Pattern Recognition in Networks

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Contents

Miranda, G. H. B. et al. Exploring Spatio-temporal Dynamics of Cellular Automata for Pattern Recognition in Networks. Sci. Rep. (2016).

Complex Systems

https://www.quantamagazine.org/the-simple-algorithm-that-ants-use-to-build-bridges-20180226/

Complex Systems

Agents or simple elements

Non linear interactions

No central control

Emergent behavior

Networks

Nodes

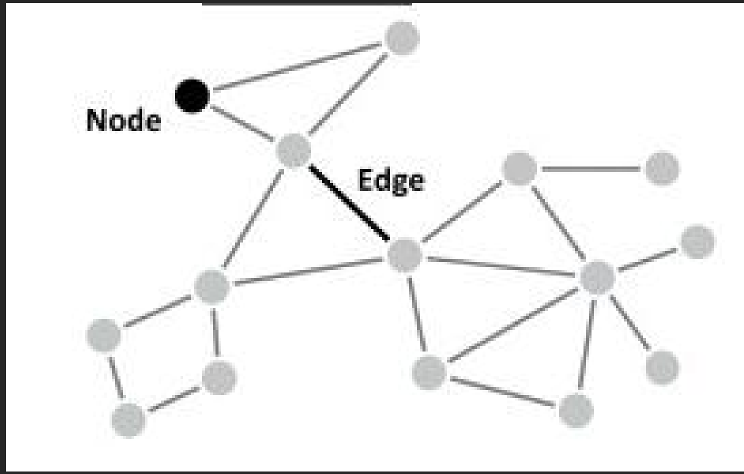
Edges

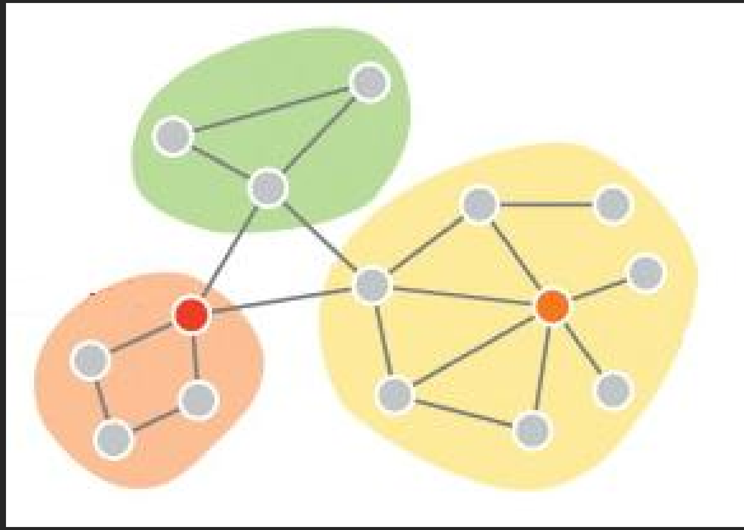
Degree of a node

Degree distribution

