3rd Year Projects AI Dimitri 2024-2025

ADDDO Analyzing Interactions Between Environment, User, and Recommender Dynamics for Predicting Addiction Risk

This project aims to analyze data generated by the interaction between users and social media recommender systems, as described in the attached study. The goal is to characterize the relationships between environmental features, user attributes, recommender behaviors, and the probability of addiction. By applying both supervised and unsupervised learning methods, we will explore these dynamics comprehensively. Key components of the analysis may include:

1. **Unsupervised Learning**:
    - Perform clustering to identify distinct user behavioral patterns based on interaction data and psycho-physical states (e.g., Healthy, Neutral, Addictive).
    - Use dimensionality reduction techniques to visualize relationships between user characteristics, environmental complexity, and recommender strategies.
2. **Supervised Learning**:
    - Build predictive models to estimate the probability of addiction based on user demographics, environmental features, previous behaviours and recommender actions.
    - Evaluate the impact of recommender system parameters (e.g., Q-values, reward functions) on user addiction tendencies using classification and regression models.
3. **Feature Analysis**:
    - Investigate how environment complexity and temporal shifts in user-recommender interactions influence addiction risk.
    - Assess how user-specific characteristics influence outcomes.

The findings will provide actionable insights for designing ethical recommender systems that balance engagement and well-being.

Contact (and keep all in cc):
Dimitri.ognibene@unimib.it,
sabrina.patania@unimib.it,
l.bolis3@campus.unimib.it
s.livella@campus.unimib.it
matteo.papini@polimi.it

LLM1DO Exploring Prisoners' Voices: Keyword and Topics Analysis of CarteBollate Journals (2009-2024)

The original documents are a collection of journals (pdf files) called "carteBollate". Each journal issue consists of multiple stories written by prisoners e.g., about their life in prison. There are multiple issues per year spanning over a period from 2009 to 2024.

The pdf files were processed into a csv file that provides a structured version of all the journals in textual format. The csv file that will be given to the students has the following columns (with descriptions):

COLUMN NAME	DESCRIPTION
year	Year (number) - indicating the publication year of an journal/story
issue	Issue number - indicating the issue an article was published in within the respective year
topic	Name of the topic an article was assigned to by the publisher (articles are grouped by topic within each issue)
article	Headline of a specific article
text	Actual content of the article

Tasks to process/analyze the articles:

For each task: group by (1) article (2) topic (3) issue (4) year. Compare between these groups and compare over time.

1. Keywords (based on article text)
    - Preprocess, e.g. stopword removal, tokenize text
    - Extract keywords from the text
    - Consider stemming/lemmatization as well as n-grams
    - Save keyword terms in a table and visualize them (e.g., word clouds or bar charts)

2. Topic analysis (based on article title)
    - Preprocess, e.g. stopword removal, tokenize text
    - Extract keywords from the headings
    - Consider stemming/lemmatization as well as n-grams
    - Save topics in a table and visualize them (e.g., word clouds or bar charts)
    - Compare with the Keywords identified in (1)

3. Lexical analysis (optional)
    - Analyze word length, sentence length etc.

- Assign part-of-speech tags to words (e.g., identify nouns, verbs, adjectives, etc.)
- Visualize findings

4. Sentiment analysis (optional)
    - Use pre-trained sentiment language model
    - Calculate score on article text basis
    - Visualize distribution

Contact (and keep all in cc):

dimitri.ognibene@unimib.it
luca.pancani@unimib.it
donabauer.gregor@gmail.com
simona.amenta@unimib.it

LLM2DO Exploring Prisoners' Voices: Semantic Analysis of CarteBollate Journals (2009-2024)

The original documents are a collection of journals (pdf files) called "carteBollate". Each journal issue consists of multiple stories written by prisoners e.g., about their life in prison. There are multiple issues per year spanning over a period from 2009 to 2024.

The pdf files were processed into a csv file that provides a structured version of all the journals in textual format. The csv file that will be given to the students has the following columns (with descriptions):

COLUMN NAME	DESCRIPTION
year	Year (number) - indicating the publication year of an journal/story
issue	Issue number - indicating the issue an article was published in within the respective year
topic	Name of the topic an article was assigned to by the publisher (articles are grouped by topic within each issue)
article	Headline of a specific article
text	Actual content of the article

Tasks to process/analyze the articles:

For each task: group by (1) article (2) topic (3) issue (4) year. Compare between these groups and compare over time.

