Project 1

Project title: Benchmarking Medical Language Models for analysing Electronic Health Records

Supervisor: Anuradha Kar

Brief description The integration of artificial intelligence (AI) in healthcare is transforming the way medical information is processed, analyzed, and utilized. Among the various AI applications, medical language models (MLMs) have emerged as critical tools for understanding and interpreting electronic health records (EHRs). These records, comprising unstructured clinical notes, laboratory results, prescriptions, and imaging reports, offer valuable insights but pose significant challenges due to their complexity, variability, and sensitivity. This project focuses on **benchmarking medical language models** tailored for EHRs to evaluate their performance, reliability, and applicability in clinical settings. The benchmarking process will involve the following key components:

1. **Steps:**
    - Identifying state-of-the-art MLMs, such as Med-BERT, ClinicalBERT, or BioGPT.
    - Curating EHR datasets representative of real-world clinical environments.
    - Evaluating models based on **accuracy, interpretability, efficiency, and generalization** across tasks like information extraction, clinical entity recognition, and note summarization.
    - Assessing use cases such as decision support, risk prediction, and patient stratification.

- **Expected outcomes:** The project aims to identify strengths and limitations of existing MLMs, providing guidance for their optimization and deployment in healthcare systems. By establishing standardized benchmarks, the project will facilitate the development of more reliable, efficient, and interpretable models that align with the specific demands of EHRs. This research will significantly contribute to improving clinical workflows, enabling personalized medicine, and enhancing patient care.
- **Required skills or prerequisites (if any):** Python, LLM, Huggingface

Project 2

Project title: Multimodal AI for indoor monitoring for Parkinson's disease patients

Supervisor: Anuradha Kar

Brief description : This project leverages multimodal AI to improve the quality of life and clinical outcomes for Parkinson's disease (PD) patients through continuous, non-invasive indoor monitoring. Parkinson's disease is a progressive neurological disorder that impairs motor functions, balance, and speech, requiring tailored interventions. Monitoring these patients in real-world environments can offer critical insights into disease progression and treatment efficacy.

The system integrates data from one or more cameras and wearable sensors, to provide a holistic view of the patient's condition. Advanced machine learning models analyze multimodal inputs to track symptoms such as tremors, gait disturbances, and freezing episodes. It also evaluates non-motor symptoms like sleep disturbances and cognitive decline.

This project emphasizes interpretability of the used models ensuring that AI-generated insights are transparent and actionable for healthcare providers. The system is designed to support early intervention by identifying patterns indicative of symptom aggravation, enabling personalized care plans.

Expected outcomes: The goal is to create a reliable continuous monitoring solution that enhances clinical decision-making while promoting the patient's autonomy and safety within their living environment. This will also foster collaborations with clinicians, patients, and caregivers to drive the design and implementation of this AI-driven healthcare innovation.

Required skills or prerequisites (if any): Python, LLM, Huggingface, data analysis

Project 3

Project title Small language models for medical image analysis

Supervisor: Anuradha Kar

Brief description: This project explores the application of compact and efficient language models to medical image analysis, addressing the growing need for resource-effective AI solutions in healthcare. While large language models (LLMs) have demonstrated exceptional performance in interpreting medical data, their computational requirements often limit deployment in clinical environments. Small language models (SLMs), with fewer parameters and lower resource demands, offer a promising alternative for real-time, scalable, and interpretable medical applications.

The project focuses on integrating SLMs with multimodal data, particularly medical images and accompanying textual data such as radiology reports, pathology notes, or electronic health records. Tasks include image captioning, report generation, disease classification, and anomaly detection. By leveraging pre-trained SLMs fine-tuned on medical datasets, the approach ensures domain-specific accuracy while maintaining computational efficiency.

Key objectives include evaluating the performance of SLMs against LLMs in medical imaging tasks using benchmarks like accuracy, specificity, sensitivity, and inference time. The study also emphasizes interpretability, ensuring clinicians can trust and understand model outputs.

This work aims to make advanced AI tools accessible for diverse healthcare settings, from well-equipped hospitals to low-resource clinics, democratizing AI-driven medical diagnostics and improving patient outcomes.

- **Expected outcomes:** A framework with small language models trained for a medical image (CT/MRI/Xray) analysis task, comparison of multiple models for the task
- **Required skills or prerequisites (if any)** Python, LLM, Huggingface, data analysis

Project 4

Project Title: Preprocessing Radiology Imaging for Veterinary Diagnostics Using Large Language Models

Supervisor: Doreid Ammar, Anuradha Kar

Brief description: This project focuses on enhancing diagnostic capabilities in veterinary medicine by combining advanced image preprocessing techniques with a Large Language Model (LLM) to generate detailed medical reports from radiology images. The initiative addresses the need for accurate and efficient analysis of pet radiology images to support veterinarians in diagnosing and managing animal health conditions.

