Experiments in Econophysics

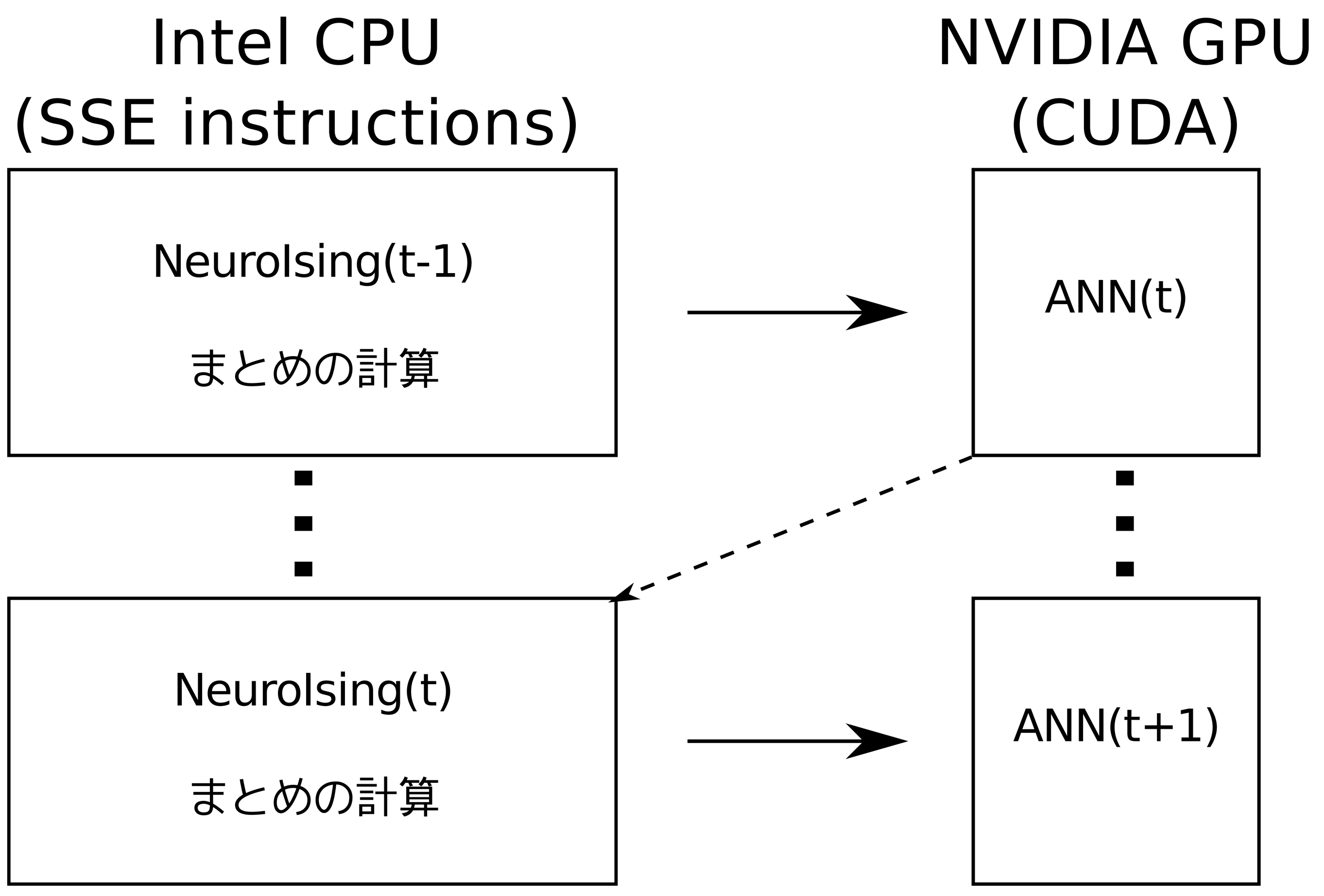
Christopher A. Zapart   Risk Analysis Research Centre

Introduction

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 (**entropy**, **Ising spin model**), econophysics (**NeuroEntropy**, **NeuroIsing**), behavioural finance (**irrational investors**) and machine learning (**neural networks**).