Distance and path

Clustering





Networks: Properties

Small world

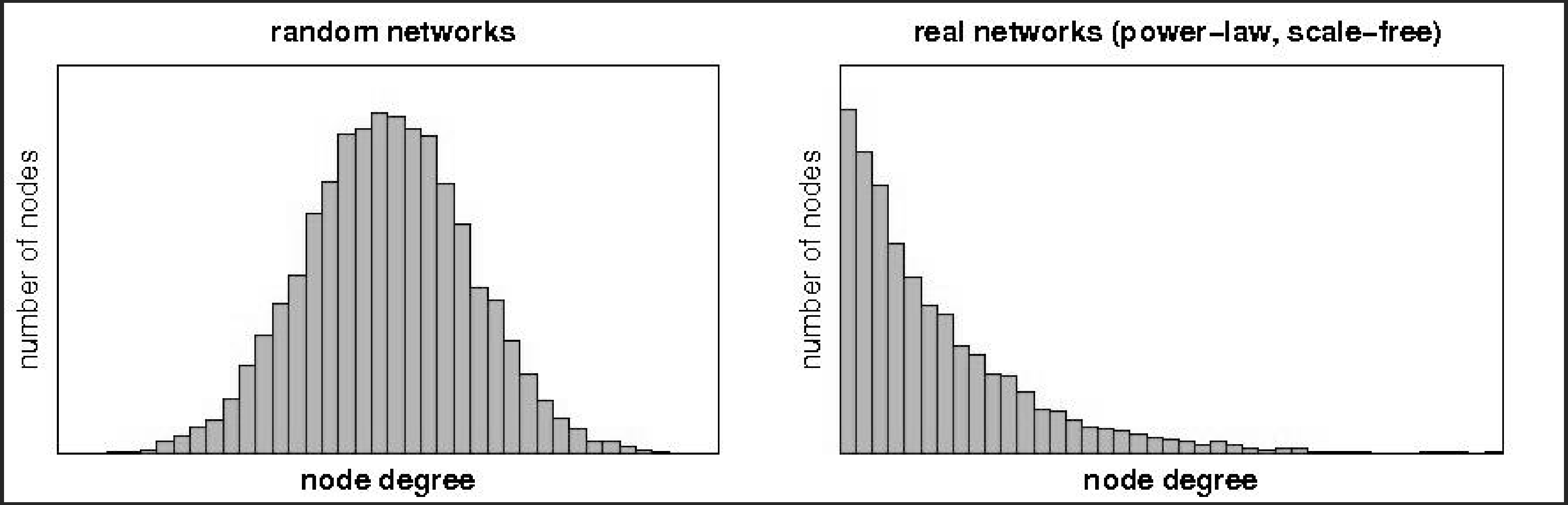
Long-tailed degree distribution

Clustering and community structure

Robustness to node failure

Vulnerability to hub attacks

Networks: Scale free and Long-tailed



Most real world networks have long-tailed degree distributions

Cellular Automata

Idealized models of complex systems

Large networks of simple components

Limited communication among components

No central control

Complex dynamics, simple rules

Cellular Automata

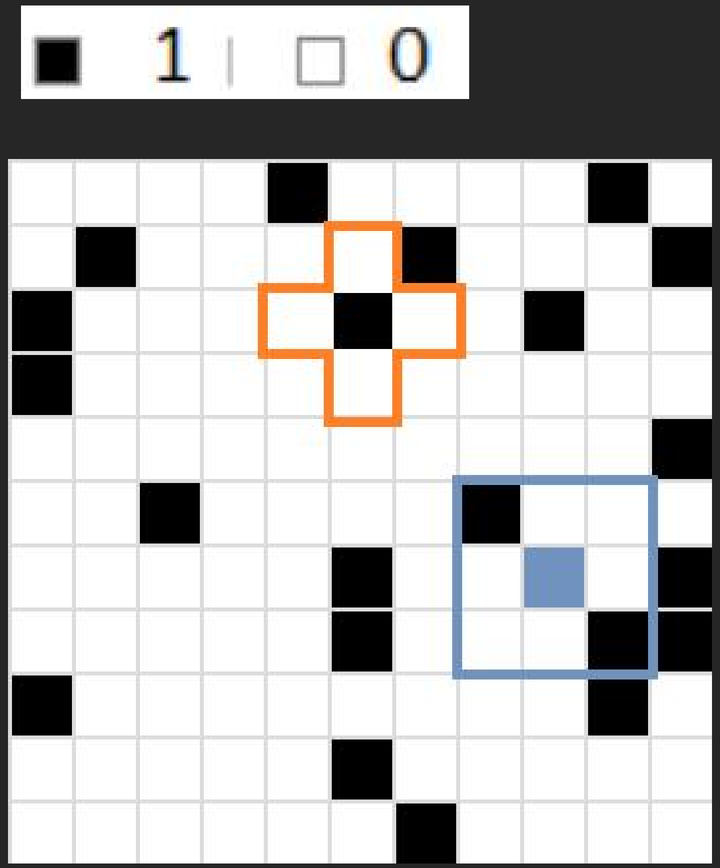
T: tesselletion

S: states

