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A Mean-Field Variational Inference Approach to Deep Image Prior for Inverse Problems in Medical Imaging

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Mean-Field Variational Inference Deep Image Prior

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Problem Formulation

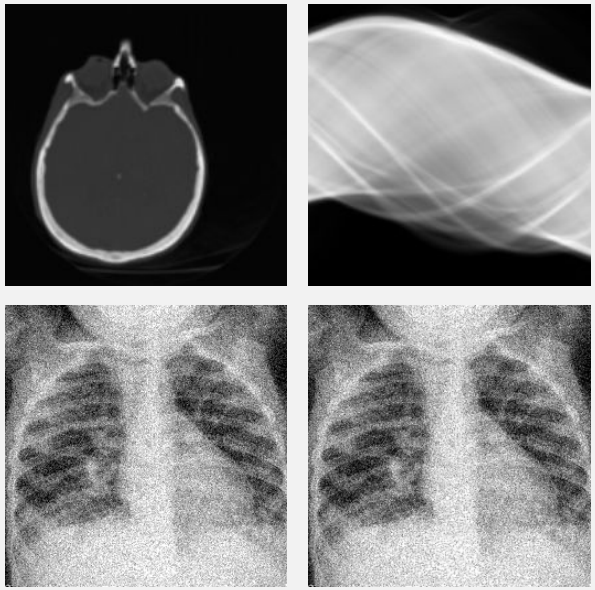


Figure: Inverse problems.

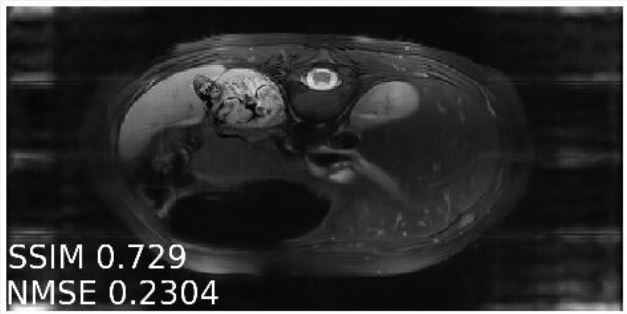


Figure: Hallucination.

Contribution

- Novel Bayesian approach for solving inverse tasks
- Based on deep image prior
- Optimized prior with Bayesian optimization

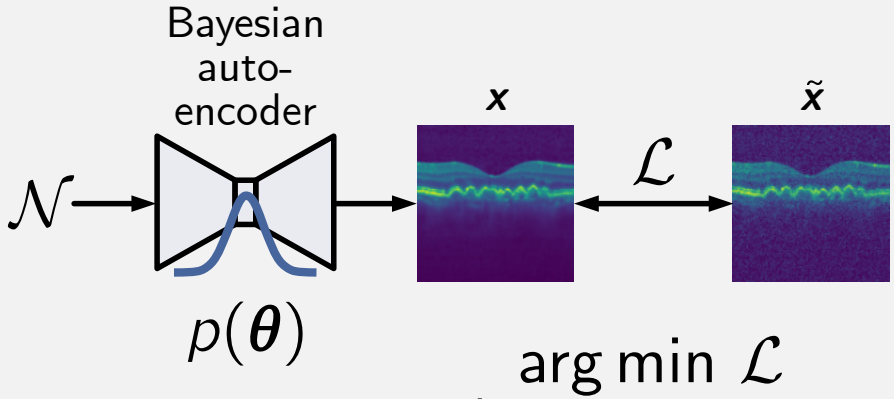


Figure: Bayesian deep image prior.

