Task & Data Analysis

Name of Dataset: Ising Model
Date: March 12, 2006
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File: spins-1.data (… spins-x.data) ; magnet-1.data (… magnet-x.data)
Format: text; blank-, return- and “!” - separated
The spin-files contain n “pictures” of 100 times 100 states of spins (either up or down, -1 or 0). Rows are separated by “returns”, pictures are separated by “!” and the end is marked by “!?”.

The information of the parameters is given in the magnet-files:

External Magnetic Field: (*Aeusseres Magnetfeld*): 0.000000
The Coupling is started at: (*Kopplung gestartet bei*): 0.300000
…for njj different couplings the values were calculated: *(...fuer soviele Kopplungen*): 0
…in steps of *(...in Schritten von*): 0.000000
Measures (=pictures) per coupling (*Messungen pro Kopplung*): 100
Equilibration steps (calculated before but not in the data set) (*Equilibrierungsschritte*): 50

Scenario

The Story:

The Ising model is a simulation of systems determined by next neighbor interaction and a statistical quantity like temperature. It was developed by Ernst Ising in the 1930s in order to describe magnetization: each atom is given a magnetic spin “up”(1) or “down”(-1), and (the four) neighboring atoms try to magnetize it (it costs energy to take a spin different from the neighbor’s parity). Temperature causes randomly distributed movements (Brownian Movement).

For a given system, there exists a critical temperature Tc (Curie-temperature), above which the states change randomly. Below the Tc the system will finally be magnetized in one parity (but always will have random contributions depending on the temperature). The closer T is to Tc, the more the median magnetization (of all spins in one picture) is oscillating against its mean value.
(The model parameter j for coupling is inversely proportional to the temperature; Tc corresponds to j=0.42 for magnetic field=0.)
A system will *try to achieve its equilibrium state* between the two competing processes.

There are given data sets for different settings:

From an imposed initial state (50% of spins up and 50% down) the system reaches its equilibrium. Two examples have been recorded:
- For T > Tc there is no continual development; big islands are alternating, and when one parity seems to have won, the system still might change completely. (<u>spins-6.data</u>)
- For T < Tc, one parity seems to dominate after about a half of pictures recorded, but there are still a lot of thermal oscillations. (<u>spins-5.data</u>)

As there have been calculated nequi pictures before, (which have not been recorded,) the data files are supposed to show the equilibrium state from the beginning on.
Three cases have been recorded:
- high temperature causes (random) Brownian Movement (<u>spins-2.data</u>);
- at the point of phase transition, the situation is undecided and the oscillations are the biggest (<u>spins-3.data</u>);
- for a low temperature one parity has “won” (<u>spins-4.data</u>).

For different values of coupling, the phase transition may be studied. In example <u>spins-1.data</u>, the coupling is gradually increased in small steps (that is the temperature is slowly taken down). For each coupling, the system is equilibrated before. The phase transition may be observed after about half of the pictures.

The task within this data set is to find a way to sonify the development of the whole system; the <u>overview</u> is more important than next-neighbors’ interaction.
A <u>qualitative difference shall be detected for the phase transition (spins-3.data)</u>: random behavior (spins-2.data)

shall be differentiated from a surplus of one parity (spins-4.data). The gained knowledge may be implemented to spins-1.data to find the point of phase transition (as the data set is rather big, pictures might be skiped).
The sonification shall be extendable for more dimensions, offering an advantage versus visualization (i.e. a film); either it reveals more detailed information or it allows a faster replay.

A second task might be to decide, when a system has found its equilibrium by sonifying/audifying the spins-5 and spins-6.data.

The Keys:

Question:	What is the development of the model?
Answers:	Single points: parity up / parity down / random / other (for instance two stable stripes of “up” and “down”). The system stays random / it develops (slowly / faster) towards a primacy of one parity / stable strips emerge. T > or < Tc.
Subject:	Distributions of spin values on a 2D grid, Evolution over time
Sounds:	Audification, simple modulation

The Task:

Generic question:	What is it? What will it be finally?
Purpose:	identify, compare
Mode:	Interactive
Type:	Discrete
Style:	Exploration

The Data/Information:

Level:	Intermediate, global
Reading:	Direct
Type:	periodic change
Range:	Coupling 0.3 – 0.5 Magnetic Field -1 to +1 Size: 100 rows and columns
Organisation:	2D frames, time

The Data:

Type:	Time-series of 2D grids
Range:	values: 0 or 1, time: 0-n steps, external params: temperature (0-10?), grid size (16-400),
Organisation	Time, index I, J