GANs for Ultrasound Compressed Sensing

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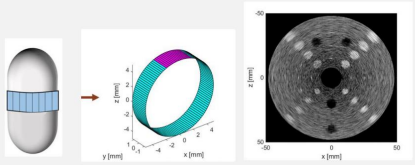
Introduction

- **Motivation:** Ultrasound (US) implants have a small array size with limited power, space, and bandwidth
- **Idea:** Proposing an end-to-end compression and reconstruction solution based on generative adversarial networks (GANs)
- **Aim:** Reconstruct high quality B-mode images from highly compressed US measurements
- **Why GANs?**
  - They perform well in image restoration in similar biomedical applications (e.g. MRI reconstruction **[1]**)
  - They have not yet been investigated for **ultrasound** CS reconstruction



Operation of cylindrical ultrasound array | Simulated B-mode image

(Pill-sized ultrasound device, credit: Arbabian Lab)

Challenges

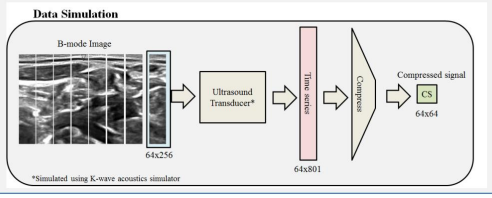
In compressed sensing:
- Aliasing artifacts due to undersampling
- Low SNR with more undersampling

In small size US arrays:
- Low resolution in lateral direction

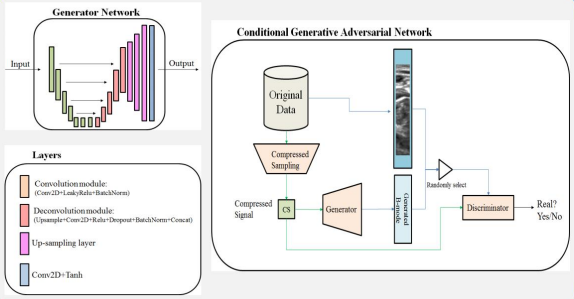
In our approach:
- RF data & ultrasound B-mode images are scarce
  - Find ways to create training data
- GANs can get unstable during training
- Loss function for compressed sensing is not well defined

Data

- **Ultrasound dataset:** publicly available as part of Kaggle nerve segmentation contest **[2]**
  - **5000** B-mode images of neck, **47** patients
  - **Evaluation set:** Images from **7** randomly selected patients
- Each B-mode image is cropped to **9** slices of size 64x256
  - simulates small ultrasound array size and deep tissue imaging scenario
- **K-wave acoustics simulator** is used to extract time series data corresponding to each target B-mode slice
- Timeseries data is then compressed to **8%** of its original size using a binary random sampling matrix



Model



Results

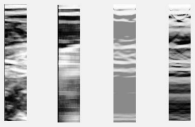
Image quality comparison

	Target	FFT
CS	7.5 dB	22 dB
GAN	15 dB	7.3 dB
FFT	7.6 dB	

Algorithmic metrics

	Time	CSP*
CS	0.02s	8%
GAN	0.004s	8%
FFT	0.02s	100%

- **PSNR** is used for comparing quality of image reconstruction to target
- GAN generates closer image to target than CS & FFT



Target GAN FFT CS

* Compression sensing percentage

Conclusion and Future Work

- GANs show promise in ultrasound image reconstruction with benefits over traditional CS algorithms
- **Benefits:**
  - Faster at image reconstruction (5 fold)
  - Produce better quality images than CS when under-sampling ratio is high
- **Next steps:**
  - Professional assessment for generated images
  - Training on larger and more diverse dataset
  - Experimenting with different loss functions

References

[1] Mardani, Morteza, et al. "Deep generative adversarial networks for compressed sensing automates MRI." arXiv preprint arXiv:1706.00051 (2017).

[2] https://www.kaggle.com/c/ultrasound-nerve-segmentation