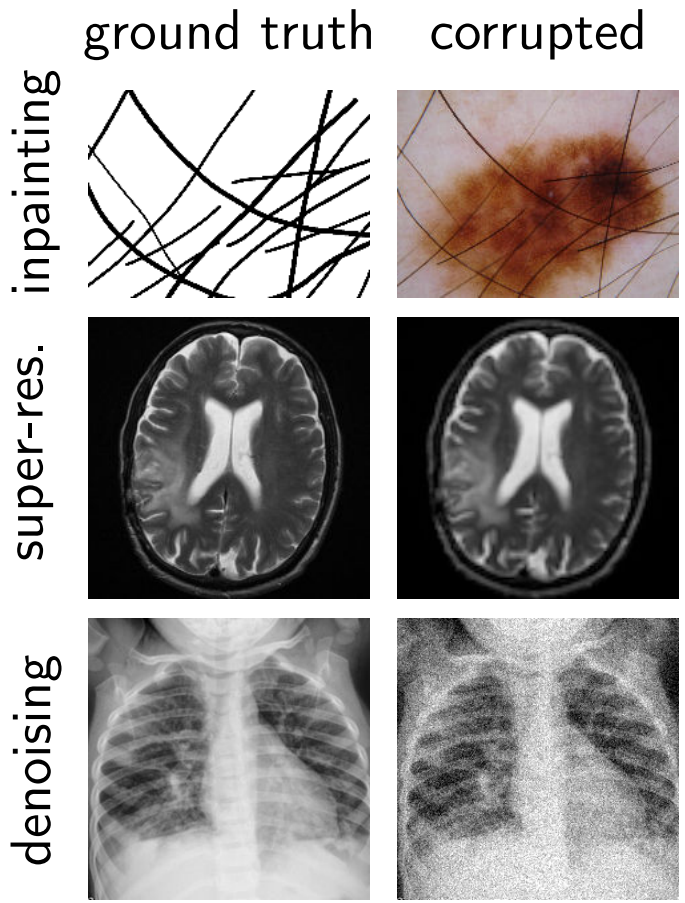
Methods & Experiments

Bayesian Deep Learning

- Posterior $p(\boldsymbol{\theta}|\mathcal{D})$ intractable
- Approximate posterior with $q(\boldsymbol{\theta})$ (Variational Inference)
- Aleatoric and epistemic uncertainty Var[$\boldsymbol{y}$]

Bayesian Optimization

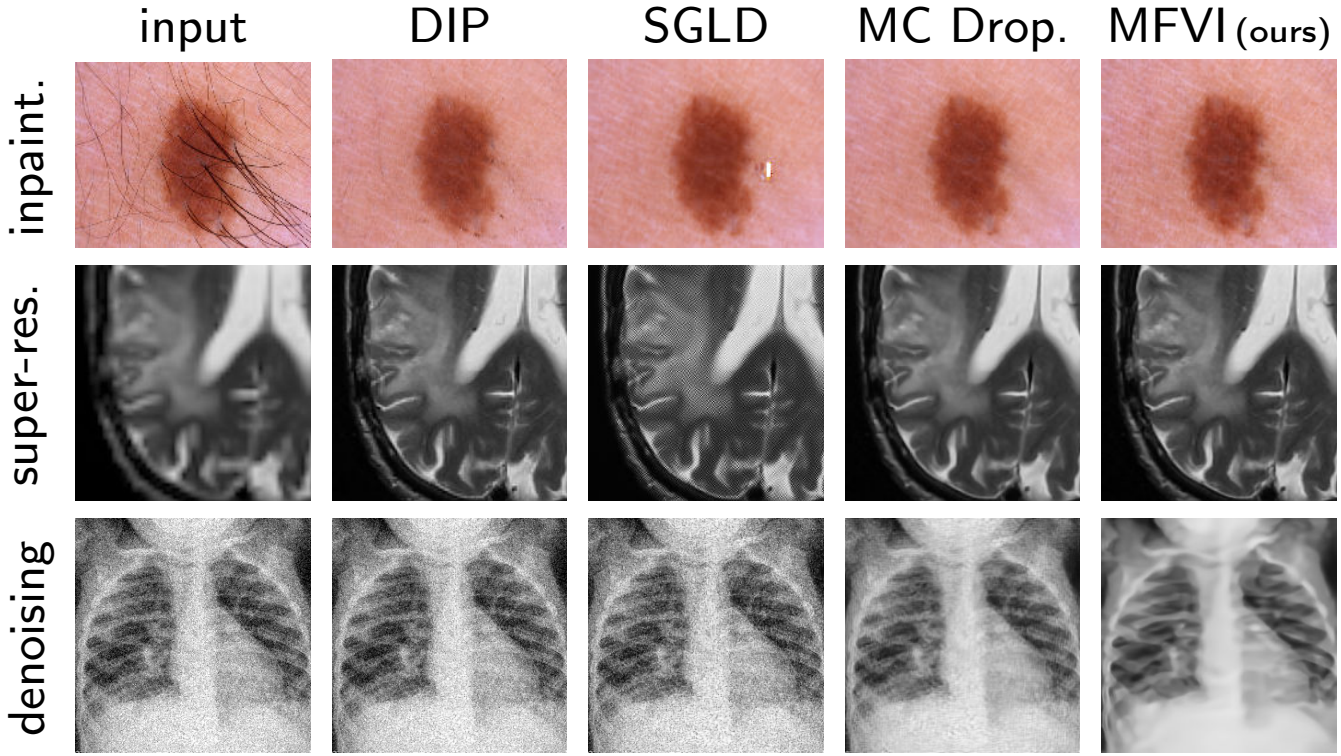
- Surrogate Model, e.g. Gaussian process
- More efficient than, e.g. grid search

