

Status Meeting - Application of Graph Learning to inverse problems

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05.05.2022

Problem and Goal

- Denoise observations
- Motivation from imaging (computed tomography, cryo-EM)

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Input

\mathcal{I} : class of images (where $i \in \mathbb{R}^M$ with M as image dimension.)

Output

$$\text{denoiser} : (i + \eta) \mapsto i^* \approx i$$

Where $i \in \mathcal{I}$ and $\eta \sim \mathcal{N}(0, \sigma^2) \in \mathbb{R}$.

Sinogram Denoiser

forward : radon transform

backward : filter back projection

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Sinogram Denoiser

$denoiser_{sino} : forward(i) + \eta \mapsto forward(i)^* \approx forward(i)$

$denoiser = backward(denoiser_{sino}(forward(i) + \eta))$

Where $i \in \mathcal{I}$ and $\eta \sim \mathcal{N}(0, \sigma^2) \in \mathbb{R}$.

GAT Denoiser

GAT - Graph Attention Network

$GAT(A, \text{GAT args}) \rightarrow \text{fixed angles} \rightarrow \text{k-nn circle graph}$

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Input Graph

- › Learning does work with circle graph
- › Learning does not work with random (Erdős–Rényi) graph

GAT Denoiser - 2

GAT - Graph Attention Network

$GAT(A, \text{GAT args}) \rightarrow \text{fixed angles} \rightarrow \text{k-nn circle graph}$

GAT Loss

$$\mathcal{L}_1 = ||\text{forward}(i) - \text{denoiser}_{\text{ sino}}(\text{forward}(i) + \eta)||_2$$

$$\mathcal{L}_2 = ||i - \text{backward}(\text{denoiser}_{\text{ sino}}(\text{forward}(i) + \eta))||_2$$

Where $i \in \mathcal{I}$ and $\eta \sim \mathcal{N}(0, \sigma^2) \in \mathbb{R}$.

Current experiments - Toy images

- › Input images uniformly position shapes on image.
- › Mostly fixed SNR, validation with same SNR
- › Graph size = 1024 nodes, k-nn = 8
- › Results with \mathcal{L}_1 available, few with \mathcal{L}_2 .

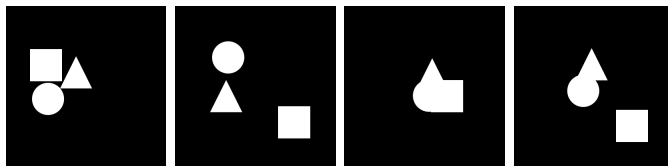


Figure: Example Toy images

Current Results - \mathcal{L}_1 vs \mathcal{L}_2

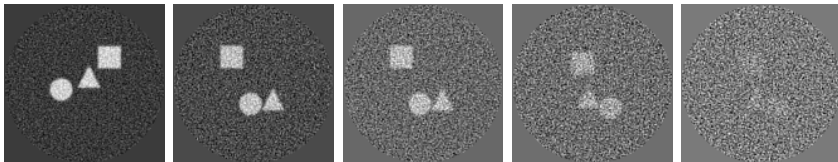


Figure: Noisy fbp with snr [5, 0, -5, -10, -20]

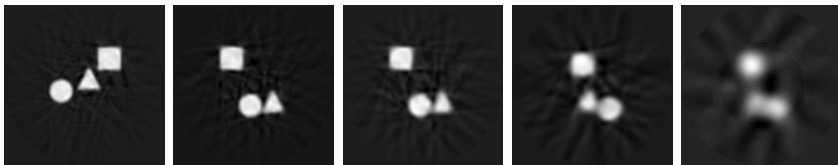


Figure: Denoised fbp with snr [5, 0, -5, -10, -20]

Current Results - \mathcal{L}_1 vs \mathcal{L}_2 vs BM3D

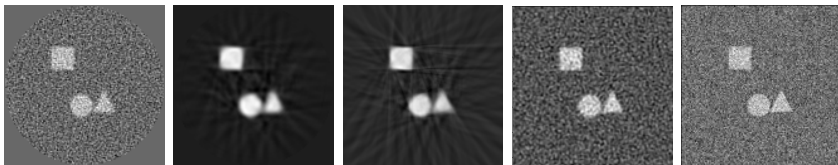


Figure: SNR -5 : noisy, denoised model \mathcal{L}_1 , denoised model \mathcal{L}_2 , BM3d noisy sinogram, BM3D noisy input

Some wandb reports

- end-to-end: <https://wandb.ai/cedric-mendelin/end-to-enduniformgeneratedtoyimagesscicore?workspace=user-cedric-mendelin>
- K-nn: <https://wandb.ai/cedric-mendelin/autogeneratedtoyimagesscicoreknn/reports/Auto-toyimages-knn--VmlldzoxOTA4MjM2>
- 3d-Model: <https://wandb.ai/cedric-mendelin/bunniesscicore?workspace=user-cedric-mendelin>
- GAT parameters: <https://wandb.ai/cedric-mendelin/toy-images-input-size/reports/Toy-Images-Overview-Advanced-GAT--VmlldzoxNzczNDc0>

Final steps

- › Gather final results
- › Write report
- › Comparing with BM3D