OCT2HIST

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Abstract

Generative AI has the potential to transform non-invasive imaging by generating histology-like images from intravascular optical coherence tomography (IVOCT). This study explores the use of the pix2pix conditional GAN architecture to perform IVOCT-to-histology image translation, aiming to enhance diagnostic capabilities and reduce reliance on invasive biopsy procedures. While initial results show structural validity, challenges such as dataset misalignment and model instability highlight the need for further refinement.

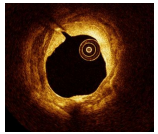

Figure 1. OCT Image

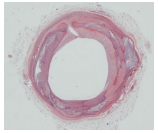

Figure 2. Histology Image

Background

IVOCT is a minimally invasive imaging technique that captures high-resolution cross-sectional images of coronary arteries. Histology is the gold standard for examining vascular structures, but it requires invasive biopsy, which is not feasible for live patients. The challenge is that IVOCT images are difficult to interpret due to their complexity, while histology data is limited and expensive to obtain. The goal is to use AI to transform IVOCT into histology-like images, enabling non-invasive insights comparable to biopsy.

Objective

This study aims to leverage generative AI, specifically the pix2pix architecture, to translate IVOCT images into histology-like representations.

Methods

Pix2pix is a conditional GAN designed for paired image-to-image translation. The generator produces synthetic histology images from IVOCT inputs, while the discriminator evaluates image patches to distinguish real vs generated histology.

Our dataset includes 3826 paired IVOCT and histology images gathered from 59 organ donor hearts, with a 70/30 train-test split. For our training metrics, we used structural similarity index (SSIM), peak signal-to-noise ratio (PSNR), mean squared error (MSE), and loss curves.

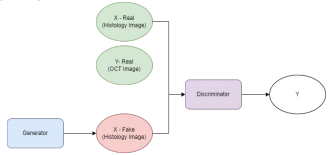

Figure 3. Pix2pix architecture used for our model.

Results

Generated histology images show some structural resemblance to real histology but suffer from artifacts due to input-output misalignment.

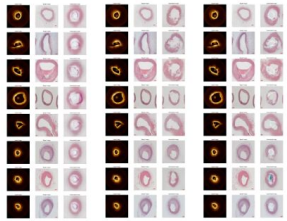

Figure 4. Model output when trained on varying number of epochs. The columns are real OCT, real histology, and generated histology respectively.

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SSIM and PSNR indicate low structural similarity. Loss curves reveal instability in training, common in GANs. Misalignment between IVOCT and histology images led to poor-quality results.

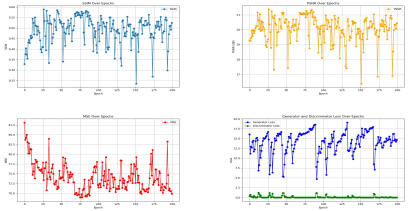

Figure 5. Plots of SSIM (top left), PSNR (top right), MSE (bottom left), and generator and discriminator loss (bottom right) over 200 epochs.

Conclusions

While the pix2pix architecture shows promise for IVOCT-to-histology translation, its reliance on perfectly aligned paired data sets limits its effectiveness. Addressing misalignment with advanced image registration techniques and exploring alternative models such as diffusion models or MultiMAE could improve performance. This work highlights the potential of AI to bridge the gap between non-invasive imaging and the diagnostic power of histology.

References

Winetraub Y, Van Vleck A, Yuan E, et al. Noninvasive virtual biopsy using micro-registered optical coherence tomography (OCT) in human subjects. Sci Adv. 2024;10(15):eadi5794. doi:10.1126/sciadv.adi5794

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