NOISE

By
Aditya Modi | 18305R007
Athul Nambiar | 183059003
Anand Pisal | 183059001

NOISE

Have we ever seen it closely?

NOISE

Or we have only seen it too closely!

Imagine

Imagine

- Scenario where you wish to take a photo, a life-time shot, an extremely rare occurrence.
- But you somehow, the lighting is too less or the camera exposure itself is too low.
- What NOW?
- There is no way we can replicate the shot.
- All we can do is digitally process the image.

Example


NIVEA
MEN
FRESH
ACTIVE
LONG LASTING
FRESHNESS
48H
GARNIER
FRUCTIS
NIVEA

Which boat to sail?

Sail the old boat?

- We can definitely the conventional methods like
  - Gaussian Filtering
  - Bilateral Filtering
  - Reconstruction using Eigen Vectors
  - PCA Based Denoising

  etc.

Sail the old boat? Or a trendy one?

- But we all know that their performances are limited.
- By the way, we have heard that Neural Networks are great at doing this job!
- That’s great news!
- Let’s train a Neural Network!
- Yes! Yes!! It’s a solved problem!!!
- Done and Dusted!

Sail the old boat? Or a trendy one?

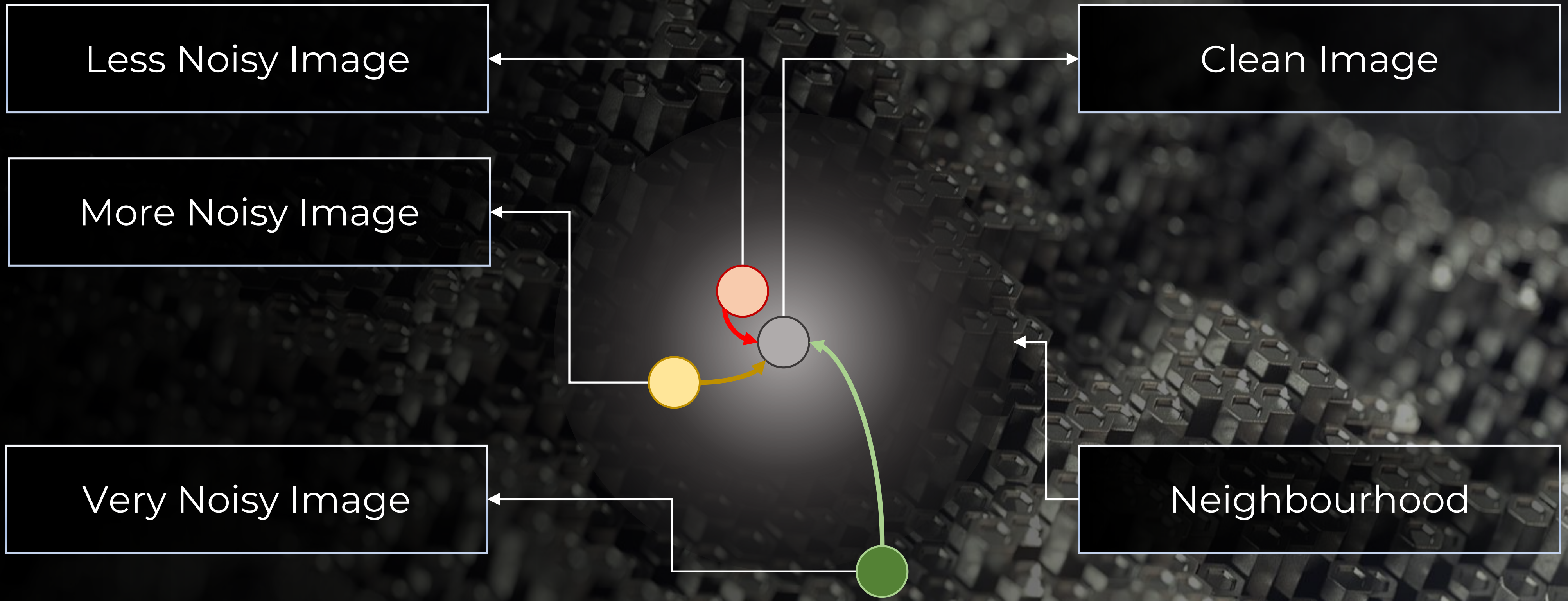
- We’ve learned that we can train a Neural Network with

$$(x_i, y_i)$$

pairs where x_i is the noisy input and y_i is the clean output.

- That is, we need lots and lots of noisy images for inputs and equally mapped clean images for output.
- So we’ll as the model (for training) to do the following:

Sail the old boat? Or a trendy one?



The Big BUT!

- But what if we don’t have the clean image?
- There is just no means to get a clean image?
- How are we going to train the model then?
- Can we use the Noise itself to train it?
- Seriously?

The WISDOM of the CROWD

The WISDOM of the CROWD!

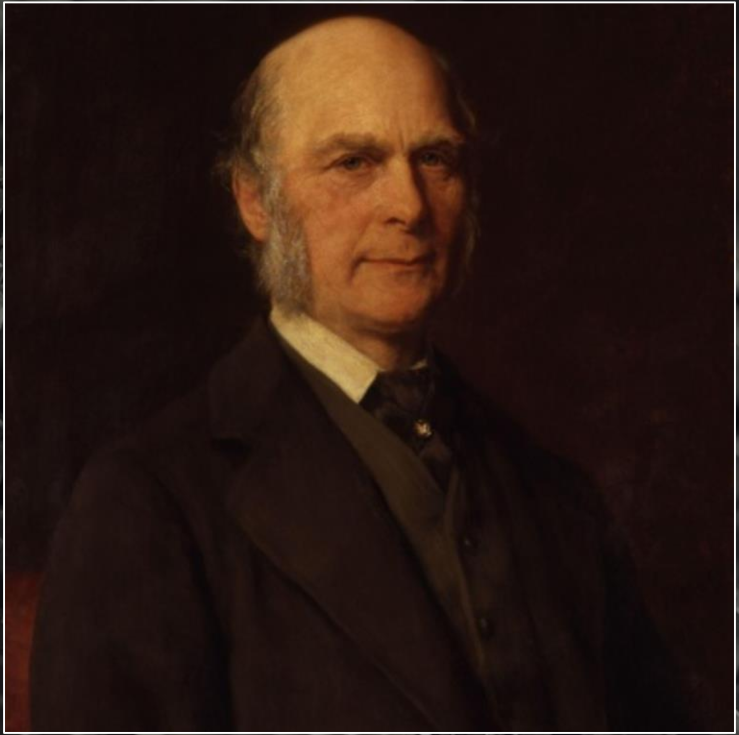
Before we can challenge the problem at hand, let's go back in time to Aristotle and for some insights and knowledge.

The WISDOM of the CROWD!

He said, *"it is possible that the many, though not individually good men, yet when they come together may be better, not individually but collectively, than those who are so, just as public dinners to which many contribute are better than those supplied at one man's cost"*.

The WISDOM of the CROWD!

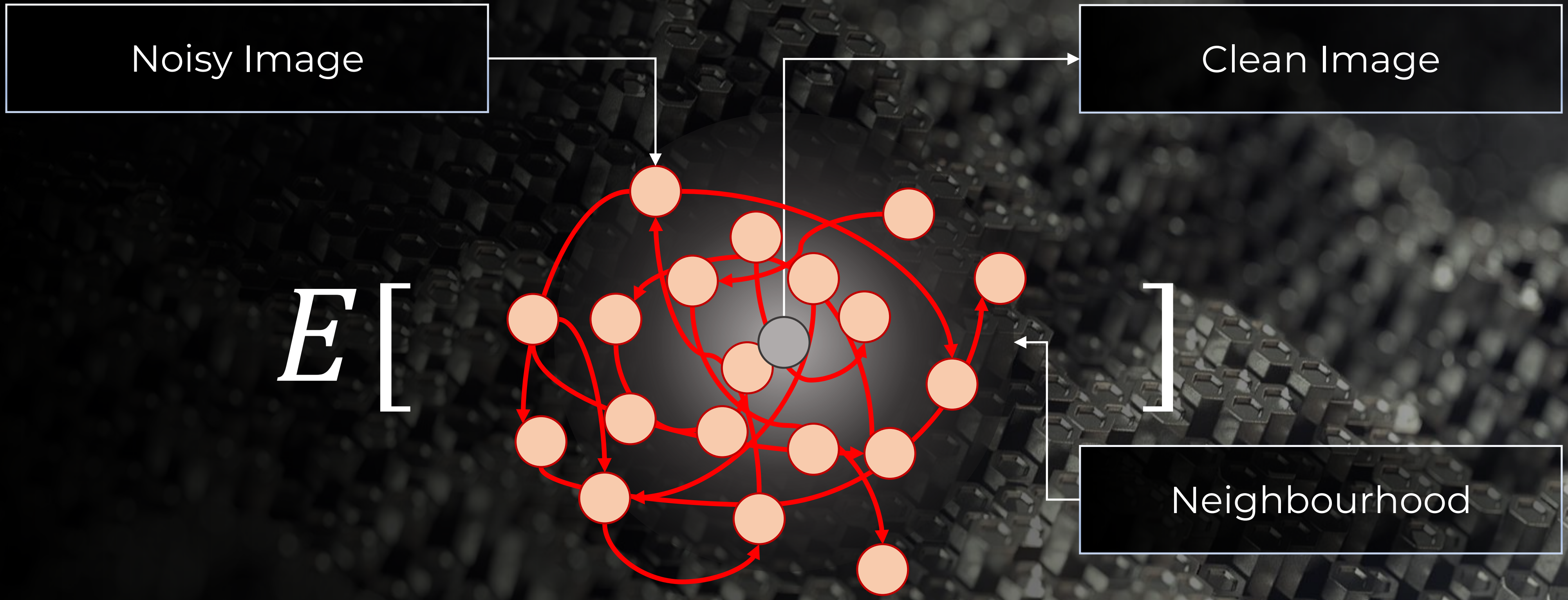
- In 1907, Sir Francis Galton asked 787 villagers to guess the weight of an ox.
- The person to guess correctly would win that ox.
- People’s guess were all over the place.
- But surprisingly, the mean was too close to the actual weight!