NVIDIA CUDA & OpenCL

- initially NeuroIsing was implemented on the **IBM CELL** Broadband processor present in **SONY PLAYSTATION 3**
- at present training artificial neural networks inside NeuroEntropy and NeuroIsing models has been offloaded onto **NVIDIA GPU** using CUDA C extensions
- this results in a hybrid CPU-GPU implementation. Multiple artificial neural networks execute as CUDA threads on the GPU. CPU gathers the results and performs parameter optimisation using genetic algorithms



- GPU vendor-independent **OpenCL** implementation has also been prepared in order to future-proof the code
- compared with **NVIDIA**, OpenCL-support on much faster **ATI** graphics cards is considered more mature and efficient
- OpenCL code can also run unchanged on CPUs with **SIMD** vector instructions support

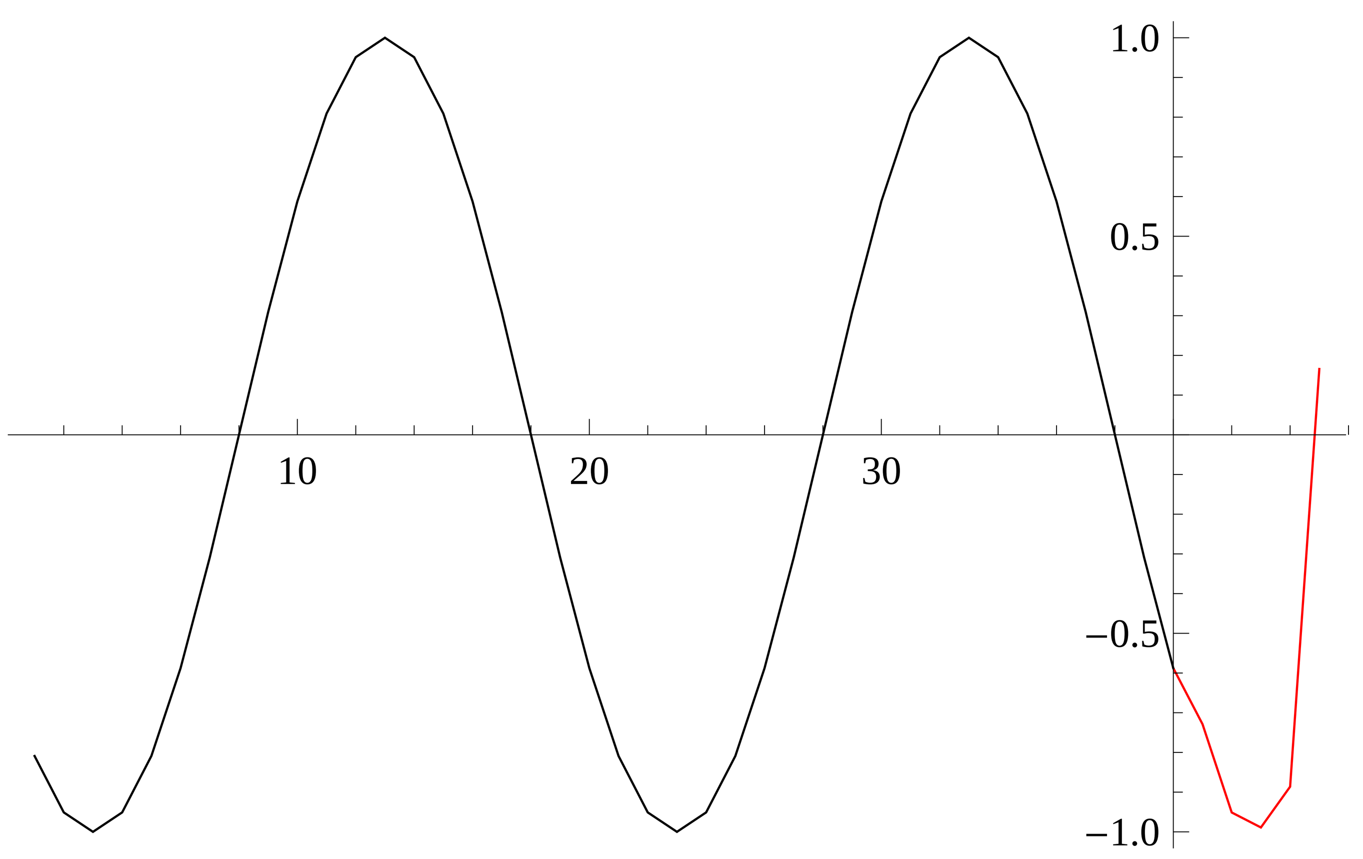
NeuroEntropy

- **purpose**: directional forecasting several ΔT steps ahead of stock market indices
- **entropy-adjusted** Random Walk model that can be used as a forward-looking short-term risk indicator in financial markets
- the estimated information-theoretic **entropy** $H(t)$ for given time series $x(t)$ is derived from a set of N **two-state** neural networks using the following equation:

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

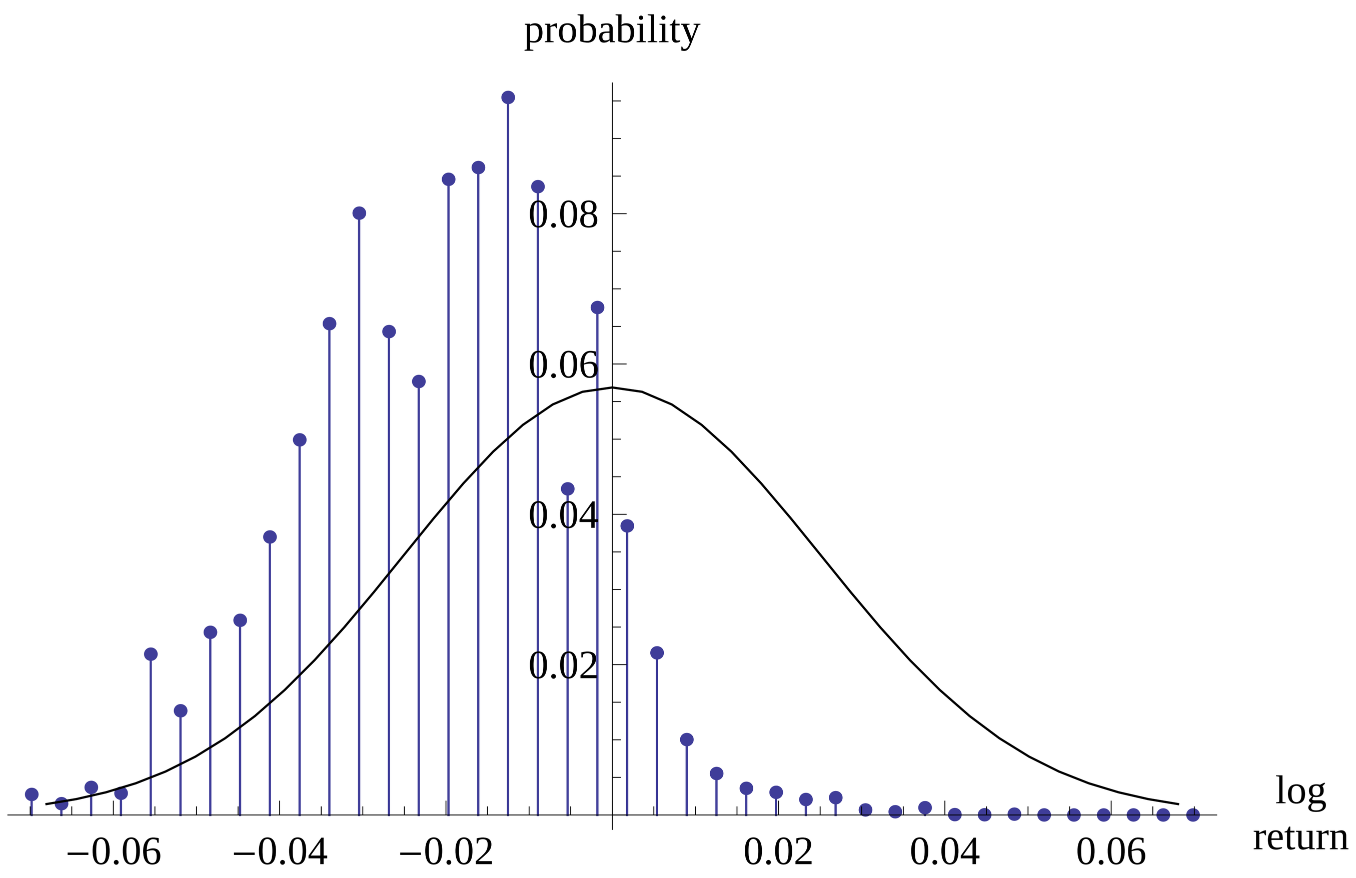
- a separate small **neural network** is used to forecast entropy time series $H(t)$

