TENSOR MONTE CARLO: UNCERTAINTY IN DEEP MODELS WITH COMPLEX LATENT SPACES

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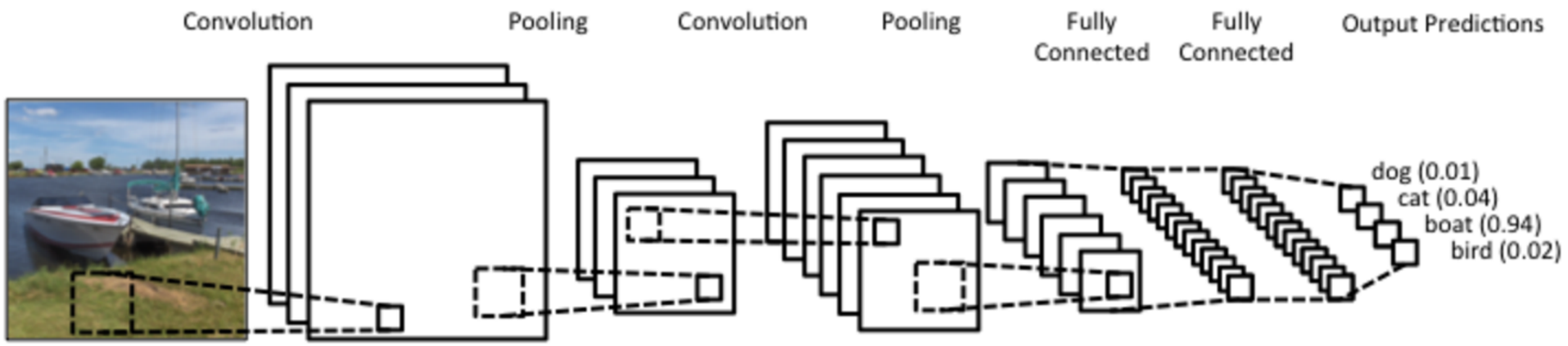
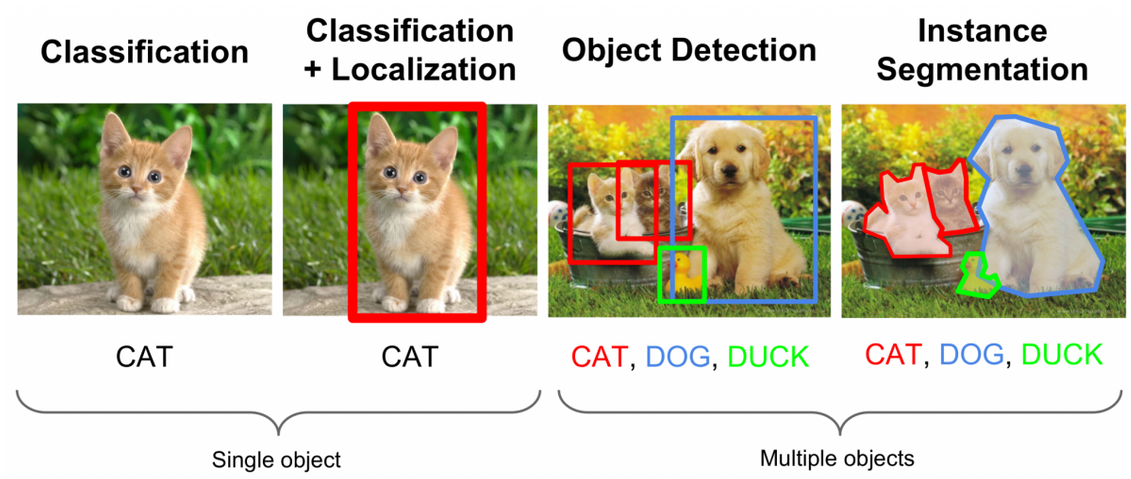
MODERN DEEP LEARNING HAS BEEN HUGELY SUCCESSFUL





- Machine translation
- Speech recognition
- Text-to-speech
- Protein folding
- Game playing (Go)

