OpenCLにおけるNeuroWavelet

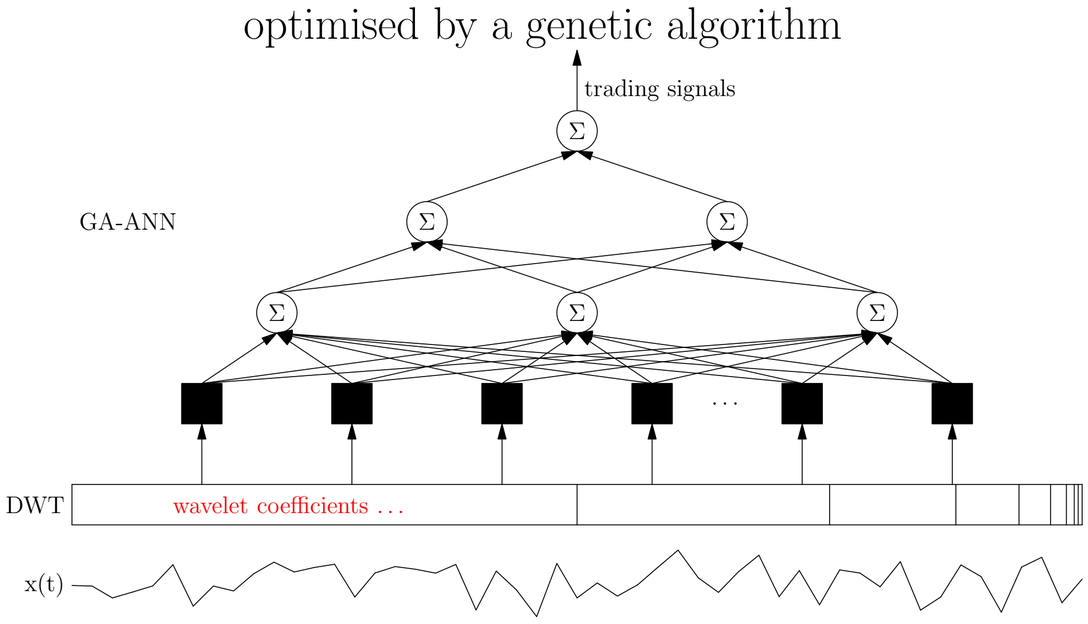
ザパート　クリストファー　データ同化研究開発センター　特任助教

1 Multiresolution Analysis (フラクタルと同様)

Wavelets + Neural Networks → NeuroWavelet

- fractals: natural basis for financial time series (Mandelbrot)
- Wavelet Transform resembles fractals in that it operates on multiple time scales
- early examples of fusing neural networks with wavelets can be found in papers by Murtagh et al.

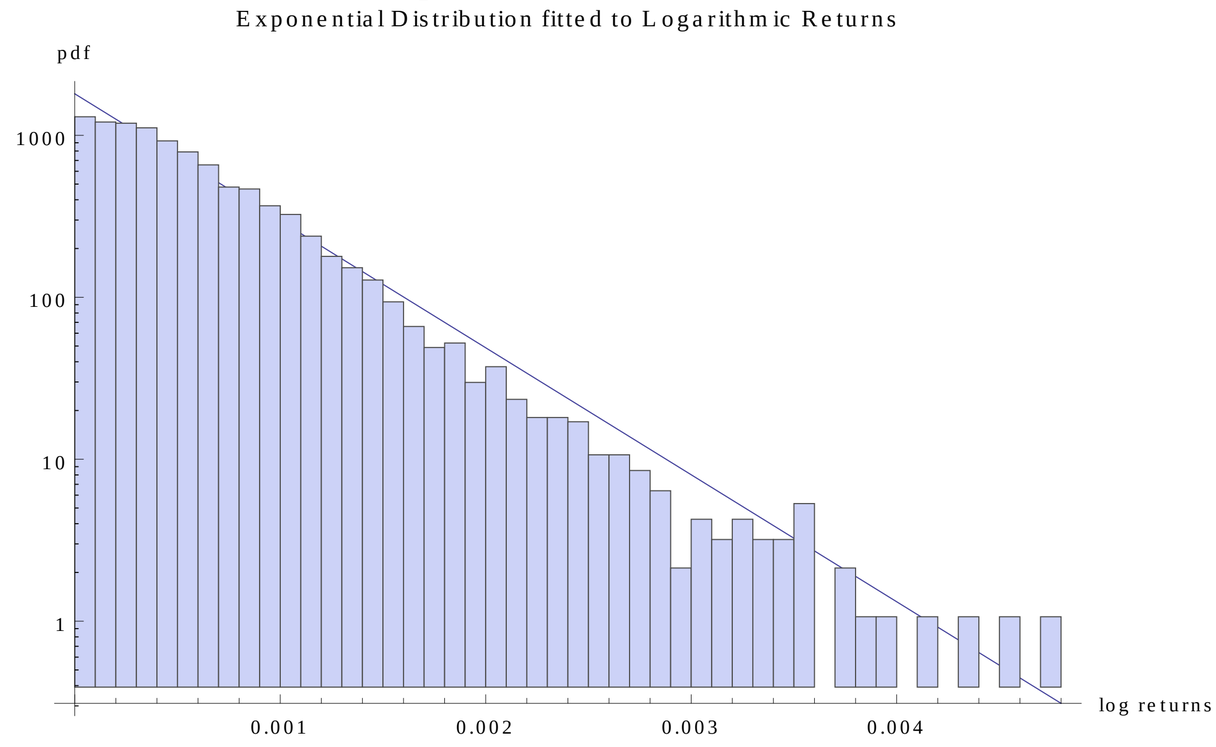
A NeuroWavelet architecture: artificial neural networks are optimised by a genetic algorithm



