeBellis 


English 

Search the ORCID registry... 

Matej Par



 <https://orcid.org/0000-0002-2846-1840>   [Show record summary](#)

Personal information

Other IDs 

ResearcherID: J-2019-2019

Activities

 Works (32)  Sort


Mechanical Properties of Alkasite Material with Different Curing Modes and Simulated Aging Conditions

Materials [Show more detail](#)

2024-06 | Journal article | *Author*

DOI: [10.3390/ma17112777](https://doi.org/10.3390/ma17112777)

CONTRIBUTORS: Visnja Negovetic Mandic; Laura Plančak; Danijela Marovic; Zrinka Tarle; Milena Trutina Gavran; Matej Par

Source:  Multidisciplinary Digital Publishing Institute

[Collapse all](#)



Future Plans and Issues

- Most Important Enhancement: Host on the Internet and conduct trials with actual users
- Interesting Issue: ChatGPT Keeps getting smarter. An arms race between RAG and ChatGPT. RAG needs to be regularly updated with latest articles to maintain superiority.
- Solutions:
 - Automate the data pipeline on slide 4.
 - Extend UI so that answers from both ChatGPT and RAG can be displayed.

Questions??

- For technical questions: mdebellsf@gmail.com
- For domain questions: niveditadgp@gmail.com
- GitHub repository: https://github.com/mdebellis/DrMO_Docs
- DrMo paper from FOIS 2023:
https://www.academia.edu/108590021/Dental_Restorative_Material_Ontology_DrMO?sm=a
- Acknowledgements:
 - Thanks to Franz Inc. for giving us a pre-release of their LLM integration and answering our many questions.
 - Thanks to OBO Oral Health and Disease (OHD) Ontology group for their support. Especially Bill Duncan.
 - This project utilized the Protégé ontology editor. Thanks to the Protégé User Support Email list.