# Experiments in Econophysics

リスク解析戦略研究センター　金融・保険リスク研究グループ
融合プロジェクト特任研究員　ザパート　クリストファー

## 1 Overview

The research attempts to analyse and predict financial time series (for example stock market indices, foreign exchange rates etc) using selected concepts and techniques from statistical physics, econophysics, behavioural finance and machine learning.

During the PhD research prior to October 2009 computer simulations of the new NeuroIsing architecture (see Zapart(2009a)) were carried out on a SONY PlayStation 3, which contains a multicore CELL processor. However, recently the computational power of NVIDIA graphics cards has overtaken the CELL CPU. As a result, after first learning NVIDIA CUDA programming, the NeuroIsing model has been migrated from the CELL to execute in a hybrid Intel CPU-NVIDIA GPU environment using Intel SSE and GPU CUDA instructions, as illustrated in figure 1. A risk-neutral regularisation term has also been added to the NeuroIsing fitness function in order to improve robustness to short-term trends. Alternatively one can consider using entropy regularisation by keeping the NeuroIsing model in the vicinity of the critical point, i.e. where the entropy reaches maximum sensitivity to the inverse temperature $\beta$. For NeuroIsing entropy and its derivatives can be obtained analytically as a function of $\beta$.

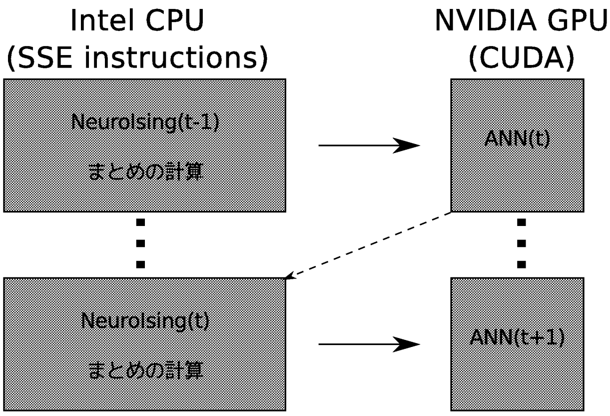


Figure 1: Hybrid CPU-GPU NVIDIA CUDA implementation of NeuroIsing. Multiple artificial neural networks execute as CUDA threads on the GPU. CPU gathers the results and performs parameter optimisation using genetic algorithms.

In addition, by taking advantage of the CUDA programming envi-

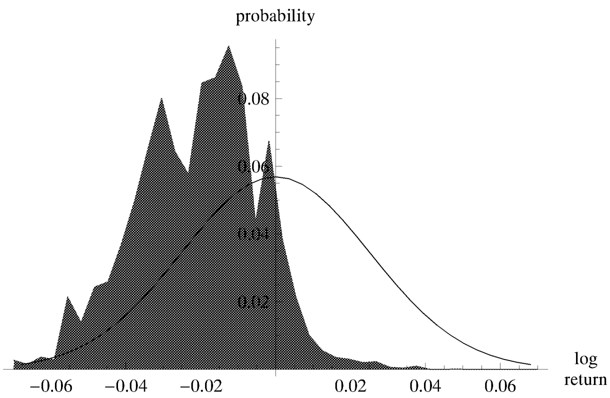


Figure 2: Entropy-adjusted Random Walk (blue filled plot) versus standard Random Walk (black solid line) for future logarithmic returns of the Nikkei 225 index as of 2010/01/15, just before major falls lasting over two weeks. According to the NeuroEntropy model the forward risk is skewed to the downside, in contrast with a symmetrical risk profile offered by the standard Random Walk model.

ronment, a new NeuroEntropy model has been developed building upon the author's previous publication Zapart(2009b). NeuroEntropy, being a form of an entropy-adjusted Random Walk model, can be used as a forward-looking short-term risk indicator in financial markets. However, the early version appearing in Zapart(2009b) used binary minority games which ignored the magnitude of returns in financial time series. This restriction can be removed by replacing binary agents with real-valued multilayer perceptron neural networks. Information-theoretic Shannon entropy is derived from a set of $N$ two-state neural networks using equation 1.1:

$$H = -\sum_{i=1}^{N} \left[ P(y_i = +1) \log P(y_i = +1) + P(y_i = -1) \log P(y_i = -1) \right] \tag{1.1}$$

where $P(y_i = +1)$ and $P(y_i = -1)$ are probabilities of the $i$th neural network being in the $+1$ or $-1$ state. Tsallis or Rényi entropies can also be used. Figure 2 shows an example of an asymmetric forward risk profile yielded by NeuroEntropy.

## 参考文献

Zapart, C. A.(2009a). Econophysics in Financial Time Series Prediction, PhD dissertation, SOKENDAI, Japan

Zapart, C. A.(2009b). On entropy, financial markets and minority games, Physica A: Statistical Mechanics and its Applications, 388:7, 1157-1172.