Exploring generative models for OCT Image generation

1. General Info

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Outcome: The result of the project will potentially be published in MICCAI or MIDL

2. Project Abstract

In this project, we explore the image generation space to create models that can be used to extract knowledge for other downstream tasks. Disentangled representation from the Optical Coherence Tomography (OCT) generation model can be useful for tasks that require knowledge of the salient attributes of the OCT image data. Generative adversarial models (GANs) have dominated image generation for a long time but it is hard to use their representations in downstream tasks. We will therefore explore, for example, Diffusion models[1,2]. We will build several different models and discuss why some are better fitted to our problem. The models will be trained on open source OCT images from different databases[3] [4] [5] [6] etc. The findings and the trained elements of the model will be used in further research. We will also investigate which evaluation metric is best suited to distinguish the most natural OCT image.

3. Background and Motivation

Optical Coherence Tomography is a medical imaging modality originally developed for noninvasive cross-sectional imaging in biological systems. Since then, this imaging modality has become a widely accepted standard for diagnostic purposes in the ophthalmic domain because of its ability to visualise cross-sectional ocular structures at high resolution.[7] To classify the presence and severity of eye diseases or to generate diagnostic reports from OCT images; it is required to understand important features in the image. We, therefore, want to create representations retaining this information that we can use for semi-supervised approaches. Another use case for OCT generation is used in a virtual surgical environment used for surgical

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[1] https://github.com/CompVis/latent-diffusion
[2] https://github.com/openai/guided-diffusion
[3] https://www.kaggle.com/datasets/paultimothymooney/kermany2018
[4] Jothi Balaji J, Lakshminarayanan V. ODTiD: Optic Nerve Head SD-OCT Image Dataset. Clin Ophthalmol. 2021;15:4239-4245 https://doi.org/10.2147/OPTH.S337174
[5] Gholami, Peyman, and Lakshminarayanan, Vasudevan. Optical Coherence Tomography Image Retinal Database. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2019-02-20. https://doi.org/10.3886/E108503V1
[6] Farsiu S., et al. , "Quantitative classification of eyes with and without intermediate age-related macular degeneration using optical coherence tomography," Ophthalmology 121(1), 162–172 (2014).10.1016/j.ophtha.2013.07.013
[7] D. Huang, E. A. Swanson, C. P. Lin, J. S. Schuman, W. G. Stinson, W. Chang, M. R. Hee, T. Flotte, K. Gregory, C. A. Puliafito, and J. G. Fujimoto, "Optical coherence tomography," Science 254(5035), 1178–1181 (1991).

training. In a previous project, we synthesized iOCT B-scans and volumes based on real retinal layer meshes and virtual instruments using a GAN.[8]

4. Technical Prerequisites

- Background in computer vision and deep learning (Preferably with diffusion models)
- "Sick" Python/Pytorch skills

5. Benefits:

- Working on a state of the art deep learning image generation approach
- Working on the largest public medical datasets available
- Possibility of finding novel findings and writing a scientific paper.

[8] Michael Sommersperger, Alejandro Martin-Gomez, Kristina Mach, Peter Louis Gehlbach, M. Ali Nasseri, Iulian Iordachita, and Nassir Navab, "Surgical scene generation and adversarial networks for physics-based iOCT synthesis," Biomed. Opt. Express 13, 2414-2430 (2022)

6. Work-packages and Time-plan:

	Description	From	To
WP1	Understanding diffusion models and image generation literature		01.06
WP3	Modeling and implementing the generation task on multiple architectures	01.06	intermediate presentation
M1	Intermediate Presentation II		
WP5	Explore and analyze the results		
WP7	Explore different ways of evaluating OCT images		
WP8	Documentation		
M2	Final Presentation		