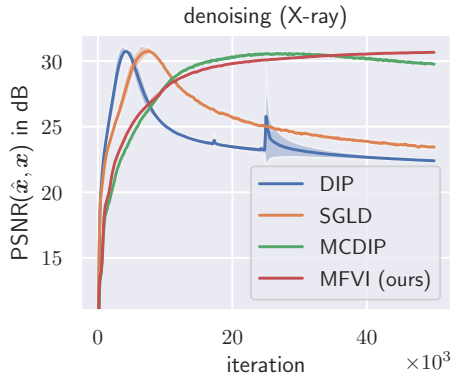


Optimization Objective

$$\mathrm{ELBO}(q(\boldsymbol{\theta})) = \underbrace{\mathbb{E}_{\boldsymbol{\theta}\sim q} \log p(\mathcal{D}|\boldsymbol{\theta})}_{\text{likelihood}} - \underbrace{\mathrm{KL}(q(\boldsymbol{\theta})||p(\boldsymbol{\theta}))}_{\text{regularizer}}$$

Results & Conclusion





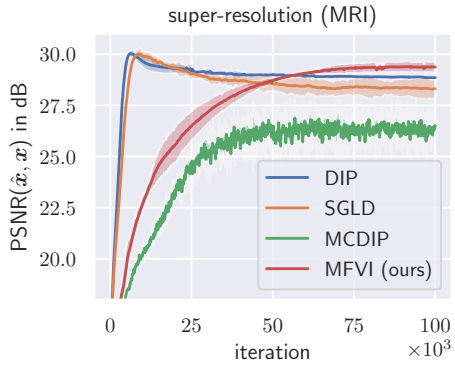
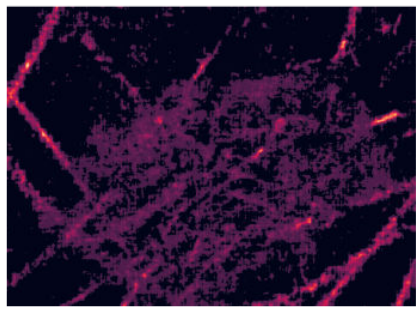


Figure: Qualitative results after convergence.



Conclusion

- New Bayesian approach to deep image prior
- No hallucinations
- Outlook: Tune full KL divergence with BO