1. Semantic analysis (I) - Sparse
    - Vectorize text using Term Frequency and TF-IDF
    - Visualize differences e.g, in vector space

2. Semantic analysis (II) - Dense
    - Vectorize text using a pre-trained language model (e.g. BERT)
    - Compare articles and topics
    - Visualize differences e.g, in vector space

3. Lexical analysis (optional)
    - Analyze word length, sentence length etc.
    - Assign part-of-speech tags to words (e.g., identify nouns, verbs, adjectives, etc.)
    - Visualize findings

4. Sentiment analysis (optional)
    - Use pre-trained sentiment language model
    - Calculate score on article text basis
    - Visualize distribution

Contact (and keep all in cc):

dimitri.ognibene@unimib.it
luca.pancani@unimib.it
donabauer.gregor@gmail.com
simona.amenta@unimib.it

THERDO **"Evaluating the Effectiveness and Computational Limitations of AI-Powered Therapeutic Chatbots in Behavioral and Mental Health Interventions"**

This project will critically evaluate AI-driven conversational chatbots, including traditional chatbot architectures and advanced frameworks like Large Language Models (LLMs) and Retrieval-Augmented Generation (RAG). The focus is on their application in providing social or emotional support to enhance the mental health and well-being of users through various counseling and therapeutic techniques and conversation strategies.

By examining both the computational architectures (e.g., NLP and procedural knowledge encoding) and therapeutic efficacy, this study may:

1. Define and evaluate model constraints in terms of fluency of the interaction, capacity to specialize to specific user conditions and progress in the therapy, reliability, effectivity, and privacy concerns.
2. Investigate the personalized capabilities of chatbots in managing anxiety, stress, addiction, and habit changes.

3. Explore iterative prompt designs and procedural knowledge integration to enhance chatbot adaptability and conversational coherence.
4. Study methods to benchmark the effectiveness of interventions through user-centered testing, leveraging quantitative measures like the Self-Report Habit Index, and exploring user experience and perceptions.
5. Address computational challenges such as verbosity, contextual adaptation, and declarative-to-procedural knowledge transformation.
6. Test custom implementations of LLMs to overcome current limitations and improve real-time therapeutic outcomes.

The findings aim to bridge the gap between computational advancements and the practical therapeutic application of AI in mental health.

Relevant paper:

Arabi, Arian Fooroogh Mand, et al. "Habit Coach: Customising RAG-based chatbots to support behavior change." *arXiv preprint arXiv:2411.19229* (2024).

Olafsson, S., O'Leary, T. K., & Bickmore, T. W. (2020, October). Motivating health behavior change with humorous virtual agents. In *Proceedings of the 20th ACM international conference on intelligent virtual agents* (pp. 1-8).

Yu, H., & McGuinness, S. (2024). An experimental study of integrating fine-tuned LLMs and prompts for enhancing mental health support chatbot system. *Journal of Medical Artificial Intelligence*, 1-16.

Xie, Z., Majumder, B. P., Zhao, M., Maeda, Y., Yamada, K., Wakaki, H., & McAuley, J. (2024). Few-shot Dialogue Strategy Learning for Motivational Interviewing via Inductive Reasoning. *arXiv preprint arXiv:2403.15737*.

Contact (and keep all in cc):
dimitri.ognibene@unimib.it
c.koyutuerk@campus.unimib.it
franca.garzotto@polimi.it
raffaella.calati@unimib.it
a.foorooghmandara@campus.unimib.it

GNNDO Enhancing MovieLens Link Prediction with Recommender-Driven Inputs

Overview
This project invites students to explore and enhance a baseline model for link prediction on the MovieLens dataset using a provided Colab notebook 9. Link Prediction on MovieLens.ipynb - Colab. The initial goal is to understand and test the default configurations of the model. Subsequently, students can extend the baseline by incorporating additional inputs, such as recommendations generated by a chosen recommender system. This

extension aligns with methodologies explored in computational and cognitive neuroscience, including the integration of multimodal and hierarchical information.

Phases of the Project:

1. **Initial Setup and Testing (mandatory):**
    - Familiarize with the MovieLens dataset (users, movies, and ratings).
    - Implement the baseline heterogeneous graph model for link prediction to predict missing links (ratings) between users and movies.
    - Test and analyze different configurations of the provided Colab code, experimenting with hyperparameters, optimizers, and loss functions.
2. **Extension with Recommender Systems (optional):**
    - Select a recommender algorithm (e.g., collaborative filtering, content-based, or hybrid) to generate movie recommendations for users.
    - Simulate additional input features for the model, such as:
        - User preferences derived from recommender outputs.
        - Contextual or temporal features (e.g., genre trends or time-specific preferences).
    - Incorporate these features into the graph model to enhance its predictive capabilities.
3. **Evaluation and Comparison:**
    - Compare the performance of the baseline and extended models using metrics like prediction accuracy, recall, and F1-score.
    - Assess the influence of added features on prediction robustness and generalizability.

