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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

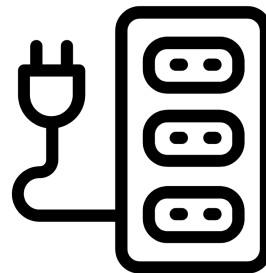
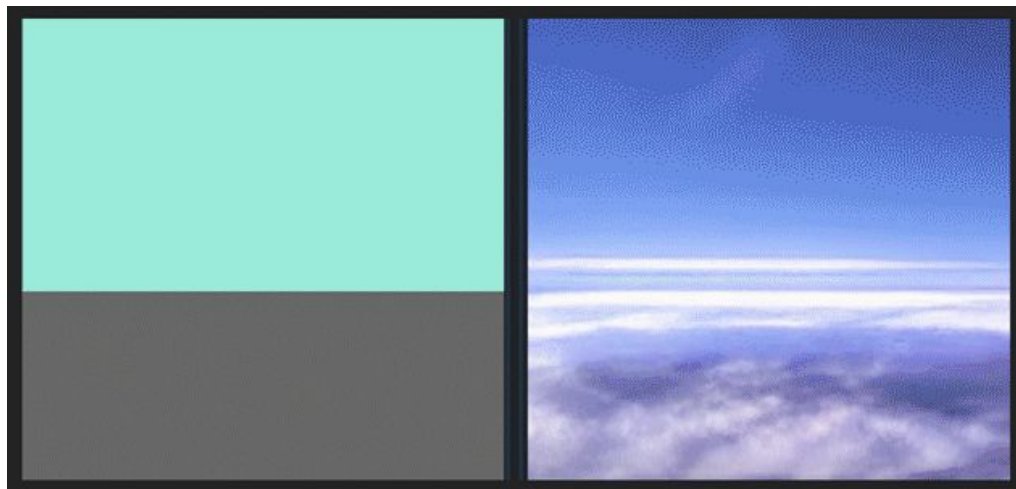


