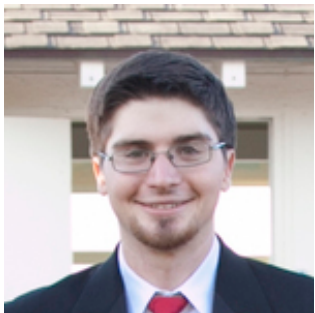


Qualitatively Characterizing Neural Network Optimization Problems



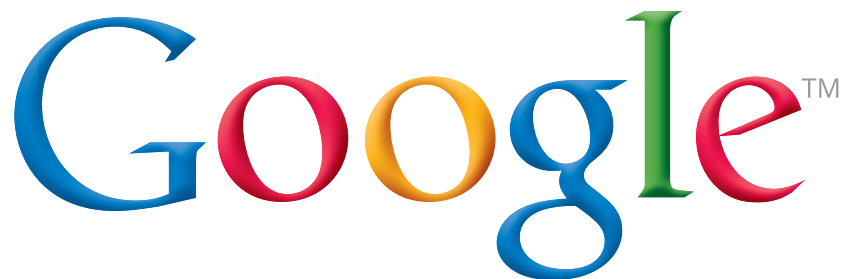
Ian
Goodfellow



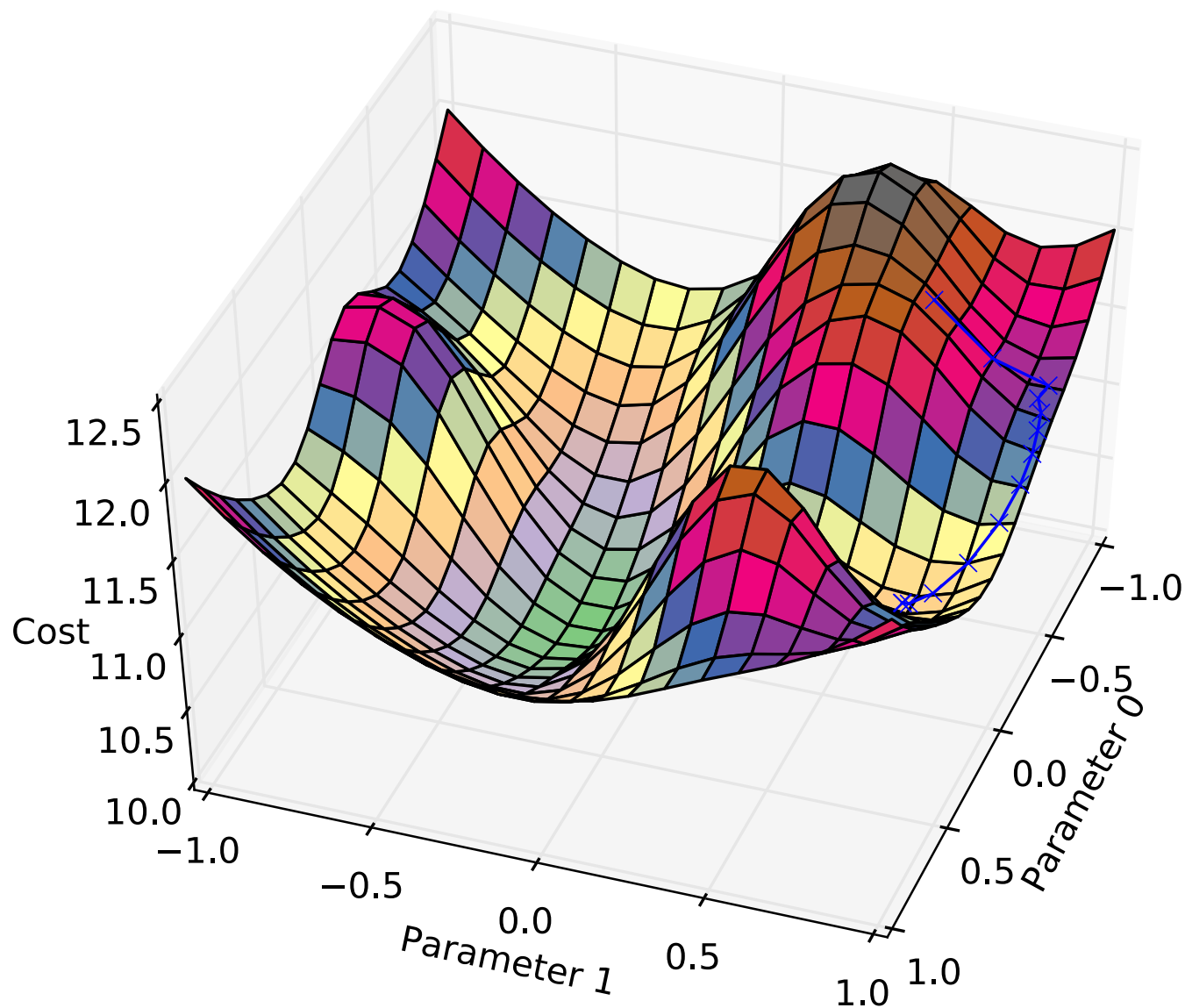
Oriol Vinyals



Andrew Saxe

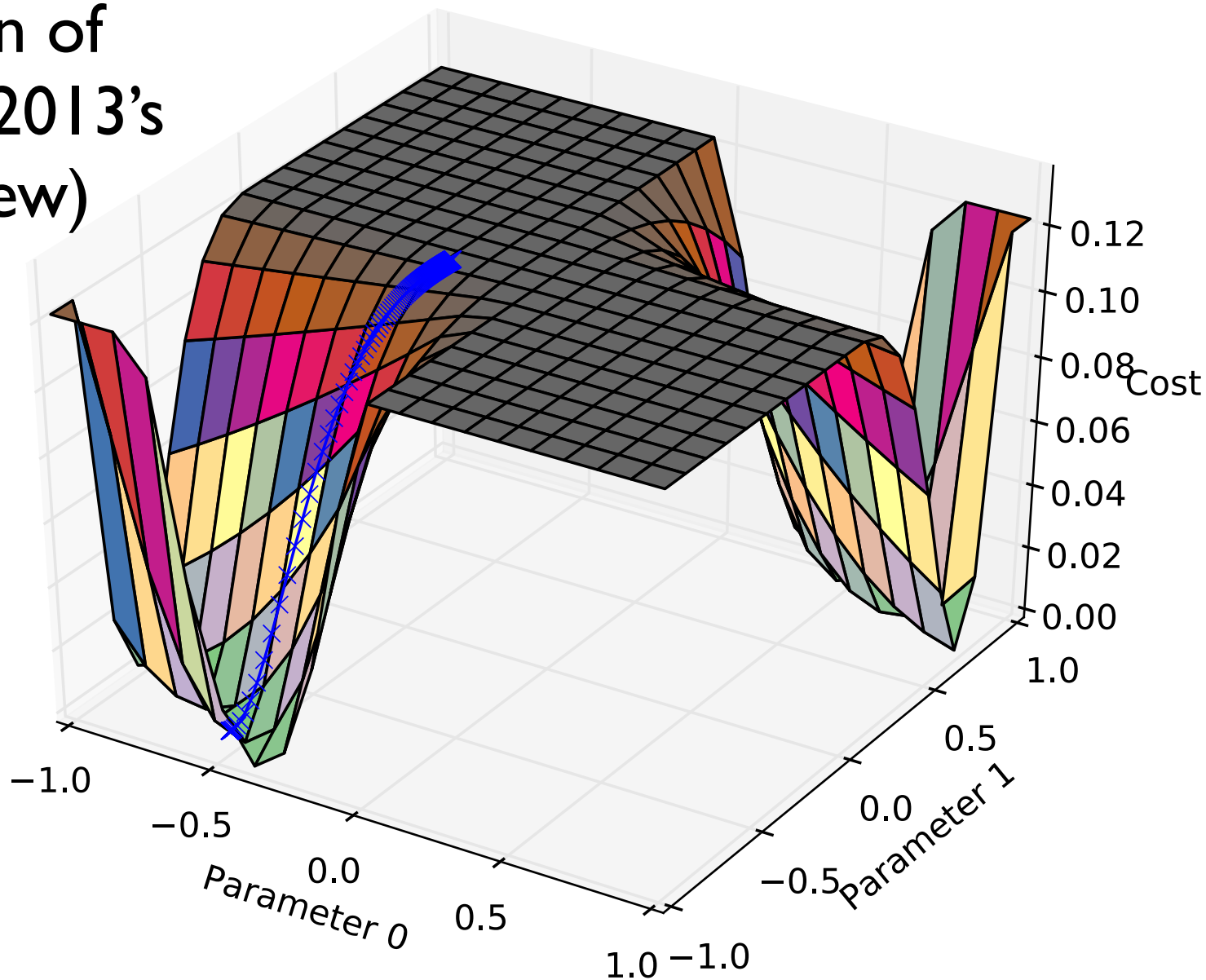


Traditional view of NN training



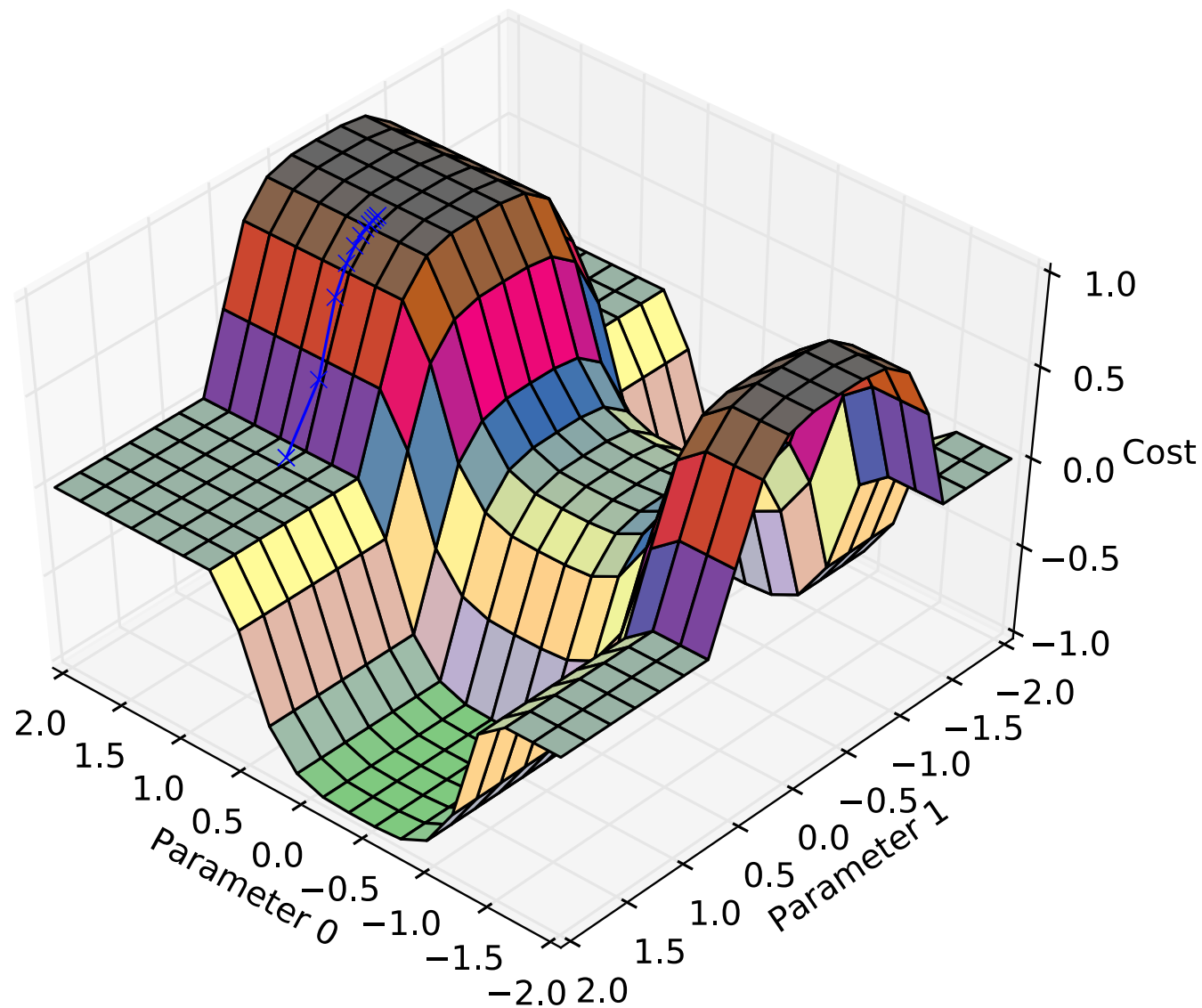