The UNIQUE boat

- Similarly, we can use the Nosie to estimate the true mean.
- That is, in expectation, the noise patterns would converge to the actual mean!
- And what if it's a ZERO MEAN NOISE?
- We calculate its expectation which to zero.
- Hence, we have eradicated the noise!

The UNIQUE boat: Noise2Noise



The UNIQUE boat: Noise2Noise

- We make the model predict noisy images which are drawn from the same model of input noisy image
- When we train it many instances, it converges to the ground truth pixel value.
- But, here, selection of Loss Function is crucial
- For example, if we want the noise to converge to mean, we choose L_2 Loss Function, but if we want to converge it to median, we choose L_1 Loss Function.

Noise2Noise

Noise2Noise

- UNET Architecture
  - 5 encoding blocks
  - 5 decoding blocks
- Loss function dependent on noise type.
- Dataset
  - BSD500

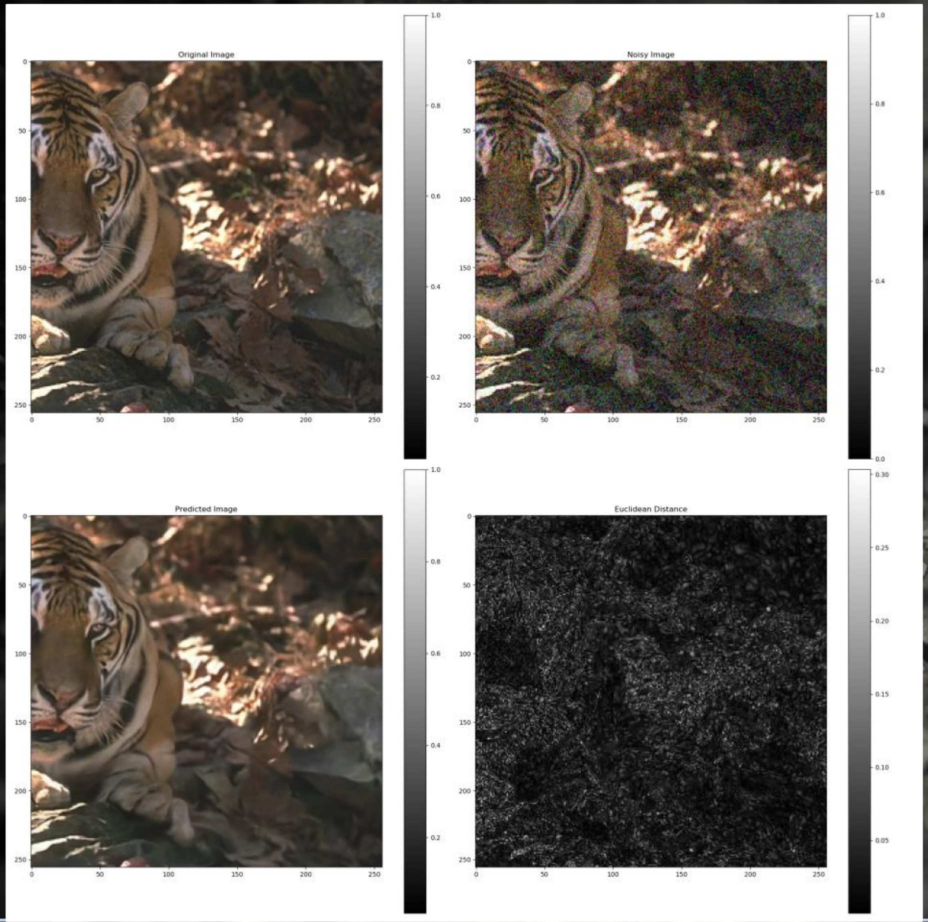
Results

Gaussian Noise

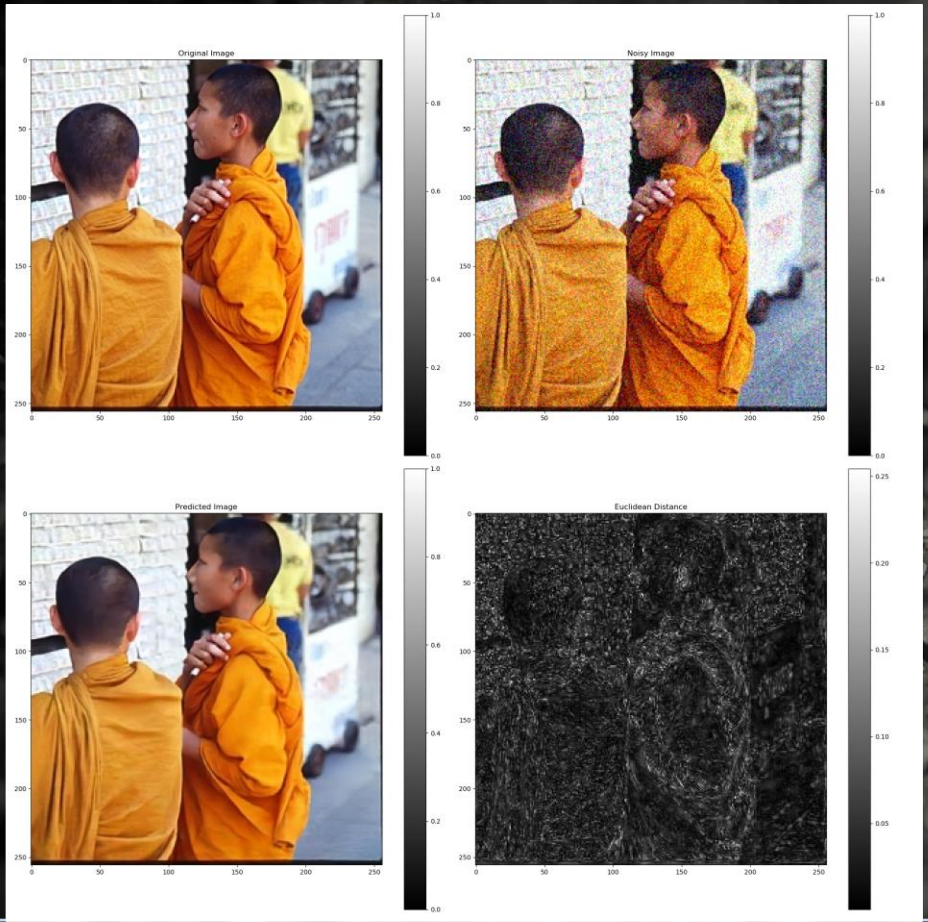
Gaussian Noise

- $\mu = 0$
- $\sigma = 0.1$
- Loss Function: L_2

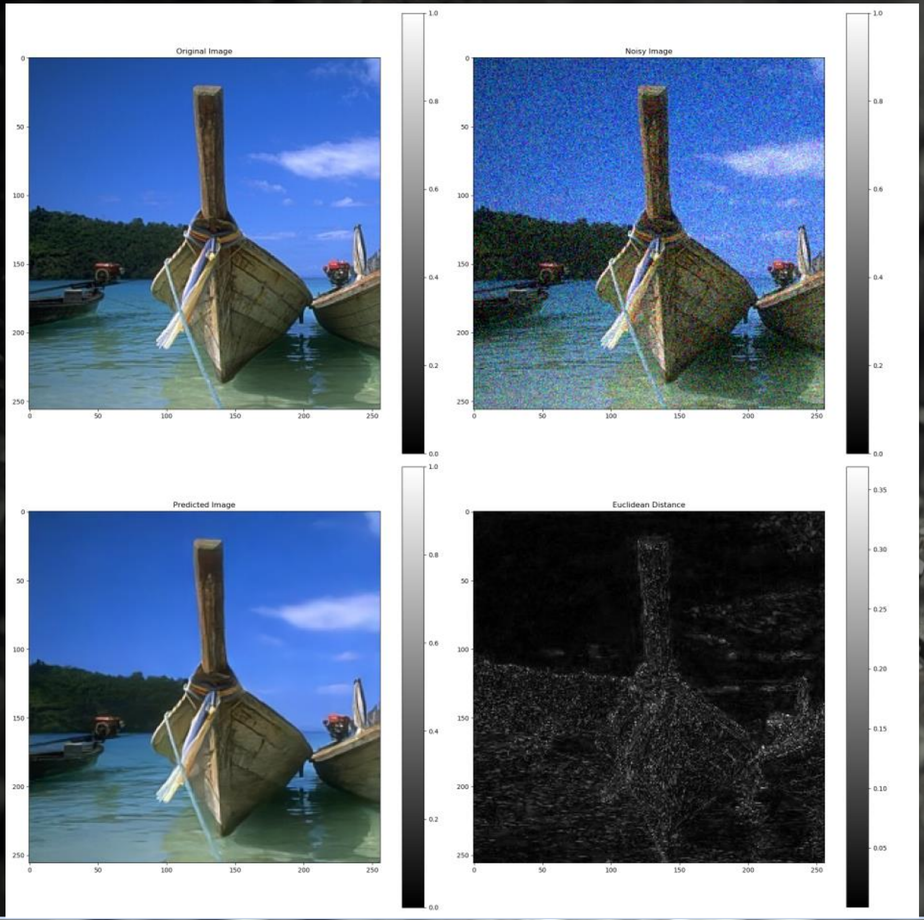
Gaussian Noise



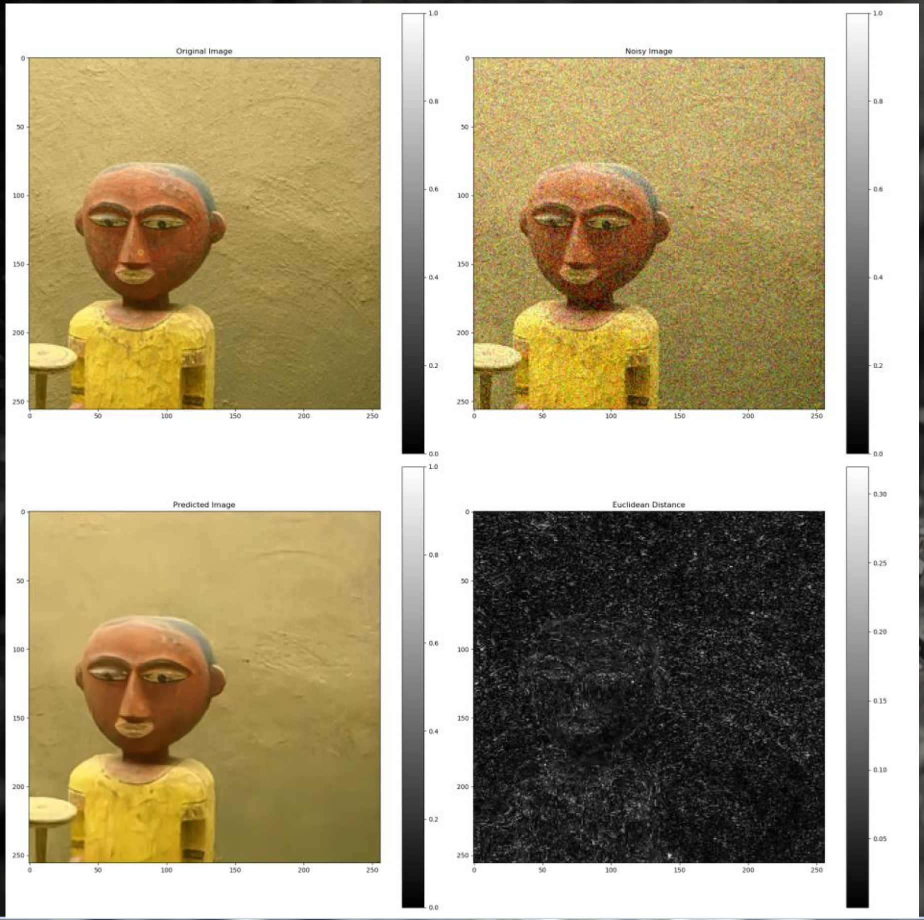
Gaussian Noise



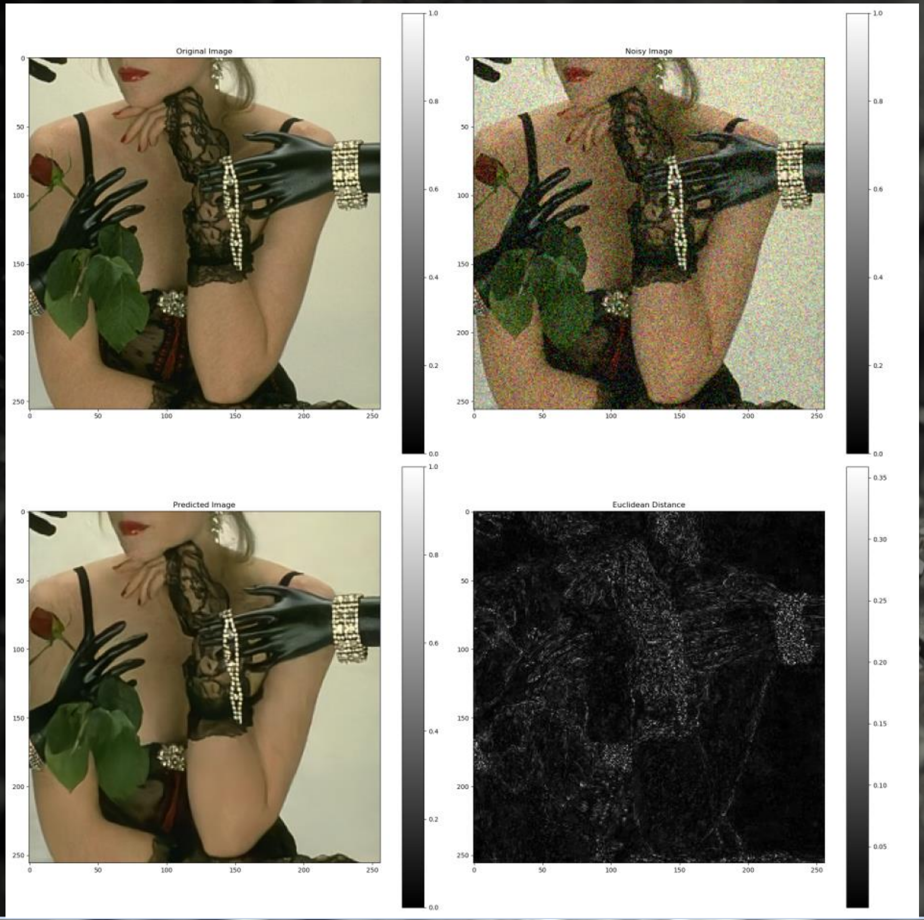
Gaussian Noise



Gaussian Noise



Gaussian Noise



Gaussian Noise

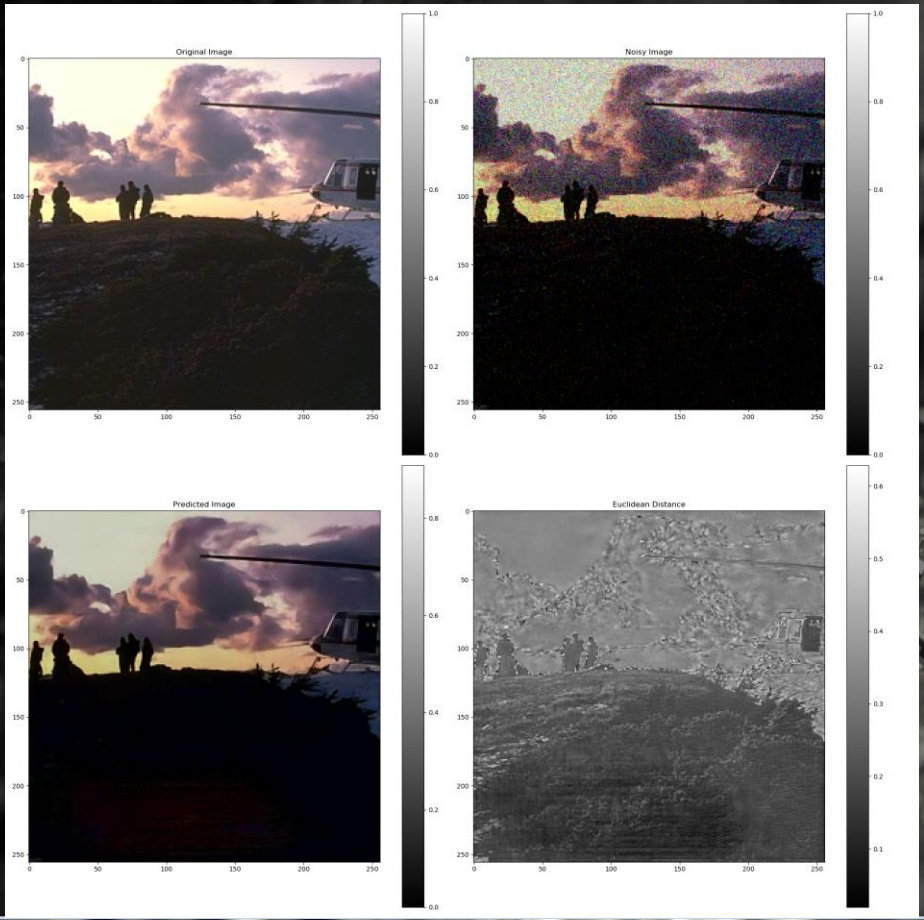
- Putting it to Test
  - $\mu = 0.2$
  - $\sigma = 0.1$
  - Loss Function: L_2
- Expectations?
  - A Brighter Image?