Image-to-Image



GauGAN

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

Image-to-Image



Original image

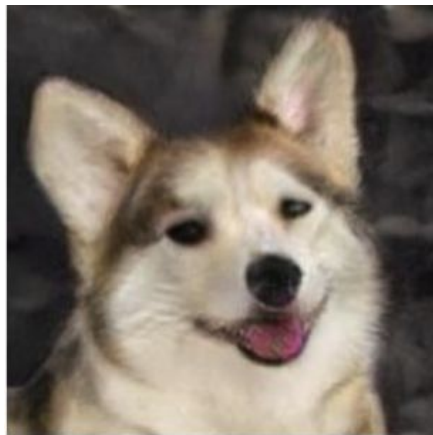
Super-Resolution GAN



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

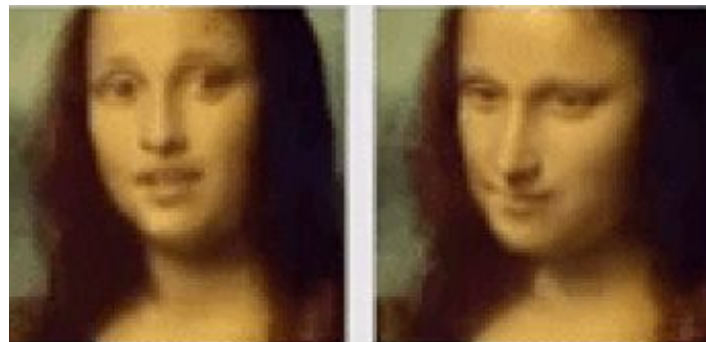


Image

+



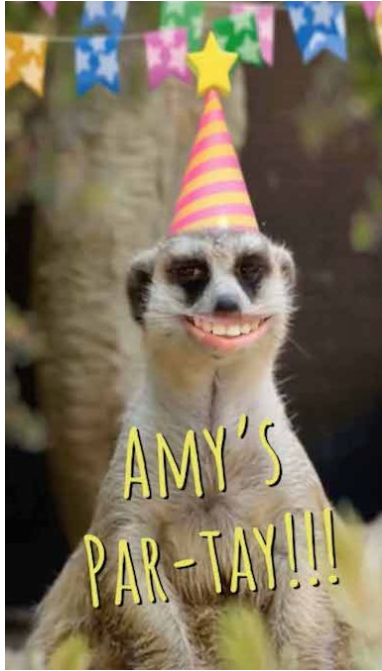
Face landmark



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

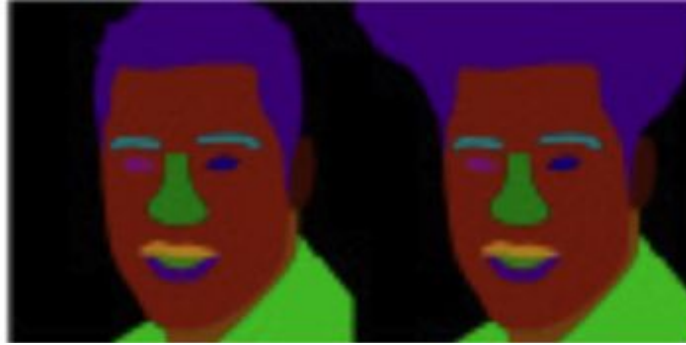
Image editing software

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

Application Areas: Image Editing



Image



Mask

Edited mask

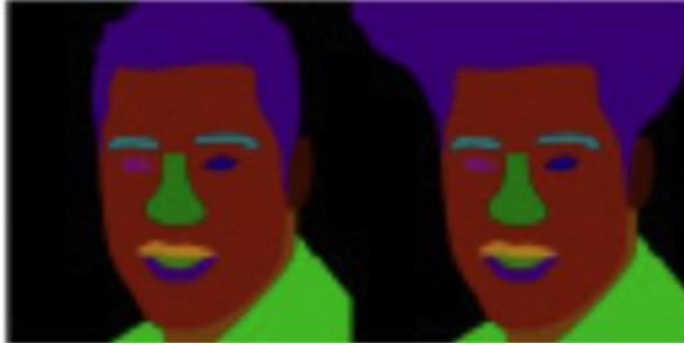
Image editing software

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

Application Areas: Image Editing



Image



Mask

Edited mask

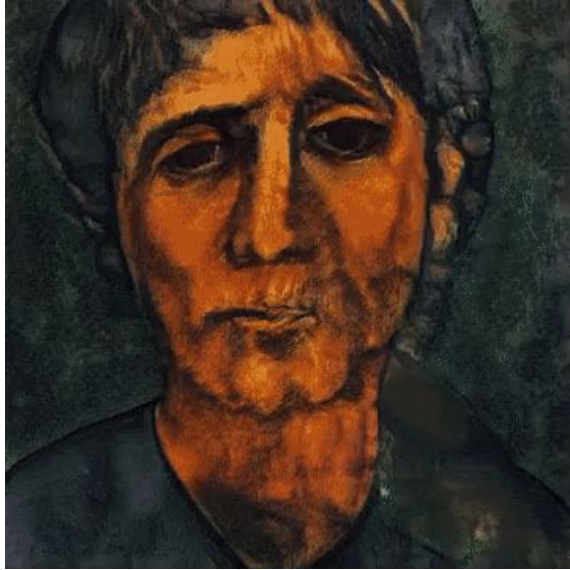


Edited image

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>

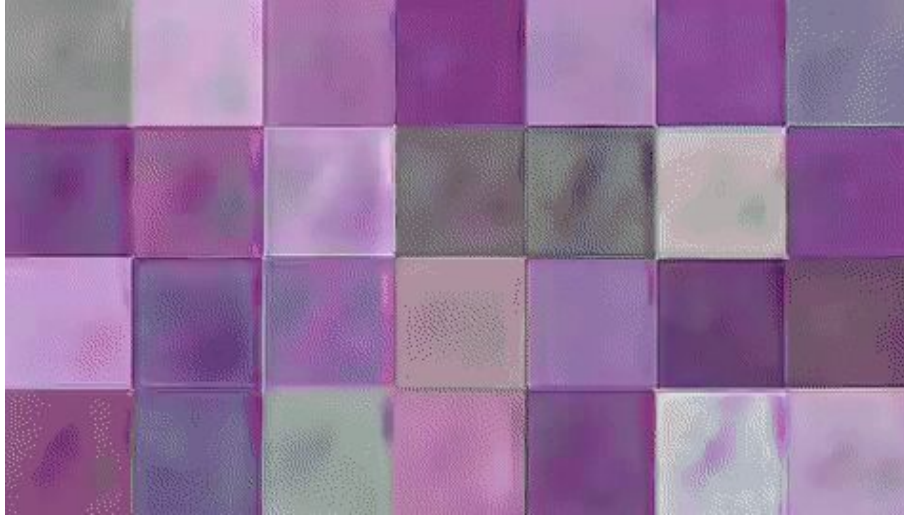
Application Areas: Data Augmentation



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

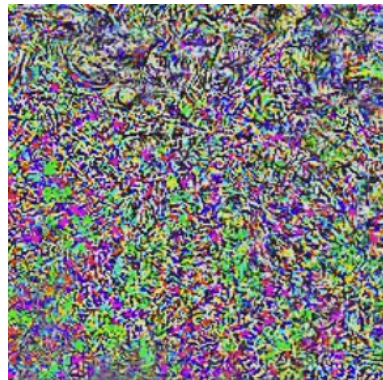
Application Areas: Media



Both pretty cute, actually

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

Adversarial Research Areas



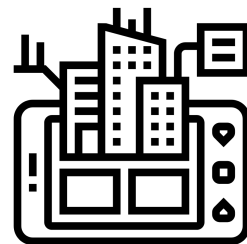
Predicted class: airliner
Predicted probability: 96.8%

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



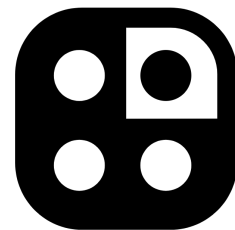


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Data Augmentation Methods and Uses