Factored linear view

(Cartoon of
Saxe et al 2013's
worldview)



Attractive saddle point view

(Cartoon of
Dauphin et al 2014's
worldview)



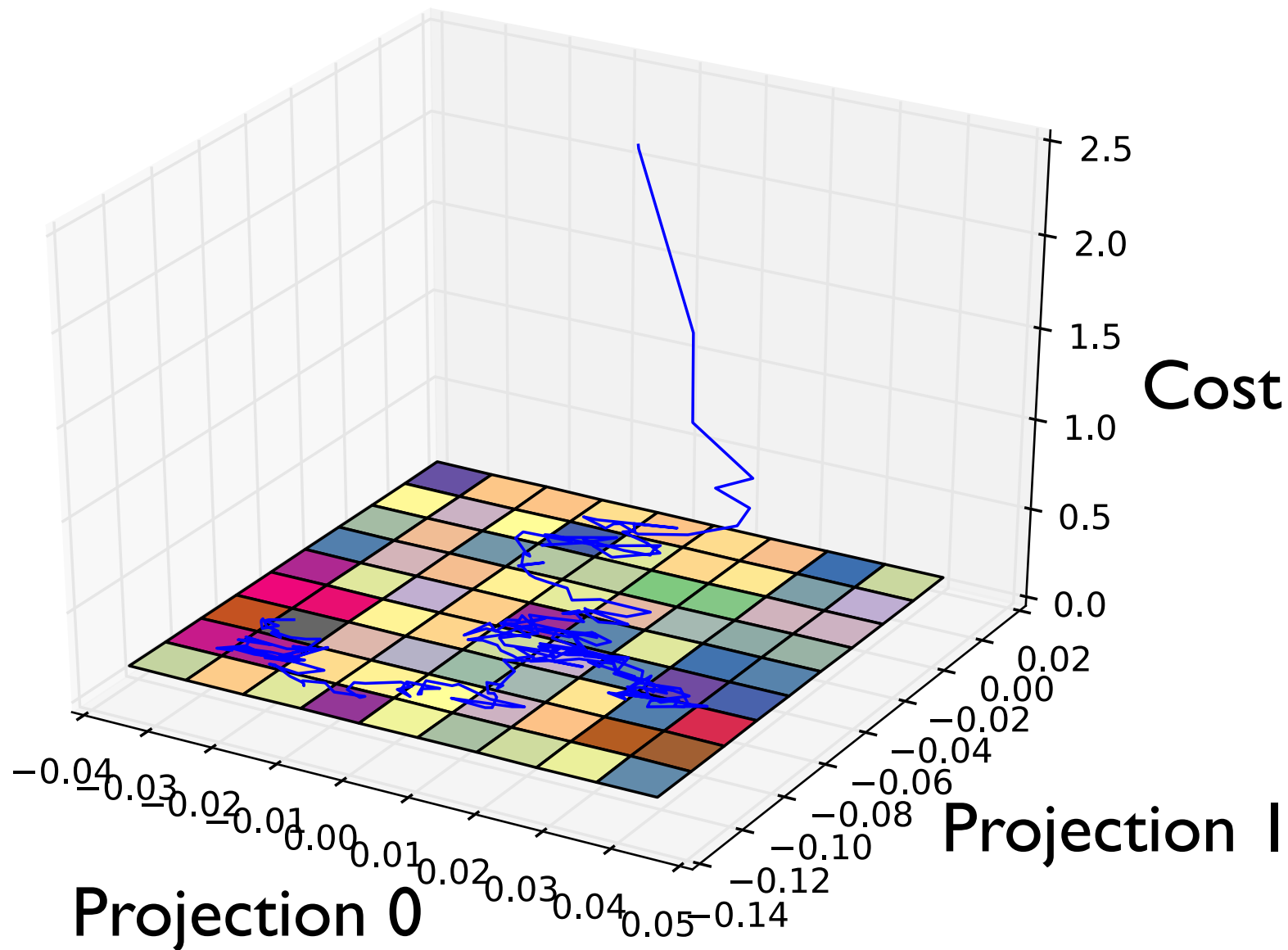
Questions

- Does SGD get stuck in local minima?
- Does SGD get stuck on saddle points?
- Does SGD wind around numerous bumpy obstacles?
- Does SGD thread a twisting canyon?