Gaussian Noise

Gaussian Noise

- Putting it to Test
  - $\mu = -0.2$
  - $\sigma = 0.1$
  - Loss Function: L_2
- Expectations?
  - A Darker Image?

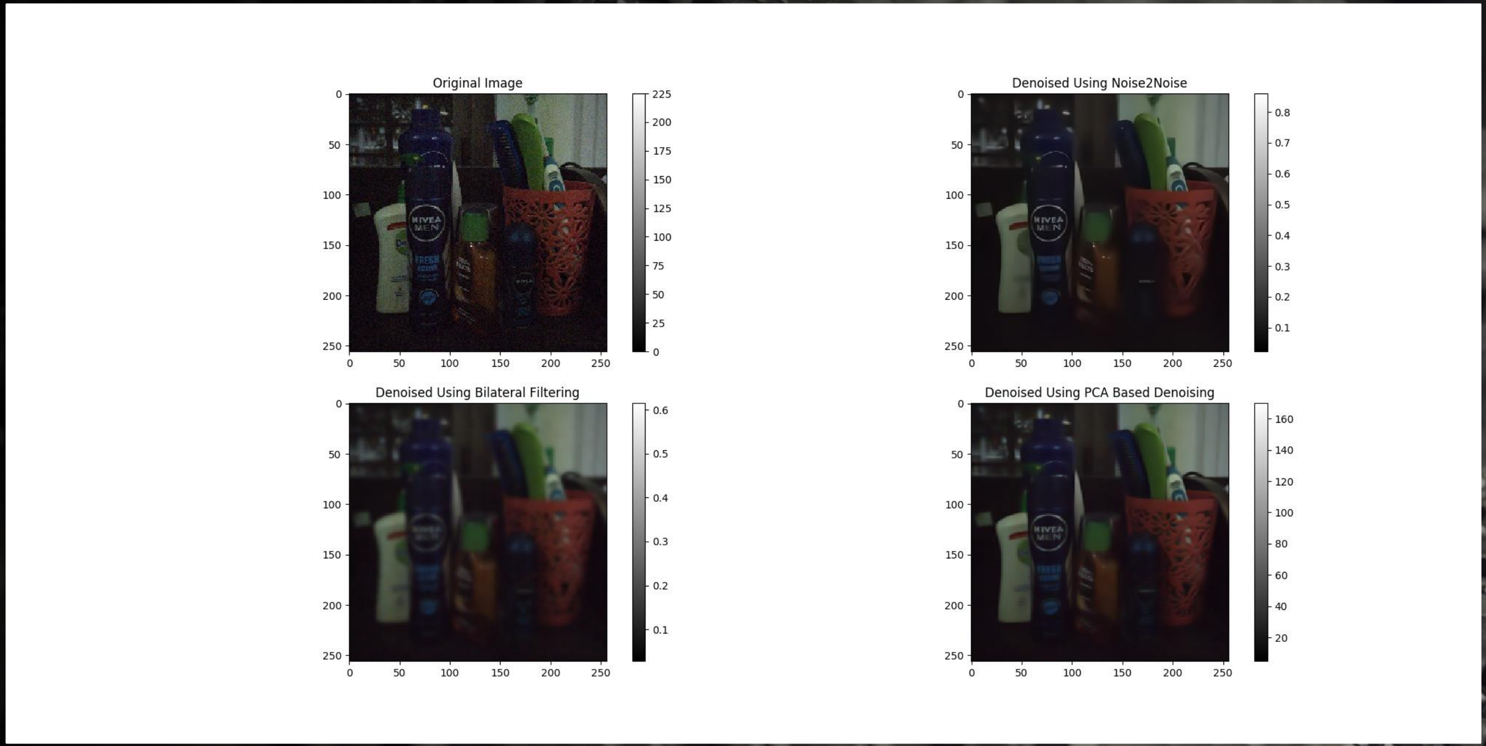
Gaussian Noise



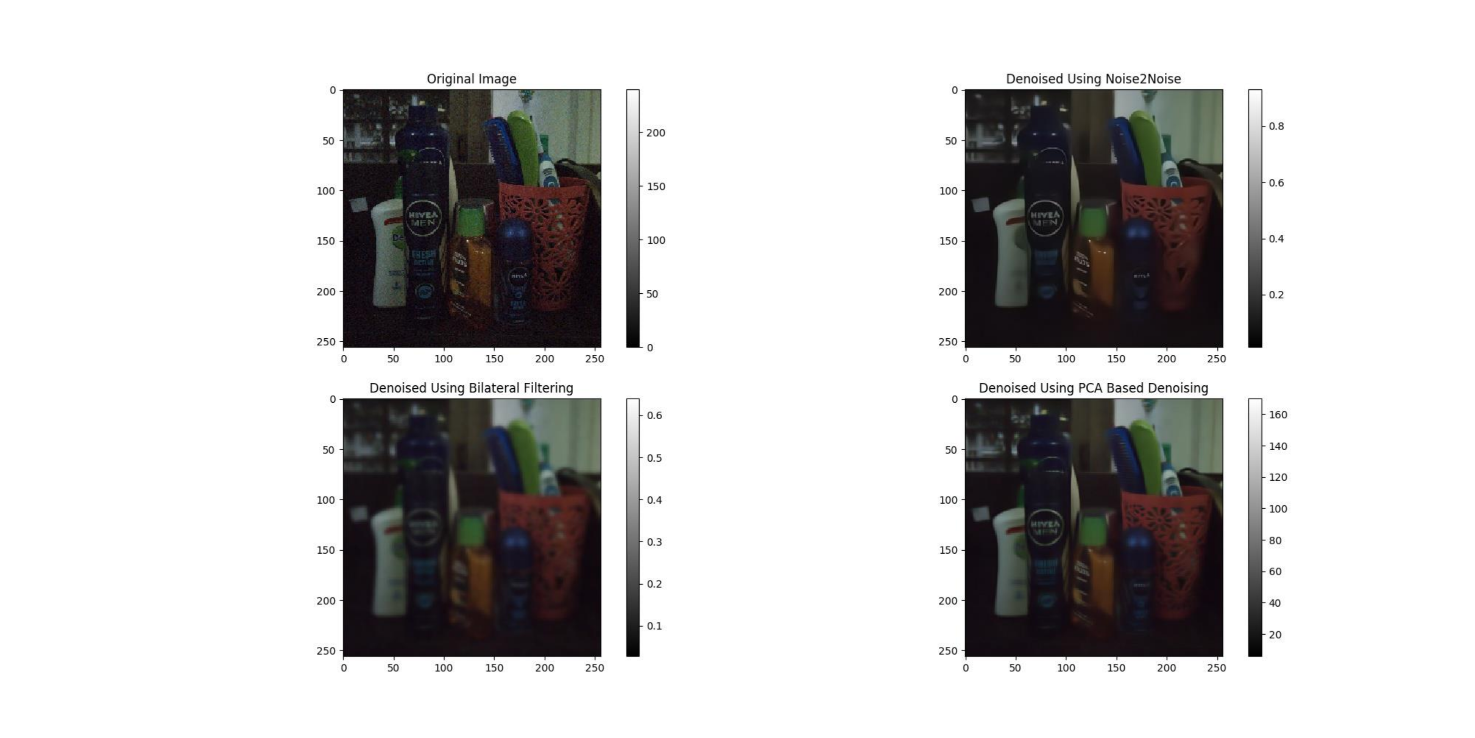
Gaussian Noise

- Real World Data
- Non-Simulated Noise, Non-Dataset images generated using camera itself while capturing pictures in low exposure
- Loss Function: L_2
- Also comparing the prevailing methods

