Controlled Conversational Models through Conversation-Dedicated Ontology

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1. Context

Recent advances in large language models (LLMs) have improved conversational agents' realism and acceptance. However, **controlling conversation flow towards positive outcomes remains crucial**. This Ph.D. aims to **represent conversational knowledge using an ontology to enable language model control**. Ontologies allow to model the knowledge in a domain, defining concepts and characterizing relations between them. While often used for domain-specific knowledge, few have explored using ontologies to guide conversation flow. Convology [1] is a recent example focusing on managing health conversations. We plan to extend Convology's conceptualization capacities to a more general setup, therefore adaptable to general-purpose user/agent conversations.

2. Methodology

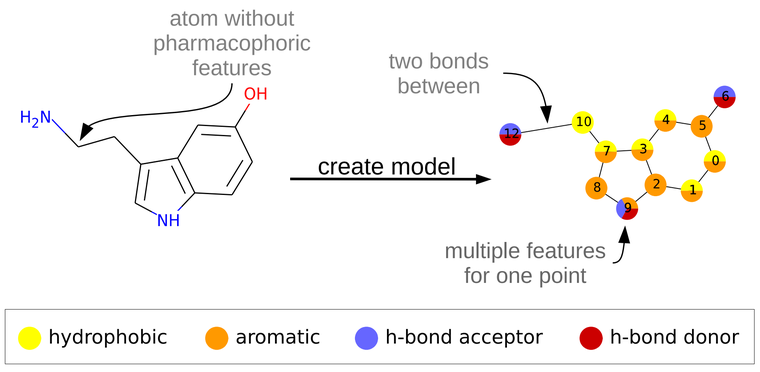
PhD approach. Iterative process by progressive enrichment of the ontology to conceptualize more and more notions related to conversations.

Tools. Protégé, HermiT and Pellet reasoners, owlready2, rdflib, PyTorch, huggingface transformers and parameter-efficient fine-tuning libraries, LoRA adapters.

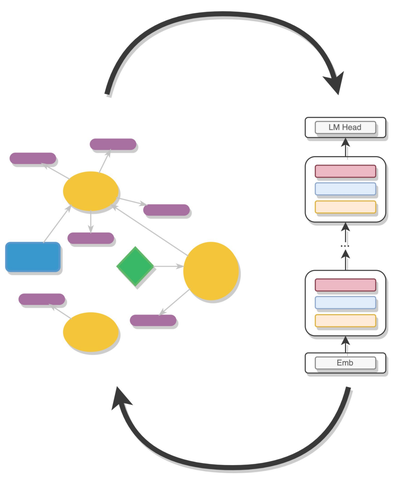
Conceptualization. Explain our ontology engineering process and how we select and create toy examples.

Control. Explain how we plan to control the conversational dynamic inthe context of a dialogue user-agent.

Challenges. It is not straightforward that what the ontology brings can be fully understood and learnt by an LLM (in our case, we consider for now only decoder-based language models).