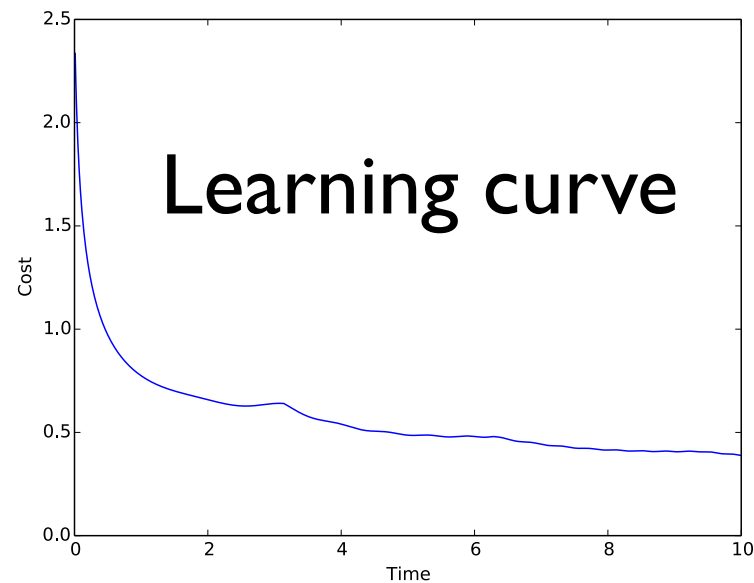
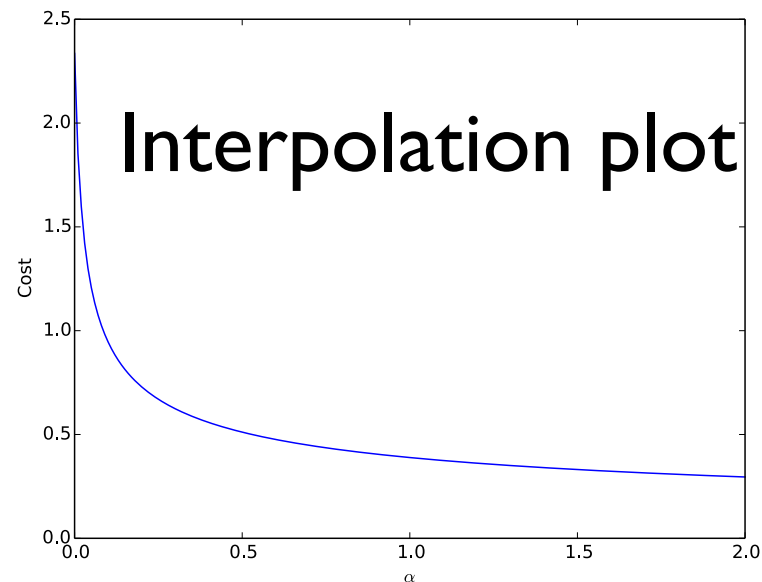
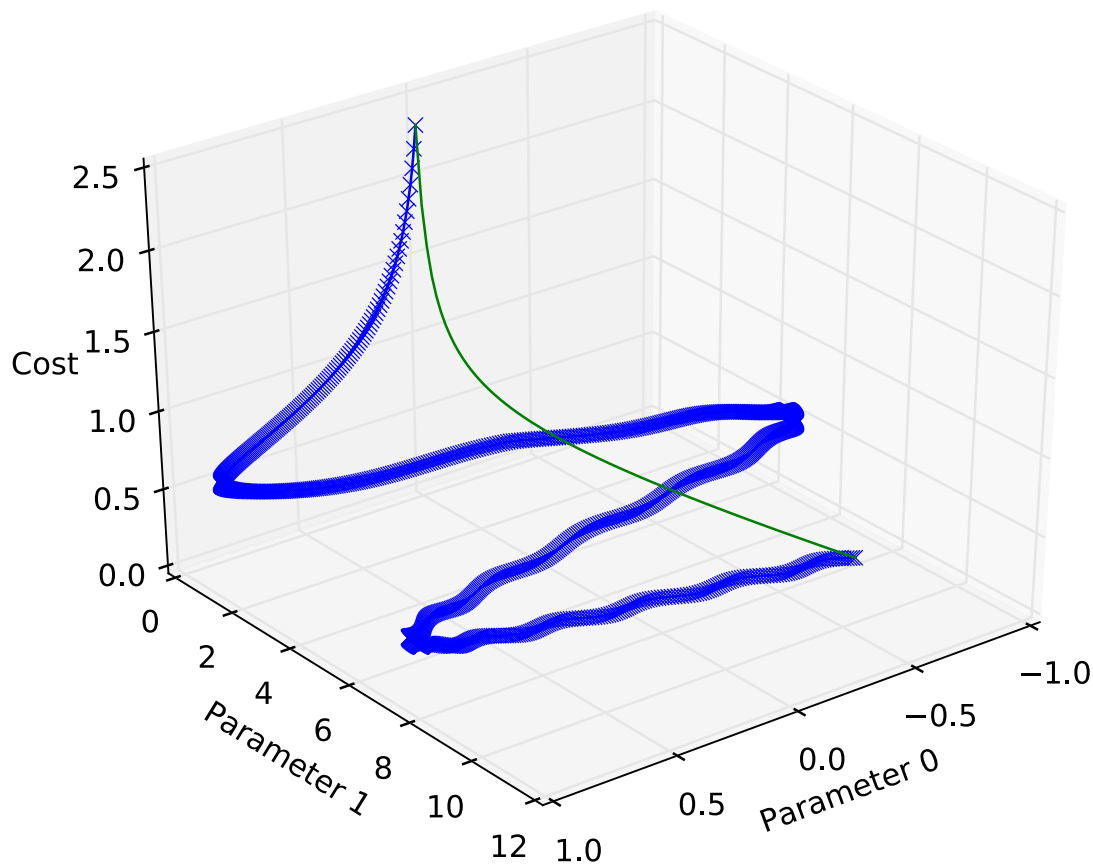
History written by the winners

- Visualize trajectories of (near) SOTA results
- Selection bias: looking at success
- Failure is interesting, but hard to attribute to optimization
- Careful with interpretation
 - SGD never encounters X ?
 - SGD fails if it encounters X ?

