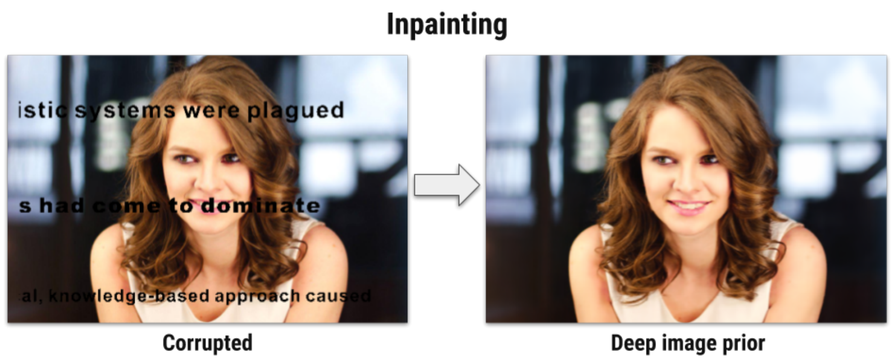
Deep Image Prior Analysed - Finding natural images on the path from noise to corrupted?

T. de Boer [1], T.C. Bos[1], M. Taal[1], [1]TU Delft;
https://github.com/thymerishere/deep-image-prior-reproduced



Left: before, middle: with mask, right: after applying inpainting.

Why Deep Image Prior?

- Can restore corrupted images starting from noise learning towards the corrupted image, finding the natural image along the way.
- Remarkable results, can restore image from only 2% of the original pixels, can paint in large missing areas in a natural way

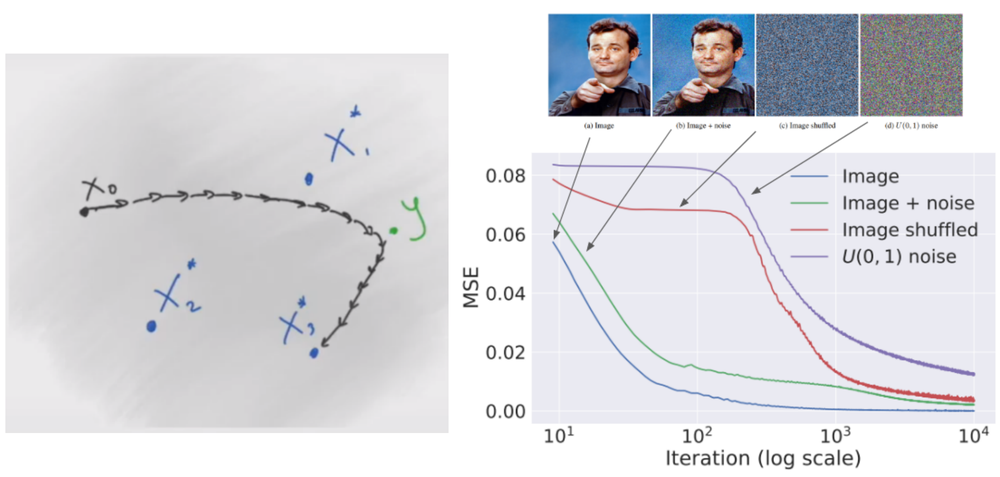
Testing the claims - our work

- **Inpainting**: Test Deep Image Prior with new images and different corruption strategies, how robust is the architecture?
- **Super-Resolution**: Experiment with different hyperparameters and new input images, can super-resolution be improved and applied to different images?
- **Restoration**: Analyze the Deep Image Prior solution path, does it work as claimed under the hood?

How does it work?

- Convolutional U Network (down and up layers) with skip connections, uses ADAM for optimization
- Train with noise, target is corrupted image, finds natural image as intermediate result

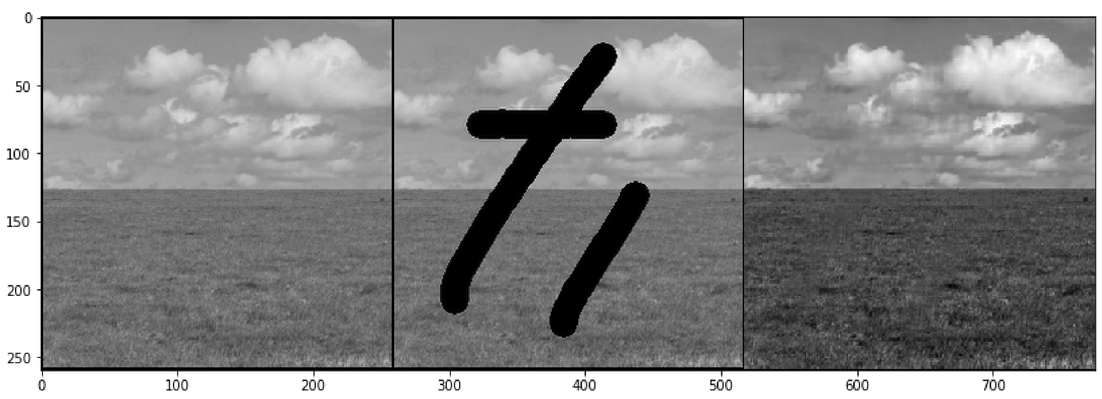
Why does it work?