s_0: initial configuration

N: neighborhood

ϕ: transition rules



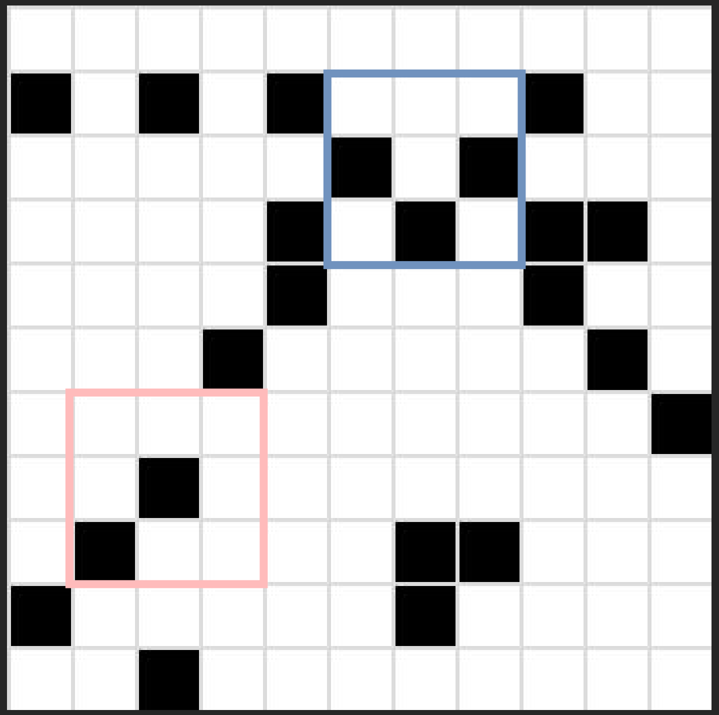
Von Neumann: 4 neighbors

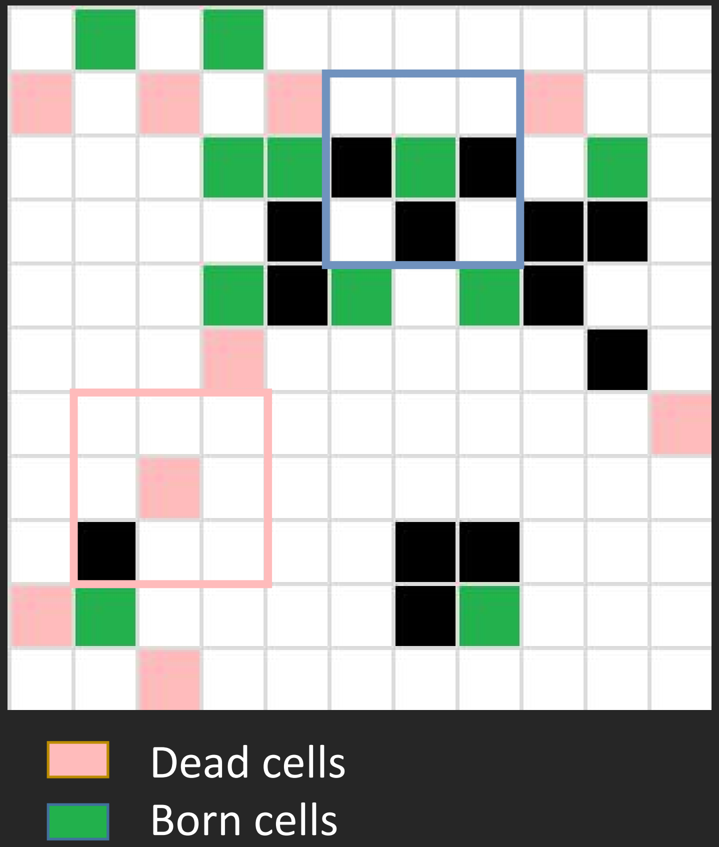
Moore: 8 neighbors

Cellular Automata: Transition rules

Conway's Game of Life B3 / S23

Life like rule: Birth: 3 / Survival: 2 or 3





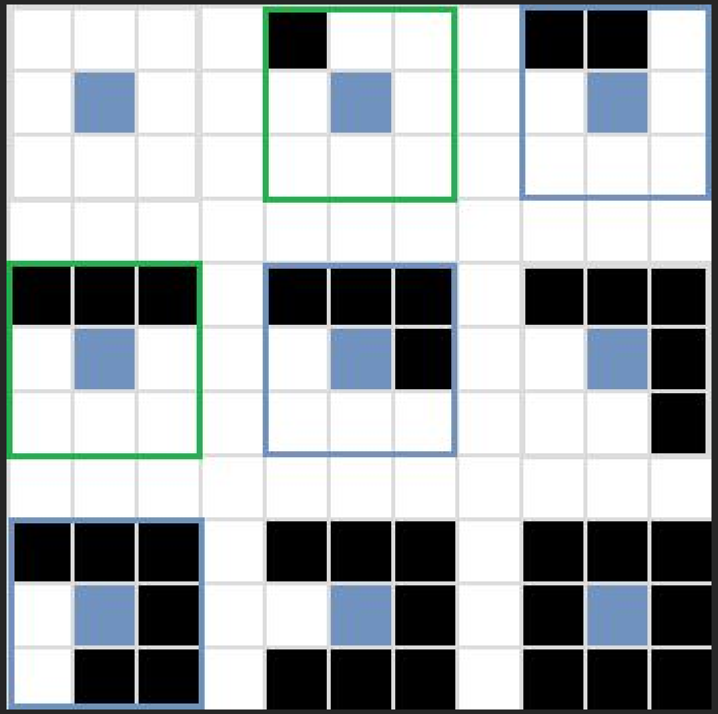
Cellular Automata: Transition rules

Nine (9) possible neighborhood configurations

{0, 1, 2, 3, 4, 5, 6, 7, 8} neighbors

Rules B13 / S246

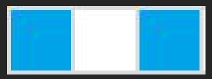
- Birth 1 or 3 cells needed
- Survival 2 or 4 or 6 needed