toy problem - reconstructing a sine wave



- a discretely-sampled sine function is predicted $\Delta T = 5$ steps ahead
- the red curve in the chart above shows the most probable future path as recovered by **NeuroEntropy**
- potential **path candidates** have been sampled randomly from a uniform distribution $U(-1, 1)$

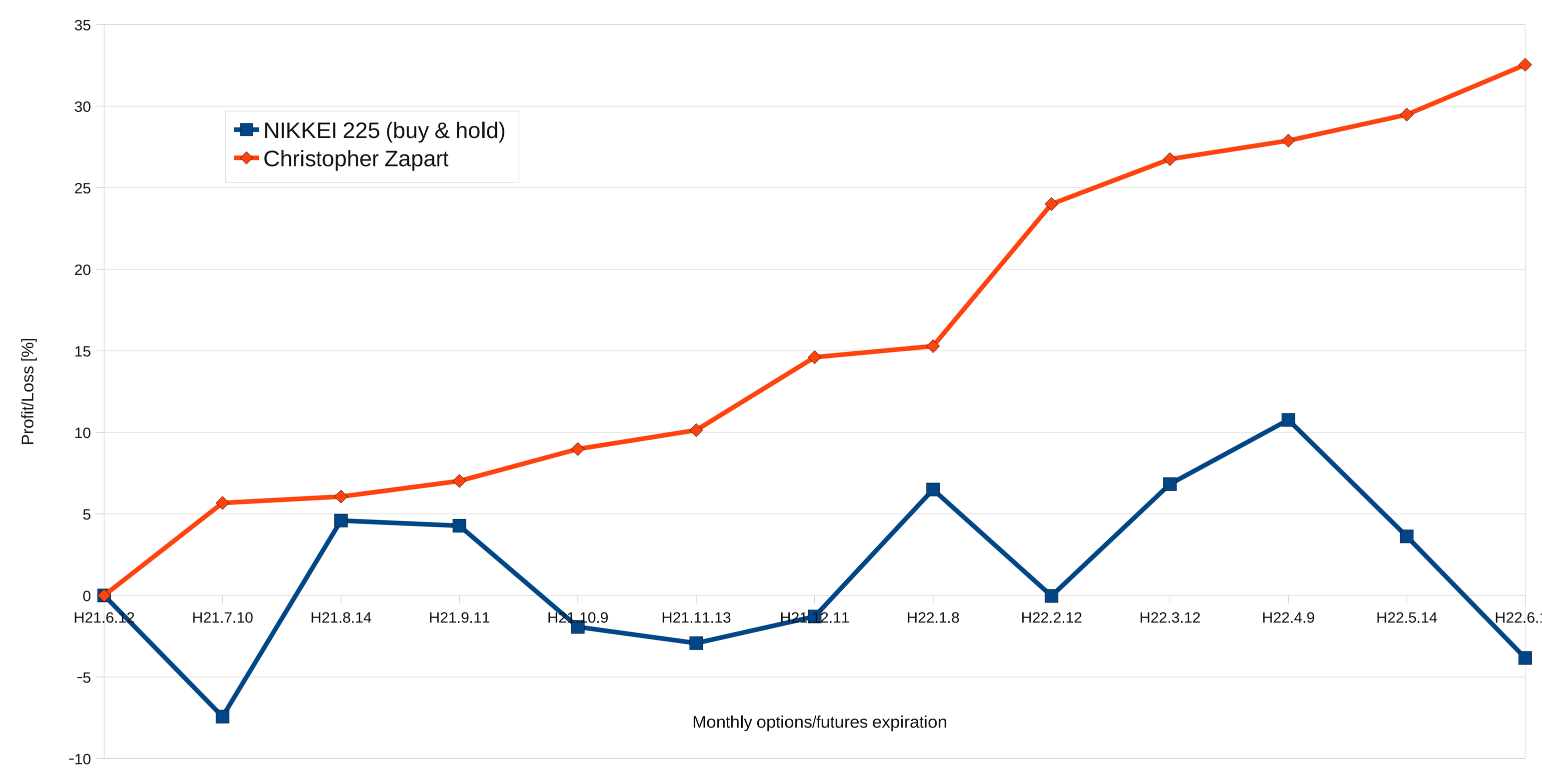
forecasting Nikkei 225 Japanese stock market index



