



Mesoscopic Structures and Diffusion Process Memory

Mauro Faccin

Jean-Charles Delvenne

ICTEAM, Université Catholique de Louvain, Belgique

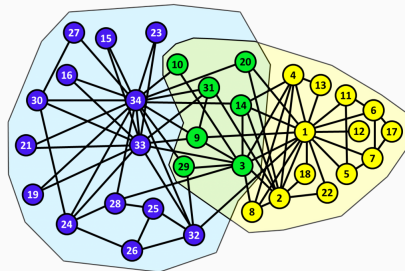
NetSci 2016 - Seoul

Introduction

Partitioning Problem

Why should we care

- simple description
- system model
- mesoscopic structures



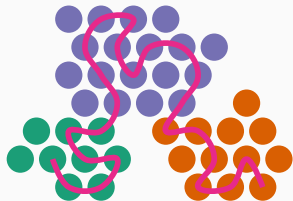
*Good partitioning is the one leading to
an interesting reduced model*



Projected Markov Chain

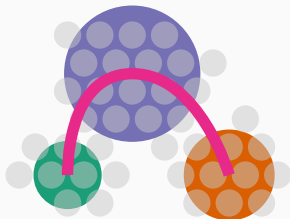
Markov Chain

$\dots, X_{\text{past}}, X_{\text{now}}, X_{\text{future}}, \dots$



Projection

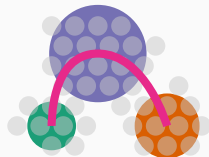
$\dots, Y_{\text{past}}, Y_{\text{now}}, Y_{\text{future}}, \dots$



Assess the Partition Quality

Projected Markov Chain:

$$\dots, Y_{\text{past}}, Y_{\text{now}}, Y_{\text{future}}, \dots$$



Maximize:

$$I(Y_{\text{future}}; Y_{\text{past}})$$

amount of information flowing from *past* to *future*.

$$I(Y_{\text{future}}; Y_{\text{past}}) \leq I(x_{\text{future}}; x_{\text{past}})$$

Minimize:

$$I(Y_{\text{future}}; Y_{\text{past}} | Y_{\text{now}})$$

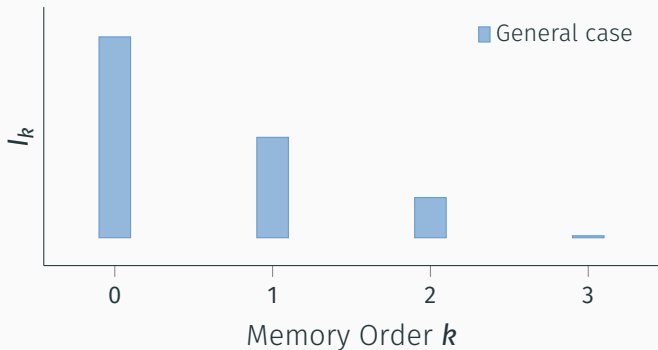
higher order memory embedded into the process.

$$I(Y_{\text{future}}; Y_{\text{past}} | Y_{\text{now}}) \geq I(x_{\text{future}}; x_{\text{past}} | x_{\text{now}}) = 0$$

Def. Markov Index:
$$I_k = I(Y_{\text{future}}; Y_{\text{past}} | \underbrace{Y_1, \dots, Y_k}_{Y_{\text{now}}})$$

Scenarios

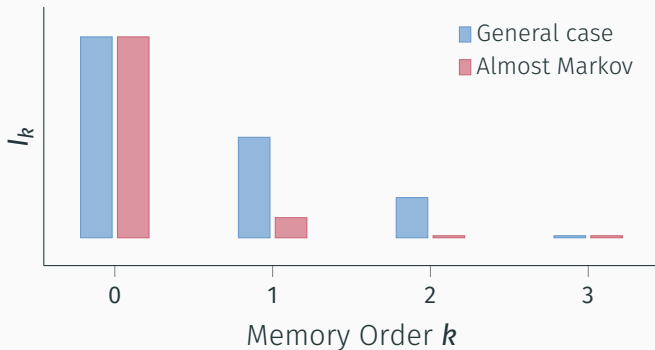
$$I_k = I(Y_{\text{future}}; Y_{\text{past}} | Y_1, \dots, Y_k)$$



