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Overview of GAN Applications

Outline

- GAN applications
  - Image-to-image translation — and extensions to other modalities such as text, audio, and video
  - Image editing, art, and media
  - Medicine and climate change
- GAN adversarial concept use in other research areas

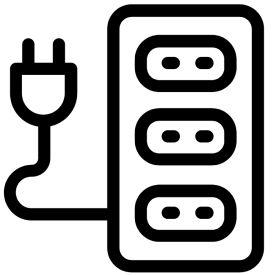
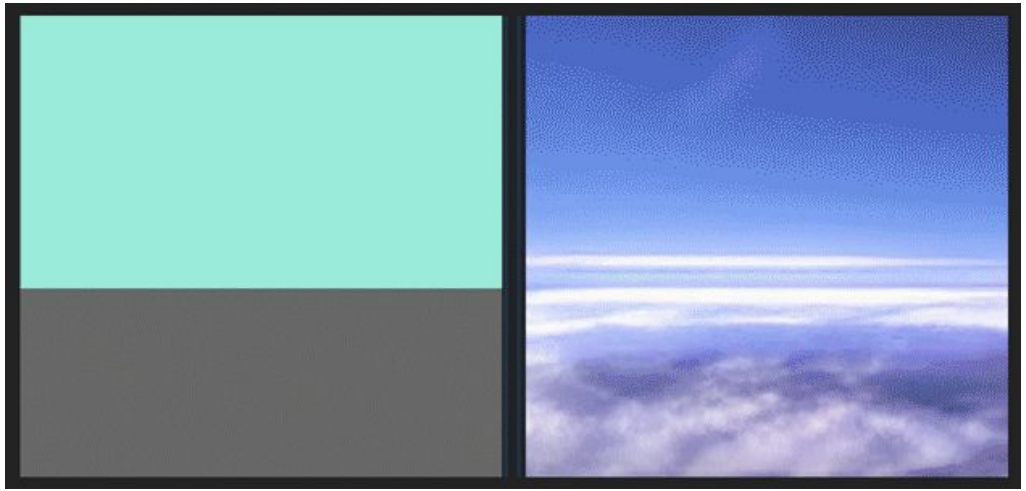


Image-to-Image



GauGAN

Available from: https://arxiv.org/abs/1903.07291

Image-to-Image

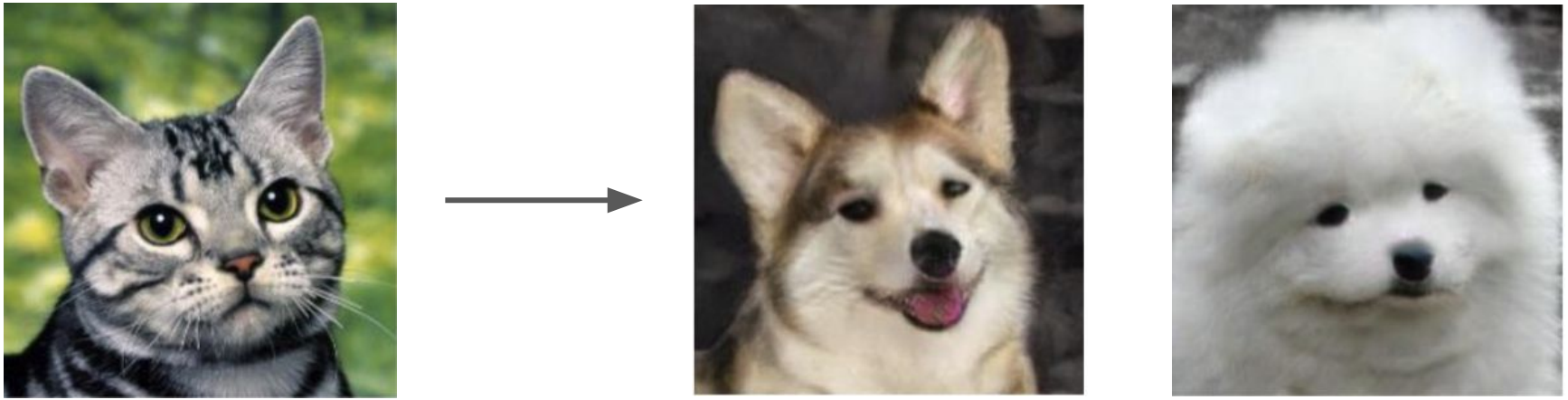
Original image

Super-Resolution GAN

Sharpened image

Available from: https://arxiv.org/abs/1609.04802

Image-to-Image



Multimodal image-to-image translation

Available from: https://github.com/NVlabs/MUNIT

Text-to-Image

"The bird is black with green and has a very short beak."

