Medical Image Denoising Using Convolutional Denoising Autoencoders

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Project Recap

- Low Dose Fluoroscopy for Orthopedic Surgery
- Team Members: Mariya Kazachkova, Michael Mudgett
- Mentors: Mathias Unberath, PhD, Bastian Bier, Nico Zaech, Nassir Navab, PhD, Greg Osgood, MD

Project Recap

- Goal: reduce total radiation inflicted on patient through x-ray imaging during orthopedic surgery while increasing the temporal resolution of X-ray imaging
- Project goal: Combine MC-GPU simulated images with deep learning to ultimately make low dose fluoroscopy usable during orthopedic surgery
  - Minimum deliverable: Denoising neural network

Paper Selection

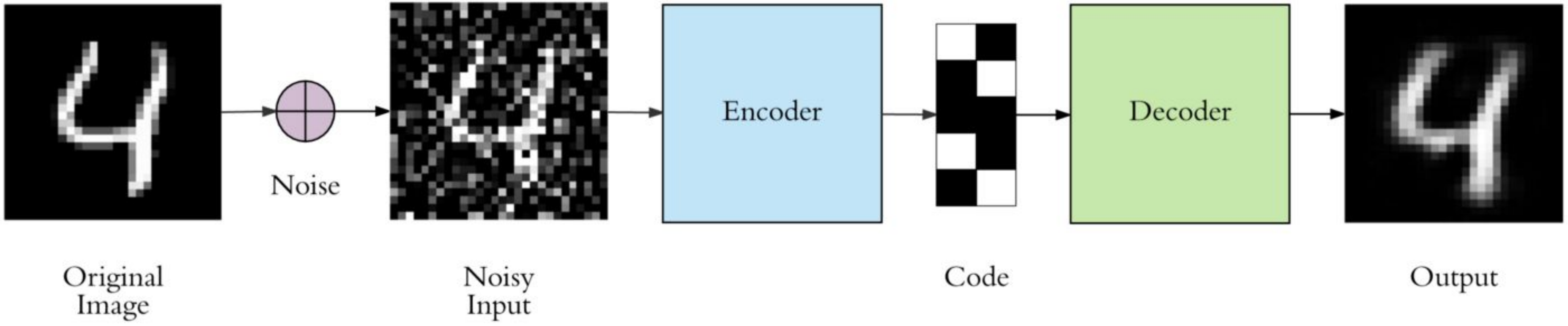
- Architecture proven to work for medical images
- Good results with small dataset

Problem Statement

- Deep learning is great, but requires a large amount of training/validation data and great computational power
- The above requirements are not always readily available
  - Need for methods that can work with small datasets and low computational power

Background

● Denoising Autoencoder



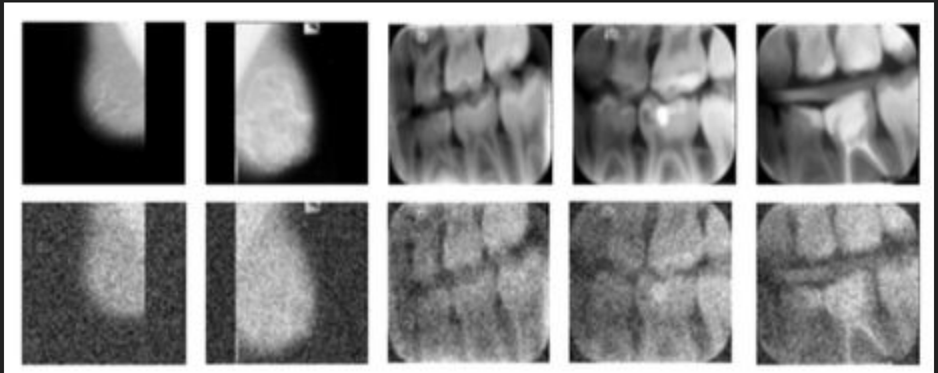
Hubens, N. Deep inside: Autoencoders – Towards Data Science. Towards Data Science (2018). Available at: https://towardsdatascience.com/deep-inside-autoencoders-7e41f319999f. (Accessed: 12th March 2018)

