



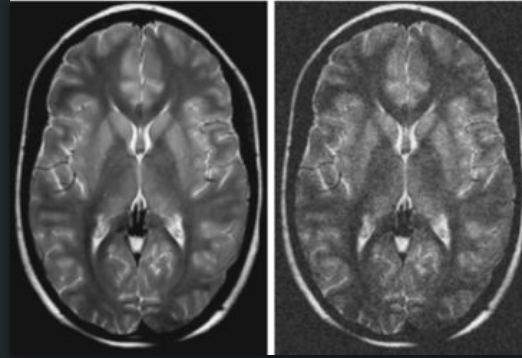
Neural Image Denoising

on Ray Traced Images

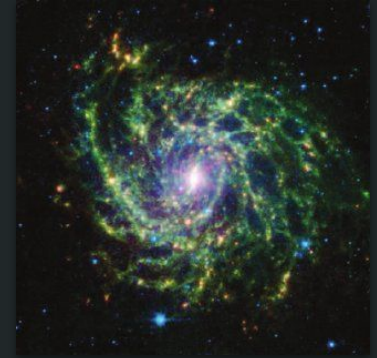
Gholamreza Dar 400131018

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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© John Jenkinson et al.

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](https://en.wikipedia.org/wiki/Ray_tracing))
- Hollywood has been using Ray tracing for over 20 years now!
- Highly valuable in the industry



\$2.06 Billion

© Lucasfilm Ltd.



\$2.84 Billion

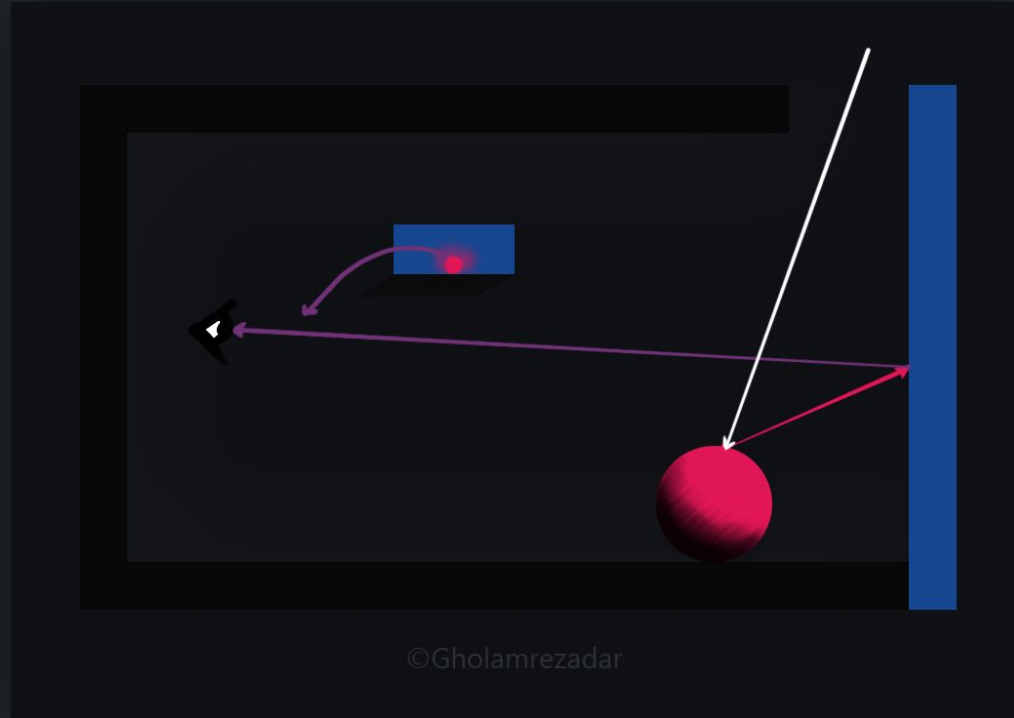
© 20th Century Fox



\$2.79 Billion

© Marvel Studios

Ray Tracing in Action



Effect of Sample Size



1 SPP
2 seconds



16 SPP
30 seconds



256 SPP
8 minutes!

Solution: “Denoising”