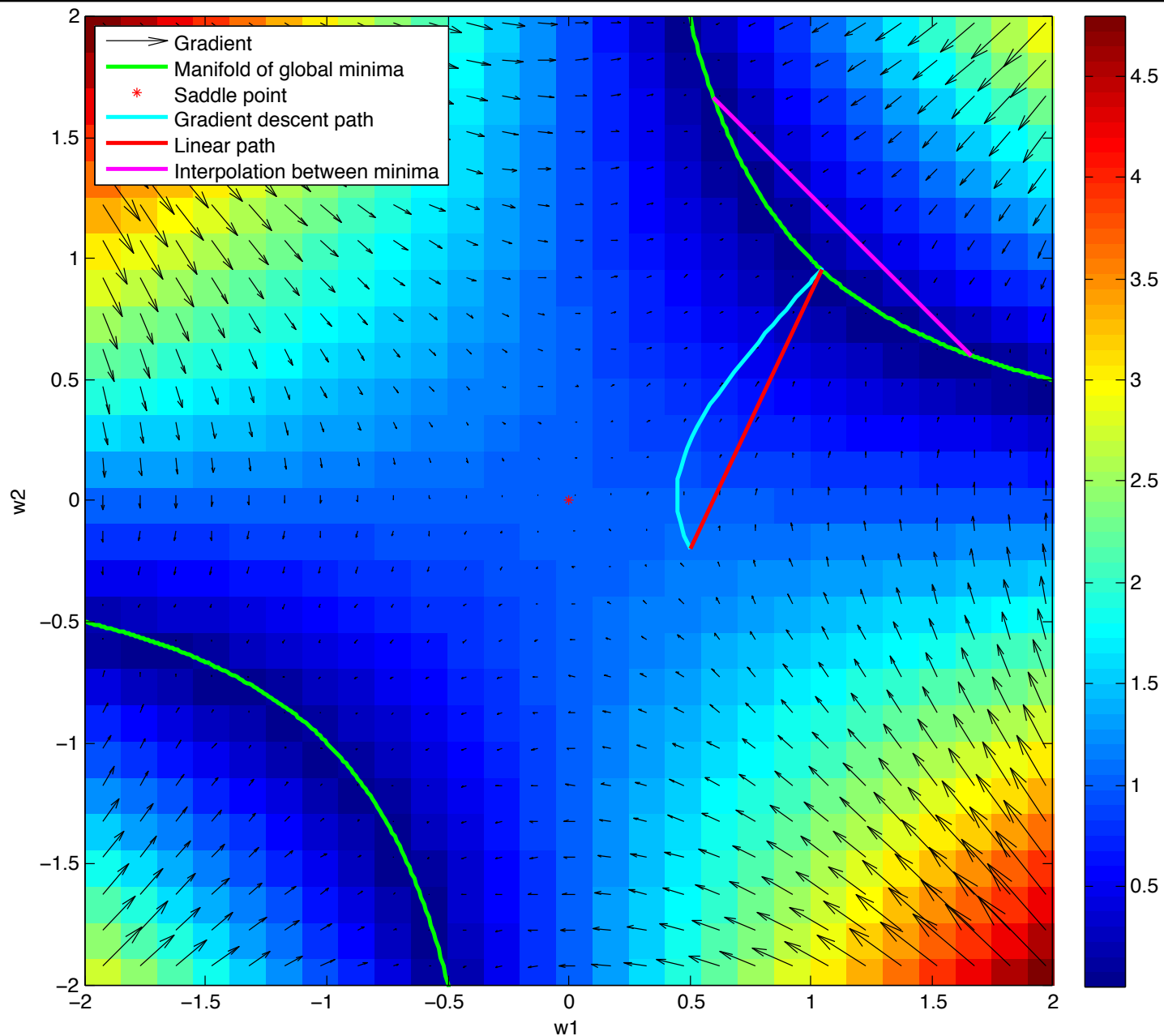
2-D subspace visualization



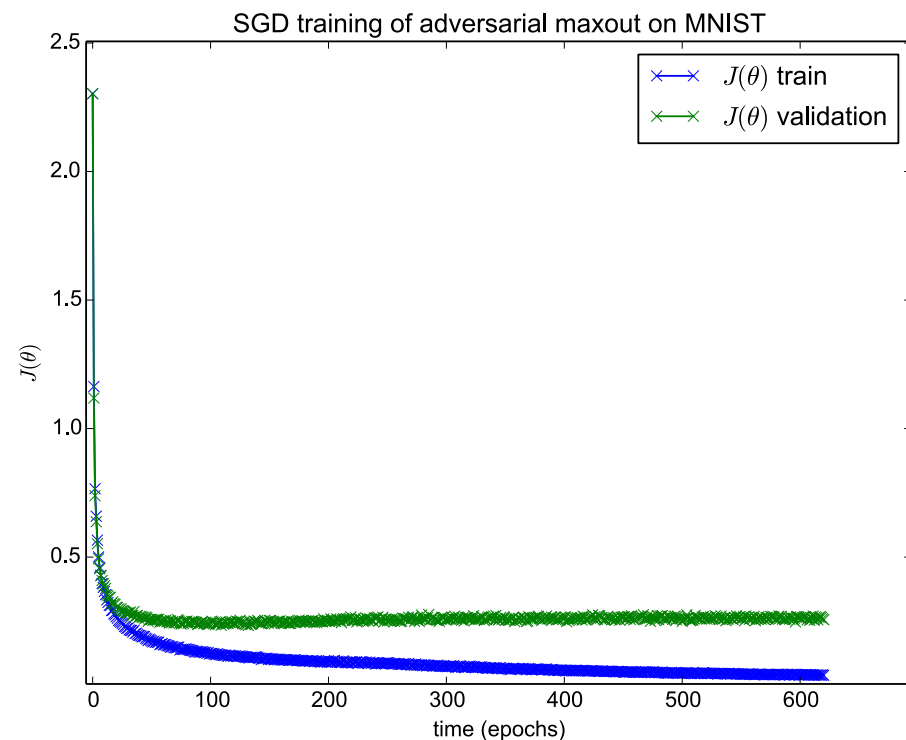
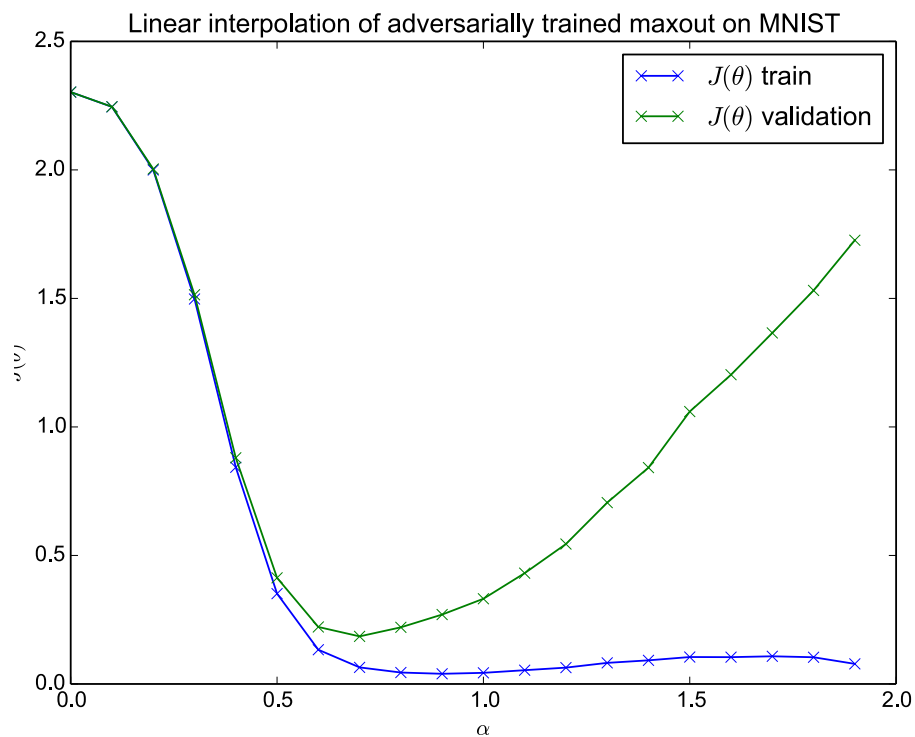
A special 1-D subspace



