CellularAutomataDemos

Demos to show how to compute local information dynamics profiles in cellular automata

CellularAutomata, octave, matlab

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This demonstration set shows how to compute local information dynamics profiles in (1D) cellular automata (CAs).

It is written for Matlab or Octave.

This demonstration set is found at demos/octave/CellularAutomata/ in the svn or full distribution.

Code design

`plotLocalInfoMeasureForCA.m` is the main file, which you call supplying arguments specifying the CA, and which local information dynamics measure to profile:

```
% function plotLocalInfoMeasureForCA(neighbourhood, base, rule, cells, timeSteps, measureId, measureParams, options)
%
% Plot one run of the given CA and compute and plot a local information dynamics profile for it
%
% Inputs:
% - neighbourhood - neighbourhood size for the rule (ECA has neighbourhood 3).
%     For an even size neighbourhood (meaning a different number of neighbours on each side of the cell),
%     we take an extra cell from the lower cell indices (i.e. from the left).
% - base - number of discrete states for each cell (for binary states this is 2)
% - rule - supplied as either:
%     a. an integer rule number if <= 2^31 - 1 (Wolfram style; e.g. 110, 54 are the complex ECA rules)
%     b. a HEX string, e.g. phi_par from Mitchell et al. is "0xfeedffdec1aaeec0eef000a0e1a020a0" (note: the leading 0
% - cells - number of cells in the CA
% - timeSteps - number of rows to execute the CA for (including the random initial row)
% - measureId - which local info dynamics measure to plot - can be a string or an integer as follows:
%    - "active", 0 - active information storage (requires measureParams.k)
%    - "transfer", 1 - apparent transfer entropy (requires measureParams.k and j)
%    - "transfercomplete", 2 - complete transfer entropy (requires measureParams.k and j)
%    - "separable", 3 - separable information (requires measureParams.k)
%    - "all", -1 - plot all measures
% - measureParams - a structure containing options as described for each measure above:
%    - measureParams.k - history length for information dynamics measures
%    - measureParams.j - we measure information transfer across j cells to the right per time step
% - options - a stucture containing a range of other options, i.e.:
%    - plotOptions - structure as defined for the plotRawCa function
%    - seed - state for the random number generator used to set the initial condition of the CA (use this
%       for reproducibility of plots, or to produce profiles for several different measures of the same CA raw states
%       We set rand("state", options.seed) if options.seed is supplied, and restore the previous seed afterwards.
%    - plotRawCa - default true
%    - saveImages - whether to save the plots or not (default false)
%    - movingFrameSpeed - to investigate a moving frame of reference (default 0) (as in Lizier & Mahoney paper)
```

Running

Several scripts are available demonstrating how to call `plotLocalInfoMeasureForCA.m` to generate the desired figures; see:

- demos/octave/CellularAutomata/GsoChapterDemo2013.m to generate figures for: J.T. Lizier, M. Prokopenko and A.Y. Zomaya, "A framework for the local information dynamics of distributed computation in complex systems", in Guided Self-Organization: Inception, edited by M. Prokopenko, pp. 115-158, Springer, Berlin/Heidelberg, 2014;
- demos/octave/CellularAutomata/DirectedMeasuresChapterDemo2013.m to generate figures for J.T. Lizier,"Measuring the dynamics of information processing on a local scale in time and space", in "Directed Information Measures in Neuroscience", ed. M. Wibral, R. Vicente, J.T. Lizier, Springer, to be published, 2013;
- demos/octave/CellularAutomata/TeBook2013.m to generate figures for chapter 5 of T. Bossomaier, L. Barnett, M. Harré and J.T. Lizier, "An Introduction to Transfer Entropy: Information Flow in Complex Systems", Springer, to be published, 2013.
- demos/octave/CellularAutomata/movingFrame.m to generate figures for: J.T. Lizier, J.R. Mahoney, "Moving frames of reference, relativity and invariance in transfer entropy and information dynamics", Entropy, vol. **15**, no. 1, p. 177-197, 2013; doi: 10.3390/e15010177

In brief, the steps that these scripts demonstrate are as follows:

Make sure that the jar location is entered correctly in `plotLocalInfoMeasureForCA.m`