Higher order memory effects affect the sampled dynamics

Scenarios

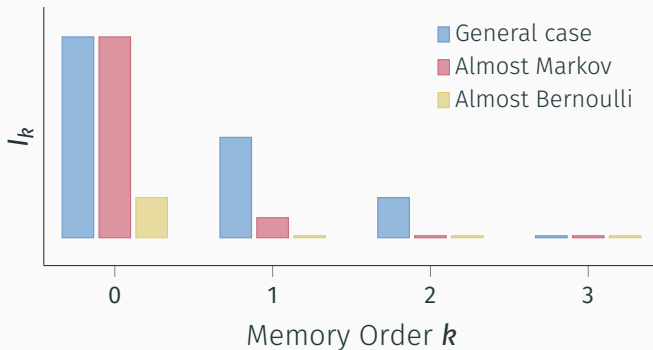
$$I_k = I(Y_{\text{future}}; Y_{\text{past}} | Y_1, \dots, Y_k)$$



High predictability of dynamics, negligible higher order effects

Scenarios

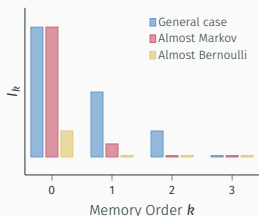
$$I_k = I(Y_{\text{future}}; Y_{\text{past}} | Y_1, \dots, Y_k)$$



Great Markovianity but low predictability

Partition Detection Algorithm

$$I_k = I(Y_{\text{future}}; Y_{\text{past}} | Y_1, \dots, Y_k)$$



Partition Detection:

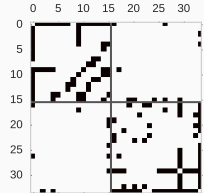
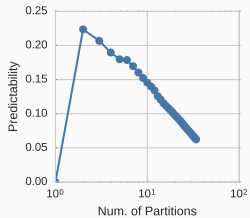
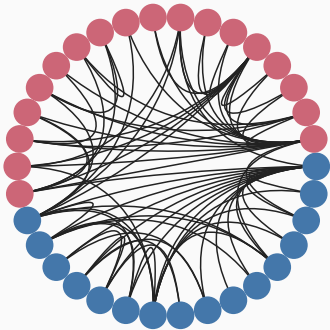
Objective Function: Maximize Markovianity and

Predictability: $f = \frac{I_0 - I_1}{N_p}$,

Maximization Algorithm: Follow a hierarchical approach

Applications

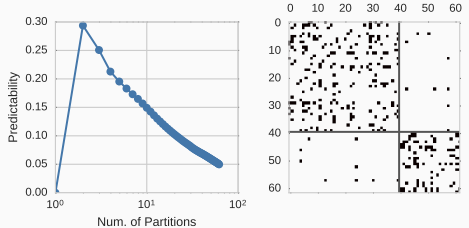
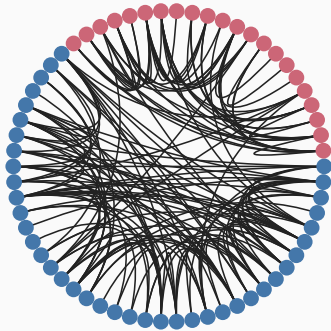
Example: Karate Club



Seriously? Let's skip this.

Zachary, J. Anthropological Research, 1977

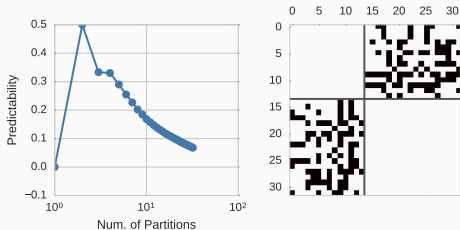
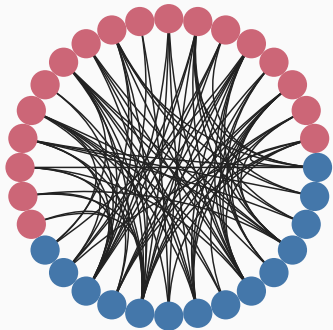
Example: Dolphins



- Dolphins community living in a fjord.
- Data collected during seven years of field observation.