Elementary Cellular Automata, ECAs

One dimensional

Two neighbors

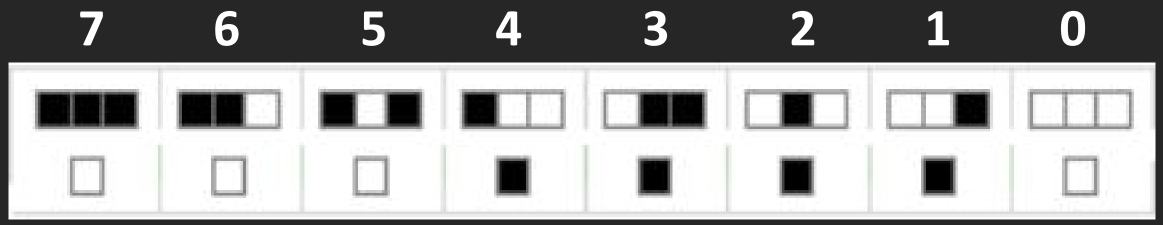


Eight configurations

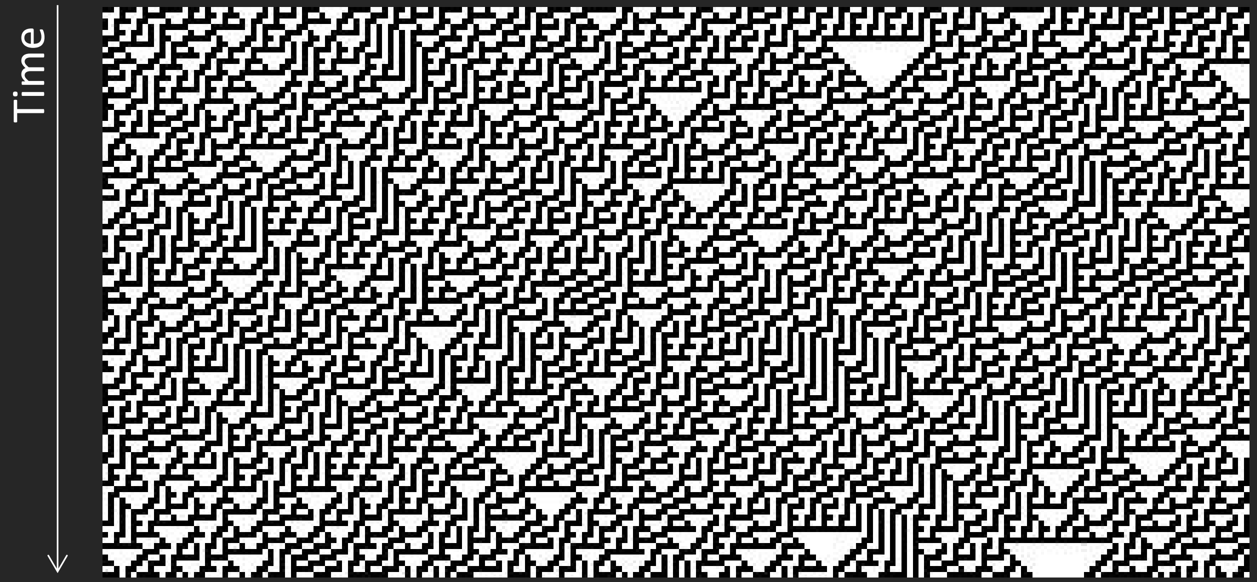
Two output states: 0 or 1

$2^8 = 256$ possible ECAs

Rule 30 patented
by Stephen Wolfram



Rule 30



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Exploring Spatio-temporal Dynamics of Cellular Automata for Pattern Recognition in Networks

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Network science is an interdisciplinary field which provides an integrative approach for the study of complex systems. In recent years, network modeling has been used for the study of emergent phenomena in many real-world applications. Pattern recognition in networks has been drawing attention to the importance of network characterization, which may lead to understanding the topological properties that are related to the network model. In this paper, the Life-Like Network Automata (LLNA) method is introduced, which was designed for pattern recognition in networks.

Pattern Recognition in Networks

Networks and Cellular Automata

Classify networks using cellular automata.

Use a network to model the behavior of CAs

LLNA: Life-like Network Automata

LLNA

Modeling CAs over irregular tessellations.

Network topology as a tessellation for CAs

Evolving networks through the use of CAs

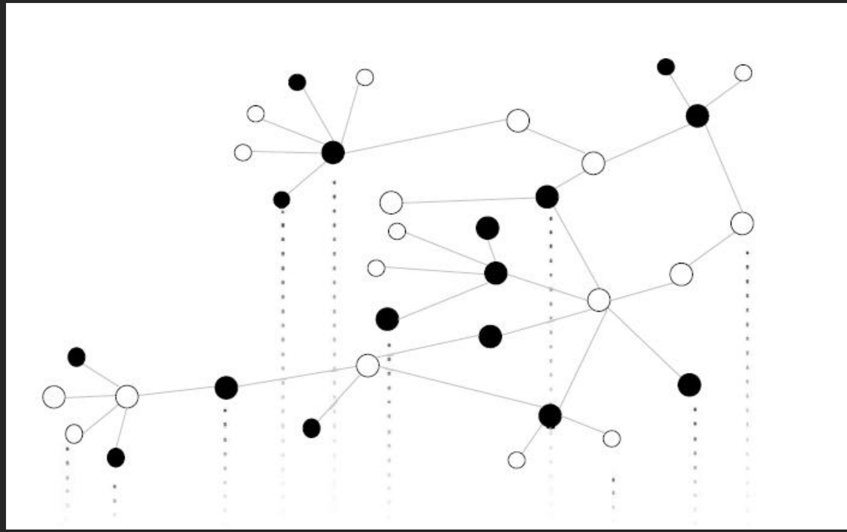
The space-temporal pattern formed from the evolution is used as feature vector