8 SPP
16 seconds



8 SPP Denoised
20 seconds



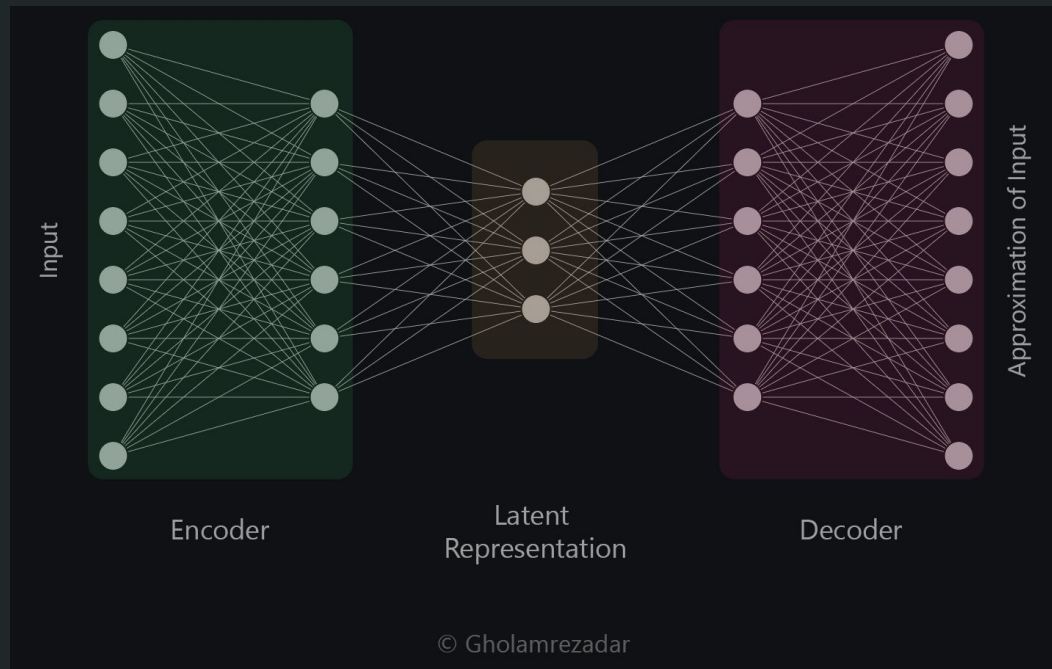
512 SPP GroundTruth
16 minutes!

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**

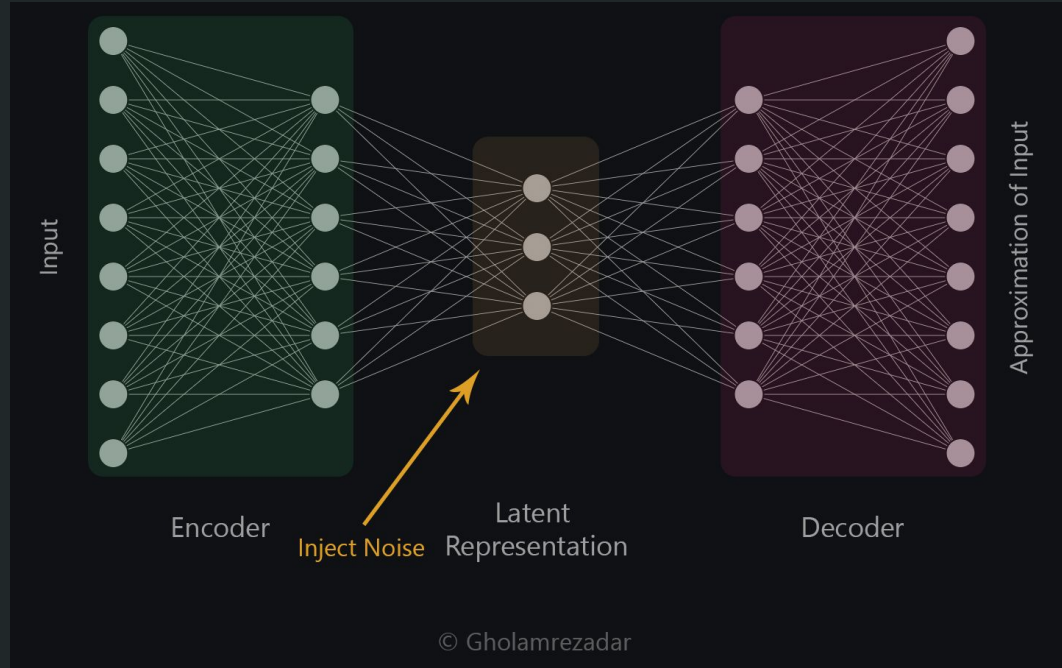
Auto Encoders

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



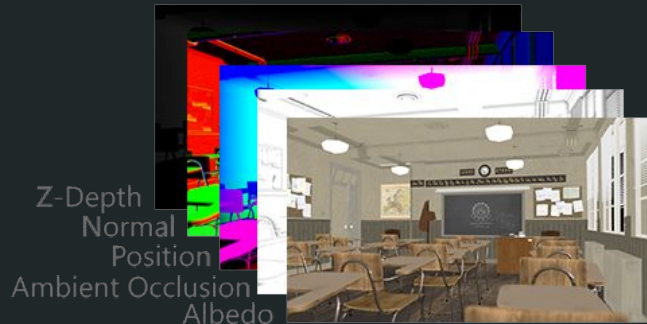
Denoising Auto Encoders

- 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



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



8 SPP
16 seconds



8 SPP Denoised
20 seconds



512 SPP GroundTruth
16 minutes!

Effect of Auxiliary inputs

Zoomed in on the chalkboard



4 SPP Noisy
16 seconds



4 SPP Denoised (RGB)
19 seconds



4 SPP Denoised (+Albedo)
25 seconds

Albedo

Flat lighting and no shadows



© “Classroom” scene by Christophe Seux, Renders and comparison by Gholamreza Dar

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

Thank you for your time!