2-parameter deep linear model

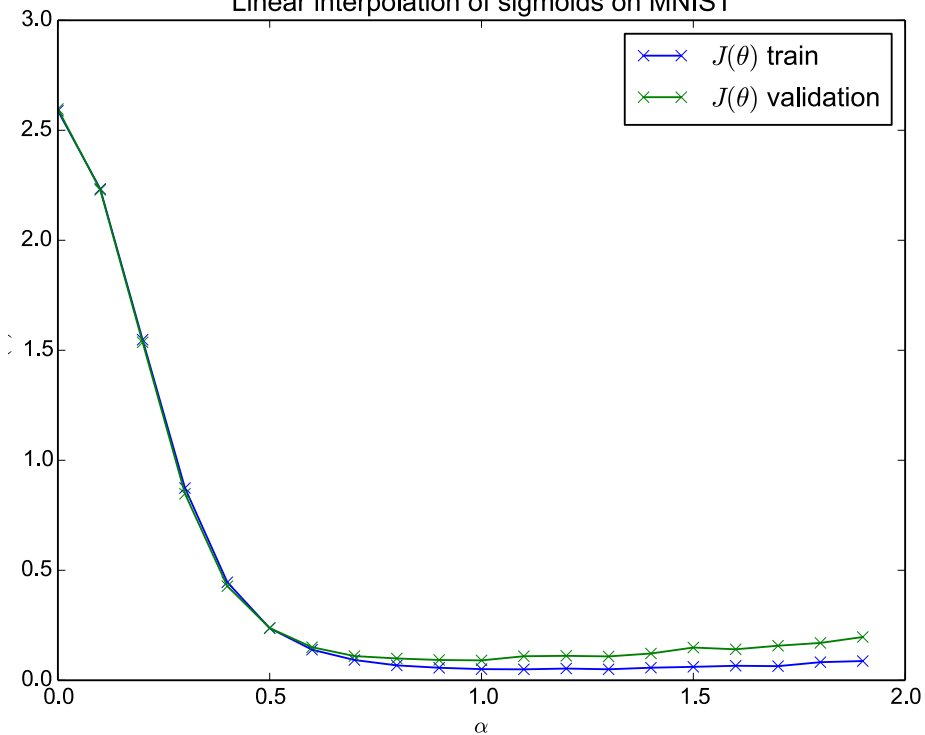


Maxout / MNIST experiment

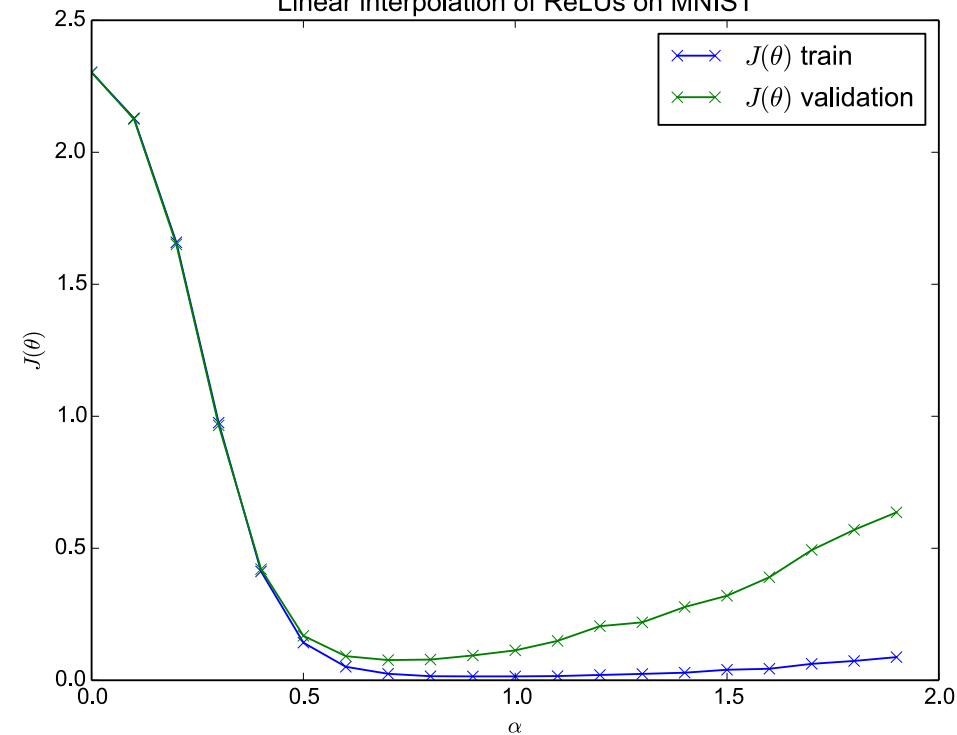


Other activation functions

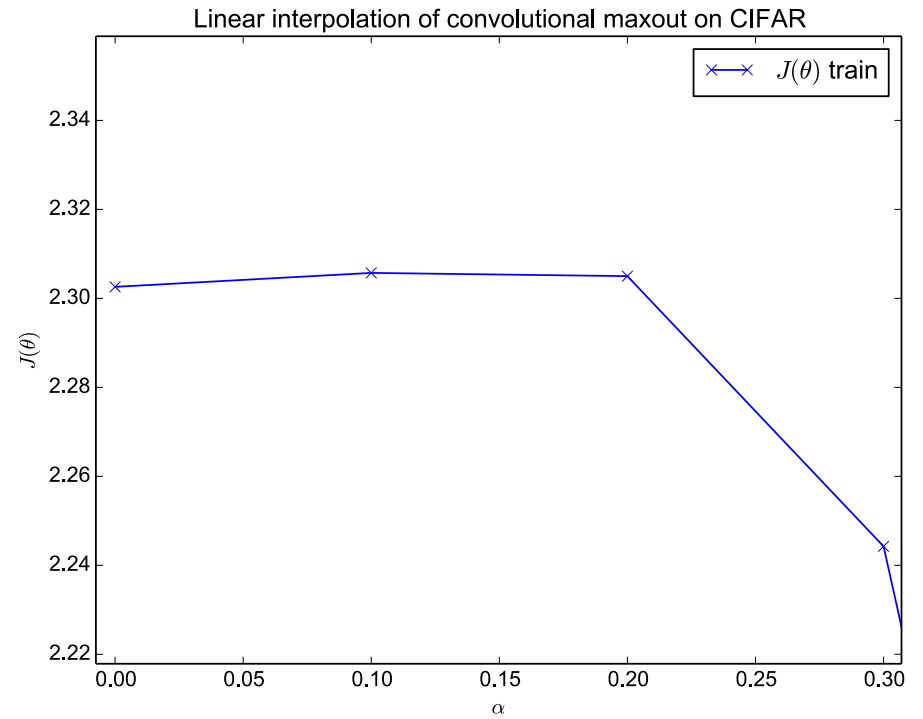
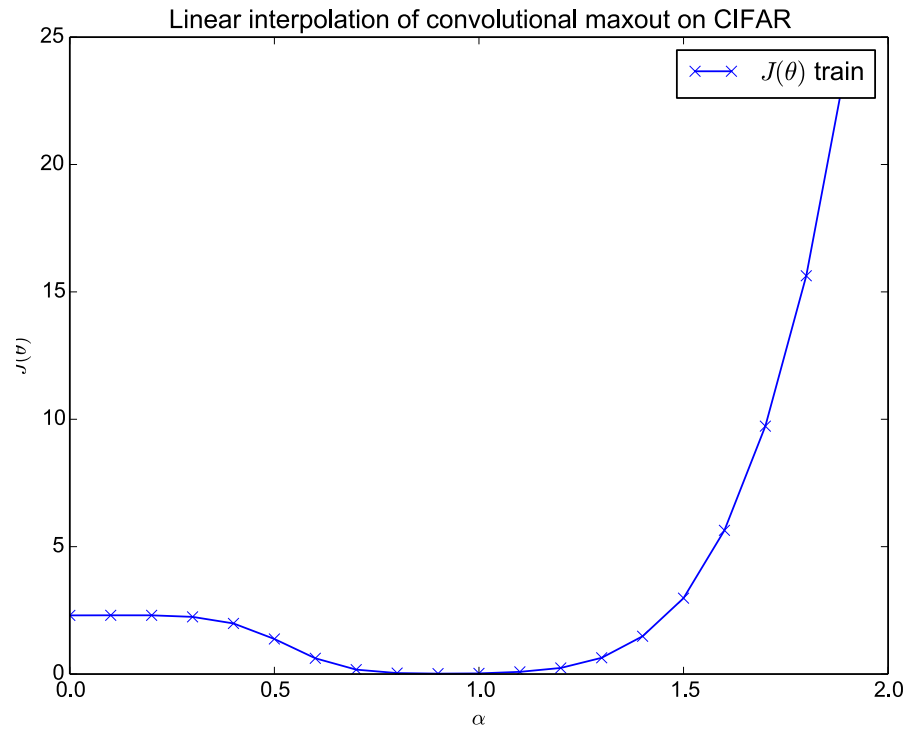
Linear interpolation of sigmoids on MNIST