Available from: https://arxiv.org/abs/1612.03242

Image-and-Landmark-to-Video

Image

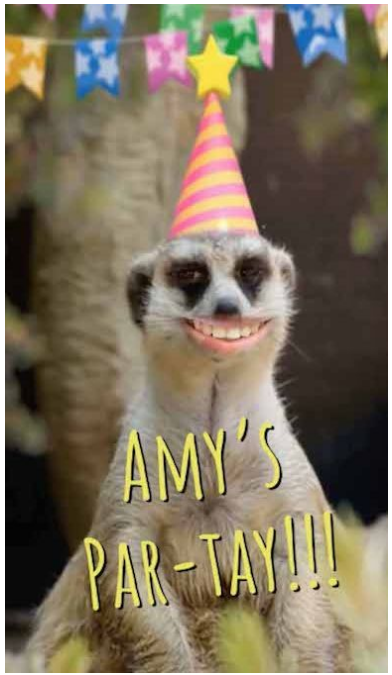
+

Face landmark

Talking heads

Available from: https://arxiv.org/abs/1905.08233

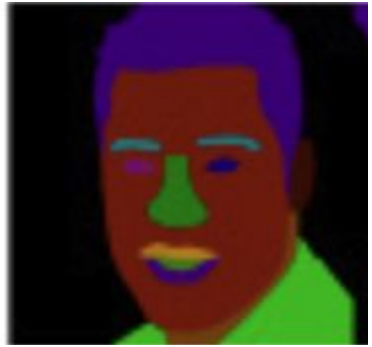
Application Areas: Image Filters



Available from: https://www.snapchat.com

Application Areas: Image Editing

Image



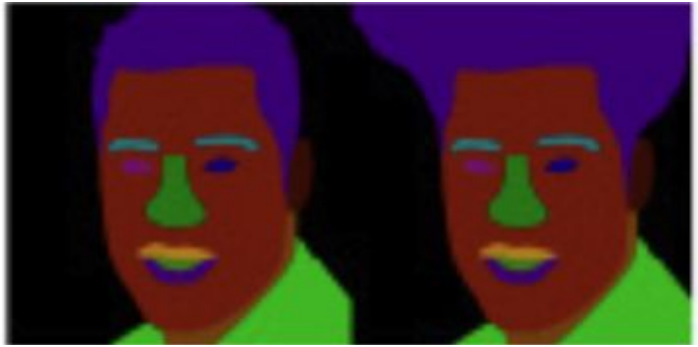
Mask

Image editing software

Available from: https://arxiv.org/abs/1907.11922

Application Areas: Image Editing

Image



Mask

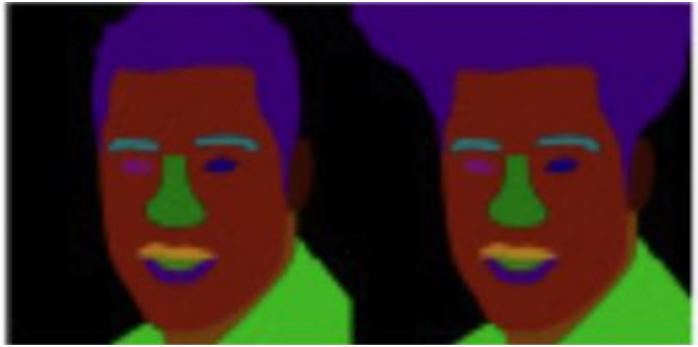
Edited mask

Image editing software

Available from: https://arxiv.org/abs/1907.11922

Application Areas: Image Editing

Image



Mask

Edited mask

Edited image

Image editing software

Available from: https://arxiv.org/abs/1907.11922

Application Areas: Stylized Images

Democratized art

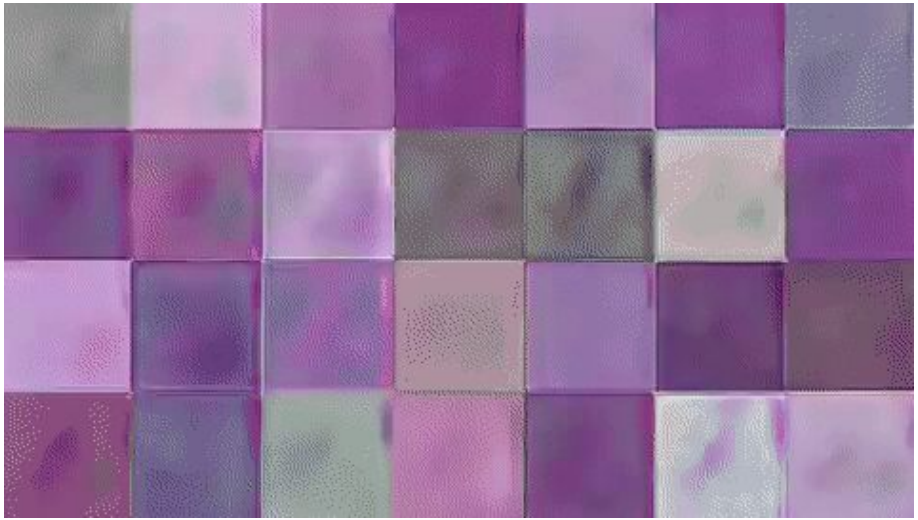
Available from: https://www.youtube.com/watch?v=85I961MmY8Y

Application Areas: Data Augmentation

Increasing dataset size and diversity

Available from: https://arxiv.org/abs/1711.04340

Application Areas: Medicine



Simulating tissues

Available from: https://twitter.com/realSharonZhou/status/1182877446690852867

Application Areas: Climate Change

Real input

Generated output

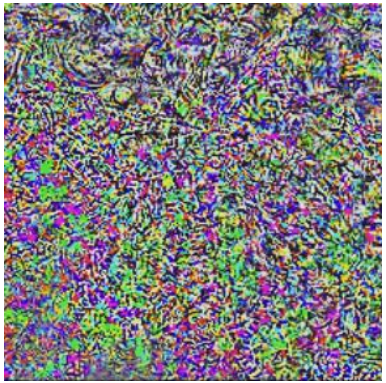
Available from: https://iopscience.iop.org/article/10.1088/2632-2153/ab7657/meta

Application Areas: Media

Both pretty cute, actually

Available from: https://en.wikipedia.org/wiki/File:Deepfake_example.gif

Adversarial Research Areas



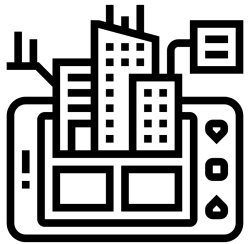
Predicted class: airliner
Predicted probability: 96.8%

Adversarial examples & robustness

Available from: https://adversarial-ml-tutorial.org/introduction/

Summary

- Image translation generalizes to many tasks
- Many immediate application areas, including data augmentation
- Other fields use adversarial techniques for realism and robustness