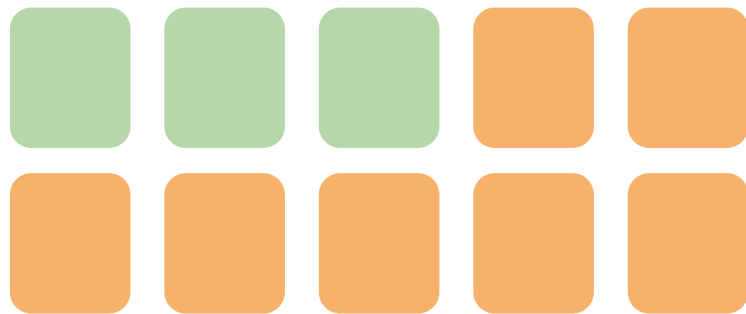
Outline

- Data augmentation and use cases
- Implementation of data augmentation



Data Augmentation

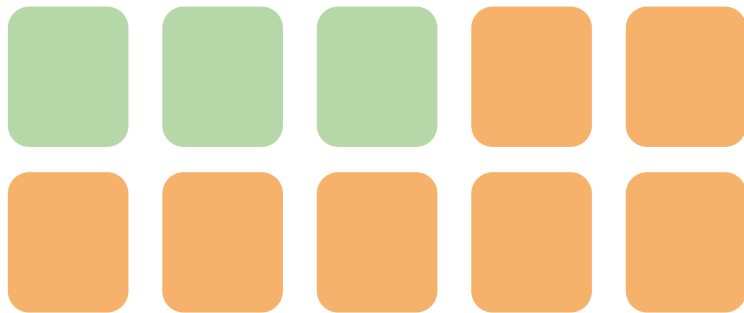
- Supplement data when real data is...
 - Too expensive
 - Too rare



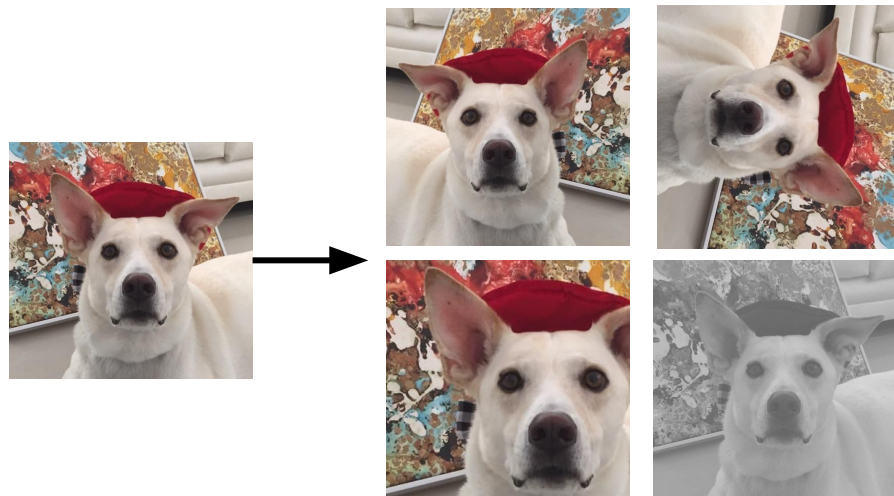
Data Augmentation

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

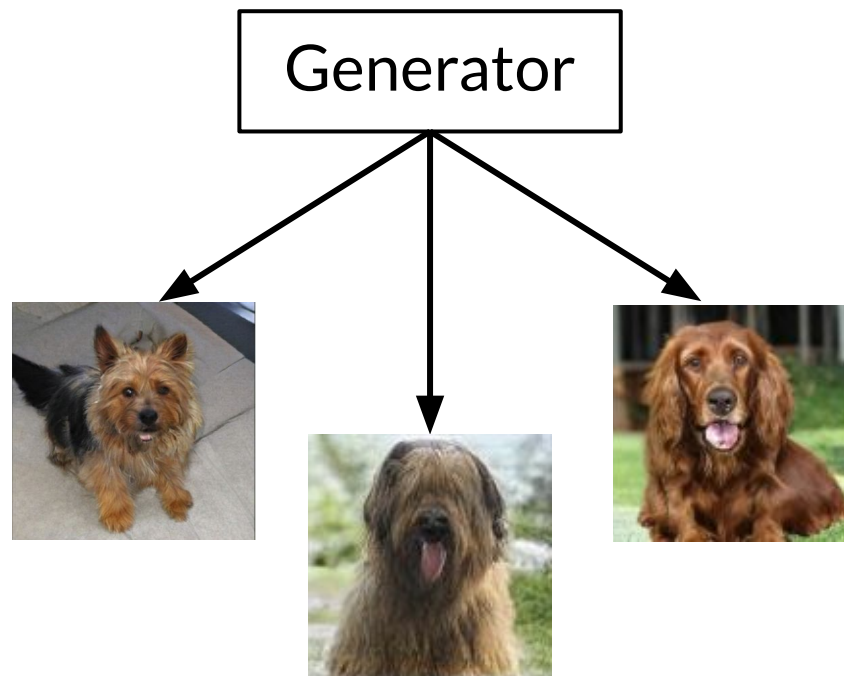
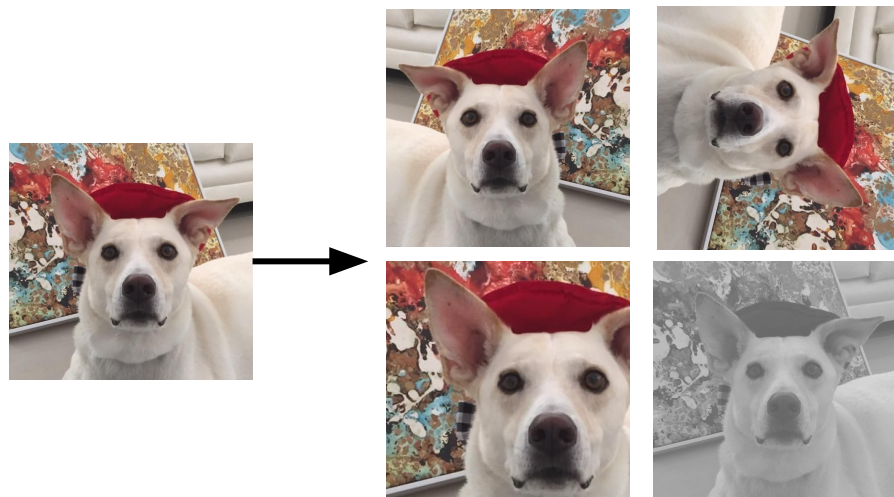
GANs are well suited for this



