Diffusion-Based Cardiac Fibrosis Progression Synthesis and Severity Estimation with FinFET-Compatible AI Accelerator Framework

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Abstract—Ischemic fibrosis is a critical pathological indicator in cardiac aging and post-infarction tissue remodeling. Yet, its temporal evolution is poorly understood due to limited annotated histopathology data across disease stages. In this work, we propose a novel diffusion-driven generative AI framework to synthesize progressive stages of ischemic fibrosis and estimate severity from high-resolution cardiac histopathology images. Based on a carefully selected dataset of 5,000 Masson's trichrome-stained patches (512×512 pixels), our model uses a Latent Diffusion Model (LDM) to produce plausible scenarios of fibrosis progression conditioned on pathological precedents. To support future real-time and low-power clinical deployment, we introduce a FinFET-compatible AI accelerator blueprint that maps core model components—including the denoising UNet, progression generator, and severity estimation module—into modular FinFET logic blocks. Our experiments demonstrate high-fidelity image synthesis with a Frechet Inception Distance (FID) of 13.2 and accurate fibrosis segmentation (Dice Score: 0.91). This work presents a forward-looking, hybrid software–nanoelectronics framework to enable explainable, energy-efficient fibrosis modelling at the edge-paving the way for next-generation digital anti-aging diagnostics in cardiovascular pathology.

Keyword—Cardiac Fibrosis, Latent Diffusion Models (LDMs), Histopathology Image Synthesis, Segmentation and Severity Estimation, FinFET AI Accelerator, Digital Pathology.

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