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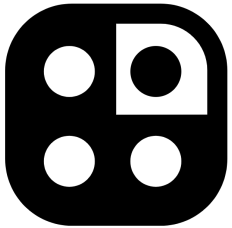
Data Augmentation Methods and Uses

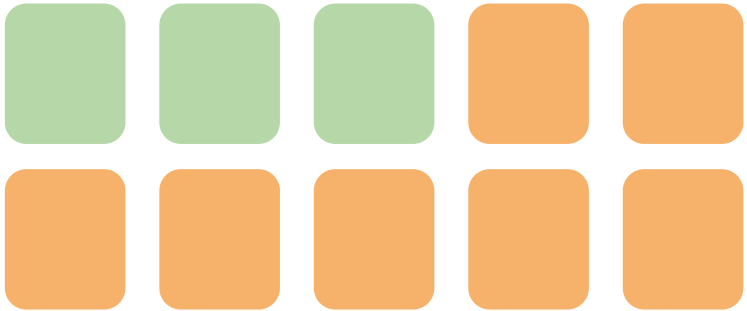
Outline

- Data augmentation and use cases
- Implementation of data augmentation



Data Augmentation

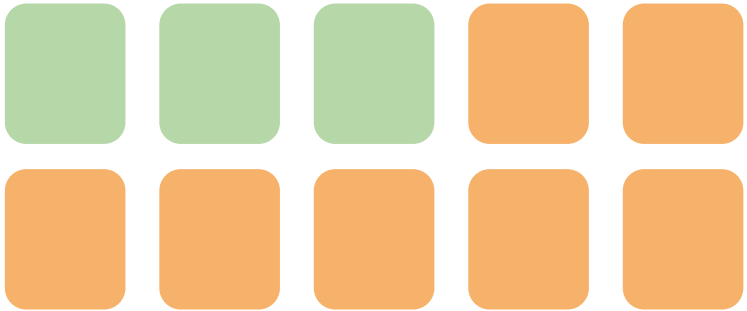
- Supplement data when real data is…
  - Too expensive
  - Too rare