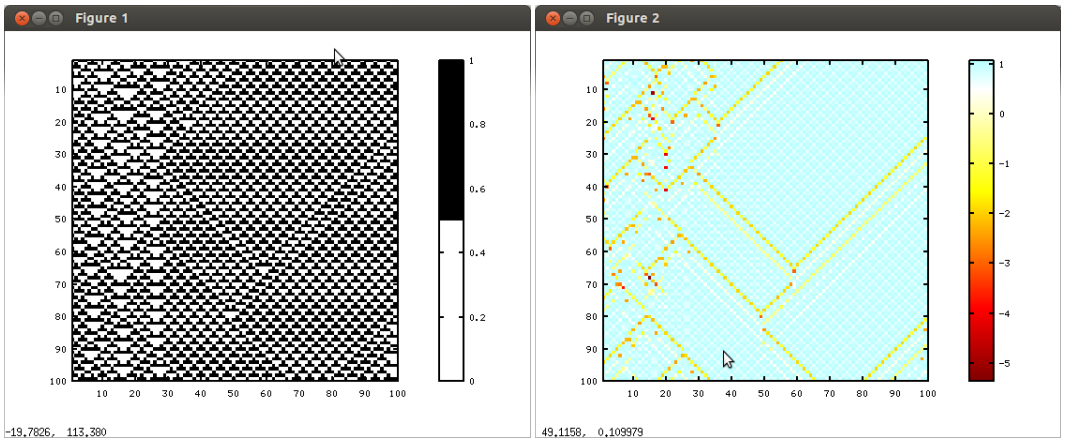
Set up the `measureParams` and `options` structures, e.g.:

```
measureParams.k = 16; % History length of 16 for info dynamics measures
options.plotOptions.plotRows = 100; % plot only 100 rows
options.plotOptions.plotCols = 100; % plot only 100 columns
options.plotOptions.plotStartRow = 100; % plot from row 100 onwards
options.plotOptions.plotStartCol = 100; % plot from column 100 onwards
```

Then call to plot a CA and a given local information dynamics profile, e.g. for ECA rule 54 and plotting local active information storage:

```
plotLocalInfoMeasureForCA(3, 2, 54, 10000, 600, "active", measureParams, options);
```

with sample results as follows:

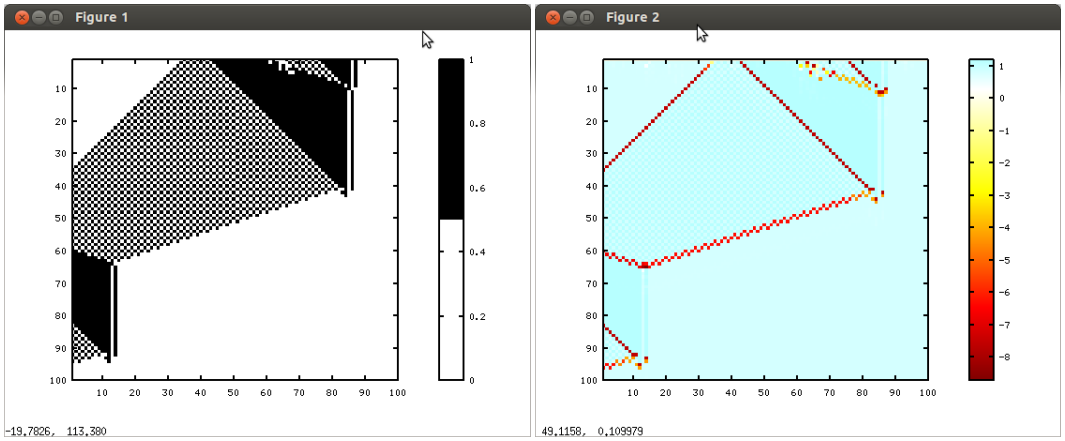


Or for the neighbourhood 7 rule \phi_par from Mitchell et al. (see this paper):

```
measureParams.k = 10; % History length of 10 for info dynamics measures
options.plotOptions.plotRows = 100; % plot only 100 rows
options.plotOptions.plotCols = 100; % plot only 100 columns
options.plotOptions.plotStartRow = 10; % plot from row 100 onwards
options.plotOptions.plotStartCol = 100; % plot from column 100 onwards

plotLocalInfoMeasureForCA(7, 2, "feedffdec1aaeec0eef000a0e1a020a0", 10000, 1000, "active", measureParams, options);
```

with sample results as follows:



To make several local information profiles for the one CA run (with the same initial CA state for each plot), set `options.seed` to a fixed value, and call `plotLocalInfoMeasureForCA` for each measure separately.

References

The code can also be used to reproduce results from the following papers (these were originally produced with an earlier toolkit):

- J.T. Lizier, M. Prokopenko and A.Y. Zomaya, "Local information transfer as a spatiotemporal filter for complex systems", *Physical Review E*, vol. **77**, 026110, 2008. doi: 10.1103/PhysRevE.77.026110
- J.T. Lizier, M. Prokopenko and A.Y. Zomaya, "Information modification and particle collisions in distributed computation", *Chaos*, vol. **20**, no. 3, 037109, 2010; doi: 10.1063/1.3486801
- J.T. Lizier, M. Prokopenko and A.Y. Zomaya, "Local measures of information storage in complex distributed computation", *Information Sciences*, vol. **208**, pp. 39-54, 2012; doi: 10.1016/j.ins.2012.04.016

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