Relevant paper:

Learning Outcomes:

- Understand the principles of link prediction in heterogeneous graphs.
- Gain hands-on experience with recommender systems and their integration into graph-based models.
- Develop skills in experimental design, hyperparameter tuning, and result interpretation.
- Explore interdisciplinary connections between AI-driven recommendation and cognitive modeling.

Potential Extensions:

- Explore the use of multimodal data (e.g., user reviews or tags) to enrich input features.
- Integrate advanced embeddings from pre-trained language models to represent user or movie metadata.

Relevant papers:

- Guidotti, Sabrina, et al. "Modeling Social Media Recommendation Impacts Using Academic Networks: A Graph Neural Network Approach." *arXiv preprint arXiv:2410.04552* (2024).

- Sibley, Ciara, and Andrew T. Crooks. "Exploring the effects of link recommendations on social networks: An agent-based modeling approach." *2020 Spring Simulation Conference (SpringSim)*. IEEE, 2020.
- Ognibene, D., Wilkens, R., Taibi, D., Hernández-Leo, D., Kruschwitz, U., Donabauer, G., ... & Eimler, S. (2023). Challenging social media threats using collective well-being-aware recommendation algorithms and an educational virtual companion. Frontiers in Artificial Intelligence, 5, 654930.

Contact (and keep all in cc):
s.guidotti2@campus.unimib.it
donabauer.gregor@gmail.com
dimitri.ognibene@unimib.it

NeuDO Development and Testing of Brain Response Prediction Architectures Using the Algonauts Challenge Dataset

Project Overview:
This open project involves developing and evaluating neural network architectures for predicting brain responses to visual stimuli (images, video) using datasets from the Algonauts Challenge or other available datasets (eg. auditory stimuli). The project offers two tracks based on dataset complexity and resource availability:

1. **Static Image Dataset (Algonauts 2023 Challenge):**
    - Students will explore and implement different neural network architectures, such as:
        - Simple linear regression models.
        - Multi-layer perceptrons (MLPs) utilizing image embeddings (e.g., from CLIP).
        - Architectures leveraging position-based encoding.
        - Advanced models, such as transformers and top-scoring competition models.
    - Emphasis will be placed on:
        - Testing and comparing baseline architectures.
        - Experimenting with optimization techniques (e.g., hyperparameters, loss functions, and regularization strategies).
        - Evaluating performance on brain response prediction for specific regions of interest (ROIs).
2. **Dynamic Movie Dataset (Current Algonauts 2025 Video Challenge):**
    - Students will utilize the organizers' baseline Colab notebook `algonauts_2025_challenge_tutorial`, focusing on:
        - Understanding and testing the pre-built model's functionality.
        - Fine-tuning hyperparameters, optimizers, and training configurations.
        - Conducting exploratory analysis on the dataset's multimodal aspects (frames, audio, and text).

    - Since the dataset and task are more complex, the goal will be to iterate and "play" with the baseline for hands-on exposure.

Learning Objectives:

- Develop an understanding of brain encoding tasks and their challenges.
- Gain experience in neural network design, testing, and optimization.
- Explore interdisciplinary connections between AI, neuroscience, and multimodal data analysis.

Key Resources:

- Datasets: Algonauts 2023 Challenge (Natural Scenes Dataset for static images) and the latest Algonauts Challenge for videos.
- Tools: Python, PyTorch, Google Colab, and pretrained models like CLIP.

Potential Extensions:

- Employ LoRA (Low-Rank Adaptation) techniques to improve network efficiency by propagating augmented and original images simultaneously.
- Investigate model generalizability by testing on out-of-distribution samples or augmented stimuli.
- Development of a Reinforcement Learning model for identifying the optimal image enhancement technique for a particular task.

This project can serve as a practical introduction to advanced AI applications in neuroscience, preparing students for interdisciplinary research and problem-solving.

Relevant papers:

- Piskovskyi, Valentyn, et al. "Generalizability analysis of deep learning predictions of human brain responses to augmented and semantically novel visual stimuli." *arXiv preprint arXiv:2410.04497* (2024).
- Chimisso, Riccardo, et al. "Exploration and Comparison of Deep Learning Architectures to Predict Brain Response to Realistic Pictures." *arXiv preprint arXiv:2309.09983* (2023).

Contact (and keep all in cc):

dimitri.ognibene@unimib.it
sabrina.patania@unimib.it
v.piskovskyi@campus.unimib.it
riccardo.chimisso@gmail.com
Marco Fagnani