The project involves designing a robust preprocessing pipeline to optimize radiology images, ensuring high-quality input for the LLM. Tasks include noise reduction, normalization, segmentation, and feature enhancement, tailored to the unique anatomical characteristics of different animals. The processed images are then integrated into the LLM, which has been fine-tuned on veterinary-specific datasets, to produce comprehensive, contextually relevant diagnostic reports.

The aim is to improve the accuracy, efficiency, and interpretability of the LLM in analyzing radiology data, enabling it to identify subtle abnormalities and suggest possible diagnoses. The outcome will be a streamlined diagnostic tool that provides veterinarians with actionable insights, improving patient outcomes and advancing animal healthcare.

By leveraging the power of AI, this project aspires to bridge gaps in veterinary diagnostics, offering accessible and reliable solutions to enhance the health and welfare of pets.

- **Expected outcomes:** A framework with small language models trained for a medical image (CT/MRI/Xray) analysis task, comparison of multiple models for the task
- **Required skills or prerequisites (if any)** Python, LLM, Huggingface, computer vision

Project 5

Project Title: Enhanced X-ray Image Diagnostics with state of the art computer vision models

Supervisor: Doreid Ammar, Anuradha Kar

Brief description: This project explores the application of advanced deep learning techniques in analyzing X-ray images for improved medical diagnosis. The goal is to develop and optimize deep learning models that can automatically detect and classify abnormalities in X-ray images, aiding radiologists in making more accurate and efficient diagnoses.

The project employs cutting-edge architectures, such as Convolutional Neural Networks (CNNs) and Transformer-based models, to enhance image quality, segment key features, and identify a wide range of conditions, from bone fractures and tumors to lung diseases like pneumonia or tuberculosis. By training these models on large, annotated X-ray datasets, the system learns to recognize patterns and anomalies that may be missed by the human eye.

Key objectives include improving the model's diagnostic accuracy, reducing false positives/negatives, and ensuring interpretability to gain the trust of healthcare professionals. The system also aims to support real-time analysis of X-ray images, making it a valuable tool in busy clinical settings.

- **Expected outcomes:** The expected outcomes of this project include the development of a deep learning-based X-ray analysis system capable of accurately detecting and classifying abnormalities such as fractures, tumors, and lung diseases. The system is expected to significantly reduce diagnostic time and enhance the accuracy of interpretations, minimizing false positives and negatives. It will also provide interpretable results, offering insights that radiologists can trust.
- **Required skills or prerequisites (if any):** Python, LLM, Huggingface, computer vision

Project 6

Project title: Predictive Modeling for Human Activities Using FutureGAN

Supervisor: Nasreddine Menacer

Project description: This project focuses on predictive models which can be used to forecast the next action or activity of a person in a normal-life scenario using historical data. The goal is to enhance understanding of human behavior in everyday environments, leveraging temporal data such as videos of prior activities or trajectories of movement. By integrating historical activity patterns, the project aims to enable accurate predictions of future actions, a capability with applications in areas like healthcare, smart homes, and human-computer interaction.

The study involves a benchmarking exercise to evaluate state-of-the-art predictive models, with a particular emphasis on FutureGAN, a generative adversarial network designed for future action prediction. FutureGAN operates by learning spatiotemporal dependencies in historical data to predict plausible future actions or trajectories. The generative model is trained adversarially against a discriminator, ensuring predictions are both realistic and contextually consistent.

Key tasks include identifying relevant datasets for training and testing, such as activity recognition or trajectory datasets, and evaluating model performance using metrics like prediction accuracy, F1-score, and temporal coherence. The benchmarking study will compare FutureGAN's performance to other models, analyzing its advantages in terms of robustness and applicability in real-world scenarios. This study contributes to advancing predictive modeling for human activity forecasting.

- **Expected outcomes:** Collection of models and datasets for activity prediction and comparison report with respect to FutureGAN
- **Required skills or prerequisites (if any):** Python, deep learning, GAN

Project 7

Project title: Benchmarking ResNet and YOLO for Real-Time Object, Scene, and Human Detection in Ambient Environments

Supervisor: Nasreddine Menacer

Project description: This project aims to compare and evaluate the performance of two prominent deep learning architectures, ResNet and YOLO, for detecting objects, scenes, and humans in real-time video streams from ambient environments. The objective is to achieve a system capable of generating contextualized outputs like "working in kitchen," "2 humans at a table," or "bottle of water on the table," by labeling multiple objects and recognizing activities within a scene.