2 工程

- financial time series sampled discretely once every 1,000 ticks
- need to "stabilise" the samples in order to reduce non-stationarity and deal with changing volatility
- an exponential distribution $f(x, \lambda) = \lambda \exp^{-\lambda x}, x \geq 0$ is fitted to absolute values of logarithmic returns, parametrised by λ set to a reciprocal of the exponential moving average of absolute returns
- a discrete Biorthogonal Spline wavelet transform is applied to a window containing 32 samples of past volatility-adjusted financial returns $x(t)$ for the EUR/USD exchange rate
- extracted wavelet coefficients are passed as inputs to a small neural network, which is trained with genetic algorithms to output trading signals $y \in (-1, +1)$
- need to prune weights in order to prevent excessive over-fitting (fitting past data too closely without learning how to generalise knowledge to handle new unseen cases), which is a common problem in financial time series prediction

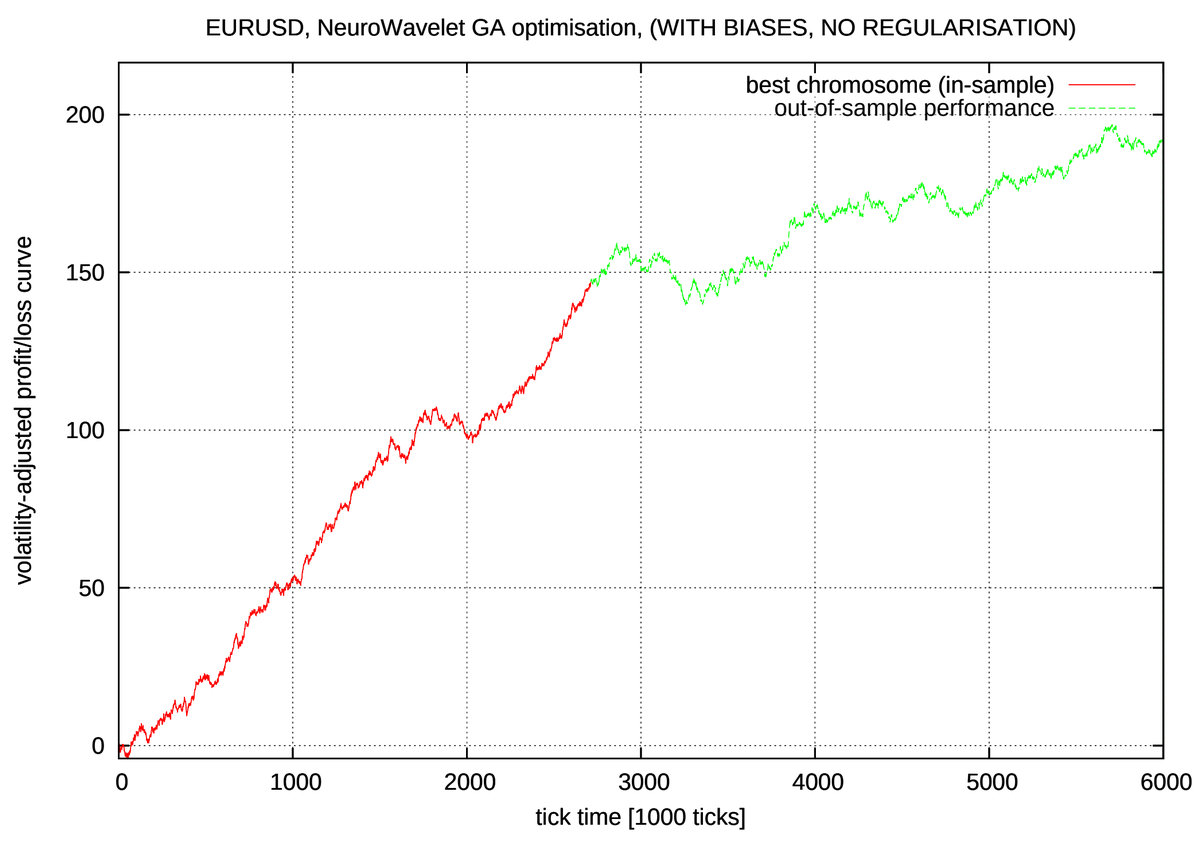
Absolute values of logarithmic returns approximated with the Exponential Distribution