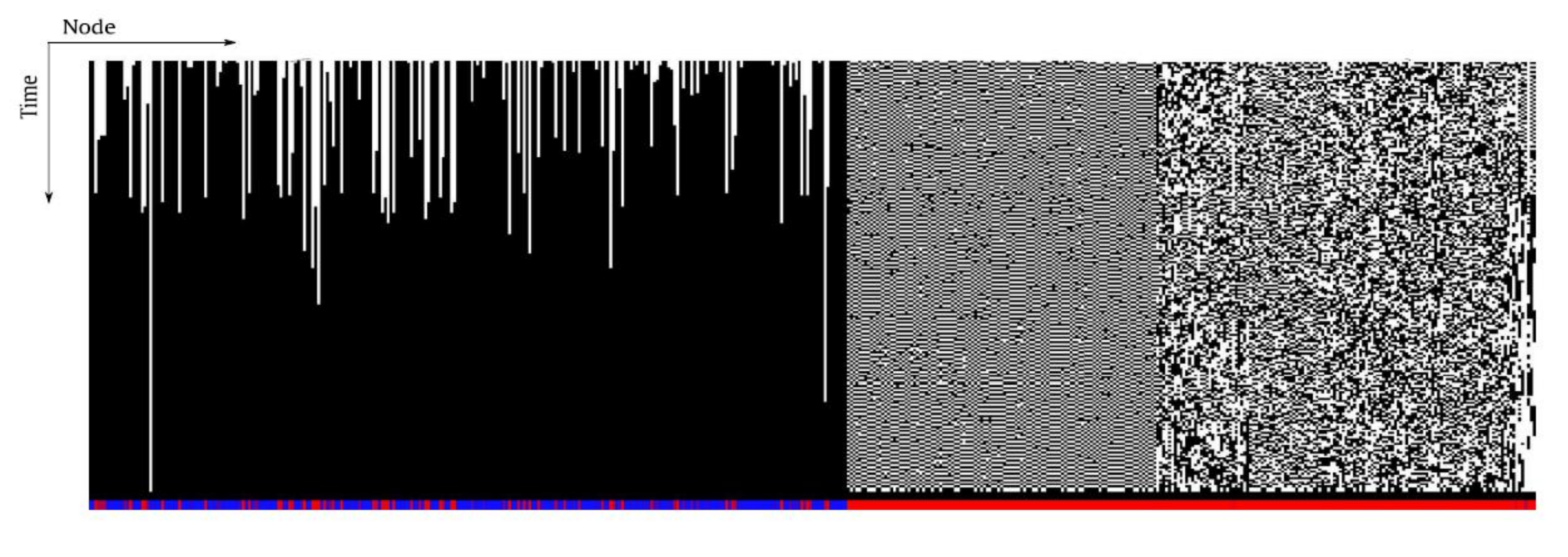
LLNA

T: tesselletion: topology network

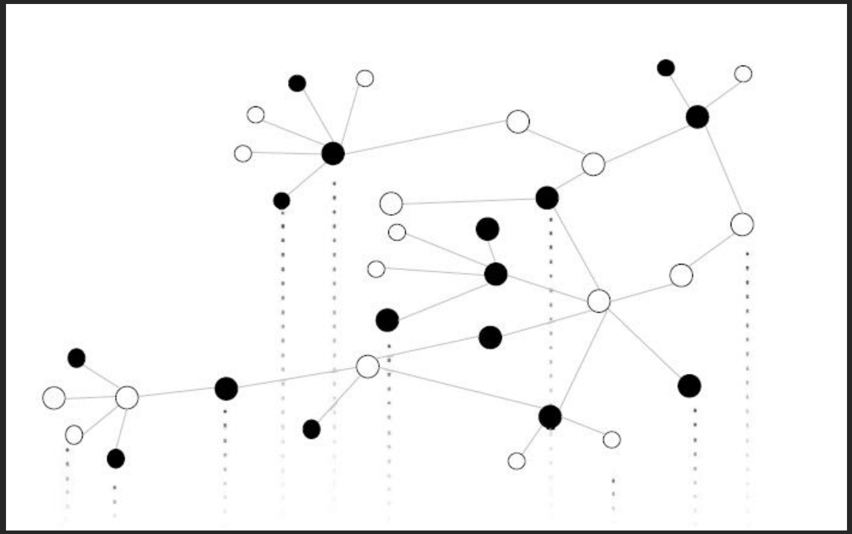
S: states: 0 or 1

Nodes ordered by degree





LLNA



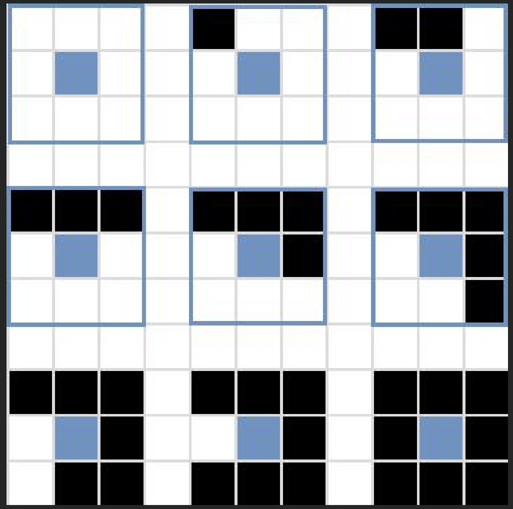
N: neighborhood

Mapping: density of living neighbors to Life-like rule