Lusseau et al., Behav Ecol Sociobiol, 2003

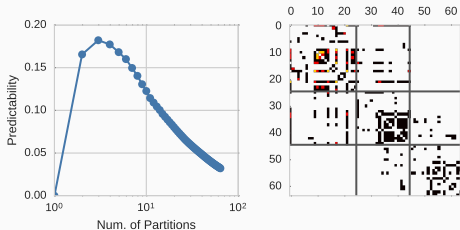
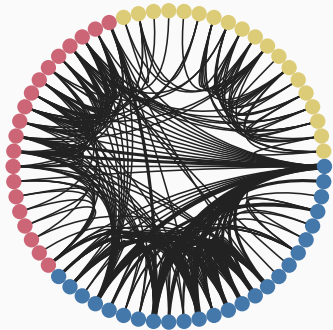
Example: Deep South



- Bipartite network of women and clubs.
- Perfectly recovered structure.

Deep South, Davis et al., Univ. of Chicago Press, 1941

Example: Terror Attacks



- Contacts between suspect terrorists involved in the attack to Madrid station (2004).
- recovered the subset of the interconnection nodes.

The March 11th Terrorist Network: In its weakness lies its strength, José A. Rodríguez

The End

Satellite workshop at CCS 2016 (Call for abstracts):



The banner features a background image of a green, crystalline or cellular structure. The main title "Coarse-graining of Complex Systems" is centered in white. Below it, the text "CCS@CCS'16" is displayed. At the bottom of the banner, there are three navigation buttons: "CCS 2016", "Invited Speakers", and "Call for Abstracts".

Coarse-graining of Complex Systems

CCS@CCS'16

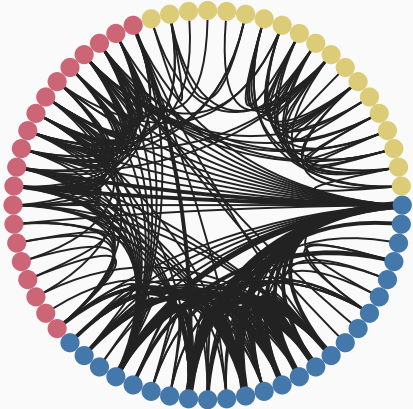
CCS 2016 Invited Speakers Call for Abstracts

Summary

A fundamental issue in the field of complex systems is to identify the most important interactions or processes within a system so that we may better understand them. Coarse-graining methods attempt to abstract away unnecessary details, leaving behind a simplified interpretable representation of the system. Coarse-graining approaches are well-established in many different

http://michaelschaub.github.io/ccs_at_ccs_2016/

Questions?



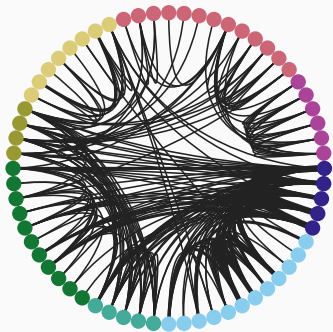
Joint work with:

JC Delvenne

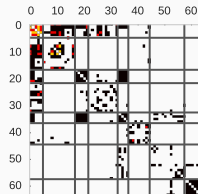
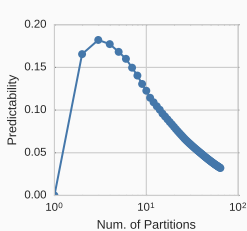
@ ICTEAM and BigData Group,
UCLouvain.

*Good partitioning is the one leading to
an interesting reduced model*

Example: Terror Attacks



We can select the detail level



(8 partitions)

The March 11th Terrorist Network: In its weakness lies its strength, José A. Rodríguez