How to Augment Data

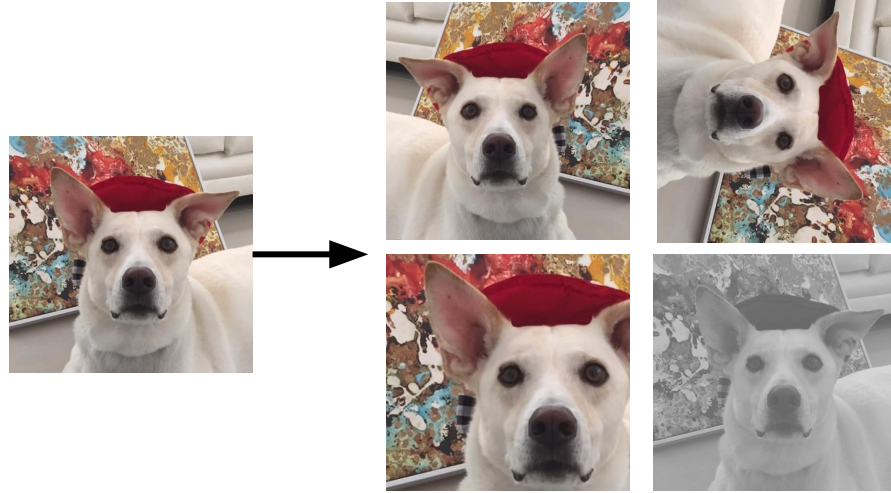


How to Augment Data

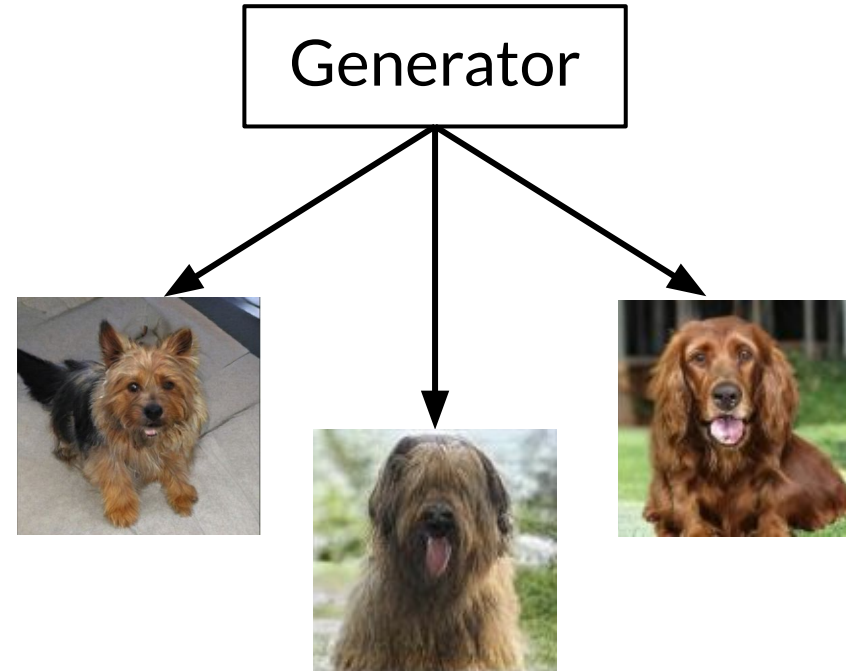


(Right) Available from: <https://arxiv.org/abs/1809.11096>

How to Augment Data



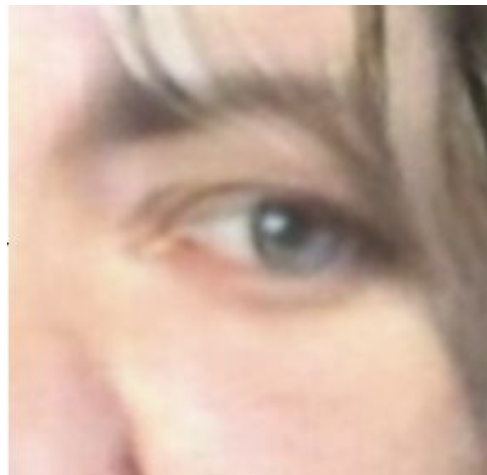
Can mix data augmentation techniques!