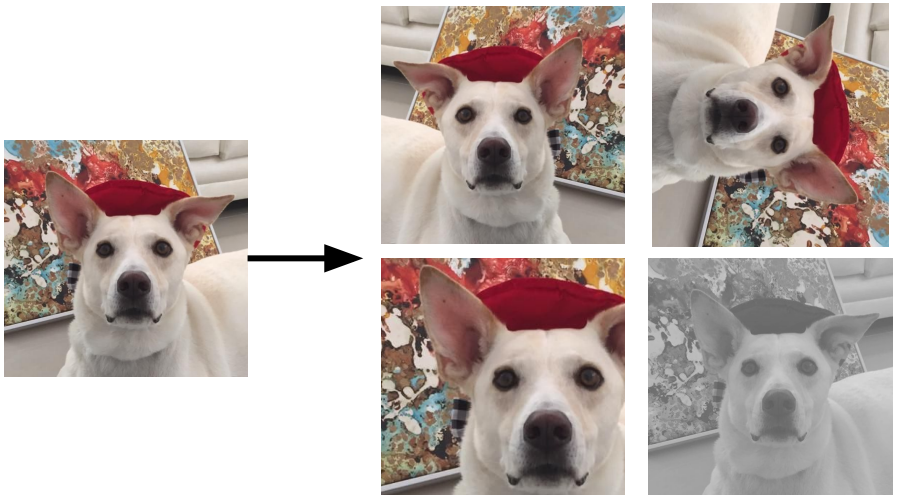
Data Augmentation

- Supplement data when real data is…
  - Too expensive
  - Too rare

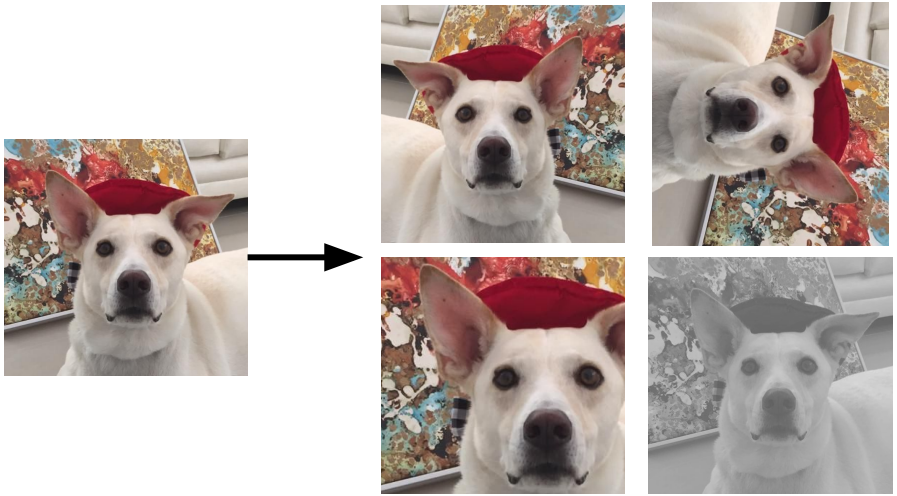
GANs are well suited for this

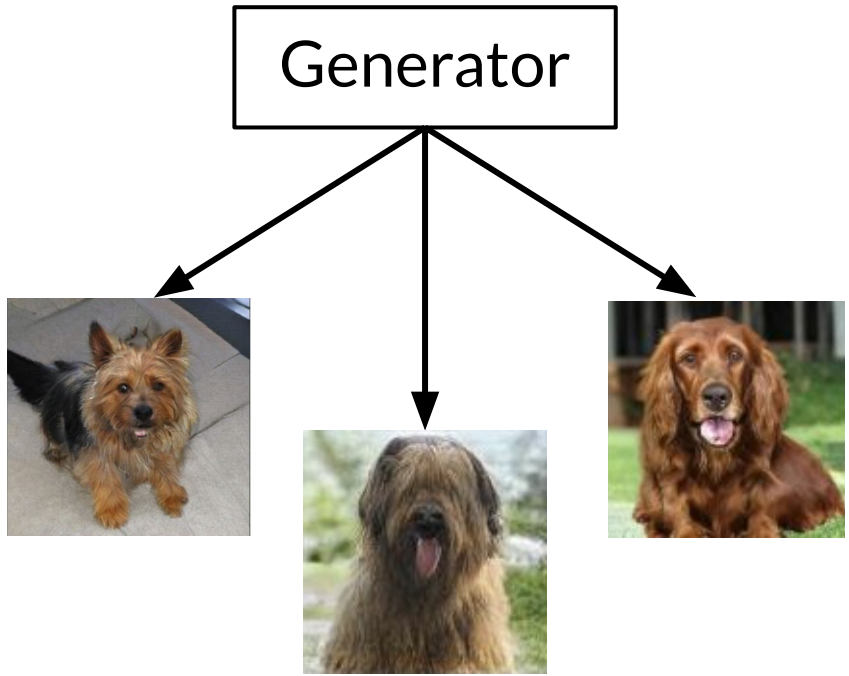


How to Augment Data



How to Augment Data

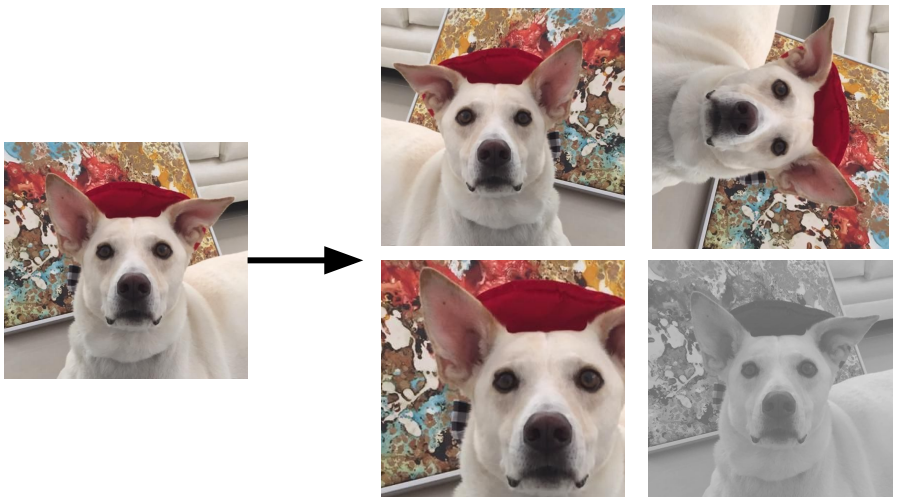


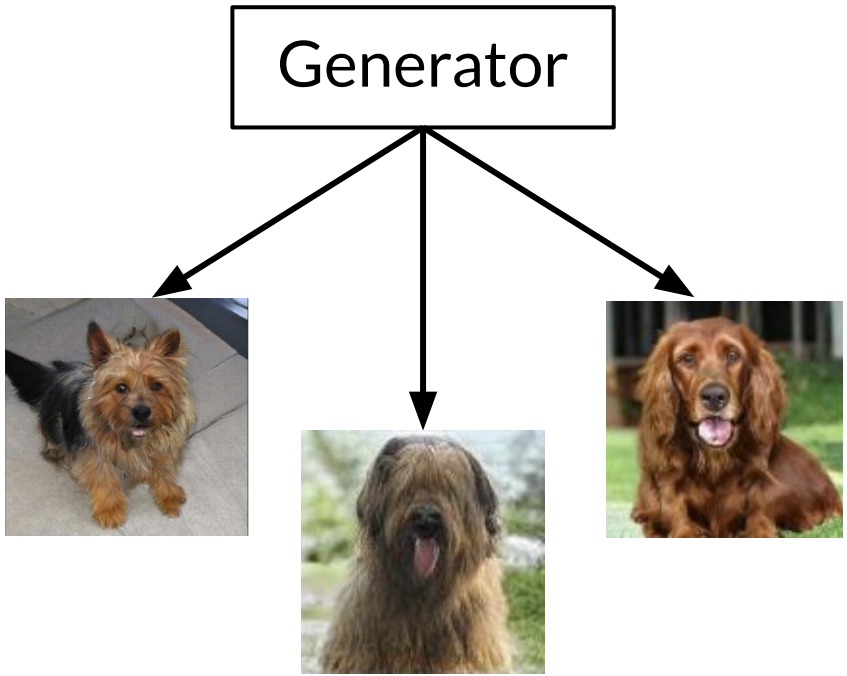


(Right) Available from: https://arxiv.org/abs/1809.11096

How to Augment Data

Can mix data augmentation techniques!





