

Deep Learning in Zero-shot Blind Image Deconvolution

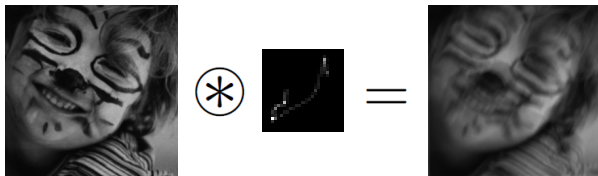
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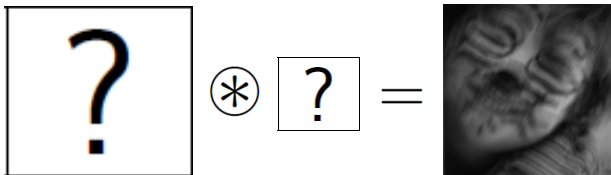
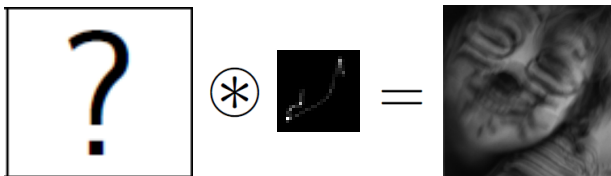
Blurred image model

Blurred image is convolution of sharp image and point spread function (PSF) (assuming space-invariant PSF)

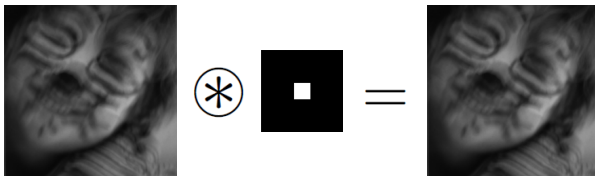
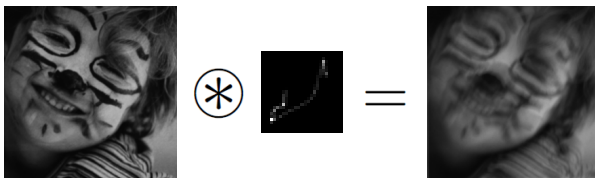
$$D = X \circledast K + n$$



Blind image deconvolution



Blind image deconvolution is highly ill-posed...

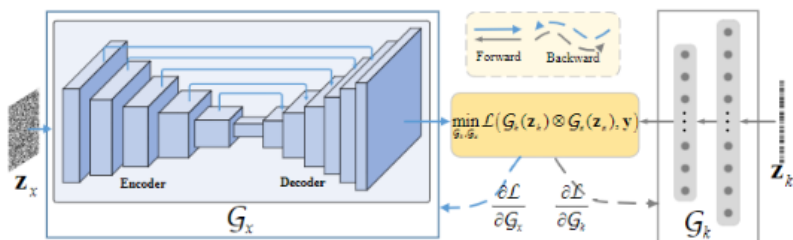


Priors

Methods that use prior

- MAP approach
- Variational Bayes
- Deep image prior (Ulyanov D., Vedaldi A., Lempitsky V., 2018) - SelfDeblur (Ren et al. 2020)

SelfDeblur



Initialization

- SelfDeblur is initialized randomly - not 100% reliable
- Traditional methods can be initialized from no-blur solution
- Would it be possible to stabilize SelfDeblur using no-blur solution?