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

Use Cases

Synthetic

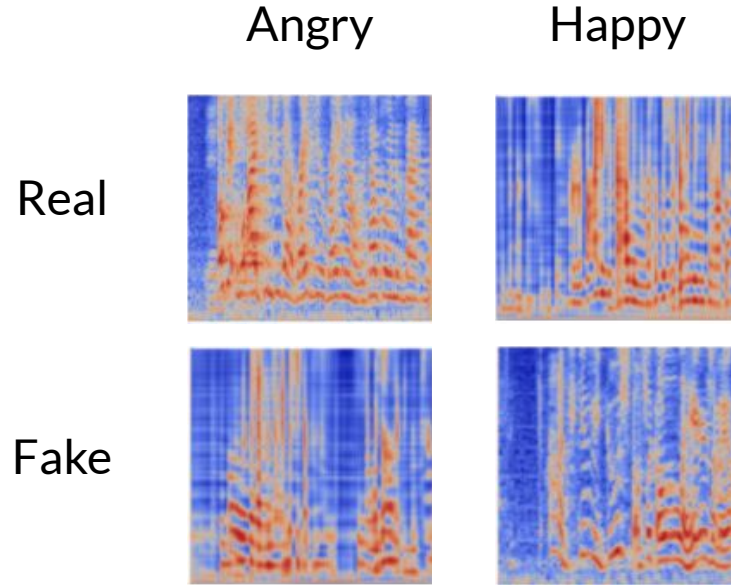


Generated

Gaze detection

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

Use Cases

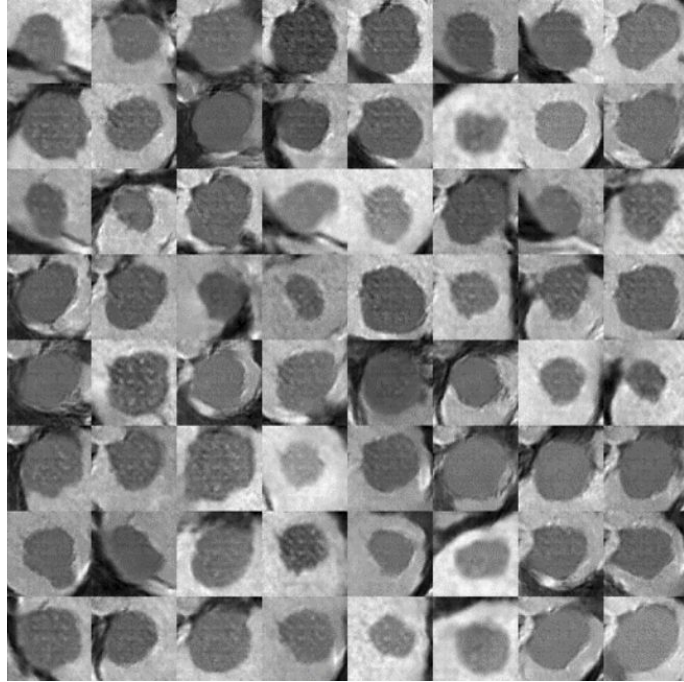


Speech emotion recognition

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

Use Cases

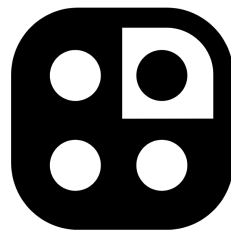
Synthetic liver lesions



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!



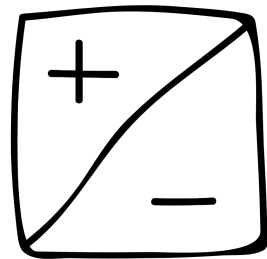


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Data Augmentation: Pros & Cons

Outline

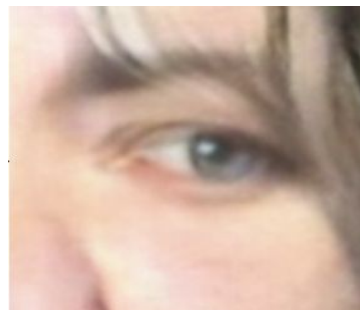
- Pros and cons of data augmentation
- Various use cases