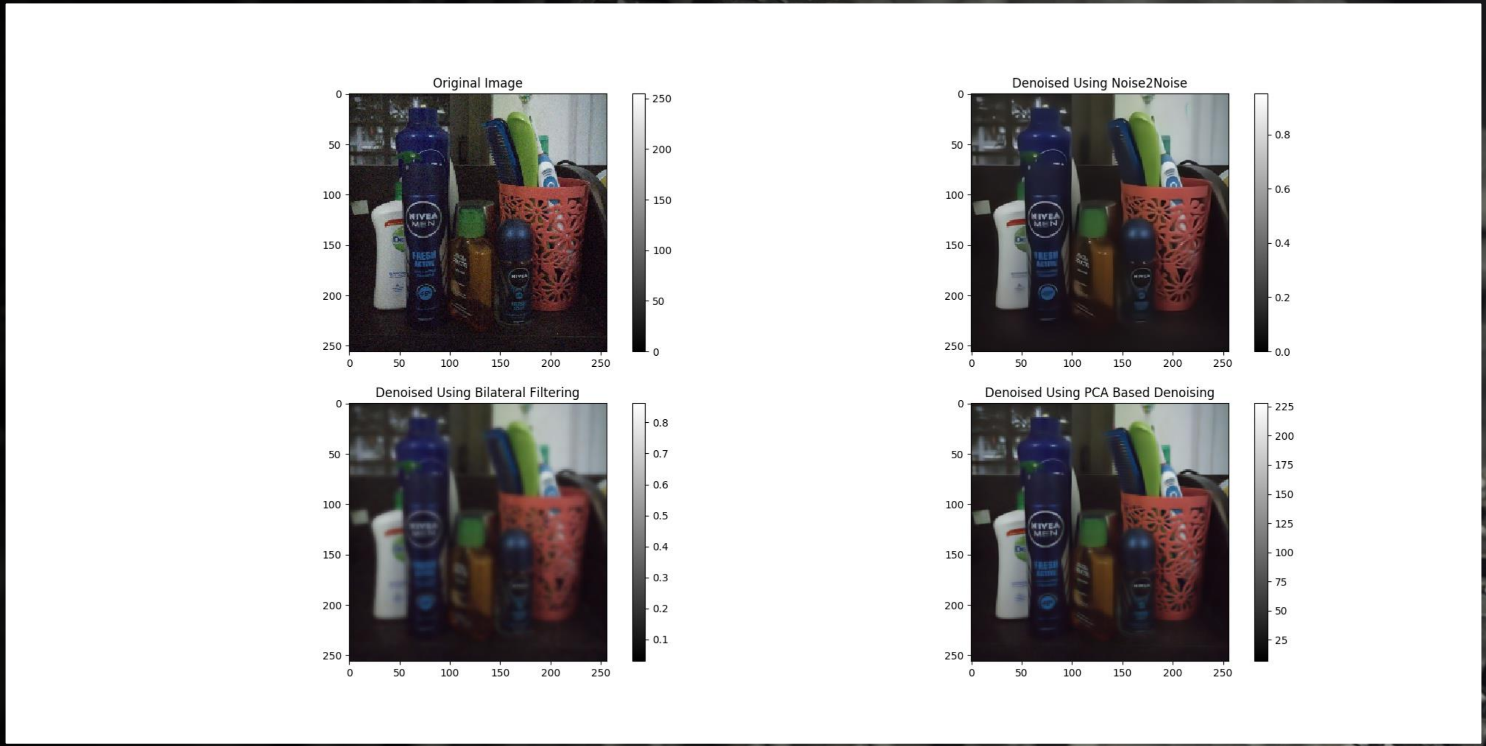
Gaussian Noise



Gaussian Noise



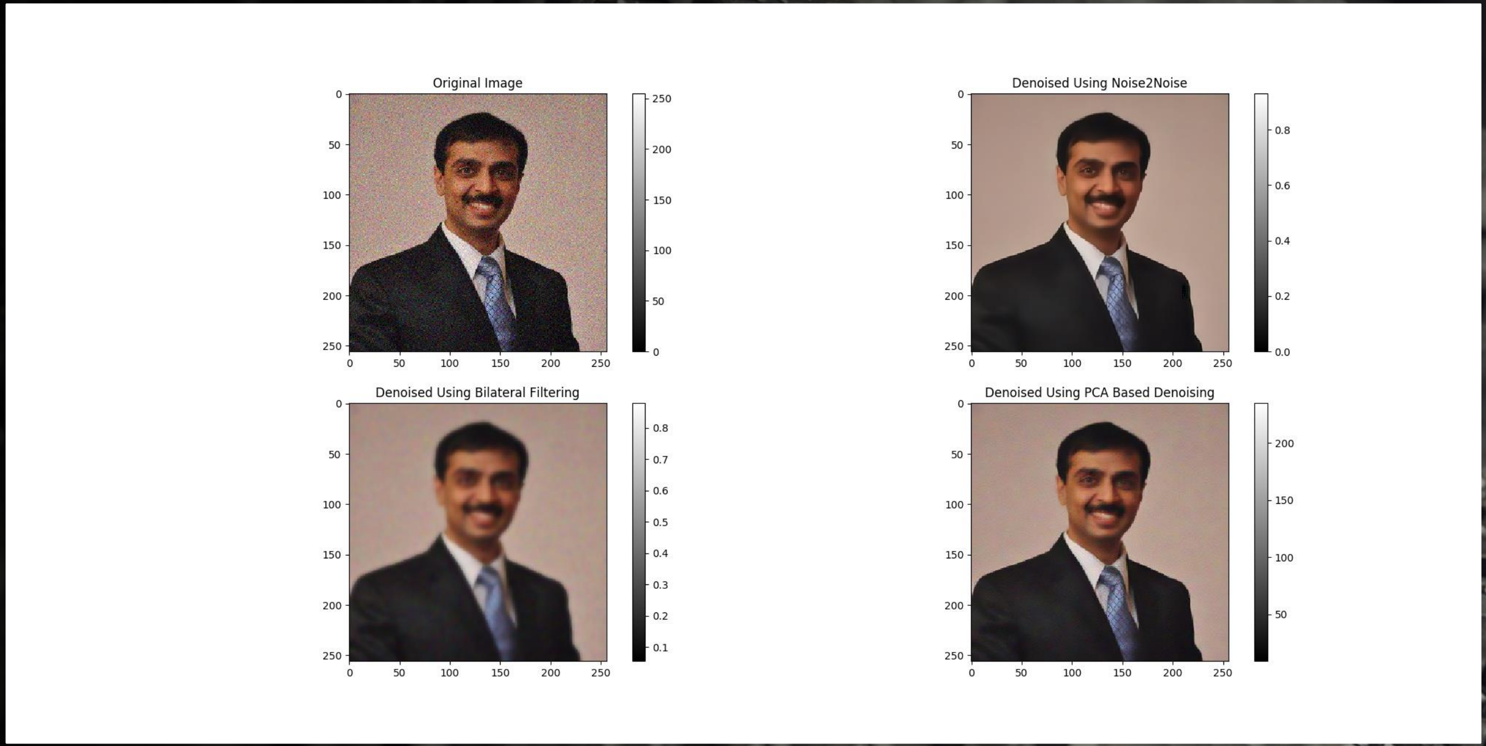
Gaussian Noise



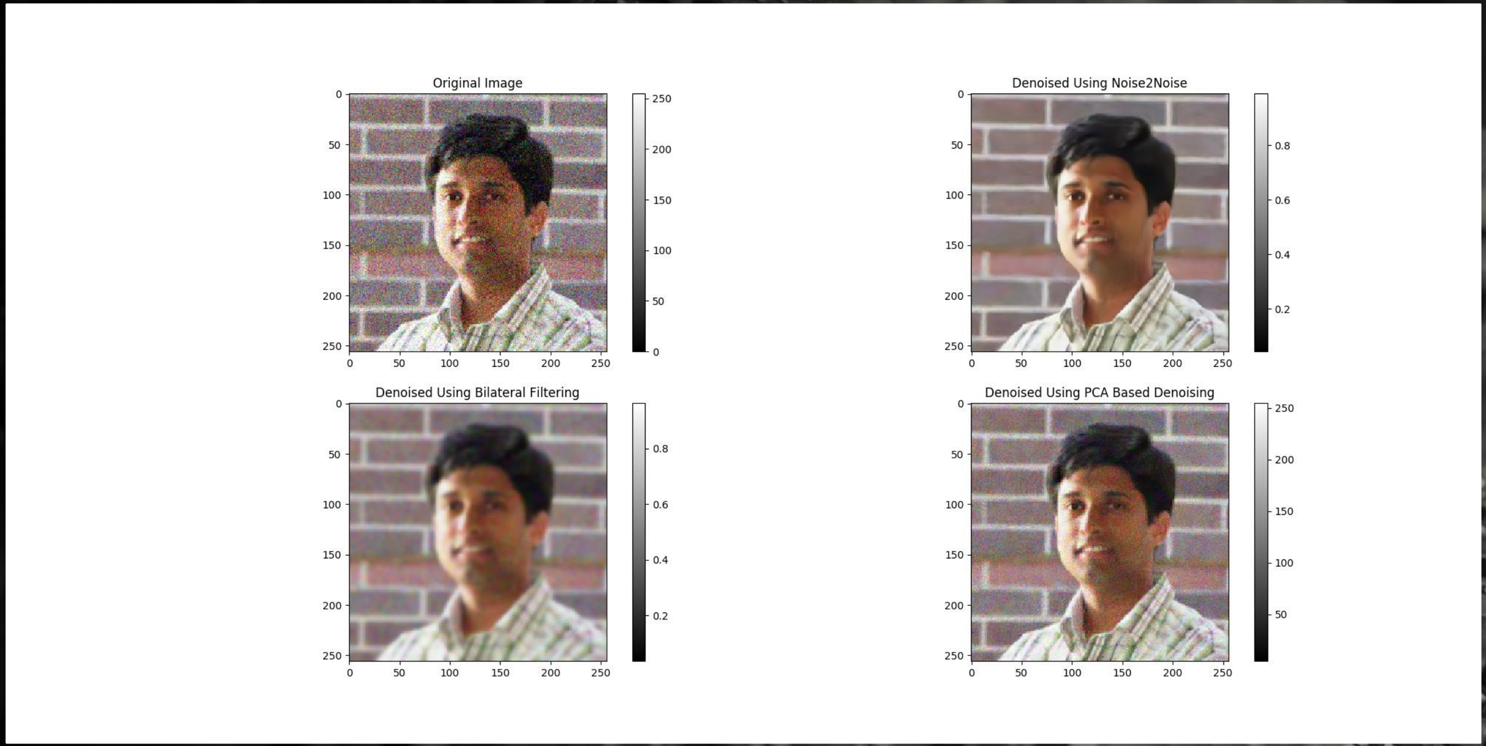
Gaussian Noise

- Real World Data
- Simulated Noise, Non-Dataset images generated using camera itself while capturing pictures in low exposure
- Loss Function: L_2
- Also comparing the prevailing methods