Mode-connectivity

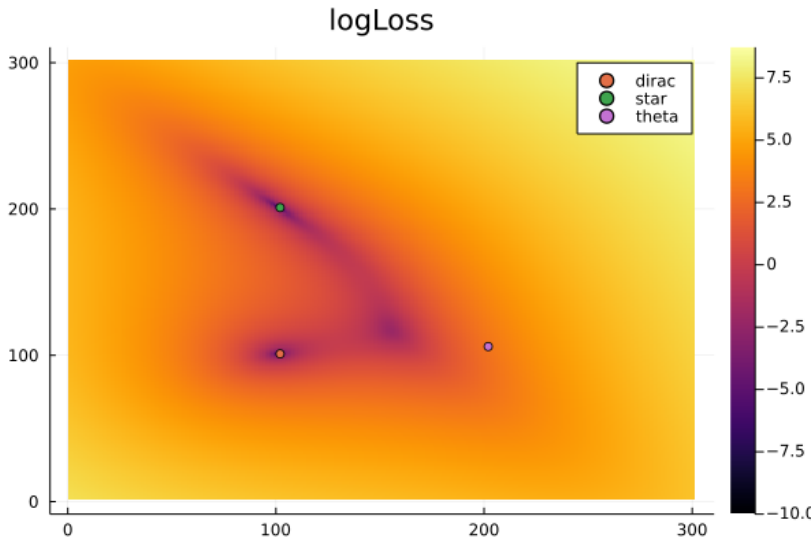
- Find a path with minimal loss between two modes (Garipov et al., 2018)
- For example as a quadratic bezier curve between w_1 and w_2

$$\phi_{\theta}(t) = (1 - t)^2 w_1 + t(1 - t)\theta + t^2 w_2$$

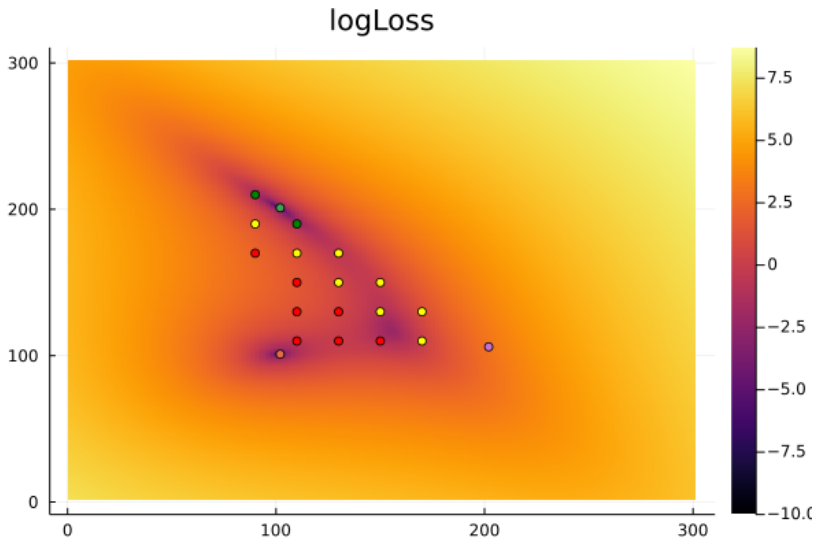
(θ needs to be found)

- Is there such a path between no-blur solution and ground-truth?
- How does the landscape look like for simple convolution?