Linear interpolation of ReLUs on MNIST

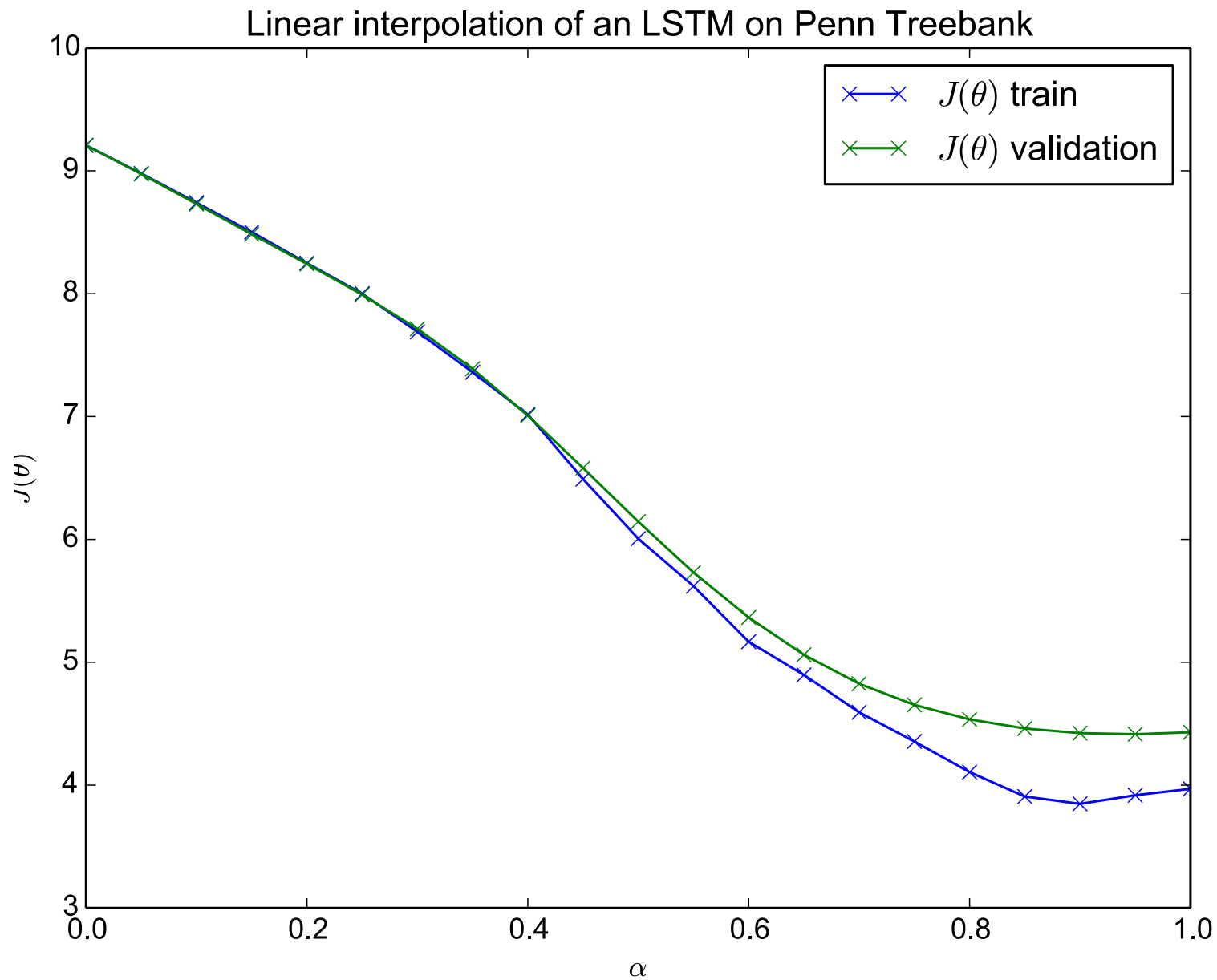


Convolutional network

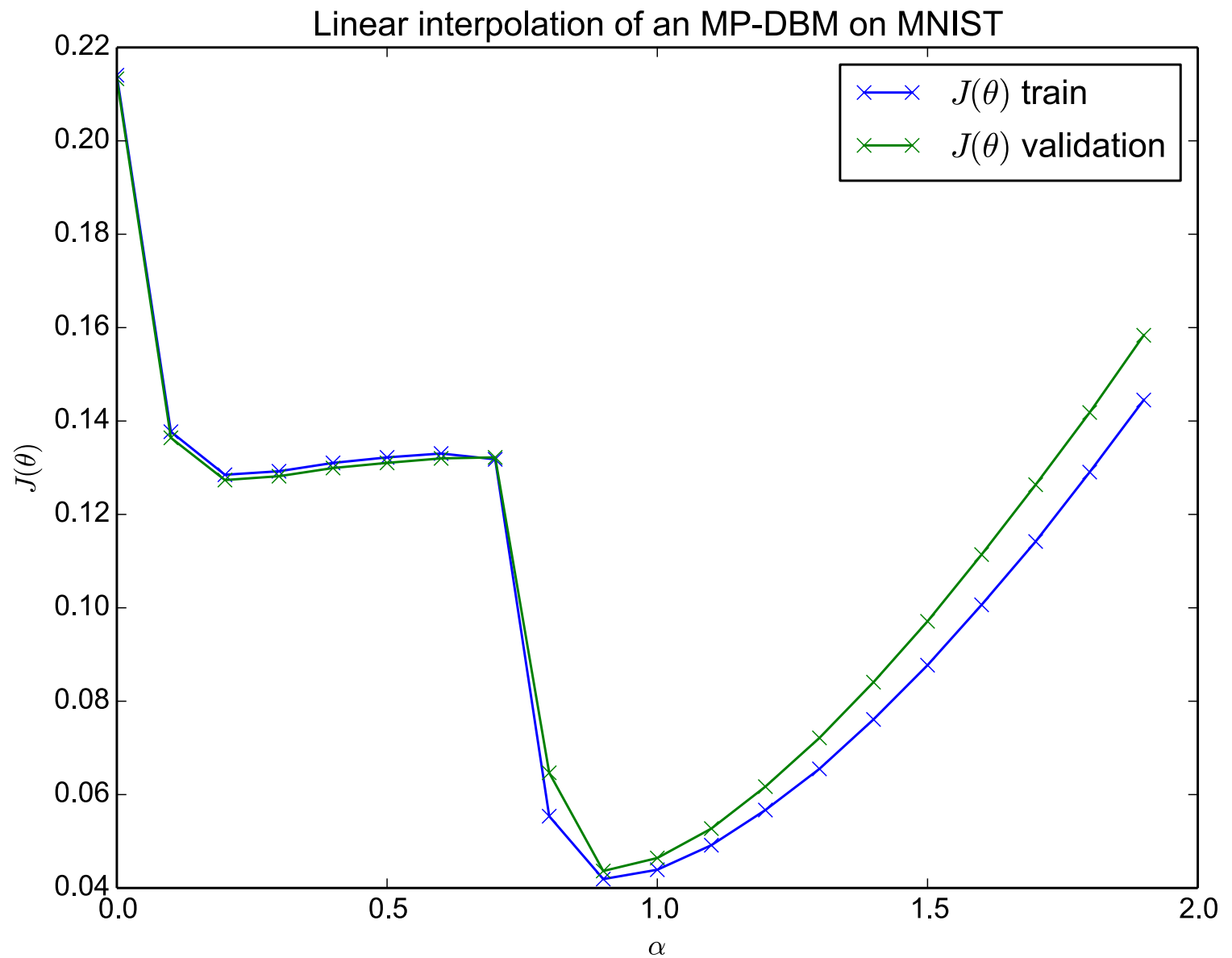


A small barrier

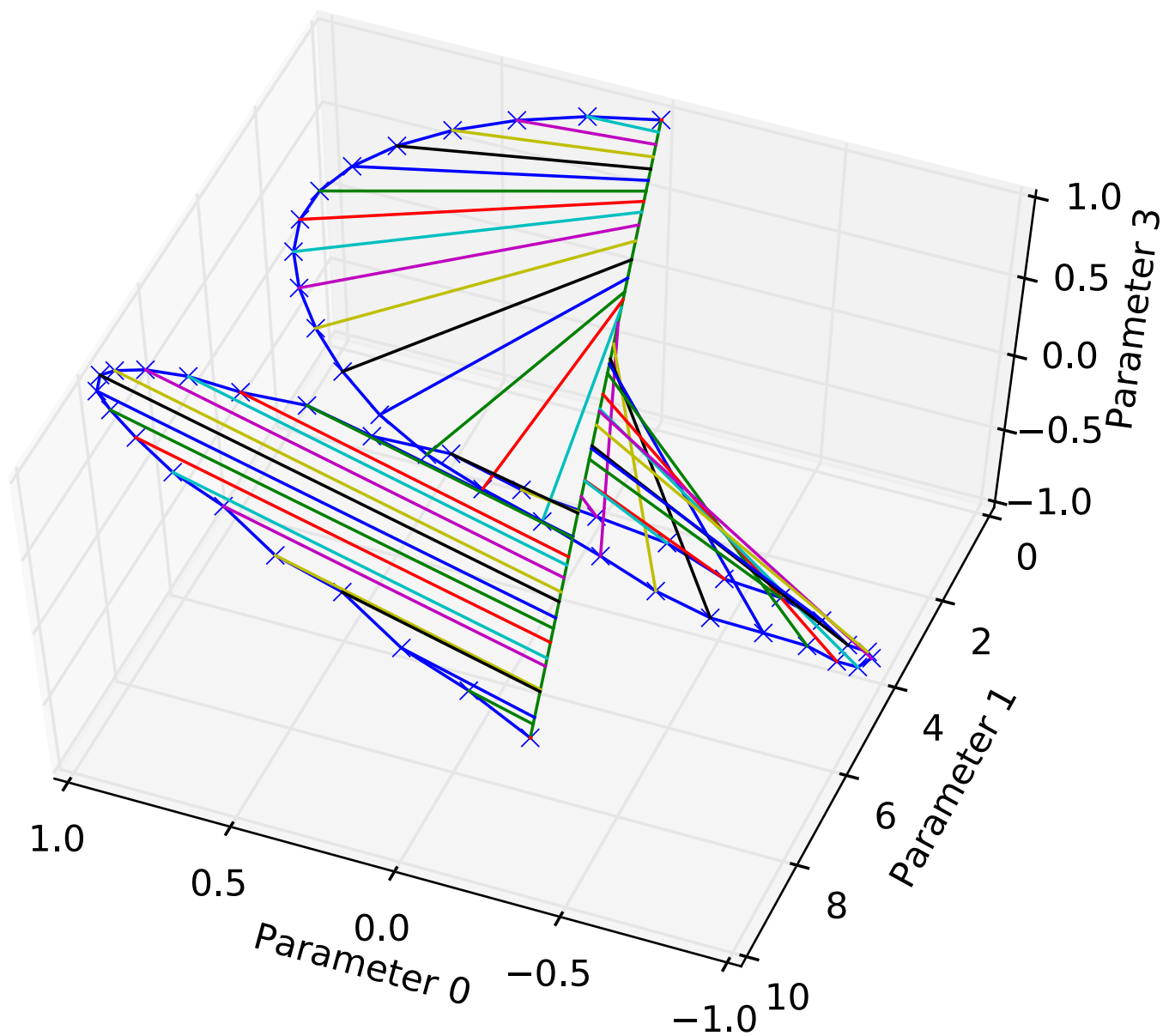
LSTM