(Right) Available from: https://arxiv.org/abs/1809.11096

Use Cases

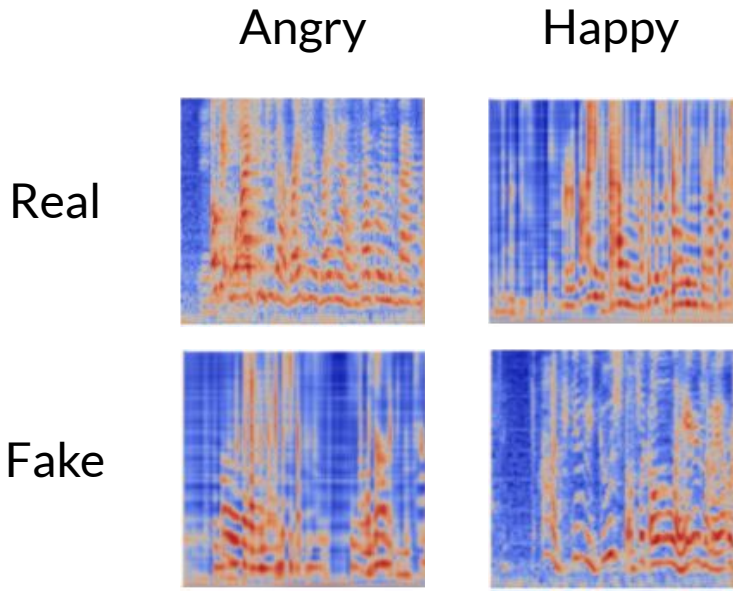
Synthetic

Generated

Gaze detection

Available from: https://arxiv.org/abs/1711.09767

Use Cases

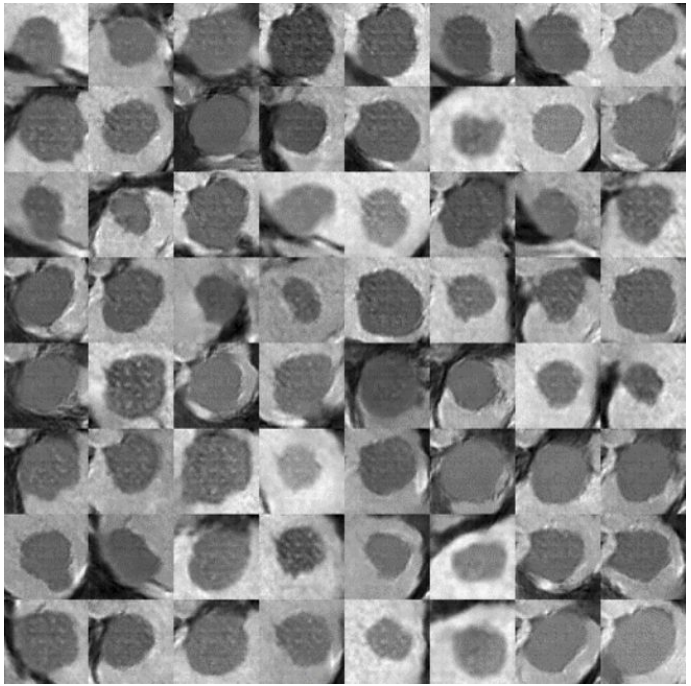


Speech emotion recognition

Available from: https://pdfs.semanticscholar.org/395b/ea6f025e599db710893acb6321e2a1898a1f.pdf

Use Cases

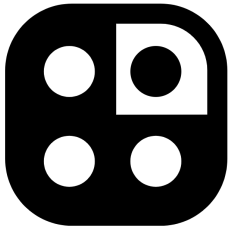
Synthetic liver lesions



Available from: https://arxiv.org/abs/1803.01229

Summary

- Use GANs to generate fake data when real data is too scarce
- GANs have various use cases in data augmentation and beyond!



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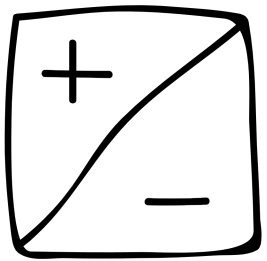
Data Augmentation: Pros & Cons

Outline

- Pros and cons of data augmentation
- Various use cases



Pros of GAN Data Augmentation

Better than hand-crafted synthetic examples

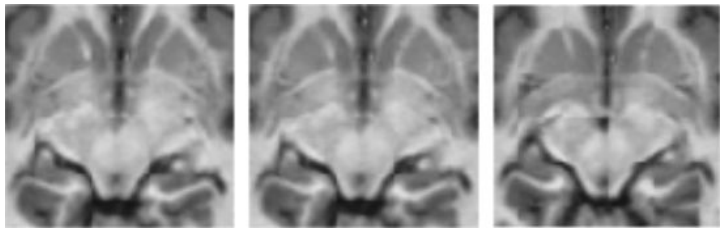
Synthetic

GAN refined

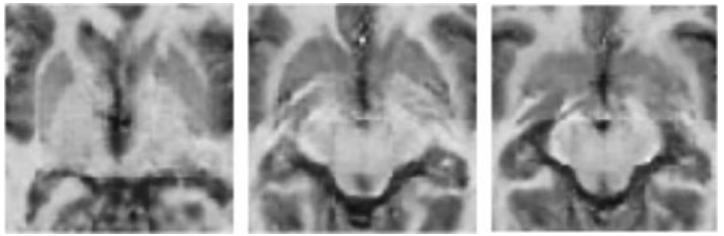
Available from: https://arxiv.org/abs/1711.09767

Pros of GAN Data Augmentation

Generate more labeled examples



Training set
(reals)