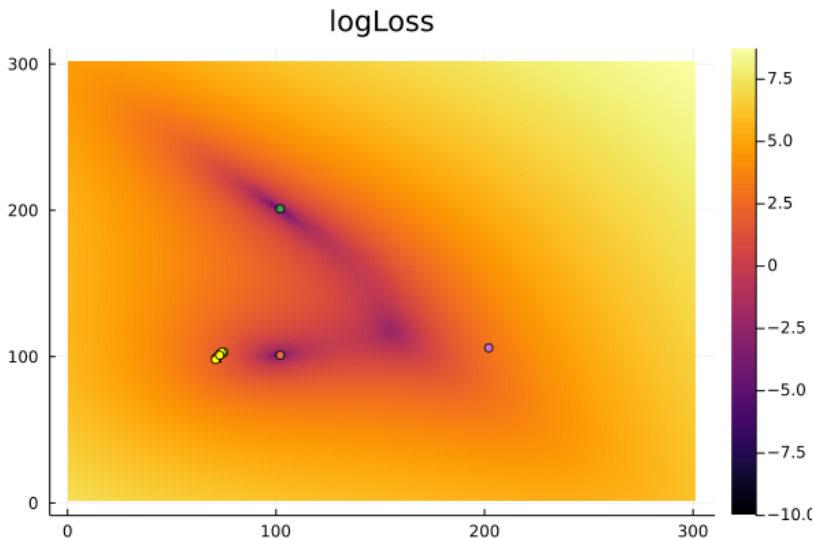
Mode-connectivity landscape



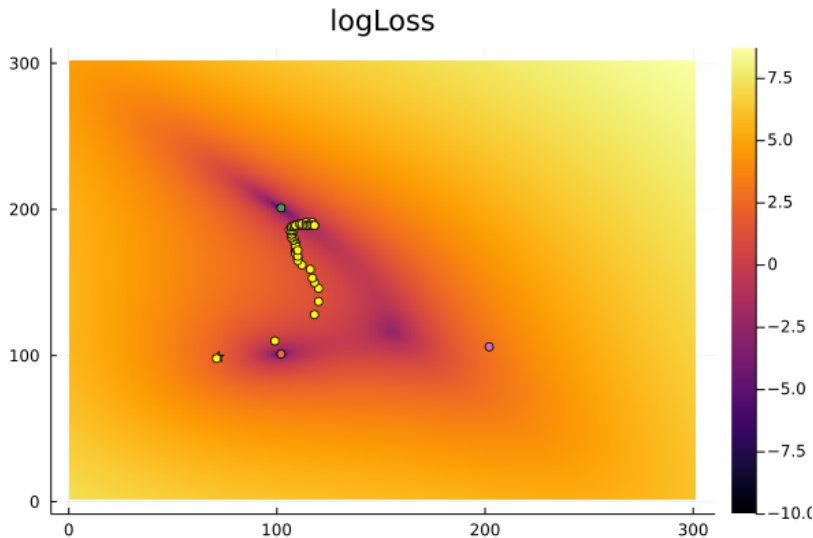
How does SelfDeblur behave in the landscape?



How about SelfDeblur initialization?



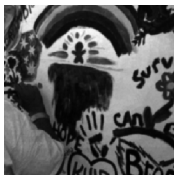
How about SelfDeblur initialization?



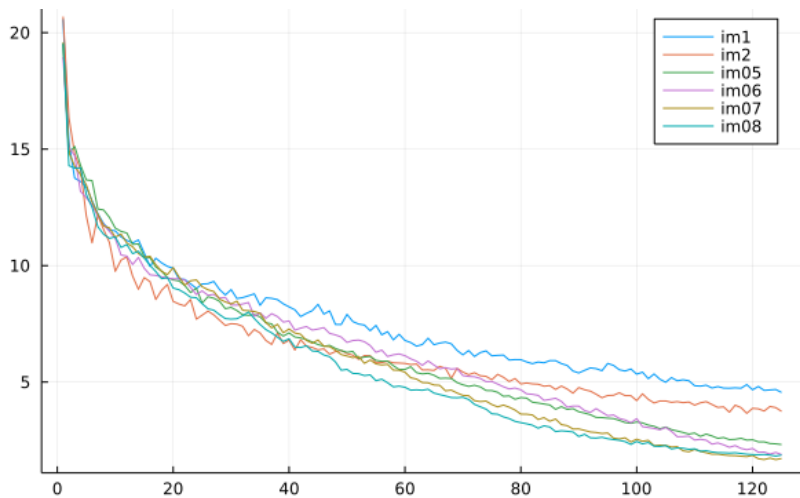
Questions to answer

- Why is the SelfDeblur initialization so special?
- Would it be possible to find the best initialization for each blurred image?
- Is the initialization the only reason of its succes?

Succes of deconvolution depends on image...



Power spectral density



Spectral bias

- Shi et al. (2022) - On Measuring and Controlling the Spectral Bias of the Deep Image Prior
- Low frequency information is learned faster in convolutional networks
- Low frequency information creates most of the image
- If stopped at the right moment, higher frequency artifacts are not learned yet → better solution
- Upsampling method plays part in frequency bias as well

Even more questions to answer

- Does unet have some inner regularization which leads to images with certain power spectra?
- How do these findings apply to SelfDeblur?
- Does it hold in general that SelfDeblur struggles to learn images with more higher frequency information?
- If it does, would it be possible to tune it to learn such images?