Neural Image Denoising

on Ray Traced Images

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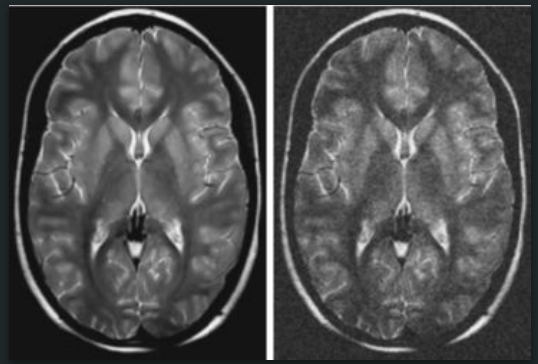
Image Denoising

- Removal (Reduction?) of noise from an image
- Used as a pre-process step or a post-process step
- Applicable to
  - Medical images
  - Astronomical images
  - Ray traced images
  - ...



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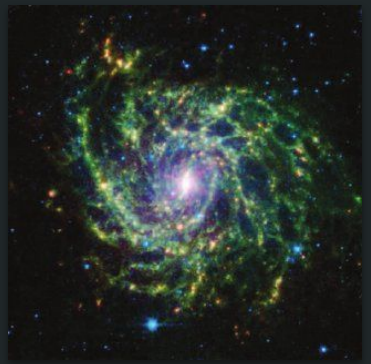

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What is Ray Tracing?

- Ray tracing is a technique for modeling light transport for use in a wide variety of rendering algorithms for generating digital images. (Taken from Wikipedia)
- Hollywood has been using Ray tracing for over 20 years now!
- Highly valuable in the industry

$2.06 Billion

$2.84 Billion

$2.79 Billion

Ray Tracing in Action

Insert raytracing image here

Effect of Sample Size

1 SPP
2 seconds

16 SPP
30 seconds

256 SPP
8 minutes!

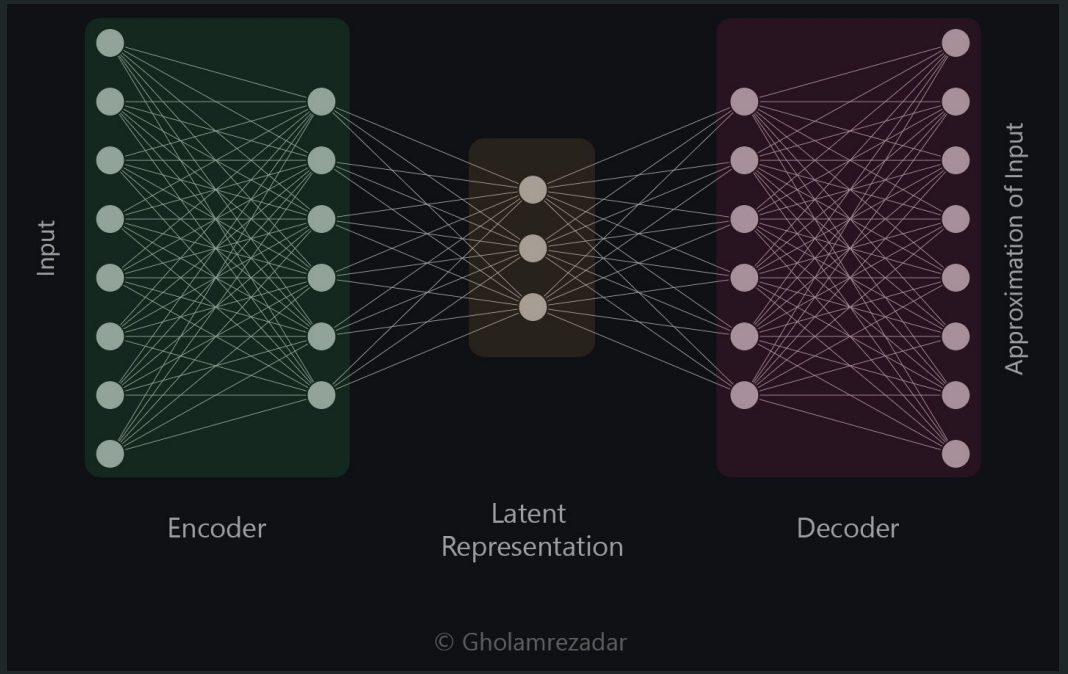
Solution: “Denoising”

How to Denoise?