3 weight prunning (regularisation)

- bias units are removed from all neurons to enforce $y(-x) = -y(x)$ (prevent over-fitting long one-sided bull or bear market phases)
- filtering of wavelet coefficients (which form an input space for neural networks) to remove spurious noise, achieved by minimising the sum-of-squares of input neuron weights
- maximisation of the separation of discovered input features (wavelet coefficients), achieved by imposing an orthonormalisation constraint on weights of input neurons (forcing input features to be uncorrelated)

4 Experimental results (OpenCLによるGPGPU)



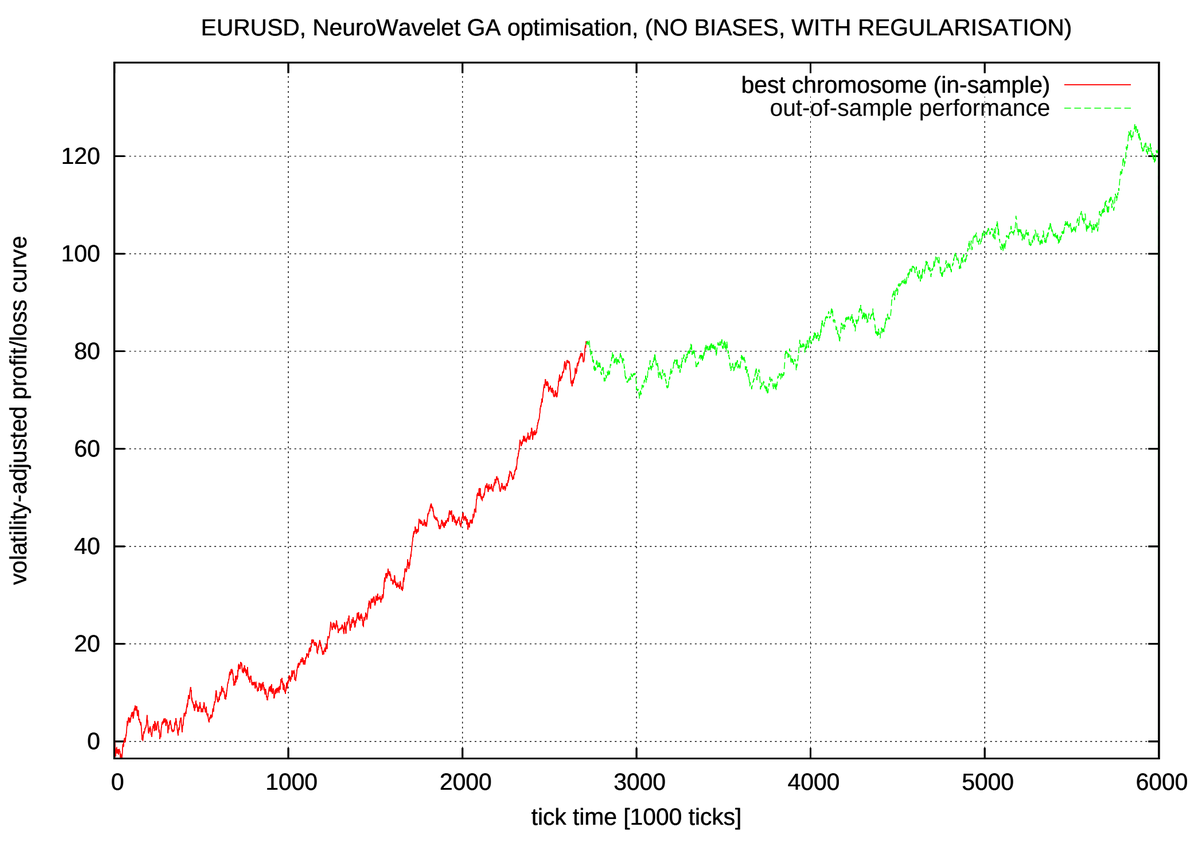


Table 1: Simulation results: no regularisation (left chart), compared with regularisation (right chart). Unseen test set performance marked in green.