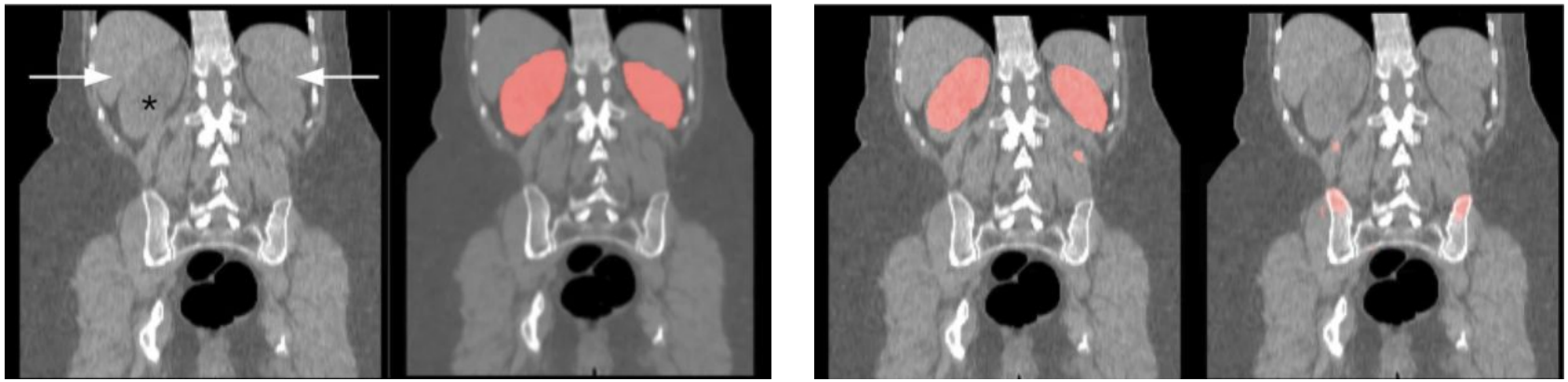


Labeled output
(fakes)

Available from: https://arxiv.org/abs/1811.10669

Pros of GAN Data Augmentation

Improve downstream model generalization



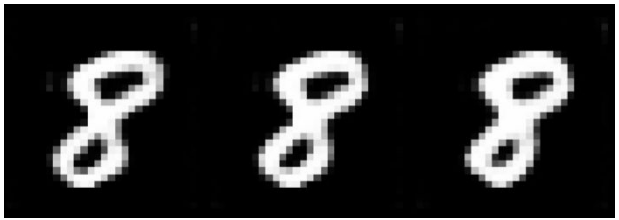
CT | Expert | CycleGAN | Standard Augmentation

Available from: https://www.nature.com/articles/s41598-019-52737-x/figures/3

Cons of GAN Data Augmentation

Diversity is limited to the data available

Training set



Generated outputs

Cons of GAN Data Augmentation

Not useful when overfit to real data

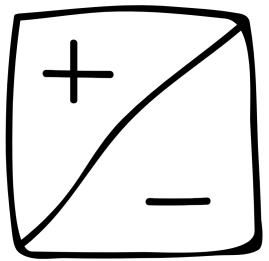
Real

Fake

Available from: https://arxiv.org/abs/1902.04202

Summary

- Pros:
  - Can be better than hand-crafted synthetic examples
  - Can generate more labeled examples
  - Can improve a downstream model's generalization
- Cons:
  - Can be limited by the available data in diversity
  - Can overfit to the real training data



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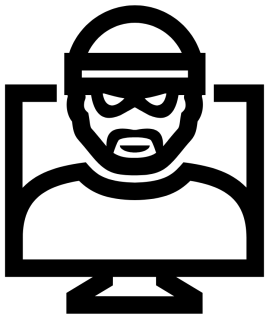
GANs for Privacy

Outline

- GANs for privacy preservation
- Medical privacy as a motivating example

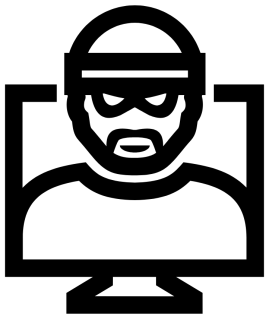
Motivations for Medical Privacy

- Protects real patient data



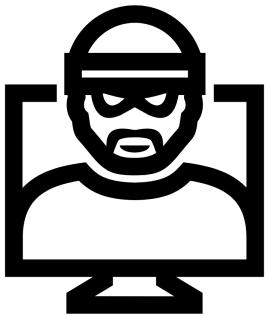
Motivations for Medical Privacy

- Protects real patient data
- Can encourage data-sharing between institutions



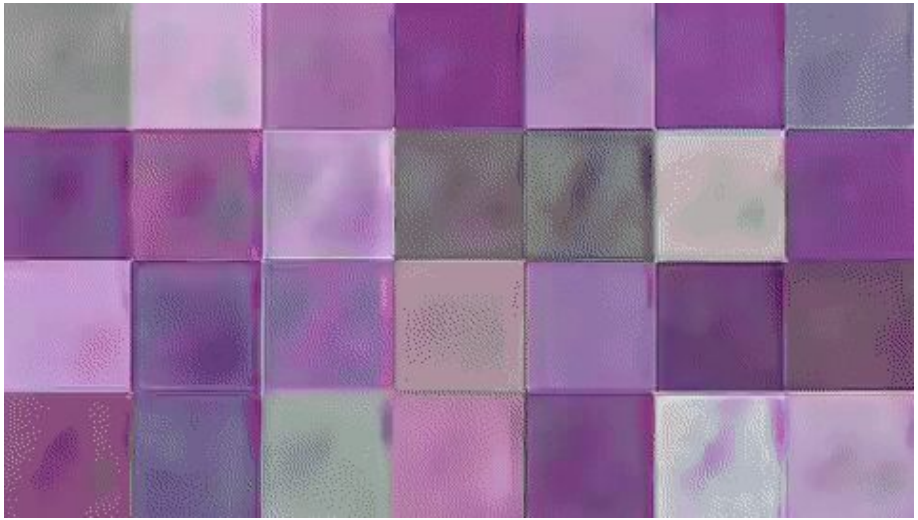
Motivations for Medical Privacy

- Protects real patient data
- Can encourage data-sharing between institutions
- Less expensive and more abundant than real data



Privacy Preservation

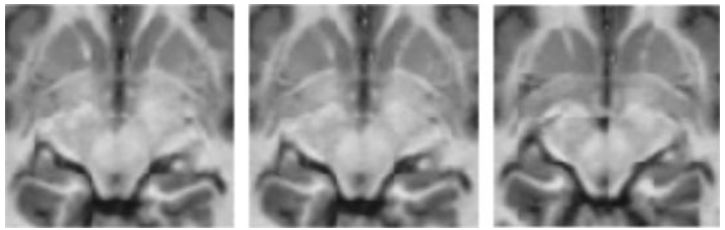
GAN tissue patches look real to pathologists