What the authors did - Data

- Two datasets
  - Mini-MIAS database of mammograms (MMM)
    - 322 Images (1024x1024 resolution)
  - Dental Radiography Database
    - 400 images (1935x2400)
- Resized to 64x64
- Added noise
  - Gaussian and Poisson

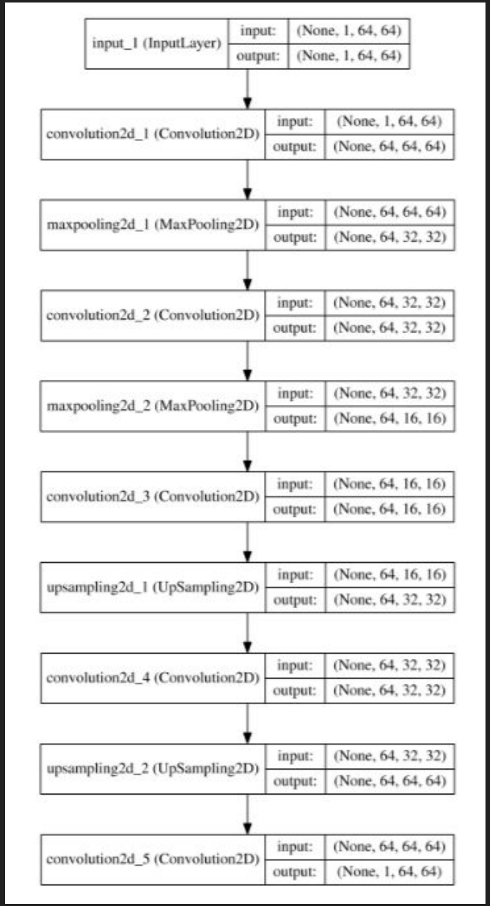
TABLE I. DATASET PERTURBATIONS

Noise type	corruption parameters
Gaussian	p=0.1, $\mu = 0$, $\sigma = 1$
Gaussian	p=0.5, $\mu = 0$, $\sigma = 1$
Gaussian	p=0.2, $\mu = 0$, $\sigma = 2$
Gaussian	p=0.2, $\mu = 0$, $\sigma = 5$
Poisson	p=0.2, $\lambda = 1$
Poisson	p=0.2, $\lambda = 5$



