Thesis Proposal

Large language models to detect drug misuses in social media: application in the context of pregnancy and breastfeeding.

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Background

Spontaneous reports of adverse drug reactions by healthcare professionals and patients are the main source of data for drug safety monitoring. Researchers have proposed mining user messages in social media as a new source to address the limitations of pharmacovigilance and in particular be able to detect cases of drug misuses [1; 2]. This thesis is part of a long-standing partnership between Limics and the Agence nationale de sécurité du médicament et des produits de santé (ANSM). More specifically, the current PHARES project funded by ANSM aims to develop the routine use of a processing chain for analyzing social media for pharmacovigilance purposes [3]. This chain includes a natural language processing (NLP) module that detects drug names and adverse event descriptions in discussion forums, but is not adapted to misuse detection. The evolution of NLP algorithms and the emergence of new language models with a large number of parameters open up a promising field of research for optimizing the PHARES software in the interpretation of misuse situations [4]. The clinical context of the thesis will be that of pregnancy and breastfeeding, where drug misuses may be associated with undesirable effects on the fetus or the newborn.

Research question and Objectives

The main difficulty in detecting misuse in social media using a machine learning approach is to collect a sufficient number of positive examples describing a wide variety of misuse cases, and to train a model that can then be generalized to a large number of drugs. In unbalanced situations where the number of positive examples is very low, fine-tuning machine learning models cannot be expected to deliver optimal performance. The best solution is generally to increase the number of positive examples, but this can be particularly costly in real-life situations. The emergence of new language models with a large number of parameters opens up the possibility of few-shot learning [5], in which the number of examples can be limited, while maintaining acceptable performance. Our hypothesis is that the use of a Large language models (LLM) could enable effective detection of drugs misuse in social media, without the need to annotate a large number of messages. The aim is therefore to implement an NLP-based approach to drug misuse detection using LLMs. We will focus on two types of misuse: when the intended use of the drug does not correspond to one of its indications, and when the drug is used at dosages higher than those recommended. We will evaluate our approach in the clinical context of drug use during pregnancy and breastfeeding thanks to our partnership with Trousseau Hospital in Paris.

Data sources

For this project, we have at our disposal material that has already been compiled in previous Limics projects. It consists of over 100 million messages extracted from French discussion forums, including *Doctissimo-Grossesse*. New messages are regularly extracted using the PHARES operational pipeline.

Today, our material is in French. One of our objectives is to consider an English-language source to test the generalizability of the model. Free public corpus such as ADE corpus V2 could be used, even if they are not specifically targeted towards drugs misusage [6].

Methods

Prompt engineering refers to an approach in which a prompt is written as LLM input to improve the generated LLM output. We will study the extent to which prompt engineering methods can be used to guide a model to identify types of misuse situations. For wrong indications, we will provide the model with examples of wordings commonly used to express inappropriate or unauthorized uses of drugs. Similarly, for wrong doses, we will provide specific prompts containing examples of excessive dosages.

An important aspect of the method is to complement the LLM's knowledge, with external resources, such as the summaries of product characteristics (SPCs) available on the website of ANSM. Retrieval Augmented Generation (RAG) consists in combining an information retrieval step with LLM text generation. We will compare the performance of RAG using different search engines based on keywords or embeddings. Word embeddings are dense vectors of words built up in a self-supervised way using a neural network. They can be used to express the similarity between words, and to produce visual representations that take these similarity measures into account.

Expected results

1) Systematic review on NLP and LLM approaches in pharmacovigilance.
2) Production of a high-performance model fine-tuned for the detection of misuse situations in the context of pregnancy and breastfeeding.
3) Integration of this model into the PHARES project's software suite, which implements processes from data extraction on social media to their restitution in the form of a user interface. This software will be evaluated and used routinely by the ANSM.
4) Creation of public bases containing documented drug misuse examples.

References

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Consortium

1) The Limics team on the PHARES project will be involved in the supervision with competencies in medical informatics, Drugs, AI and NLP (Cédric Bousquet, Xavier Tannier, Marie-Christine Jaulent).
2) The Fetal Medicine Department of Trousseau hospital will provide the necessary expertise to the clinical domain. They will be involved in the construction of the examples in the prompt engineering approach as well as the evaluation of the model.