Gaussian Noise



Gaussian Noise

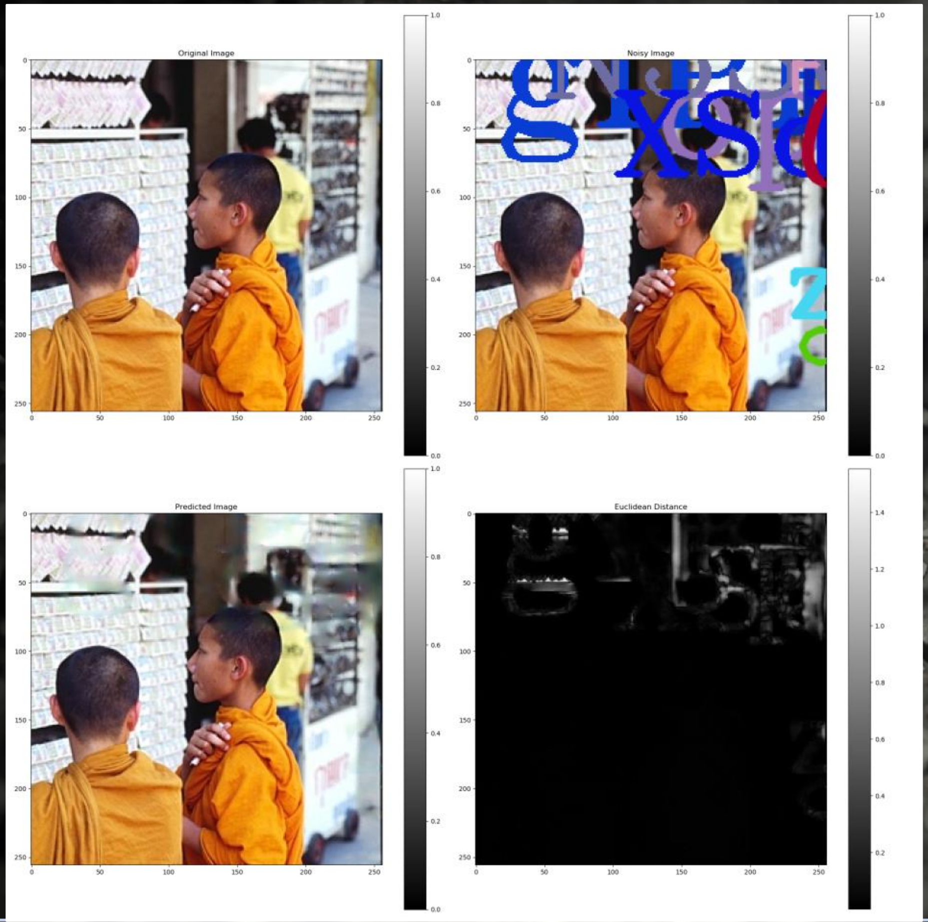



Text Overlay Noise

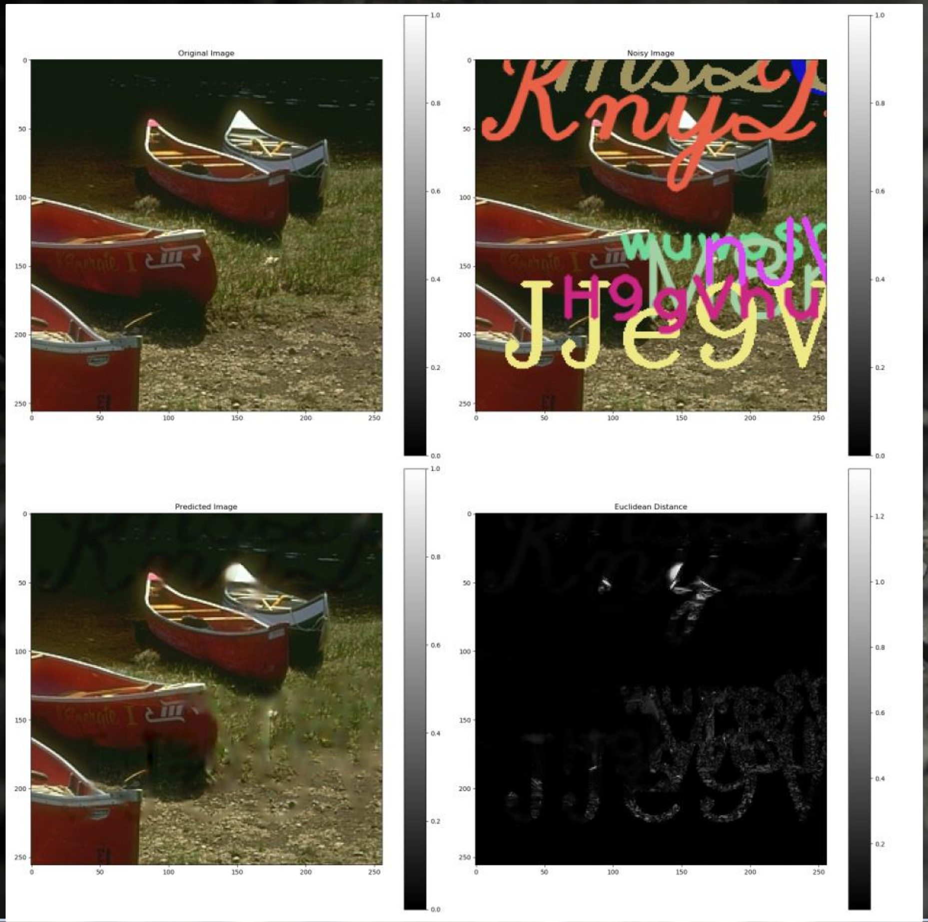
Text Overlay Noise

- Random texts
- Random number of strings
- Random colours
- Random fonts
- Loss Function: L_1

Text Overlay Noise

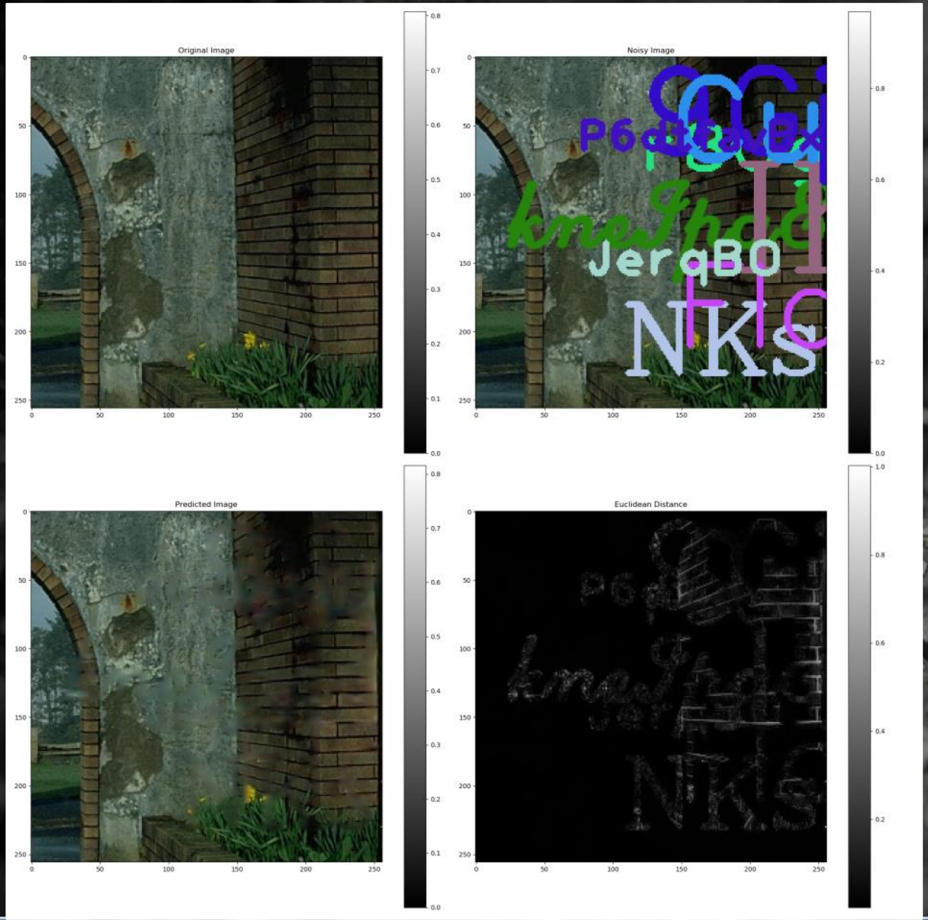


Text Overlay Noise



Text Overlay Noise

Text Overlay Noise



Text Overlay Noise

Putting it to TEST!

