Introduction to Recurrent Neural Networks with Keras and Tensorflow

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Course Syllabus and Objectives

1. Familiarise neural-networks with Keras

- Keras Models
- Automatic Differentiation
- Gradient Descent
- Keras Fit loop
- Graphing learning using matplotlib
- Saving models

2. Understand what a RNN is, and how to implement one

- Hand-built RNN
- Hand built LSTM
- Keras layers for SimpleRNN + LSTM
- Backpropagation through time

3. Build time-series examples

- Prepare datasets
- Train and evaluate effectively

4. Look at advanced applications

- Neurocontrol examples
- Build a minimal “functionally sentient” creature

Today's Outline

Lecture 1 (9:30am-11.00am): **Introduction**

- Introduction to Automatic Differentiation and Gradient Descent
- Training Neural Networks with Keras, and an introduction to universal function approximation

Lecture 2 (11:30am-1.00pm): **RNNs**

- Introduction to RNNs with Keras
- Introduction to LSTMs with Keras

Lecture 3 (2:00pm-3.30pm): **Time Series Forecasting**

- Weather forecasting example
- EUR/USD Forex forecasting example

Lecture 4 (4:00pm-5.30pm): **Neurocontrol**

- Build a minimal "functionally-sentient" creature
- Industrial Neurocontrol example and neuropilot
- Cart-pole problem with BPTT

- **Tools**
  - Python ML libraries:
    - Jupyter Notebook server
    - Python 3.8 or above
    - TensorFlow (which includes Keras) (version >= 2.2)
    - Matplotlib
    - Pandas
    - Numpy
    - scikit-learn
    - scipy
  - To install them all with one pip command:

    pip install tensorflow notebook numpy pandas scipy matplotlib sklearn
- **Editing notebooks**
  - I will be asking you to edit the notebooks and run code
  - Back everything up now before you start!

About myself

- I am a lecturer in computer science and artificial intelligence at University of Essex, UK
  - Contact: m.fairbank@essex.ac.uk
  - https://www.essex.ac.uk/people/fairb54300/michael-fairbank

My research interests

- Learning Algorithms for NNs
  - See "Deep Learning in Target Space" https://arxiv.org/abs/2006.01578
- Adaptive Dynamic Programming (ADP)
  - ADP is a model-based approach to reinforcement learning
  - *Fairbank, Michael, Eduardo Alonso, and Danil Prokhorov. "An equivalence between adaptive dynamic programming with a critic and backpropagation through time." IEEE Transactions on Neural Networks and Learning Systems 24.12 (2013): 2088-2100.*
- Neurocontrol
  - Various applications of neural networks to electrical power systems, motor controllers
- Financial forecasting
  - See *Andreas Krause and Michael Fairbank. "Baseline win rates for neural-network based trading algorithms." International Joint Conference on Neural Networks, Glasgow, (2020).*
- Natural Language processing with RNNs
  - Question and answering

Let’s get started…