Pros of GAN Data Augmentation

Better than hand-crafted
synthetic examples

Synthetic

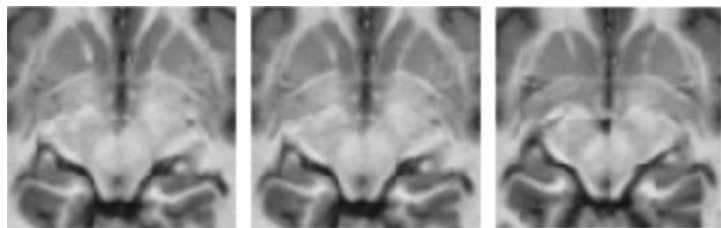


GAN refined

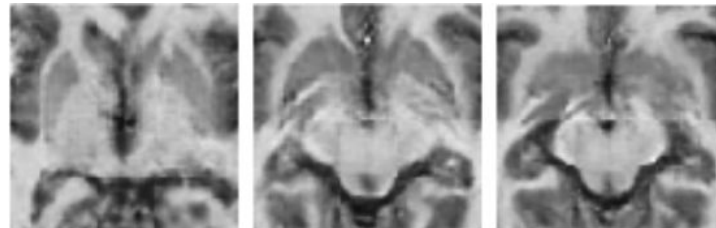
Available from: <https://arxiv.org/abs/1711.09767>

Pros of GAN Data Augmentation

Generate more labeled examples



Training set
(reals)

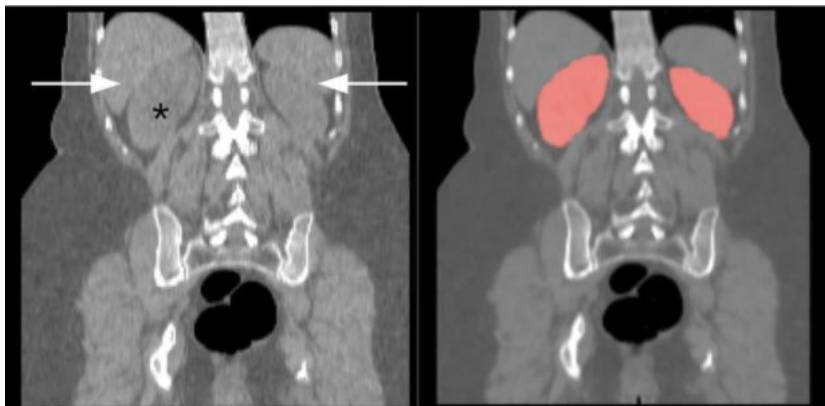


Labeled output
(fakes)

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

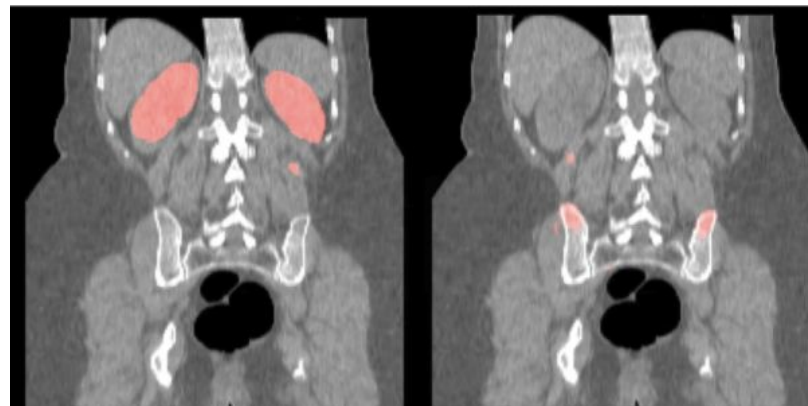
Pros of GAN Data Augmentation

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

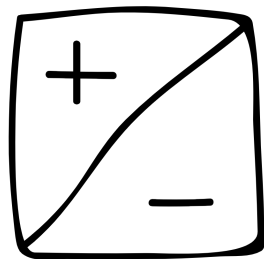


Fake

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

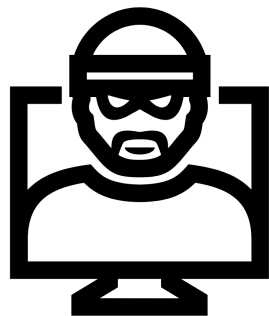
Outline

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



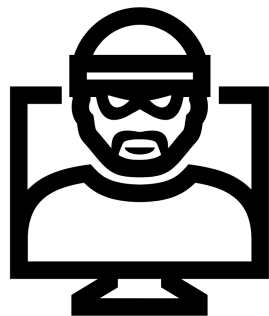
Motivations for Medical Privacy

- Protects real patient data



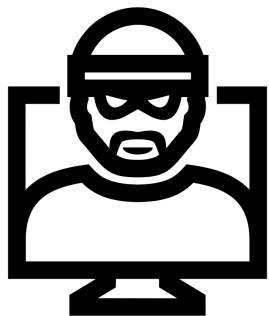
Motivations for Medical Privacy

- 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

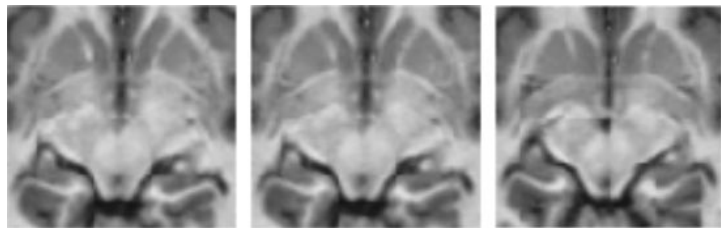
GAN tissue patches look real to pathologists