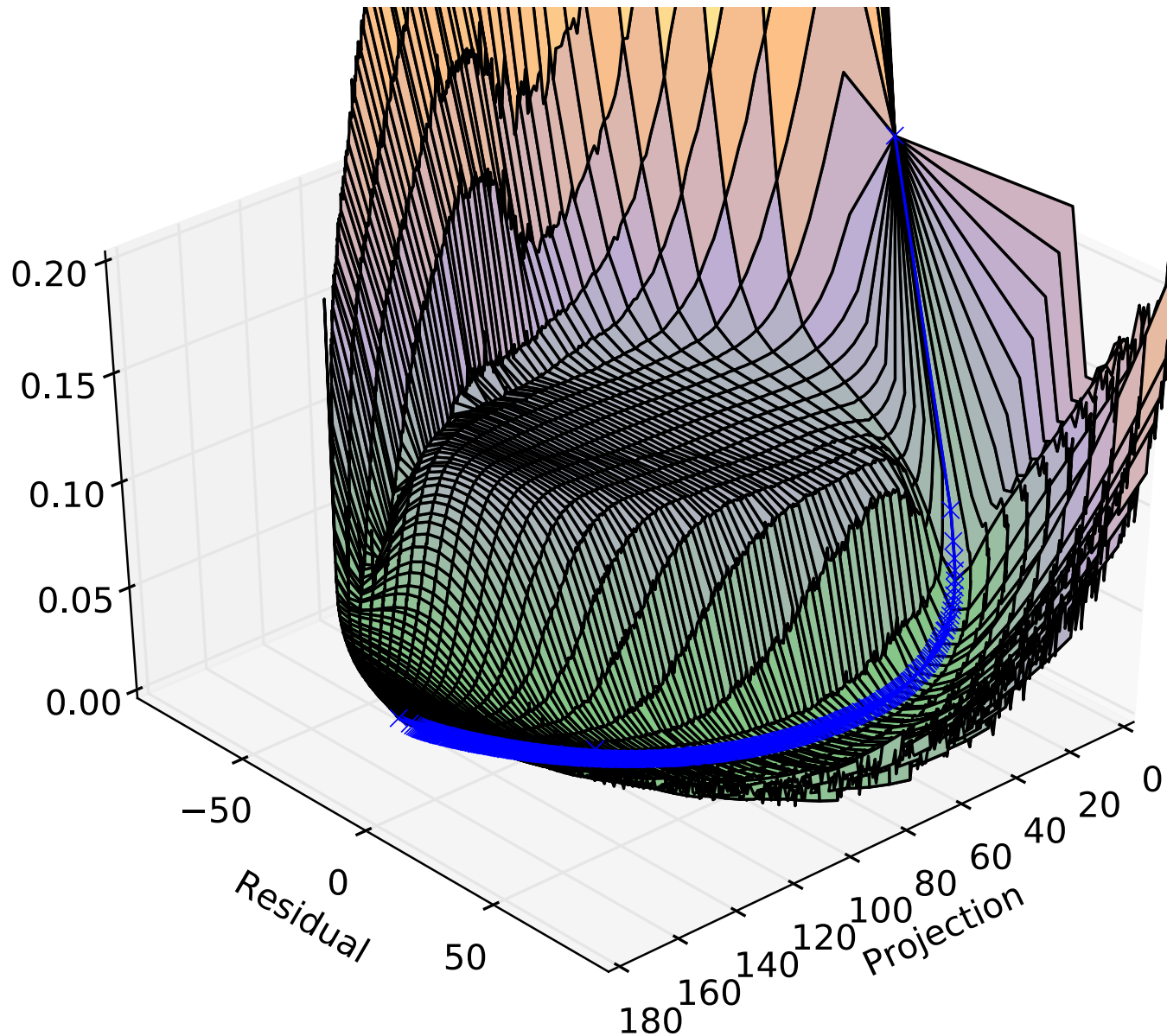
MP-DBM



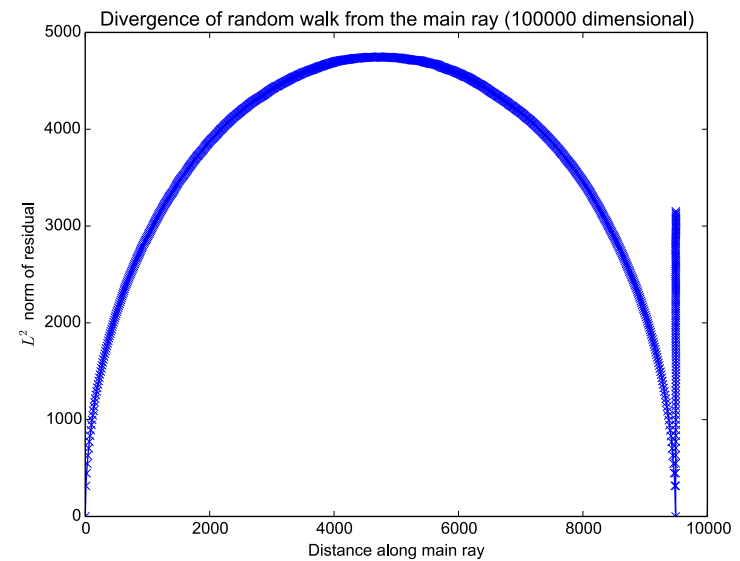
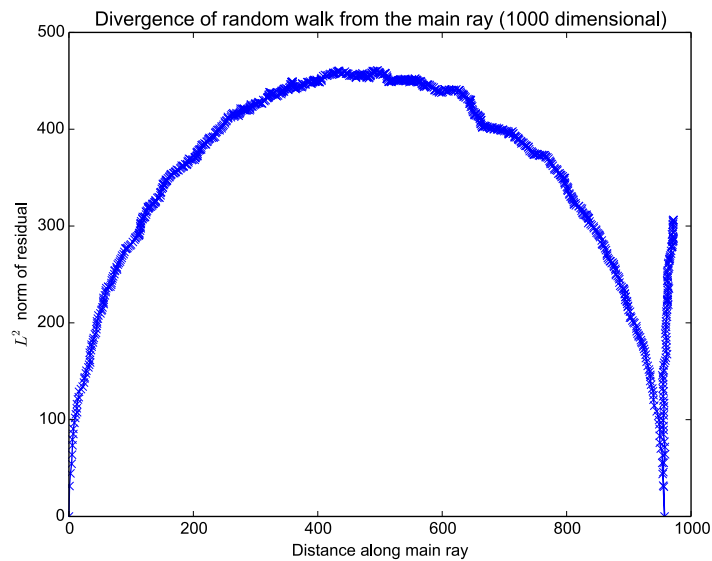
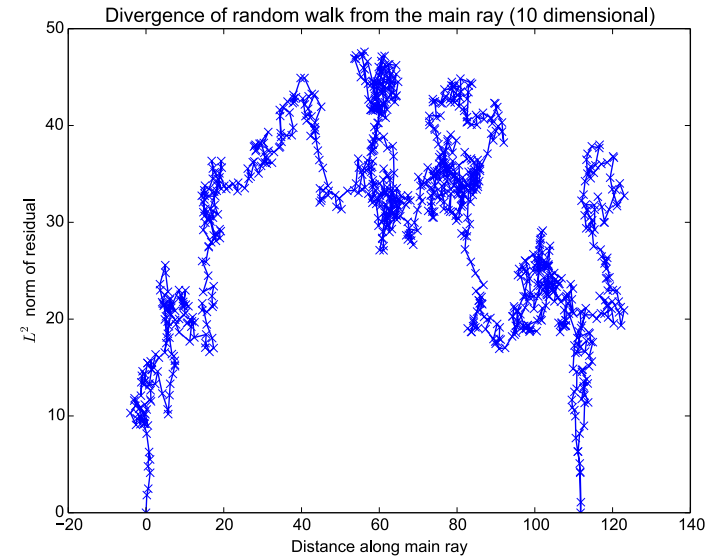
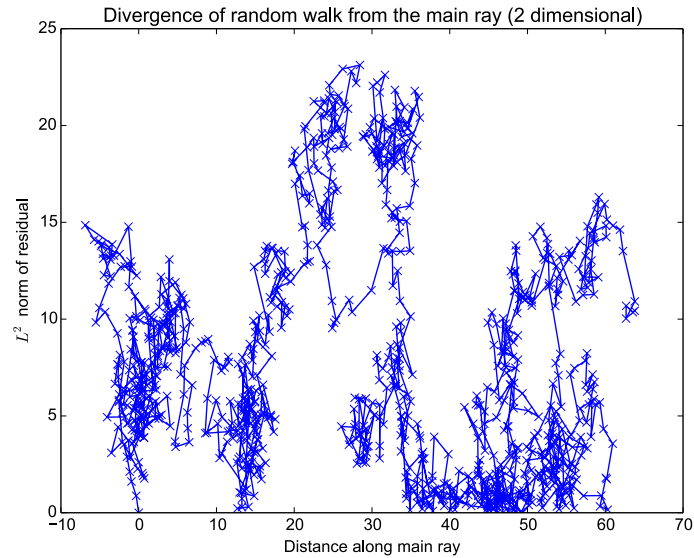
3-D Visualization