ϕ: transition rules

B_x / S_y x: {0, 1, 2, ..., 8}, y: {0, 1, 2, ..., 8}

$2^{(9+9)}$ = 262144 possible Life-like rules



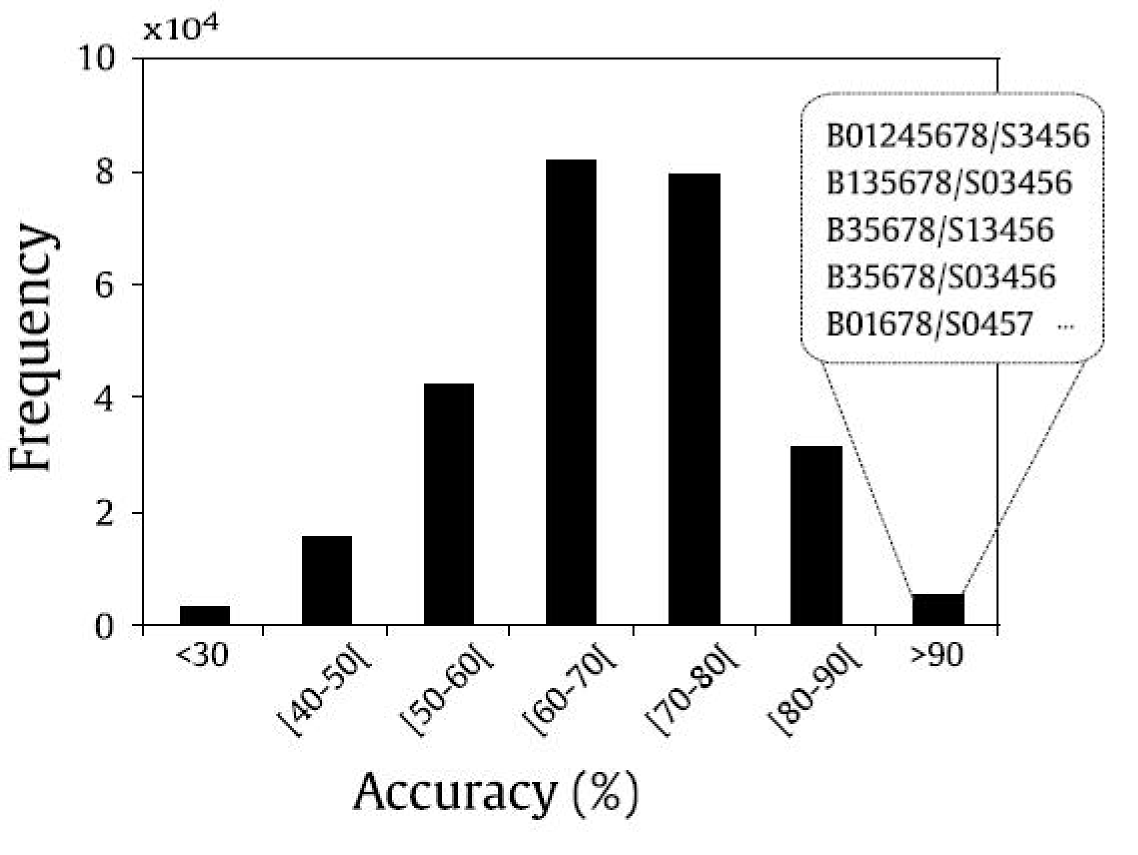
LLNA: Parameters

Exploring space of possible rules to select those resulting in best accuracy