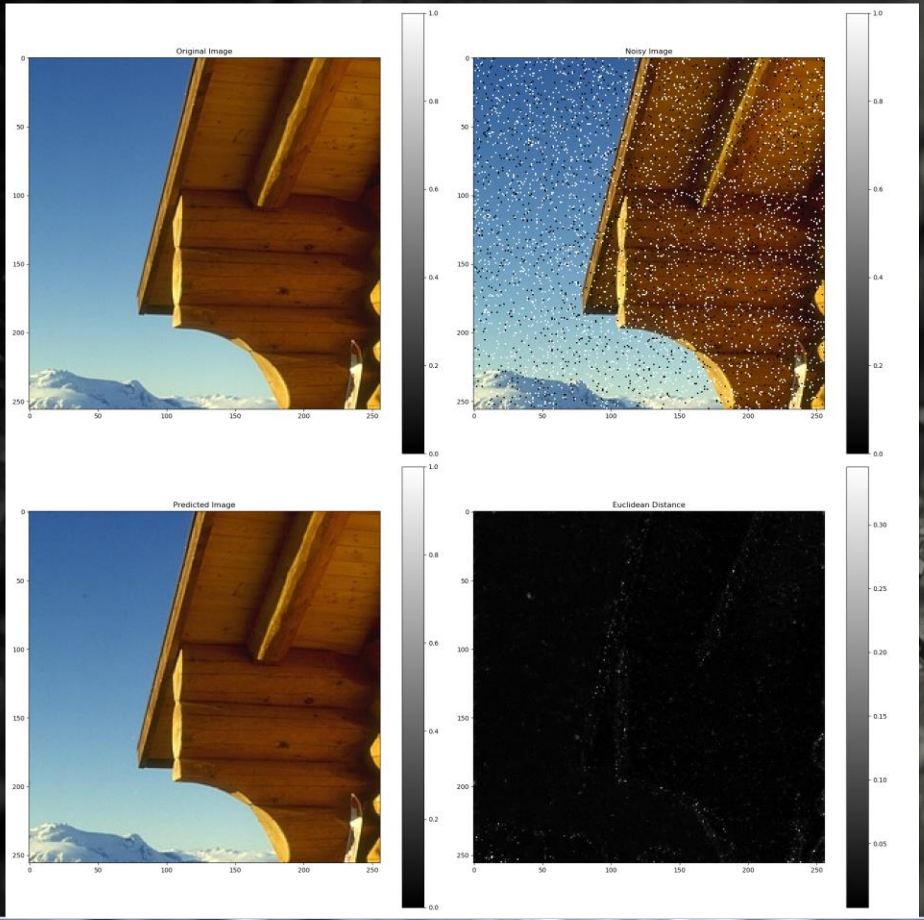
Salt and Pepper Noise

Salt and Pepper Noise

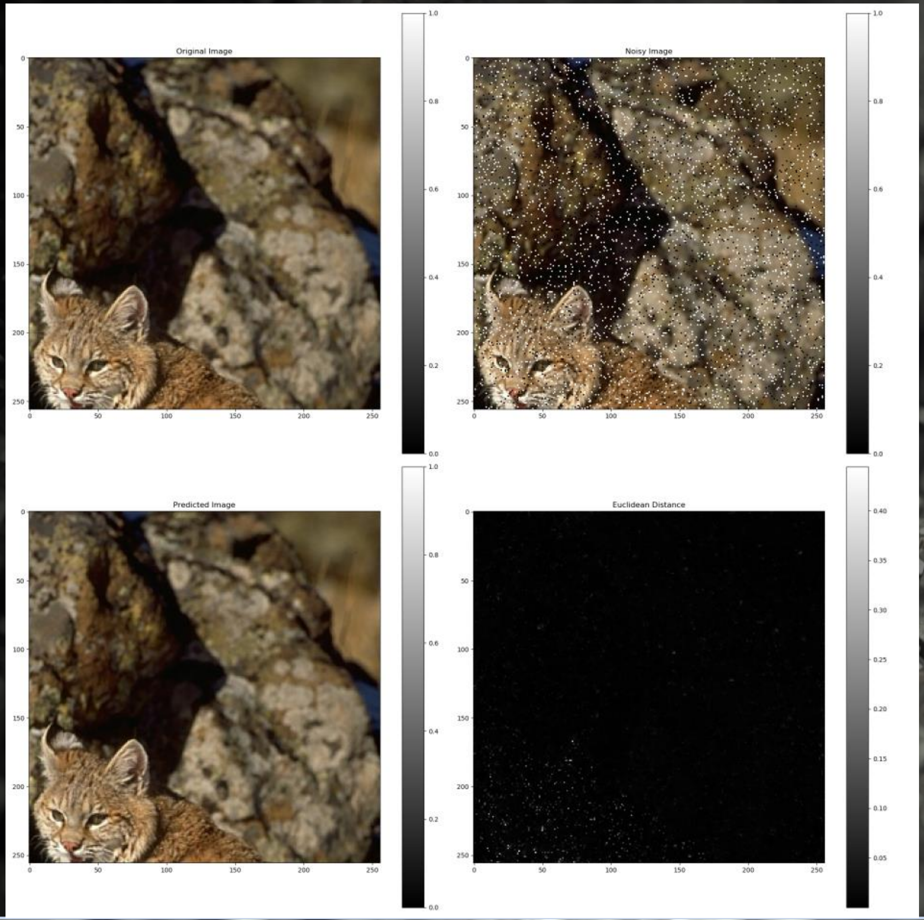
- $\Pr(Pixel\ =\ BLACK)\ =\ 0.05$
- $\Pr(Pixel\ =\ WHITE)\ =\ 0.05$
- $\Pr(Pixel\ =\ ORIGINAL)\ =\ 0.9$
- Loss Function: L_1