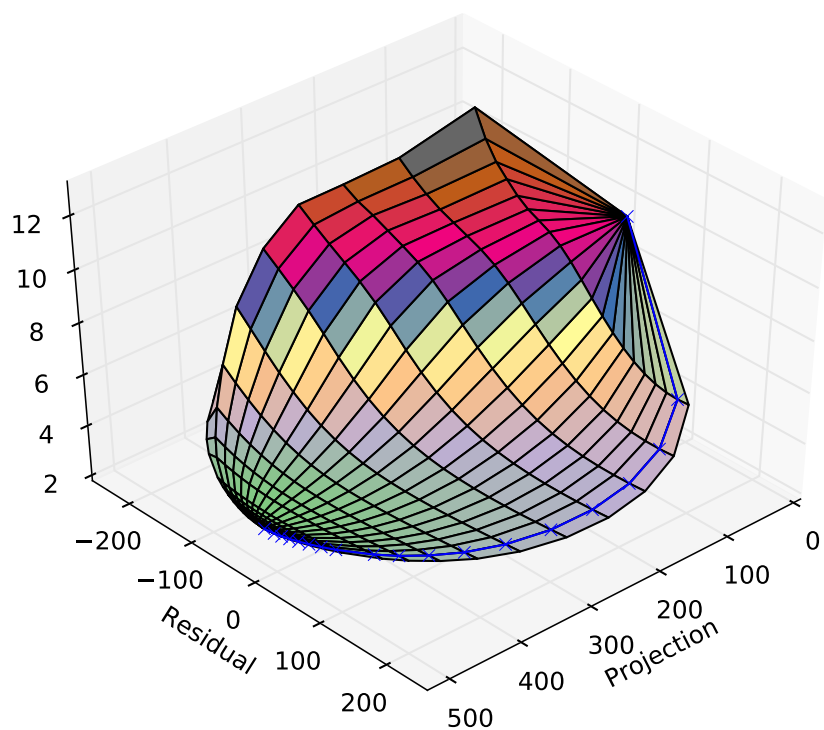
3-D MP-DBM visualization



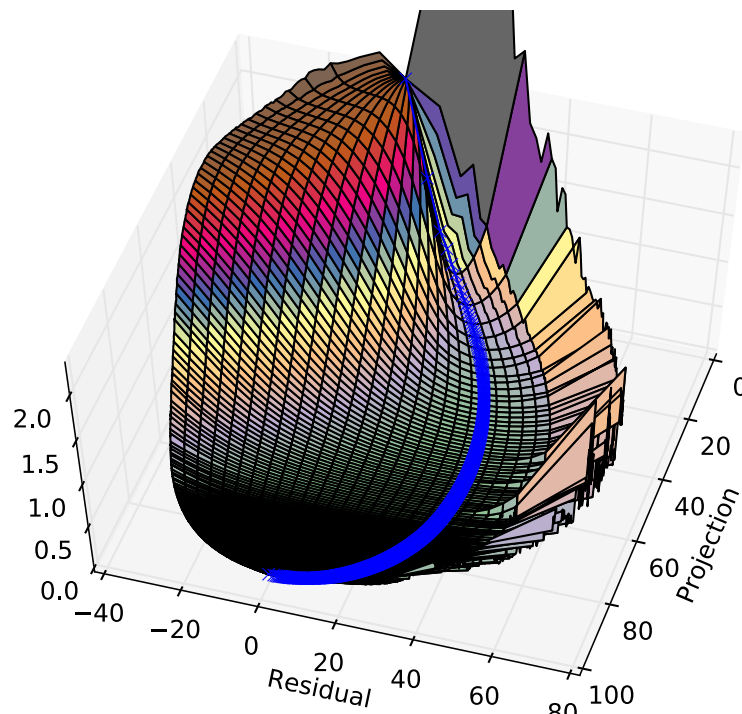
Random walk control



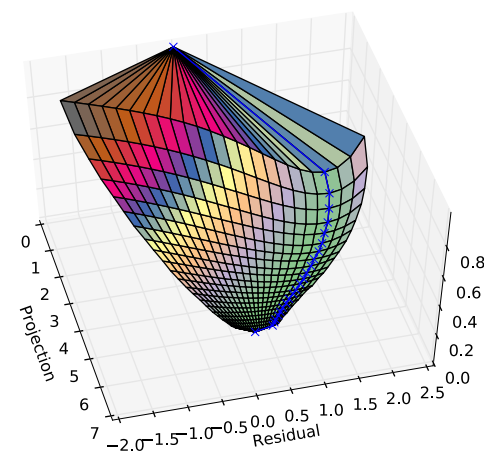
3-D Plots Without Obstacles



LSTM

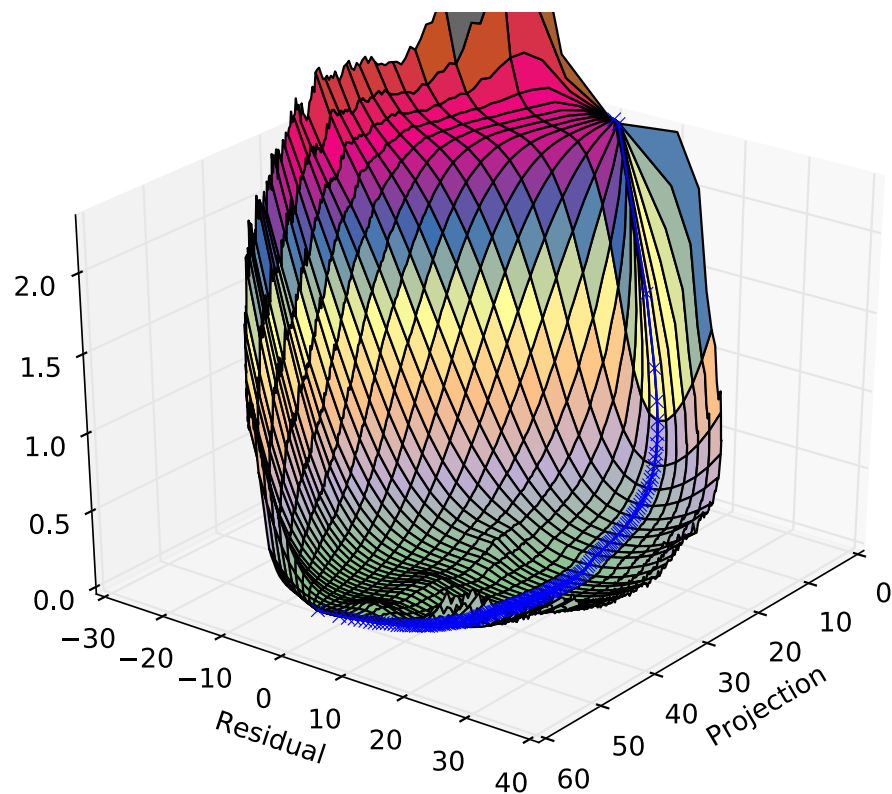


Adversarial
ReLUs

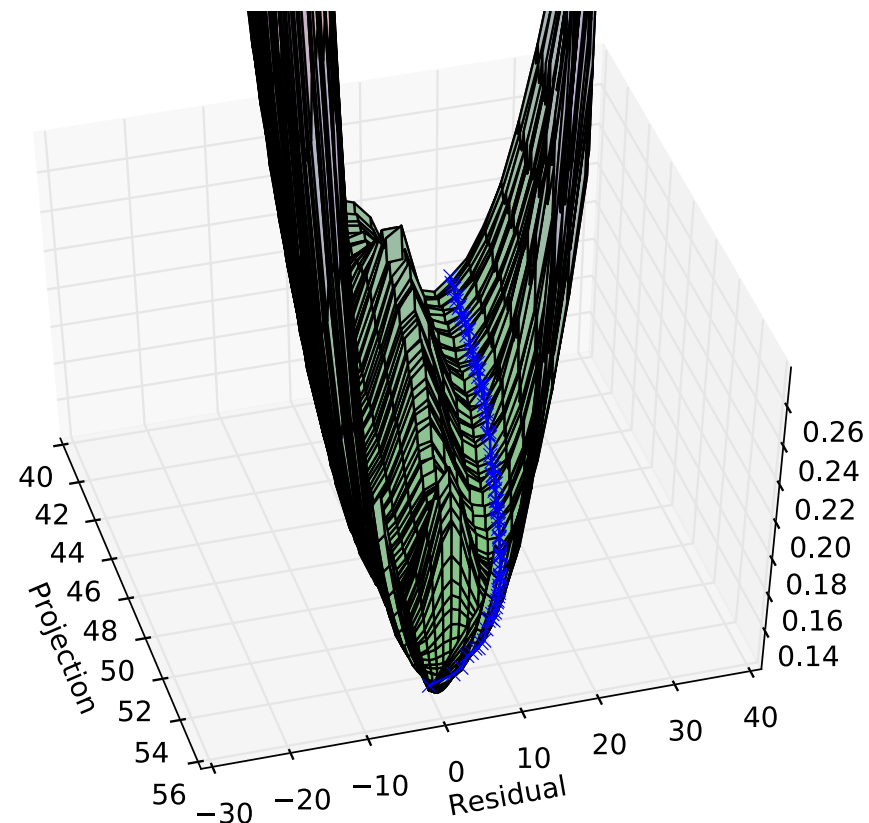


Factored Linear

3-D Plot of Adversarial Maxout



SGD naturally exploits
negative curvature!



Obstacles!

Conclusion

- For most problems, there exists a linear subspace of monotonically decreasing values
- For some problems, there are obstacles between this subspace the SGD path
- Factored linear models capture many qualitative aspects of deep network training
- See more visualizations at our poster / demo / paper