ML in Fundamental Physics

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Exercise Sheet 2

Submission by Monday 4th 19:00 via Moodle.
Corrections due by Thursday 7th 17:00 via Moodle.
Format for all questions: individual Jupyter notebooks .ipynb.
Text for question 3 in markdown in the Jupyter notebook.

1 Bias vs variance trade-off

In the lectures we have discussed two schematic plots:

- Number of data points vs. Error.
- Model complexity vs. Error.

Perform an experiment with polynomials which shows this behaviour.

2 Gradient descent – Adam

In this exercise you will implement the Adam optimiser and examine its behaviour on the function

$$(1.5 - x + xy)^2 + (2.25 - x + xy^2)^2 + (2.625 - x + xy^3)^2 \ .$$

Similar to the discussion in the lecture, implement the Adam optimiser and visualise its behaviour for two different starting points and two different learning rates.

For a learning rate of 10^{-3} ($\gamma = 0.9, \beta = 0.99, \epsilon = 10^{-8}$), scan over a sensible grid of starting points. Highlight the different endpoints associated to these starting points in a contour plot. Qualitatively, describe the results you find.

3 Some Statistics

- Given a partition function (e.g. think about the 2D Ising model), how do you obtain, in principle the probability of a given field configuration?
- List a couple of algorithms on how to generate samples drawn from such an underlying probability distribution.
- How do you ensure that samples you have generated are independently drawn from the probability distribution?
- $\star$ How can you check whether two datasets are drawn from the same underlying probability distribution?