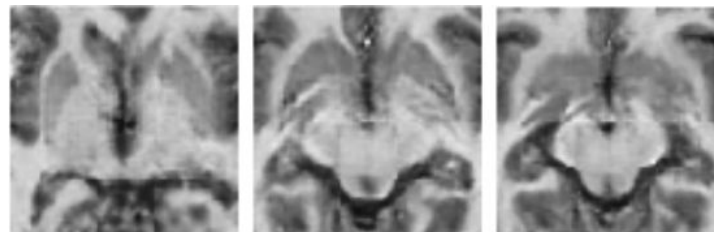
Available from: <https://twitter.com/realSharonZhou/status/1182877446690852867>

Privacy Preservation

GAN MRIs look realistic



Training set
(reals)



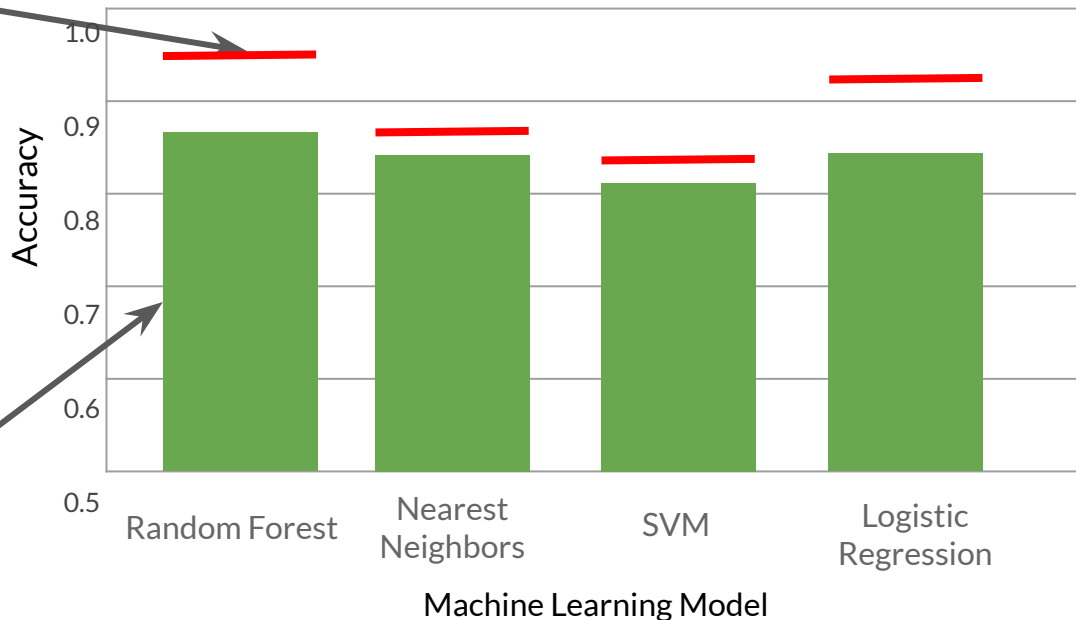
Labeled output
(fakes)

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

Pro of GANs for Privacy

Trained on
real data

ML Model Accuracy on Real data vs. GAN data



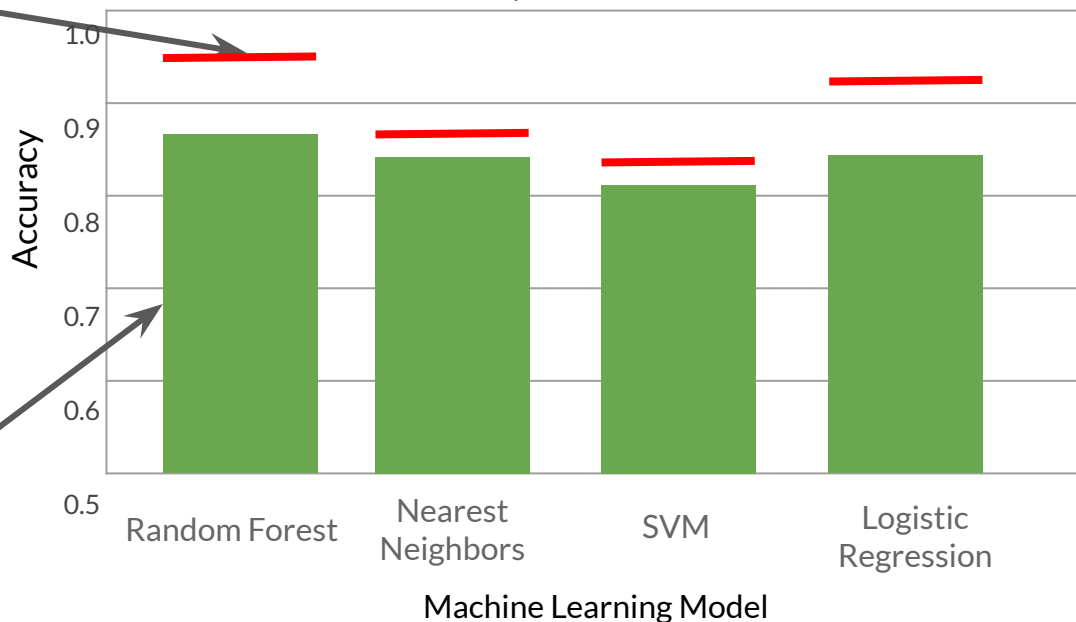
Trained on
GAN data

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

Pro of GANs for Privacy

Trained on
real data

ML Model Accuracy on Real data vs. GAN 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