- the above chart shows **entropy-adjusted** Random Walk (blue) 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 correctly to the downside, in contrast with a **symmetrical** risk profile offered by the standard Random Walk model

real trading the econophysics way

- *mainstream economics* lacks models for successful directional prediction of stock markets
- instead it emphasises the **Random Walk** and passive **buy and hold** investment strategies
- what is **random noise** to economists may be the source of trading profits to **econophysicists**



- the above chart shows a real trading performance of the author, carried out between June 2009 and 2010, based on wavelets, author's **NeuroEntropy**, **NeuroIsing** and own intuition
- trading centred around Nikkei 225 **options** and **futures**
- one year of *active* trading resulted in a gain of $+32.5\%$ and lower risk compared with a -3.8% loss for riskier passive *buy and hold*
- **all transaction costs** are included

writing a book (under-way)

Title: Experiments in Econophysics
Subtitle: A scientific guide to trading in financial markets
Author: Christopher Andrew Zapart

Working abstract:
Recently there has been an increase in interest in econophysics from physicists, statisticians and economists as well as practitioners (investment professionals, quantitative analysts and traders). Computer-minded investors and hedge fund managers alike could benefit from being able to enhance their trading with new modelling techniques emerging from the field of econophysics. Yet there is a distinct lack of publications accessible to readers unfamiliar with advanced theoretical concepts in mathematics and physics. The book attempts to fill in this gap by demonstrating two econophysics forecasting/trading models developed by the author: *NeuroEntropy* and *NeuroIsing*. Readers are led step by step through applying the new concepts to trading stock market indices and foreign exchange rates futures. Examples and simulations included in the book have been coded mainly in PyCUDA taking advantage of an interactive Python environment and fast GPGPU execution on NVIDIA graphics cards. An implementation in C using both Intel SSE and CELL AltiVec vector extensions is also explained. Some readers might be interested in trying out the included vendor-independent OpenCL code that executes across a range of different graphics cards and CPUs.