- What is Denoising?
- Why is Denoising important?
- How is Denoising done?
  - Spatial domain filtering methods (classic)
    - Mean filtering
    - Median filtering
    - ...
  - Transform Domain filtering methods (classic)
    - Spatial Frequency Filtering
    - Wavelet domain filtering
  - **Auto Encoders and CNNs**

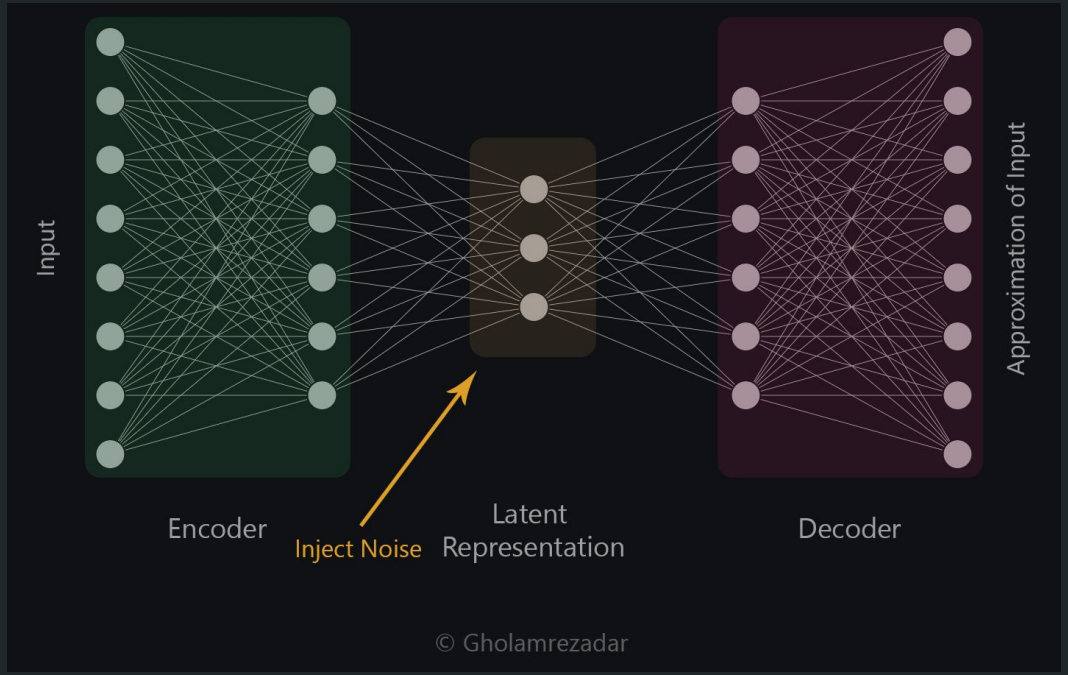
Auto Encoders

- Comprised of an **Encoder** and a **Decoder** part
- Minimizes the “**reconstruction error**”
- Used in a variety of other tasks
  - Image segmentation
  - Style transfer
  - ...



Denoising Auto Encoders

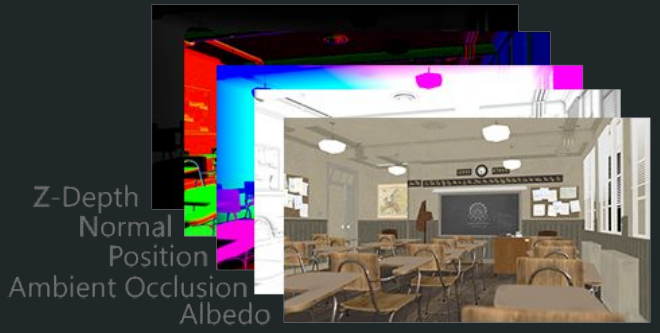
- Injects **noise** to the latent representation
- Goals:
  - Encourage the model to find more **robust features**
  - Discourage **overfitting**
  - Prevent the model from becoming a simple **identity function**
- However, it gives a good idea of how to denoise images



© Y. Bengio et al. , "Extracting and Composing Robust Features with Denoising Autoencoders" 2008

What is special about Ray traced images?

- Easy access to auxiliary passes as additional input data
  - Similar to RGB-D cameras but way more powerful
- Easily accessible training data
  - Need more data? Just make them*!
- Customizable training data
  - Need more interior images? No problem*.
  - Need more night images? No problem*.



*needless to say that you still need the computing power to generate these data but it's generally a lot easier than in other fields.

State of the art Methods

- Intel® Open Image Denoiser (OIDN)
- NVIDIA OPTIX™ Denoiser
- Both of them are Autoencoder based
- Both of them use said Auxiliary input data

Intel® OIDN Example

Effect of Auxiliary inputs

Zoomed in on the chalkboard

Conclusion

- What are Ray traced images
- Denoising Ray traced images is important
- Autoencoders as the best method of denoising images
- Benefits of working with Ray traced images
- Practical examples

References

- Open Image Denoise documentation
- NVIDIA OptiX™ Ray Tracing Engine
- Chakravarty et al. Interactive Reconstruction of Monte Carlo Image Sequences using a Recurrent Denoising Autoencoder, 2017 (Nvidia Research)
- Vincent, Pascal, et al. "Extracting and composing robust features with denoising autoencoders." Proceedings of the 25th international conference on Machine learning, 2008.
- Rumelhart, David E., Geoffrey E. Hinton, and Ronald J. Williams. Learning internal representations by error propagation. California Univ San Diego La Jolla Inst for Cognitive Science, 1985.
- Alisha P B et al. Image Denoising Techniques-An Overview, 2016
- Denoising autoencoders with Keras, TensorFlow, and Deep Learning - PyImageSearch
- Auto Encoders and Style Transfer

Conclusion