B01678 / S0457

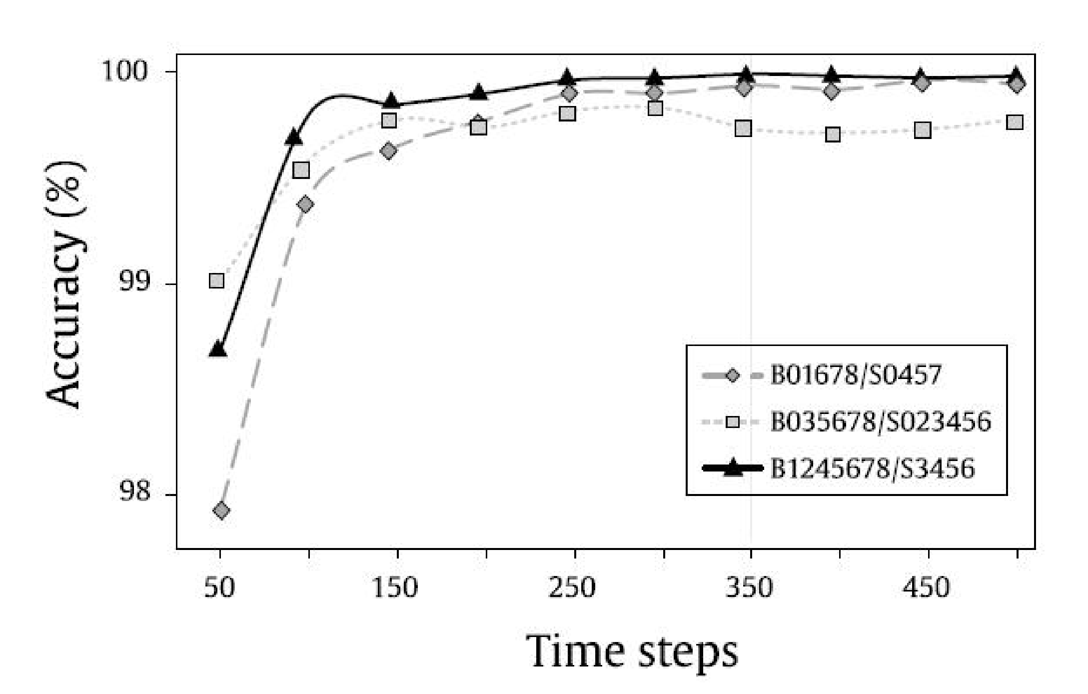
Birth: {0, 1, 6, 7, 8}

Survival: {0, 4, 5, 7}

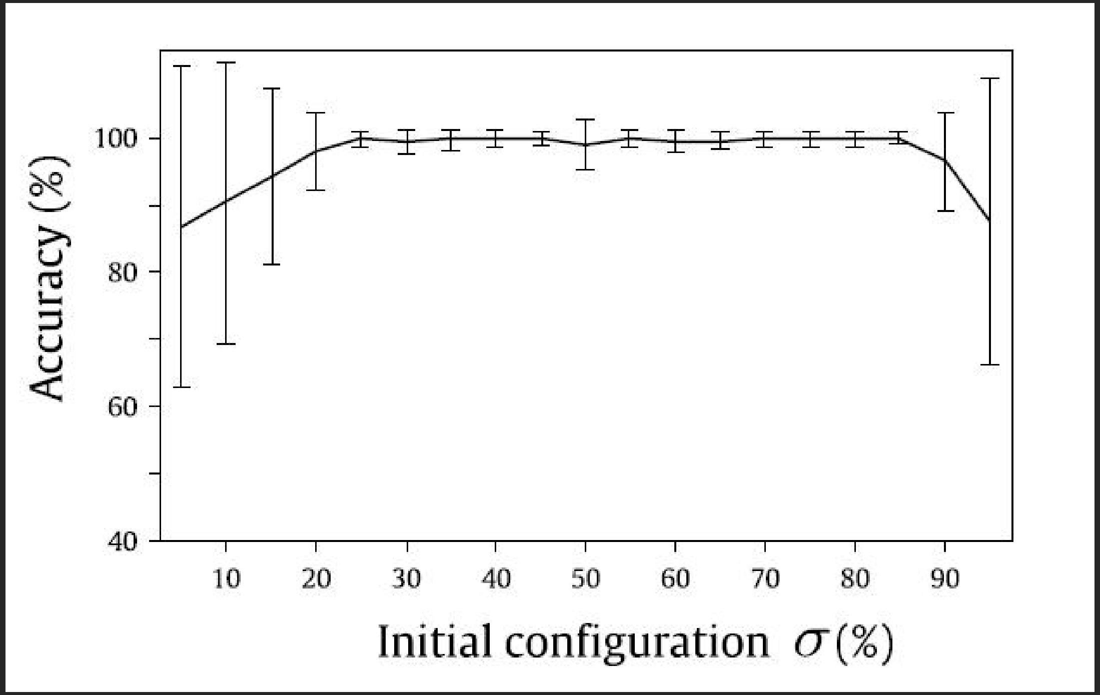


LLNA

Number of iterations: 350



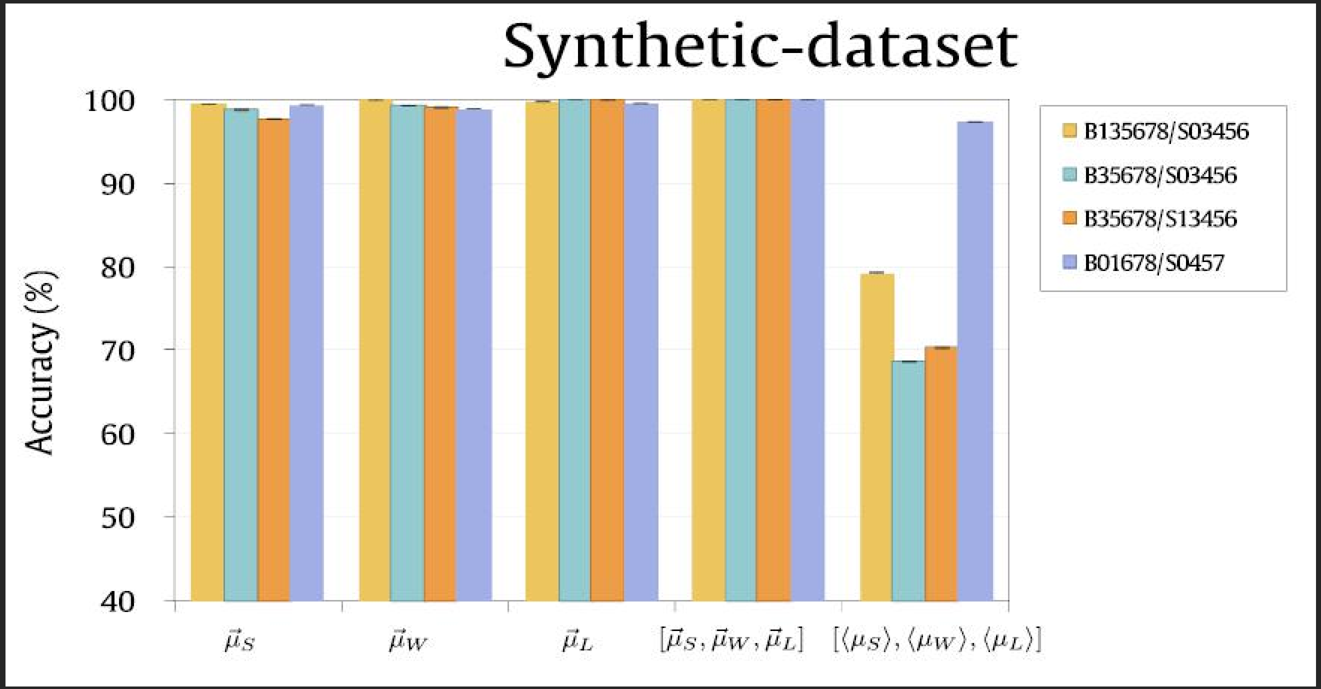
s_0: initial configuration: 50%