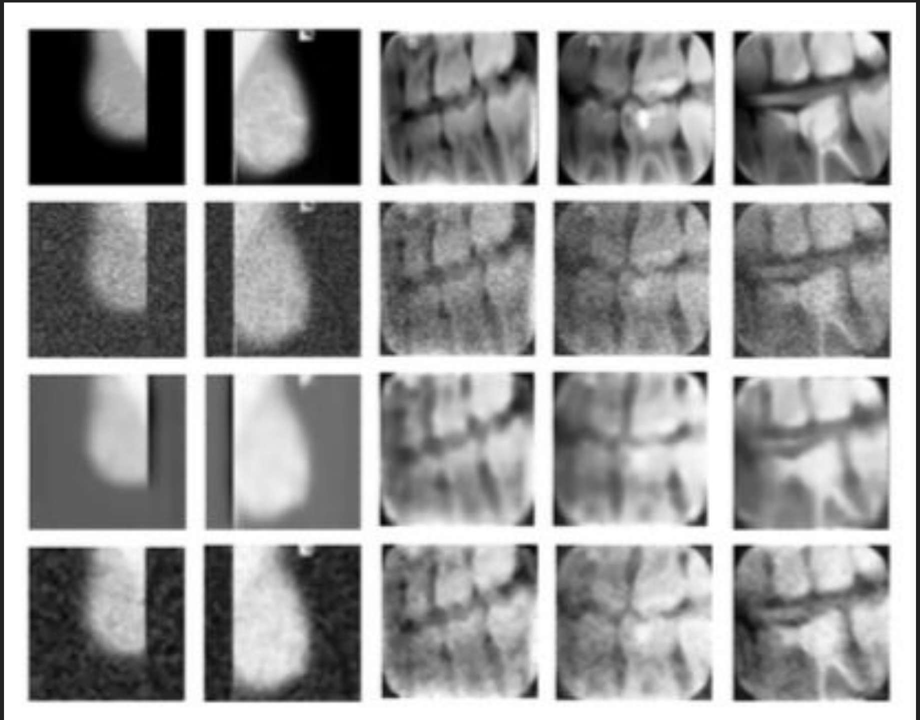
What the authors did - Testing

- Implemented Network using Keras
- Trained using Acer Aspire M5 notebook (no GPU!!)
- Structural Similarity Index Measure (SSIM)
    - Index of 3 measures:
        - Luminance
        - Contrast
        - Structural changes



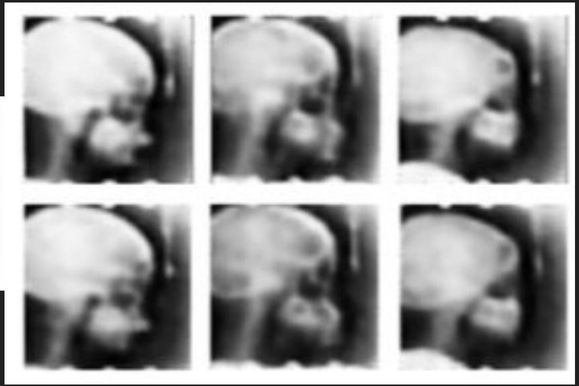
What the authors did - Results

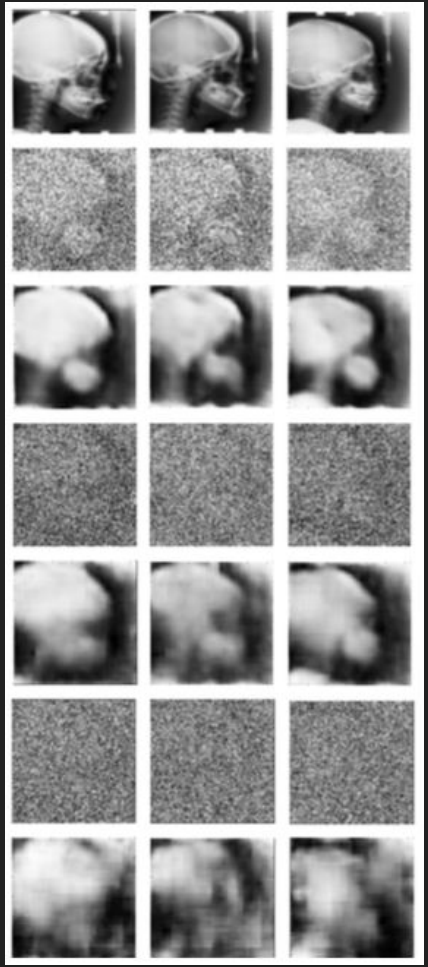
- 1st row: original
- 2nd row: noisy image
  - Gaussian noise (mu= 0, σ = 1, p = 0.1)
- 3rd row: denoised using CNN DAE
- 4th row: denoise using median filter



What the authors did - Results

- Produced results for denoising images with high noise
  - Image barely recognizable to human eye
- Combined training data
  - Training set = mammograms and dental images
  - Produced results slightly better than using only one dataset





What the authors did - Significance

- Effective denoising of medical images using a small dataset and low computational power
- Can combine heterogeneous datasets to increase sample size
- Future work:
    - Find optimal architecture for small sample denoising
    - Using known denoising techniques to preprocess images before running them through the CNN DAE

My Assessment

Pros	Cons
Provides way for deep learning to work in medical field	Reproducibility?
Uses two different datasets	No result present of network working with actual noisy image
Varies the amount and type of noise	Would have liked more comparison to existing methods

Back to our project

- Architecture described in this paper will be the beginning of our minimum deliverable
- Will use Dental Radiography Dataset to test network prior to obtaining simulated images
- Look into using SSIM to quantitatively compare produced images with their starting points

Thank you!

Citation:

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