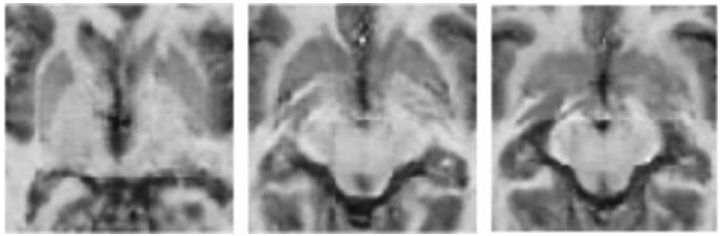
Available from: https://twitter.com/realSharonZhou/status/1182877446690852867

Privacy Preservation

GAN MRIs look realistic



Training set
(reals)



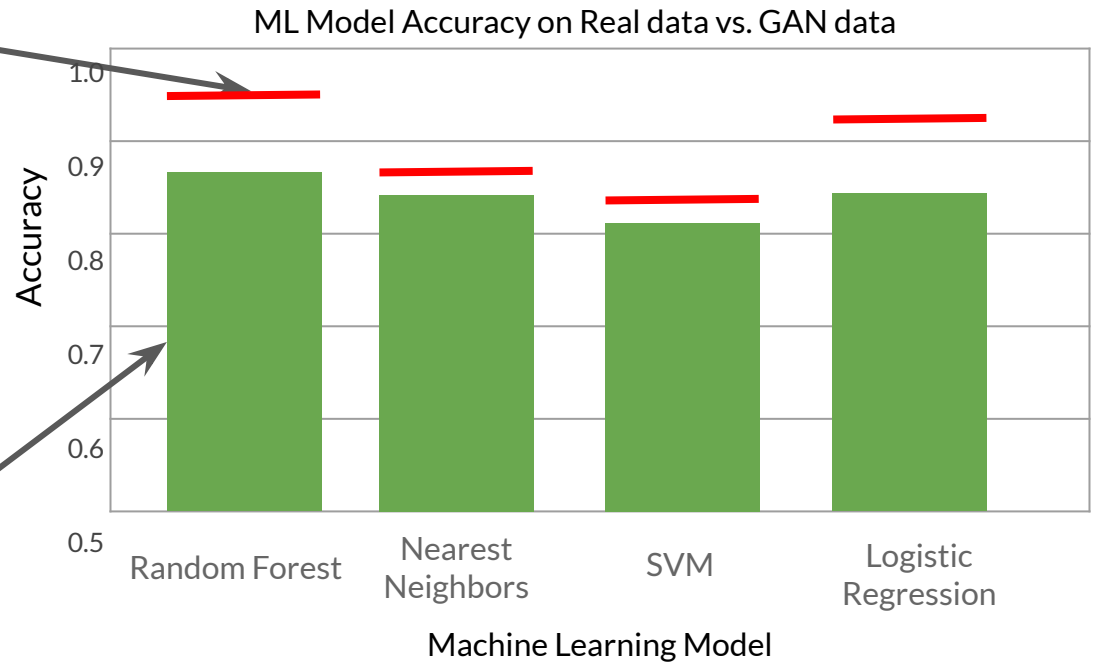
Labeled output
(fakes)

Available from: https://arxiv.org/abs/1811.10669

Pro of GANs for Privacy

Trained on real data

Trained on GAN data

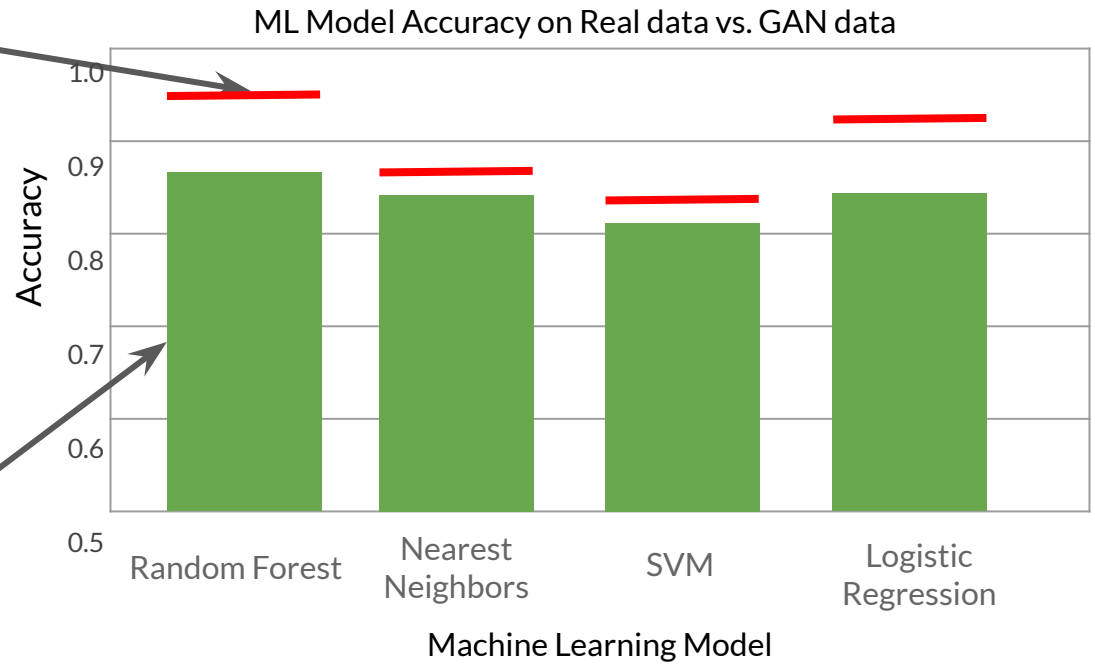


Available from: https://www.ahajournals.org/doi/epub/10.1161/CIRCOUTCOMES.118.005122