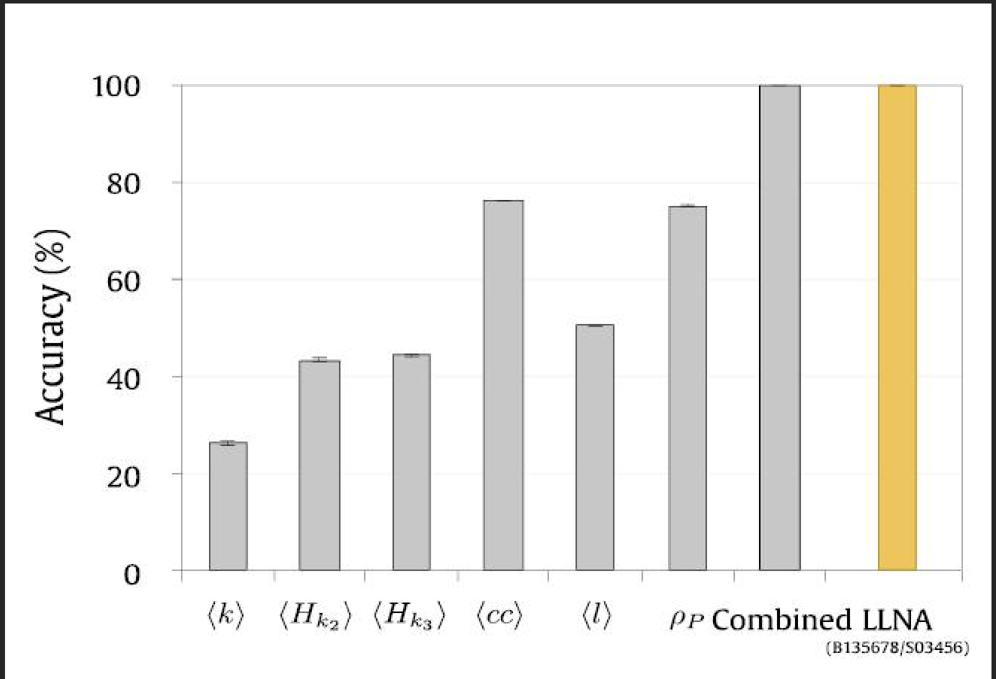
Experiment

Networks: random, small-world, scale free, geographical

LLNA measures



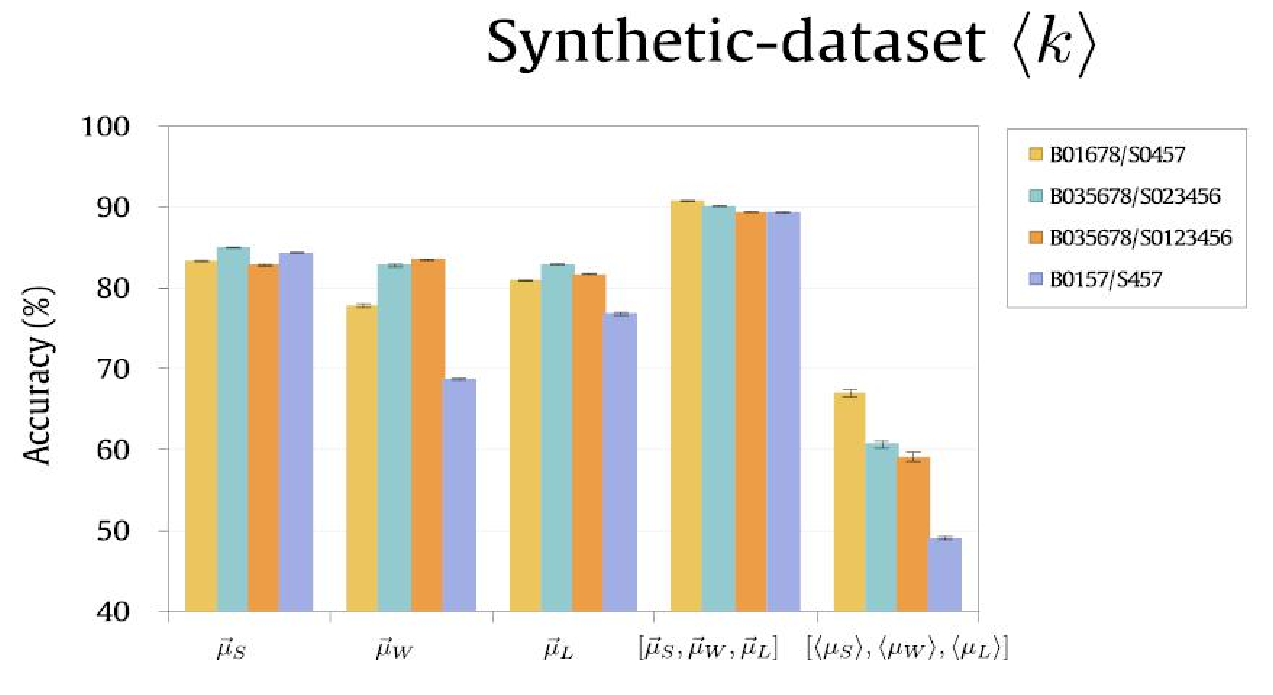
Network measures



Experiment

Network varying network degree

LLNA measures



Network measures