Adaptive Patch Salience-Guided Differential Privacy for Brain MRI

Liu Yang
Taiyuan University of Technology, Jinzhong, China

Yadi Wen
Computer Science,Taiyuan University of Technology, Taiyuan, China

Yue Fu
Taiyuan University of Technology, Jinzhong, China

Rong Du
Taiyuan University of Technology, Jinzhong, China

Dan Yu
Taiyuan University of Technology, Taiyuan, China

Abstract

Human visual perception does not treat all regions of an image as equally important or sensitive; instead, attention and cognitive priority depend on semantic relevance, task demands, and domain-specific knowledge such as clinical significance. Most existing differentially private image obfuscation methods inject uniform noise across regions, implicitly assuming that perceptual and privacy sensitivities are homogeneous. We propose a cognitively inspired, saliency-guided differential privacy framework for brain MRI images that models heterogeneous perceptual and semantic importance. High-level visual representations are extracted using a Vision Transformer (ViT)-based pretrained Masked Autoencoder (MAE) to approximate human semantic sensitivity. Region saliency scores, computed via semantic similarity, may reflect cognitive and clinically relevant patterns. Privacy budgets are adaptively allocated, applying stronger noise to salient regions while preserving structural details elsewhere. Experiments on brain MRI datasets demonstrate improved privacy-utility trade-offs, effectively protecting sensitive areas without degrading overall perceptual quality.

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