CADS – Seminar Topics

1 Google Page Rank (Graph Theory)
Random walker model for page ranking, and how the page ranking depends on various node parameters like degree centrality, clustering coefficient, betweenness centrality, closeness centrality. Consult
http://infolab.stanford.edu/pub/papers/google.pdf
http://an.kaist.ac.kr/courses/2008/cs492/lec4-pagerank.pdf
http://en.wikipedia.org/wiki/Centrality

2 Epidemic Spreading (SIR/SIRS/SIRC Models, Graph Theory)
Analysis of the attractors for different epidemic spreading models. Comparison between models or to historical data. See
http://en.wikipedia.org/wiki/Epidemic_model
http://arxiv.org/abs/cond-mat/0205009
https://data.hdx.rwlabs.org/ebola (data of ebola outbreak 2014/15)

3 Chaos and Fractals (Dynamical Systems)
Generation and graphical illustration of strange attractors and their fractals.
http://www.stsci.edu/~lbradley/seminar/index.html
http://rmp.aps.org/abstract/RMP/v57/i3/p617_1
http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1980.tb29690.x/abstract
http://en.wikipedia.org/wiki/Fractal (visualisation of fractals)

4 Prototype systems (Dynamical Systems)
Bifurcations: Explanation of the bifurcations discussed in the course (CADS script, Chapter 2) by using different parametrisations of the same prototype system. For a possible prototype system see
http://arxiv.org/abs/1504.03167

5 Stochastic Resonance (Stochastic Dynamical Systems)
Simulation and discussion of the phenomena of stochastic resonance.
http://www.physik.uni-augsburg.de/theo1/hanggi/Papers/195.pdf
http://www.scholarpedia.org/article/Stochastic_resonance

6 Car-Following Model (Dynamical Systems with Time Delays)
Analytic solution of the car-following model and discussion of the effects of time delays in general.
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.112.9292&rep=rep1&type=pdf

7 Complexity Measures (Information Theory)
Comparison of various complexity measures. (see CADS script, Chap. *Complexity and Information Theory*, for further reading)
http://adamilab.mmg.msu.edu/wp-content/uploads/Reprints/2002/Adami2002b.pdf
http://arxiv.org/pdf/nlin/0101029.pdf

8 Financial Data (Information Theory, Time-Series Analysis)
Download the historical time series of financial data, like the Dow-Jones index from the Internet (e. g. at https://www.quandl.com/data/BCB/UDJIAD1-Dow-Jones-Industrial-Average).

(a) Use a simple symbolization technique and discuss the results. (see CADS script, Sect. *Time Series Characterization*, for further reading)

(b) Using the method of inverse statistics study the gain-loss asymmetry of the index. See:
http://arxiv.org/abs/cond-mat/0211039
http://www.sciencedirect.com/science/article/pii/S0378437115001107#

9 Bond Percolation (Percolation Theory)
Write computer code for simulating bond percolation, discussing and illustrating the results.
http://en.wikipedia.org/wiki/Percolation_theory

10 Random Branching (Branching Theory, Self-Organized Criticality)
Evaluation of the avalanche duration by generalizing methods discussed in the lecture for the avalanche size, within the sandpile model. For futher reading consult
CADS script, Sect. *Random Branching Theory*
http://en.wikipedia.org/wiki/Abelian_sandpile_model
http://journals.aps.org/pra/pdf/10.1103/PhysRevA.38.364

11 Random Walks in a Potential (Bounded Random Walks)
Investigate random walks in potentials, considering for example a harmonic potential function. Compare the results to the ones obtained for the classical random walker problem.
http://ocw.mit.edu/courses/mathematics/18-366-random-walks-and-diffusion-fall-2006/study-materials/lec14.pdf

12 Spiking Neurons (Neural Networks)
Overview of spiking neuron models and different forms of adaptation.
http://icwww.epfl.ch/~gerstner/SPNM/node25.html
http://www.izhikevich.org/publications/spikes.pdf

13 Plasticity Mechanisms in Rate Encoding Neurons (Neural Networks)
Analyse the plasticity rules proposed in the BCM model or any other model for plasticity in rate encoding neurons.
http://www.scholarpedia.org/article/BCM
http://www.jneurosci.org/content/2/1/32.full.pdf

14 Models for Associative Memory (Neural Networks)
Analyse the Hopfield model for an associative memory. Study the attractors and discuss the limitations of this model.
http://www.scholarpedia.org/article/Hopfield_model
http://www.pnas.org/content/79/8/2554.full.pdf

15 Bayesian Inference (Information Theory)
Discuss the principle of Bayesian inference and its applications.
http://www.scholarpedia.org/article/Bayesian_statistics

16 Shannon's Source Coding Theorem (Information Theory)
Prove and explain Shannon's source coding theorem. Therefore you can see e. g.
https://en.wikipedia.org/wiki/Shannon%27s_source_coding_theorem
http://dl.acm.org/citation.cfm?id=584093

17 Other Projects (Your Suggestions)
Anything else you may find interesting as a CADS seminar topic and it's not listed here. For the literature consult one of the tutors.