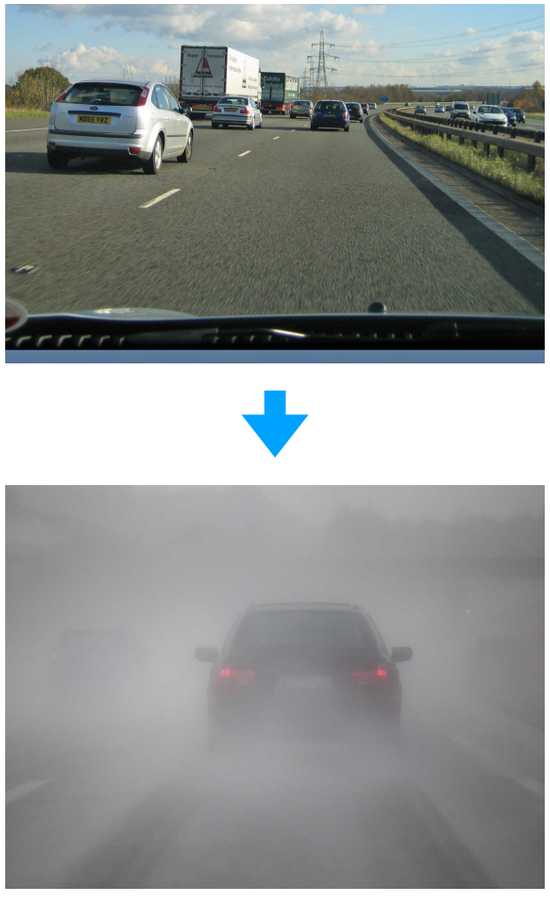
DEEP LEARNING IS INCREASINGLY BEING APPLIED IN SAFETY CRITICAL DOMAINS

Original Radiograph Output Image

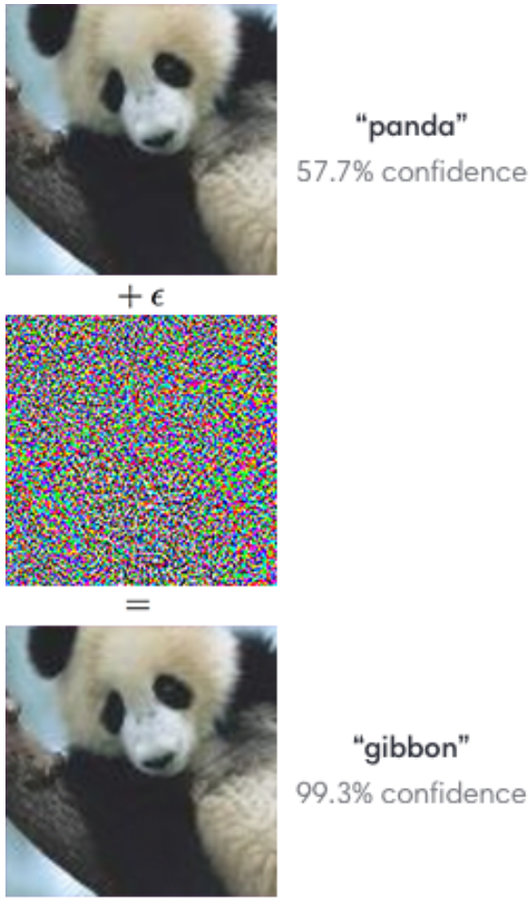
(Lindsey et al. 2018)

IN SAFETY CRITICAL DOMAINS, DEEP LEARNING HAS THREE PROBLEMS

generalisation

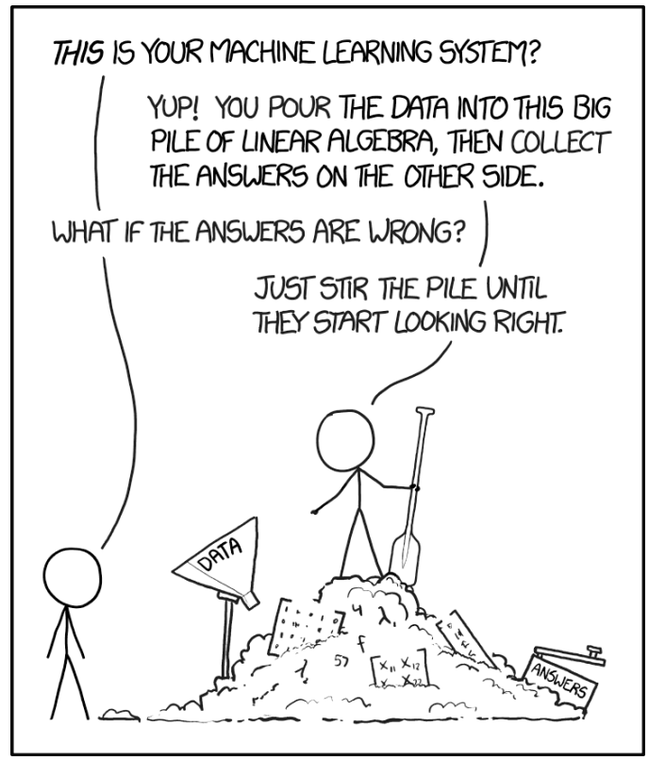


adversarial examples



(Goodfellow et al. 2014)

interpretability



FOR SAFE DEEP LEARNING, WE NEED UNCERTAINTY!