Salt and Pepper Noise

Salt and Pepper Noise



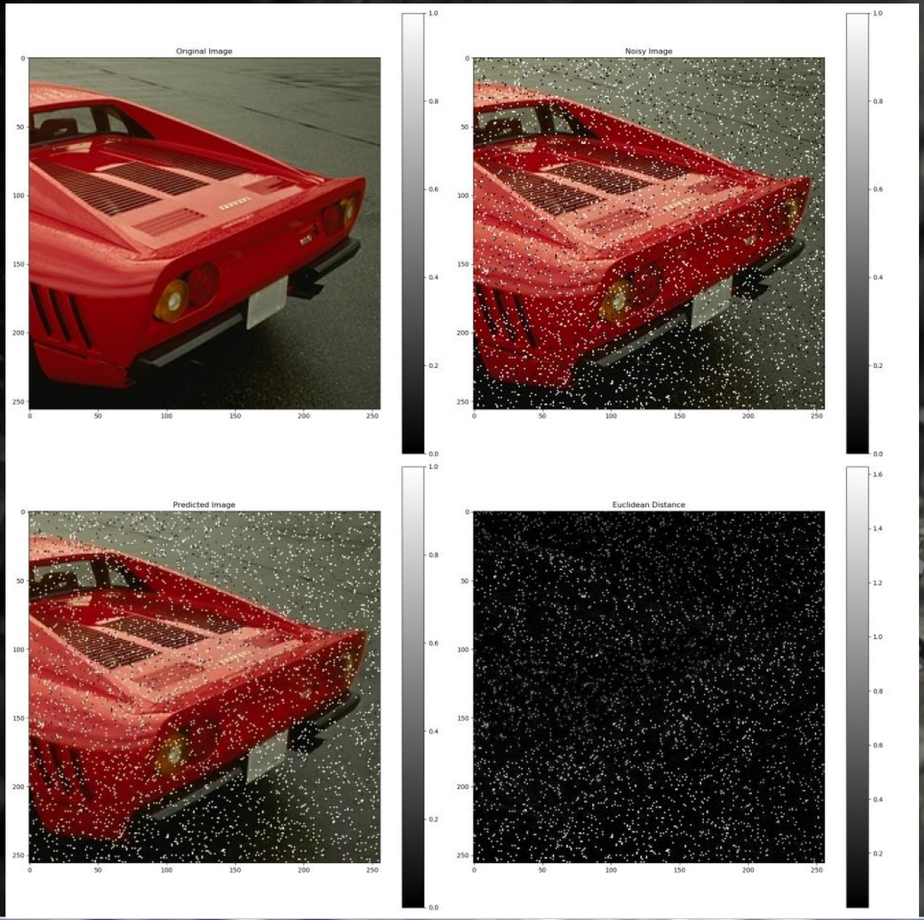
Salt and Pepper Noise



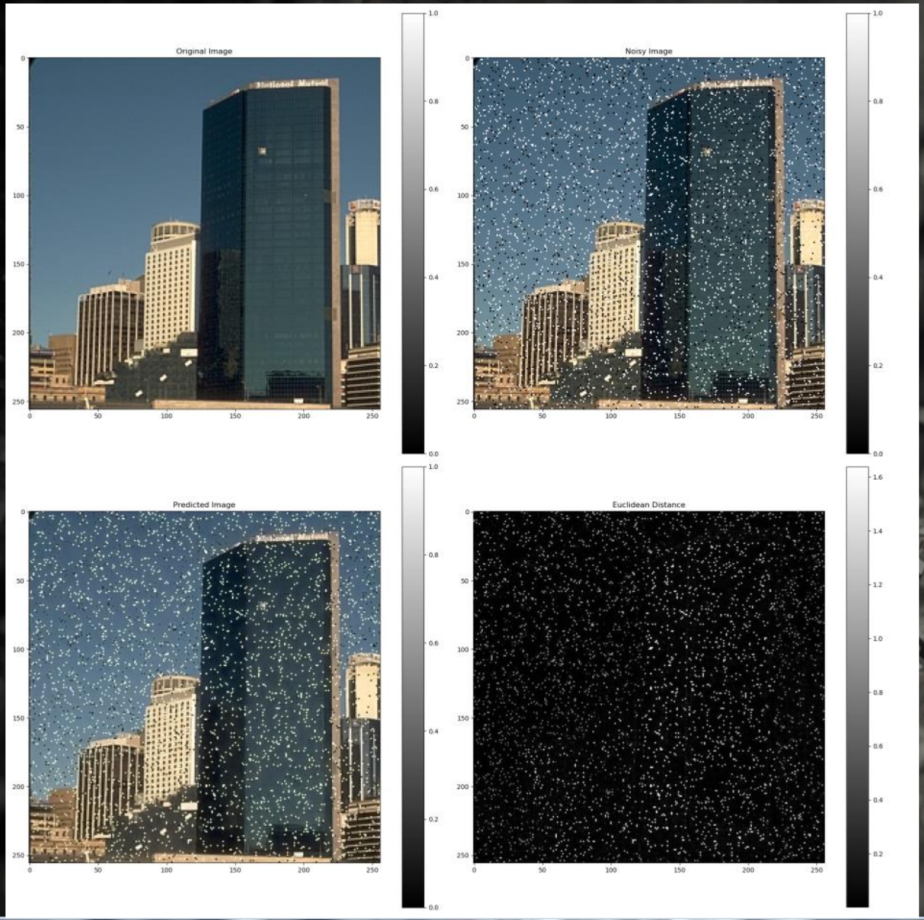
Salt and Pepper Noise

- Verifying that Salt and Pepper shouldn't converge using L_2 but only L_1.

Salt and Pepper Noise



Salt and Pepper Noise

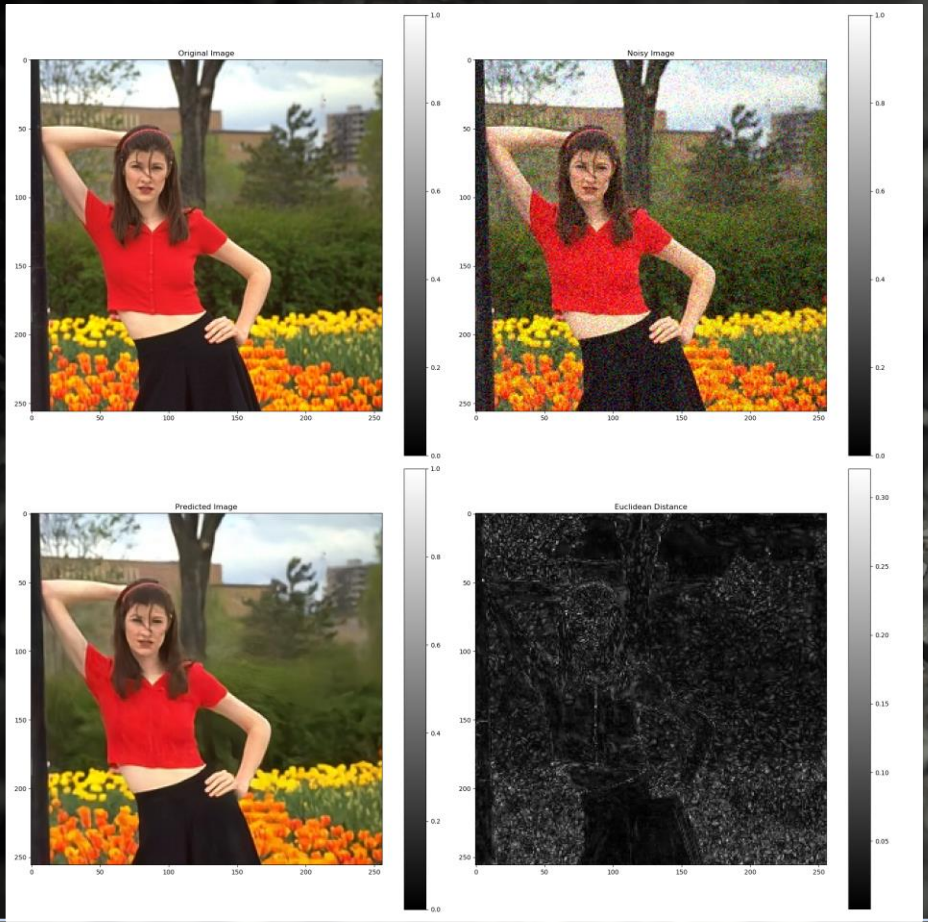


Is UNET Important?

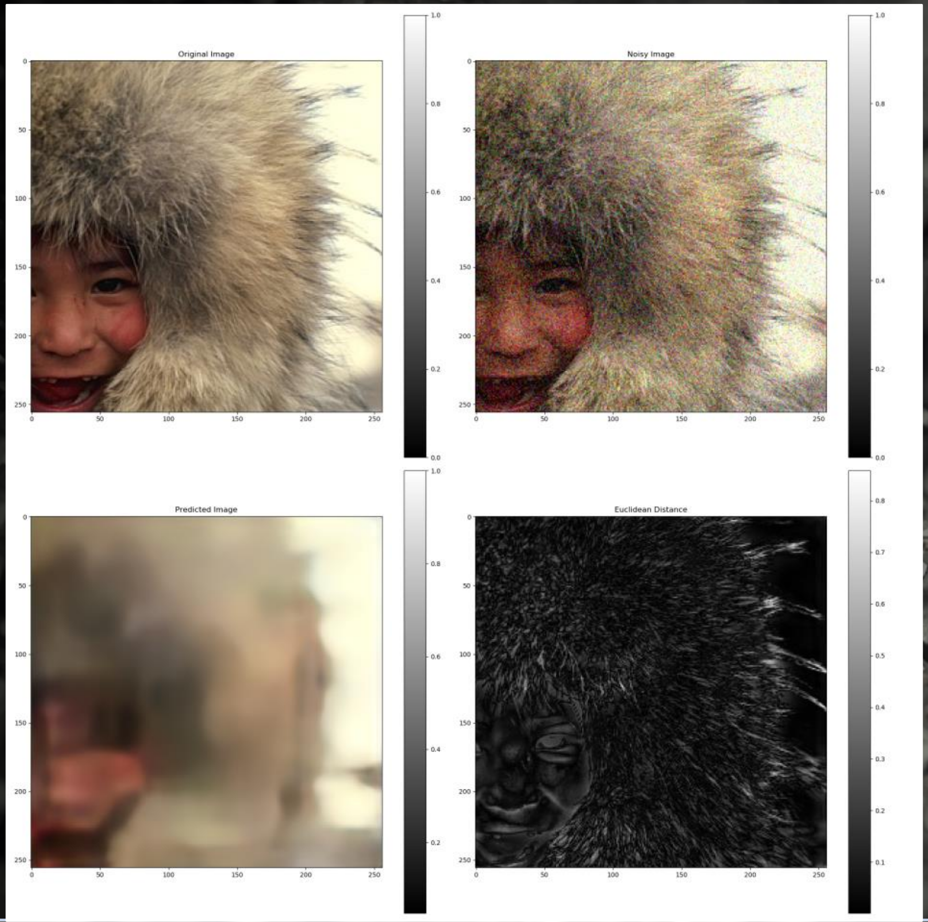
Is UNET Important?

Seems like, from the experiments we ran

UNET Performance after 1 epoch



ED Performance after 1 epoch



Thank You