Technische Universität München – Faculty of Informatics
Chair for Computer Aided Medical Procedures (Prof. Nassir Navab)
Practical Course: Machine Learning in Medical Imaging

Counterfactual Disease Progression Modelling using Generative Models

1 General Info

Project Title: Counterfactual Disease Progression Modelling using Generative Models
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2 Project Abstract

In this project, we aim to perform conditional image generation using counterfactual modeling. The goal is to simulate the disease progression using existing datasets of brain imaging such as the ADNI dataset [2], using the other modalities to train a model that simulates the effect of different factors such as age on the disease progression. We plan to use advanced generative models such as diffusion / consistency models.

3 Background and Motivation

Building on the achievements of recent large-scale models such as ChatGPT [1], our project endeavors to develop an advanced generative model [4, 5] that illuminates the complex interconnections between counterfactual factors and their influence on brain structure, function, and cognition. Our primary objective is to design a model that delves deeply into the intricate interactions of counterfactual factors [3], including age, sex, and education, and how they affect the brain. To accomplish this, we will harness the power of extensive brain datasets, such as the UK Biobank, ENIGMA Project, ADNI, PPMI, and AIBL. These datasets provide a wealth of information on various aspects of brain health and function, which will serve as the foundation for our research. We will explore feature disentanglement techniques to improve the performance of counterfactual modeling.

4 Technical Prerequisites

- Good background in machine learning and deep learning
- Experienced in PyTorch
- Experienced in Python
- Familiar with MONAI Framework

5 Benefits

- Weekly supervision and discussions
- Possible novelty of the research
- The results of this work are intended to be published in a conference or journal
- Possible collaboration with Stanford

6 Work packages and Time-plan

* The dates are adopted from the previous year and are not finalized yet.

	Description	# Students	From	To
WP1	Familiarizing with the literature.	4	10.05	17.05
WP2	Implementing the baselines	4	17.05	31.05
WP3	Improving the baselines and validation on relevant datasets	4	31.05	14.06
	Midterm Presentation	4	14.06	23.06
WP4	Implementing the model	4	14.06	07.07
WP5	Finalizing the results and evaluation	4	07.07	21.07
	Final Presentation	4	21.07	28.07

Table 1: Project Timeline

References

[1] Tom B Brown, Benjamin Mann, Nick Ryder, Melanie Subbiah, Jared Kaplan, Prafulla Dhariwal, Arvind Neelakantan, Pranav Shyam, Girish Sastry, Amanda Askell, et al. Language models are few-shot learners. *Advances in Neural Information Processing Systems*, 33, 2020.

[2] Susanne G Mueller, Michael W Weiner, Leon J Thal, Ronald C Petersen, Clifford Jack, William Jagust, John Q Trojanowski, Arthur W Toga, and Laurel Beckett. The alzheimer's disease neuroimaging initiative. *Neuroimaging Clinics*, 15(4):869–877, 2005.

[3] Jiahong Ouyang, Qingyu Zhao, Ehsan Adeli, Greg Zaharchuk, and Kilian M Pohl. Disentangling normal aging from severity of disease via weak supervision on longitudinal mri. *IEEE Transactions on Medical Imaging*, 41(10):2558–2569, 2022.

[4] Wei Peng, Ehsan Adeli, Qingyu Zhao, and Kilian M Pohl. Generating realistic 3d brain mris using a conditional diffusion probabilistic model. *arXiv preprint arXiv:2212.08034*, 2022.

[5] Yang Song, Prafulla Dhariwal, Mark Chen, and Ilya Sutskever. Consistency models. *arXiv preprint arXiv:2303.01469*, 2023.