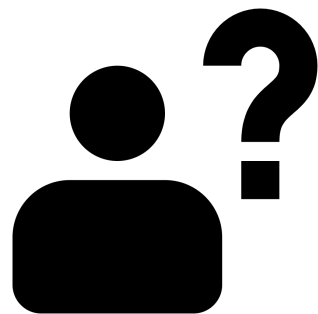


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GANs for Anonymity

Outline

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



Anonymity

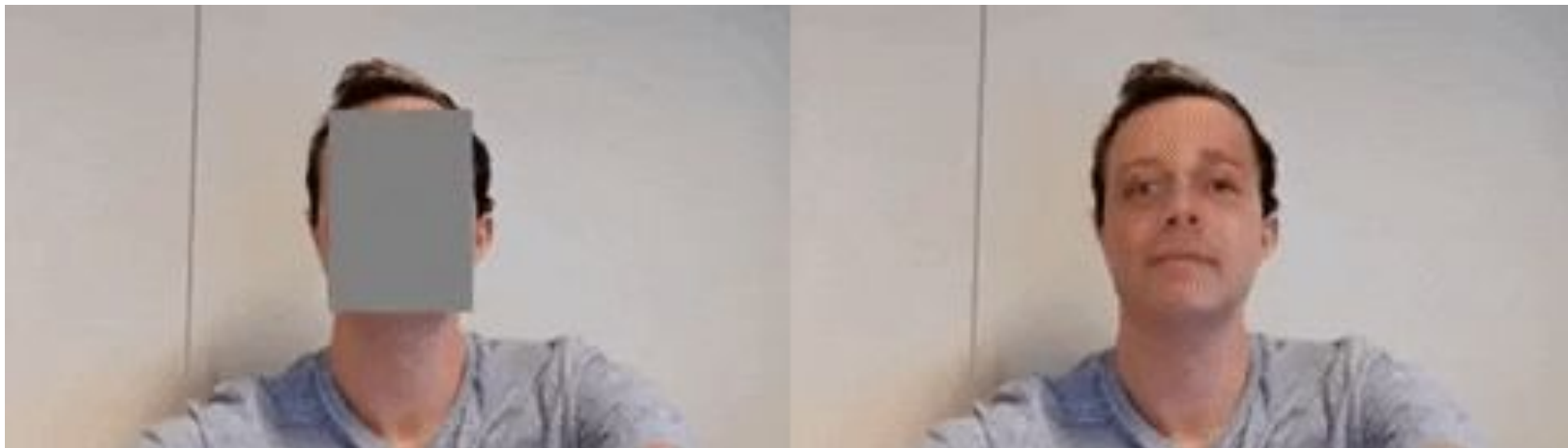


Original image

De-identified image

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

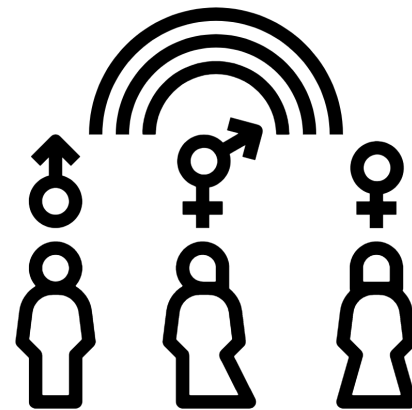
Anonymity



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

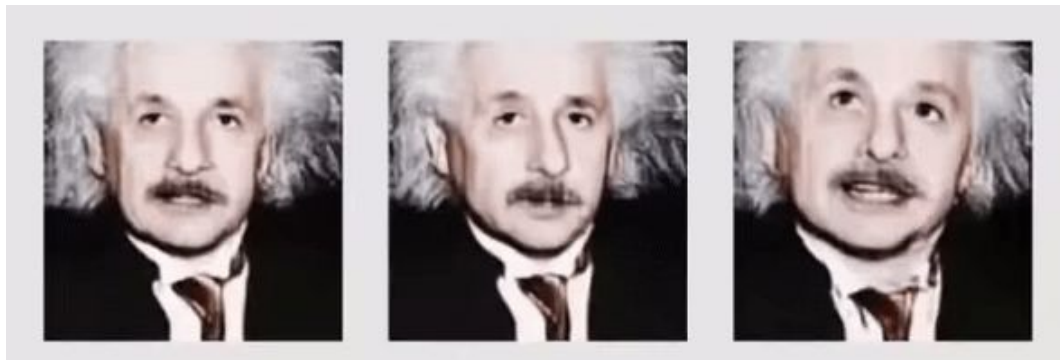
Pro of GANs for Anonymity

- 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