- On the path towards the noisy image (X_3)the neural network passes the natural looking image (Y).
- The neural network has the tendency to resist fitting to noise, it fits easier to structures to natural images. See Bill Murray example, the MSE goes down much quicker with natural images than with more heavily corrupted images.

Inpainting

- Fills in missing pixels determined by a black mask.
- Optimises over the pixels of the image it knows.
- Result is very sensitive to hyperparameter changes.



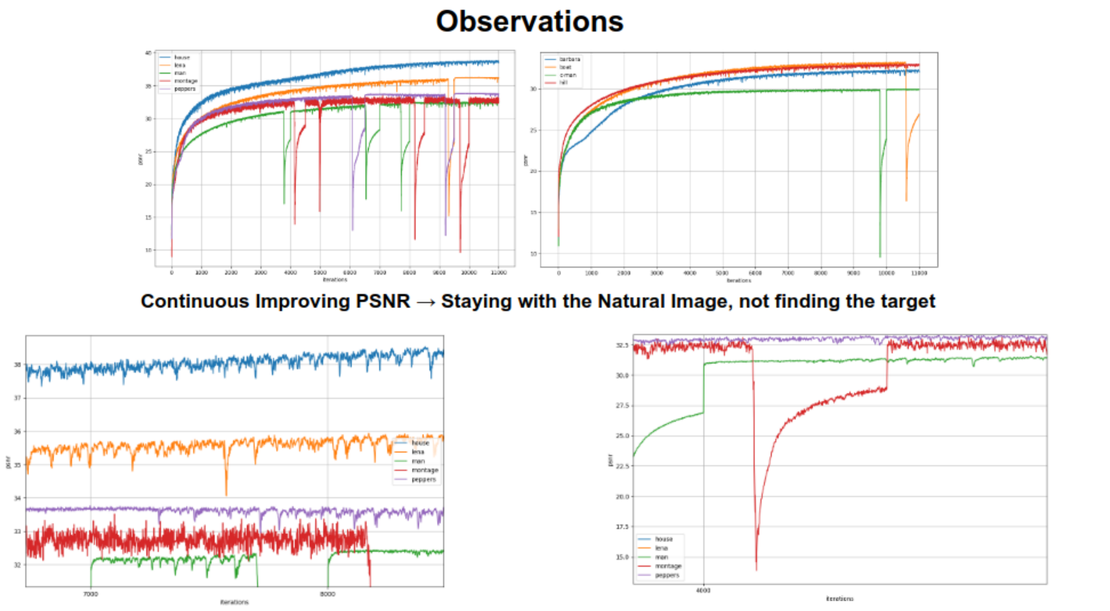
Super-resolution

- Upsampling a low resolution image to a higher resolution image.
- Tests on downsampling the generated image and comparing it to the low resolution image.

Left: low resolution input image. Center: generated high resolution image. Right: original high resolution image.

Restoration

- Fills in 50% missing pixels determined by a black mask.
- Optimises over the pixels of the image it knows.
- Tested on 11 images from Set14 dataset.
- Compare Peak-Signal-to-Noise-Ratio (PSNR) from NN output to natural image



Article claims holding up or not?

- **Yes**: a clear tendency to stick to the natural image structure
- **Maybe Yes**: characteristic to stick to natural images seems much stronger than described by the authors.
- **Maybe Not**: variations in PSNR make it difficult to reproduce claim by authors in table 1 from [3], that Deep Image Prior is better than other solutions.
- **Maybe Should**: interesting to know why the PSNR sudden drops happen, should possibly have been more explicitly mentioned/analysed by the authors.

References

[1] Victor Lempitsky Dmitry Ulyanov, Andrea Vevaldi. Deep image prior. `https://github.com/DmitryUlyanov/deep-image-prior`.

[2] Dmitry Ulyanov. Deep image prior presentation. `https://www.youtube.com/watch?v=-g1NsTuP1_I&feature=youtu.be`.

[3] Dmitry Ulyanov, Andrea Vedaldi, and Victor Lempitsky. Deep image prior, 2017.