DEEP IDEAL OBSERVERS IN COMPLEX DOMAINS

simplified setting

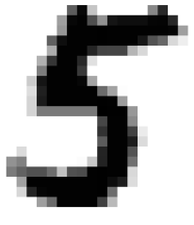
simple vector latent space

$$\begin{pmatrix} 1.2 \\ -2.3 \\ 0.3 \\ 0.5 \end{pmatrix}$$

recognition neural net

generative neural net

pixel space



complex multi-factor latent space

real-world

weather

lane markings

crash barriers

car 1
car 2
car 3
…

ped. 1
ped. 2
ped. 3
…

cyclist. 1
cyclist. 2
cyclist. 3
…

recognition neural net

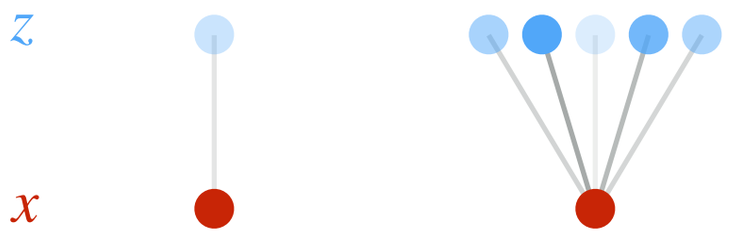
generative neural net

MESSAGE PASSING IN STATE-OF-THE-ART DEEP GRAPHICAL MODELS

simplified setting
problem: mismatch between recognition network and true posterior
solution: draw multiple samples from recognition network, focus on best ones (Burda et al. 2015)

VAE:
one sample

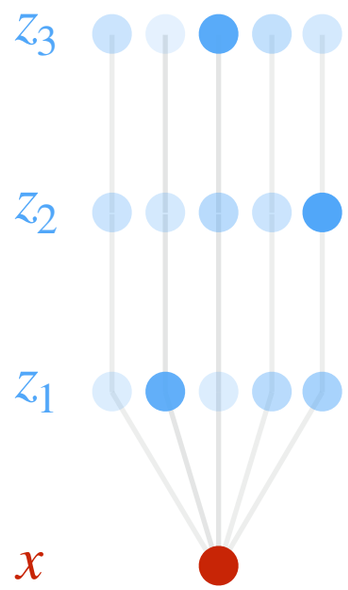
IWAE:
multi-sample



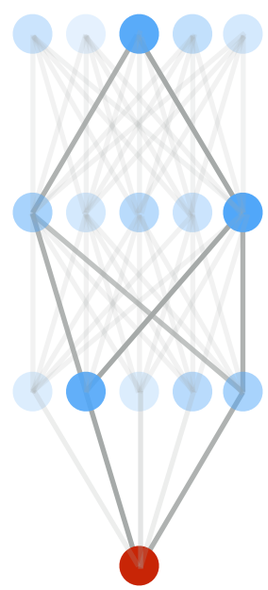
high probability sample
low probability sample

real-world
problem: in large models, few samples will be good
solution: draw multiple samples for each latent, and consider all possible combinations (similar to message passing)

IWAE:
multi-sample



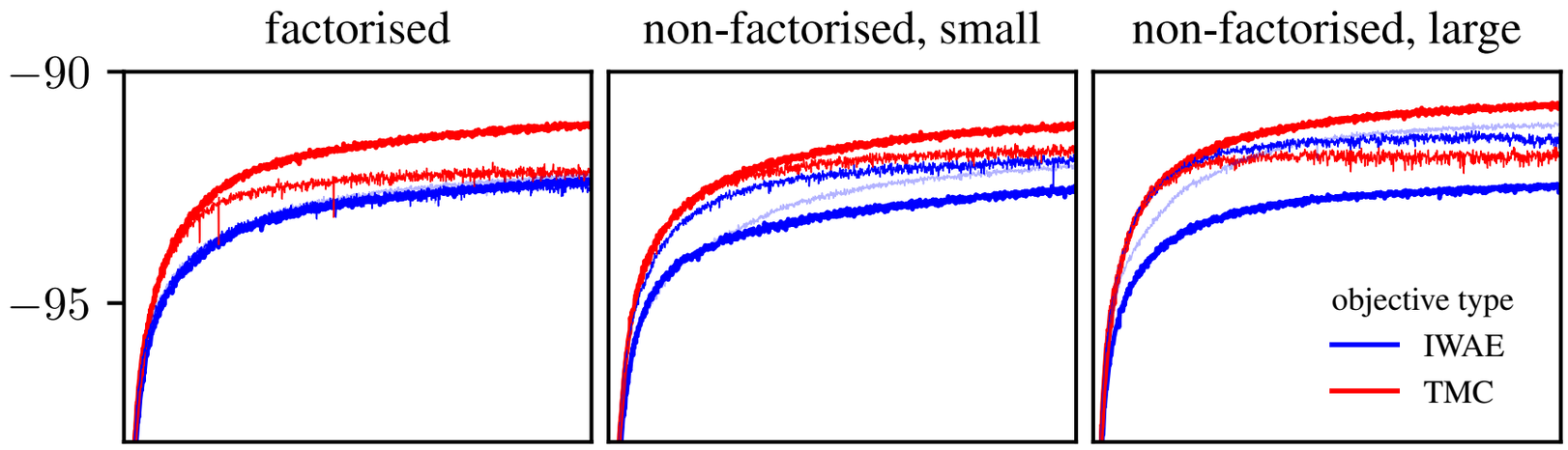
our approach:
Tensor Monte Carlo



RESULTS AND CONCLUSIONS

results:

- dramatically improved performance with simpler recognition models
- benefits get smaller as recognition models get better



future work: exploit these developments to learn large-scale deep models

- on graphs (e.g. social networks)
- scene understanding
- language modelling (ambiguity)