3. Objectives

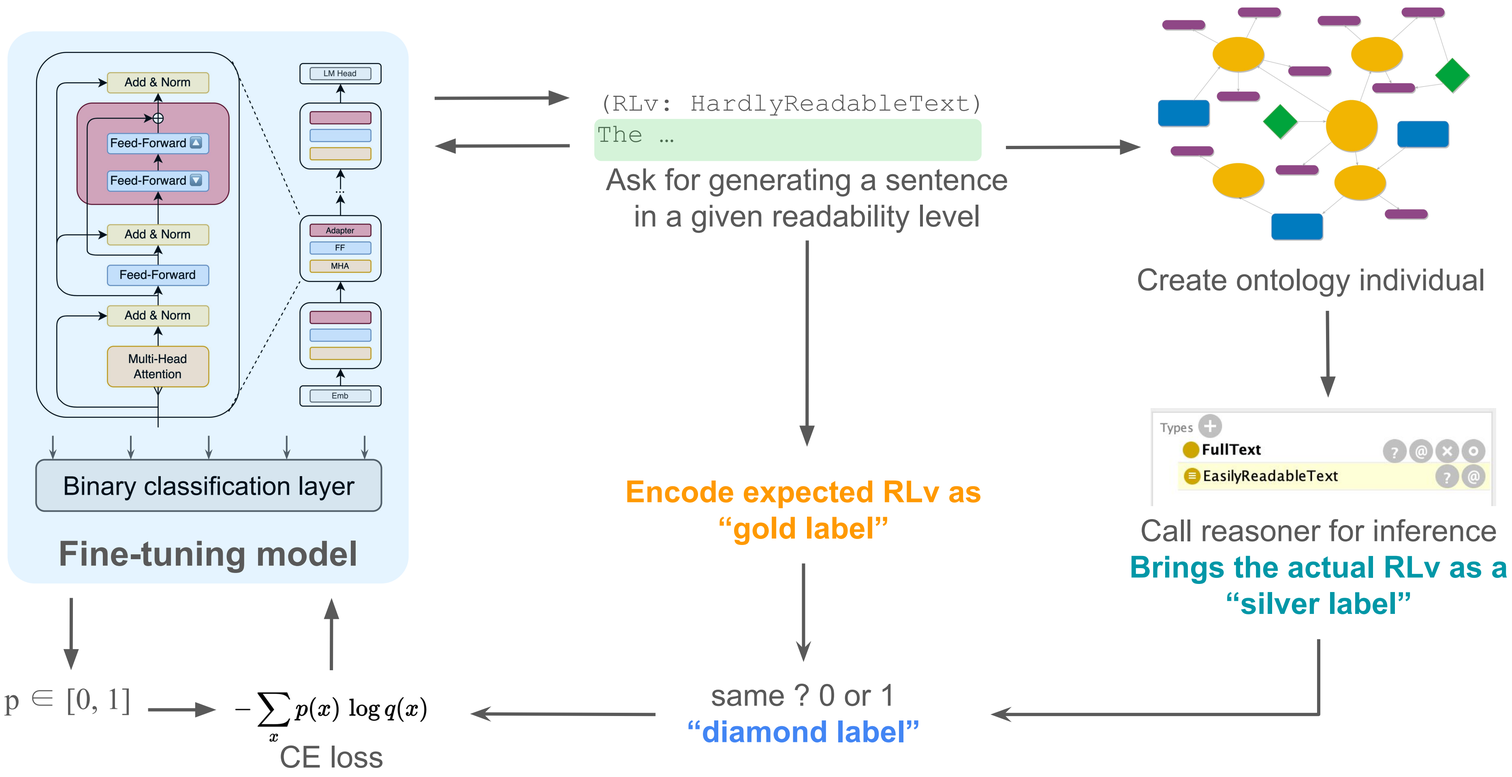


Develop **knowledge-enhanced conversational models** that exploit Large Language Models (LLMs) and Ontologies. The aim is to provide **structured knowledge** to open-domain conversational agents [2].

- Build a conversation ontology that accounts for interpersonal relationships concepts and their evolution.
- Integrate and assess ontology understanding during fine-tuning.
- Bring control on conversational LLM outputs through encapsulated conversation knowledge.

4. OntoGPT: LLM Fine-Tuning Based on Ontology Validation

We work on a LLM/Ontology hybridation setup where the ontology is supposed to help the LLM produce more accurate utterances in dialogue (being as compliant as possible towards the user requirements). For this, we provide a an end-to-end integration pipeline where the ontology information is assimilated at fine-tuning time.



5. Related Work

- Many approaches use LLMs to improve KGs [Mateiu et al., 2023, He et al., 2023, Giglou et al., 2023]
- "KGs to improve LLMs" approaches are less common but gain interest
  - KG embeddings fed to BERT-like model [Gong et al., 2020]
  - Integration of knowledge information using GANs [Varshney et al., 2023b]
  - KLLM @ ACL 2024 (1st workshop on Knowledge Graphs and Large Language Models)

Some interesting papers:

- Paper 1
- Paper 2
- Paper 3

6. Selected references

[1] Mauro Dragoni, Giuseppe Rizzo, and Matteo A. Senese. Chapter 2 - convology: an ontology for conversational agents in digital health. In Sarika Jain, Vishal Jain, and Valentina Emilia Balas, editors, *Web Semantics*, pages 7–21. Academic Press, 2021.

[2] Deeksha Varshney, Asif Ekbal, and Erik Cambria. Emotion-and-knowledge grounded response generation in an open-domain dialogue setting. *Knowledge-Based Systems*, 284:111173, 2024.