Pro of GANs for Privacy

Trained on real data

Trained on GAN data



Training with GAN data approaches real data accuracy

Available from: https://www.ahajournals.org/doi/epub/10.1161/CIRCOUTCOMES.118.005122

Con of GANs for Privacy

GAN sample is nearly identical to a real sample

Available from: https://arxiv.org/abs/1902.04202

Summary

- GANs can be useful for preserving privacy
  - Sensitive medical data serves as one example
- Caveat: generated samples may mimic the reals too closely
  - Post-processing may help avoid this data leakage

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GANs for Anonymity

Outline

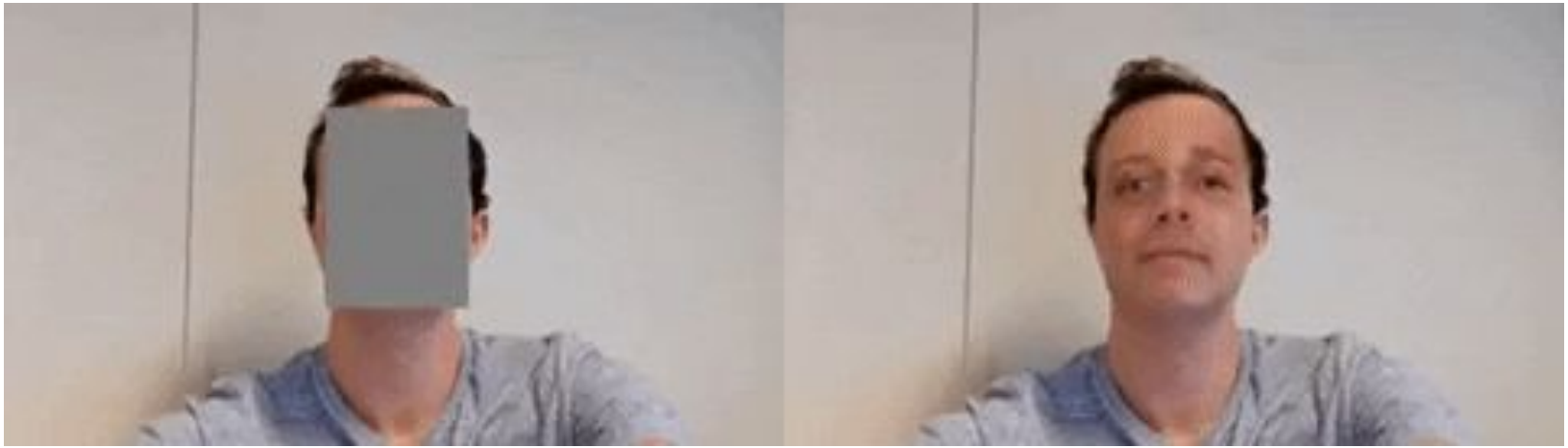
- GANs for anonymity
  - Concealing identity
  - Stealing identity
  - DeepFakes

Anonymity

Original image De-identified image

Available from: https://arxiv.org/abs/1902.04202

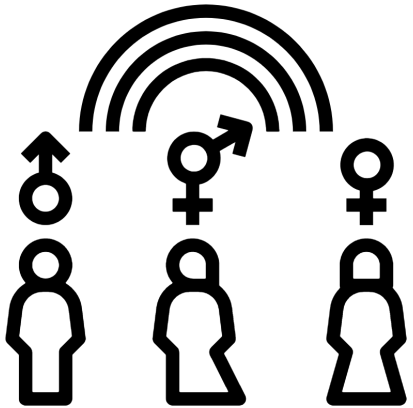
Anonymity



Available from: https://arxiv.org/abs/1909.04538

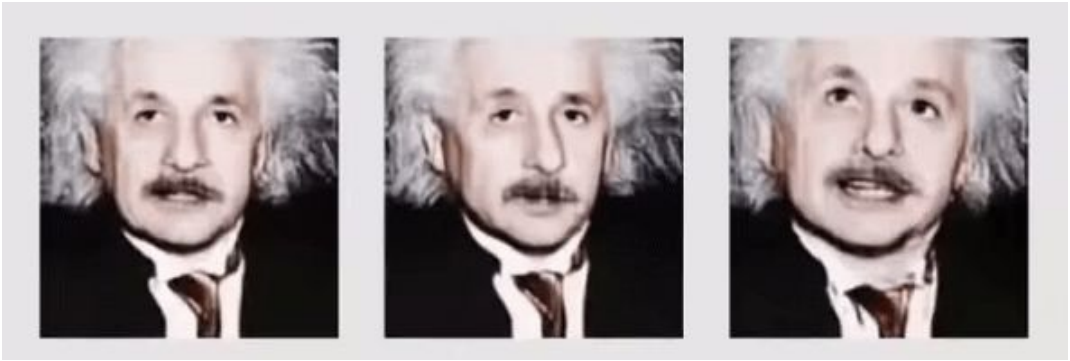
Pro of GANs for Anonymity

- Provide safe environment for expression to:
  - Stigmatized groups
  - Assault victims
  - Witnesses
  - Activists



Con of GANs for Anonymity

Deepfakes put words into people's mouths



Available from: https://arxiv.org/abs/1905.08233

Summary

- GANs can enable healthy anonymous expression for stigmatized groups
- GANs for anonymization can be used for good or evil
  - Identity theft is not good
  - Use your powers for good