The study involves designing a comprehensive benchmarking framework to test both models under various conditions, including different lighting, object arrangements, and activity scenarios. ResNet, a convolutional neural network (CNN), can be evaluated for its ability to extract hierarchical features and classify objects and scenes. YOLO (You Only Look Once), a real-time object detection model, will be assessed for its speed and accuracy in detecting multiple objects and human presence in dynamic scenes.

Performance metrics such as detection accuracy, precision, recall, inference time, and computational efficiency will be analyzed. Additionally, the models' ability to provide context-aware scene descriptions by integrating object and human detection outputs will be assessed.

- **Expected outcomes:**The outcome of the project is a detailed comparison highlighting the strengths and limitations of each model for real-time applications. This will help inform the selection of the most suitable model for tasks requiring detailed scene understanding in domains like smart homes, surveillance, and human-computer interaction..
- **Required skills or prerequisites (if any):** Python, deep learning, object detection

Project 8

Project title:AI Ethics and Compliance Chatbot Development

Supervisor: Nathalie Devillier, Anuradha Kar

Project description: This project aims to design and develop an intelligent chatbot to provide accessible, real-time guidance on AI ethics, regulations, and compliance. As organizations increasingly adopt AI technologies, navigating the complex landscape of ethical considerations and regulatory frameworks becomes critical. This chatbot will act as a knowledge hub, offering accurate and contextual insights to developers, policymakers, and business leaders.

The chatbot will leverage a fine-tuned language model trained on a curated dataset of global AI regulations (e.g., EU AI Act, GDPR), ethical principles (e.g., fairness, transparency, accountability), and industry compliance standards. It will be capable of answering queries on topics such as ethical AI design, risk mitigation, bias detection, data privacy, and compliance audits.

Key features include natural language understanding for context-aware conversations, dynamic updates to reflect evolving regulations, and tailored advice based on user-specific scenarios. The chatbot will also provide links to relevant resources, case studies, and best practices.

By integrating advanced AI and domain expertise, this tool aims to democratize knowledge, empowering organizations to build AI systems that are not only innovative but also responsible and legally compliant. The project's outcome will support ethical decision-making and foster trust in AI technologies across industries.

- **Expected outcomes:**The outcome of the project is a detailed comparison highlighting the strengths and limitations of each model for real-time applications. This will help inform the selection of the most suitable model for tasks requiring detailed scene understanding in domains like smart homes, surveillance, and human-computer interaction..
- **Required skills or prerequisites (if any):** Python, deep learning, object detection

Project 9

Project title: Data Processing Pipelines for Seizure Detection: A Comprehensive State-of-the-Art Review and comparison of existing methodologies

Supervisor: Anuradha Kar

Project description: This project focuses on designing an efficient data processing pipeline for seizure detection in epilepsy, incorporating a comprehensive survey of state-of-the-art methods for anomaly detection in epilepsy. The pipeline will handle raw physiological and motion data from sensors, ensuring efficient preprocessing, feature extraction, and integration with machine learning models for real-time seizure detection. The survey will explore cutting-edge techniques, including time-series analysis, deep learning approaches like convolutional and recurrent neural networks, and hybrid models combining physiological and movement data. It will evaluate the strengths and limitations of existing systems, emphasizing scalability, sensitivity, and specificity. The pipeline aims to standardize the data handling process, from noise reduction to feature engineering, and integrate with advanced detection algorithms. This dual focus will advance understanding of epilepsy-related anomalies, contribute to the development of reliable seizure monitoring systems, and support improved patient care and timely intervention strategies.

Project objectives:
Design a robust pipeline for managing raw physiological and motion data, ensuring efficient preprocessing, feature extraction, and integration with machine learning models.
Perform a detailed review of current techniques in anomaly detection for epilepsy, focusing on time-series analysis, deep learning models, and hybrid approaches.

Establish a standardized framework for handling epilepsy-related data, from noise reduction to feature engineering, to improve reproducibility and accuracy in seizure detection.

- **Expected outcomes:** A survey of state of the art in methods for anomaly detection from epilepsy datasets. A data processing pipeline for epilepsy data analysis.
- **Required skills or prerequisites (if any): -** Python – Scikit-Learn - Git - Bash -SQL