TOPOSYS

TOPOLOGICAL COMPLEX SYSTEMS

KICKOFF MEETING

PRIMOZ SKRABA

LJUBLJANA, SLOVENIA

OCTOBER 29, 2012

WELCOME

WELCOME

SEVENTH FRAMEWORK PROGRAMME

TOPOSYS

WELCOME

TOPOSYS

Mathematical foundations of complex systems...

PARTNERS

PARTNERS

Introductions...

PARTNERS

Introductions...

Jožef Stefan Institute

PARTNERS

Introductions...

KTH VETENSKAP OCH KONST

Jožef Stefan Institute

PARTNERS

Introductions...

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Introductions...

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Jožef Stefan Institute

Technion Israel Institute of Technology

IST AUSTRIA Institute of Science and Technology

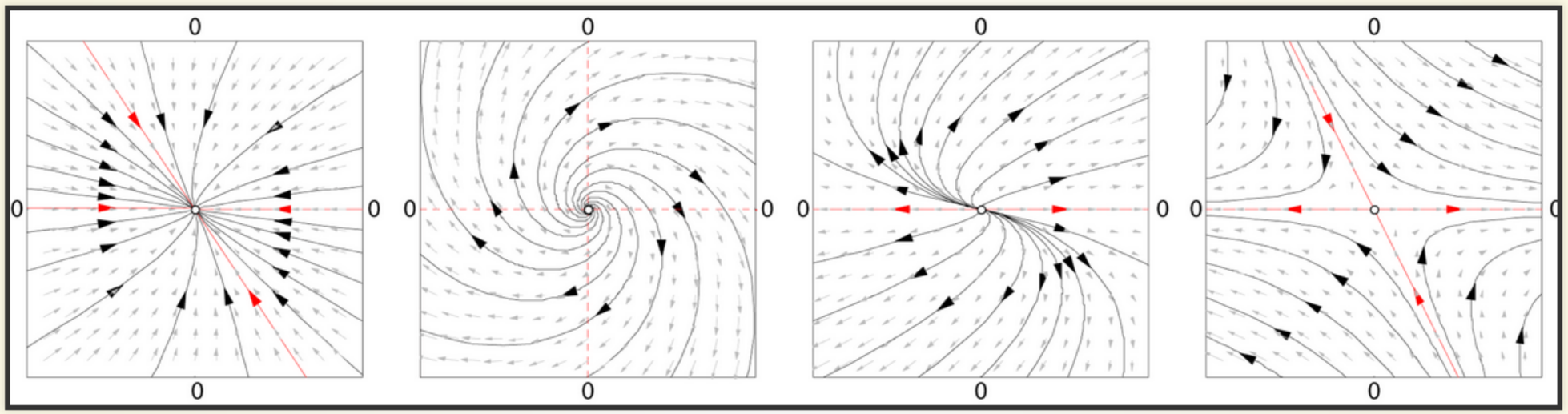
JAGIELLONIAN UNIVERSITY IN KRAKOW

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

*" **Complexity, Evolution and Adaptation:** Large systems are encountered in both nature and engineering: systems of a technical nature, of a techno-social, social or biological nature. The theory and fundamental insights needed to address the ICT challenges relating to such systems are explored in Dynamics of Multi-Level Complex Systems and Fundamentals of Collective Adaptive Systems. "*

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Differential Equations



DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Differential Equations

Iterated Systems

$$p \to f(p) \to f(f(p)) \to \dots$$

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Properties

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Properties

Periodicity

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Properties

Periodicity

Recurrence

DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Properties

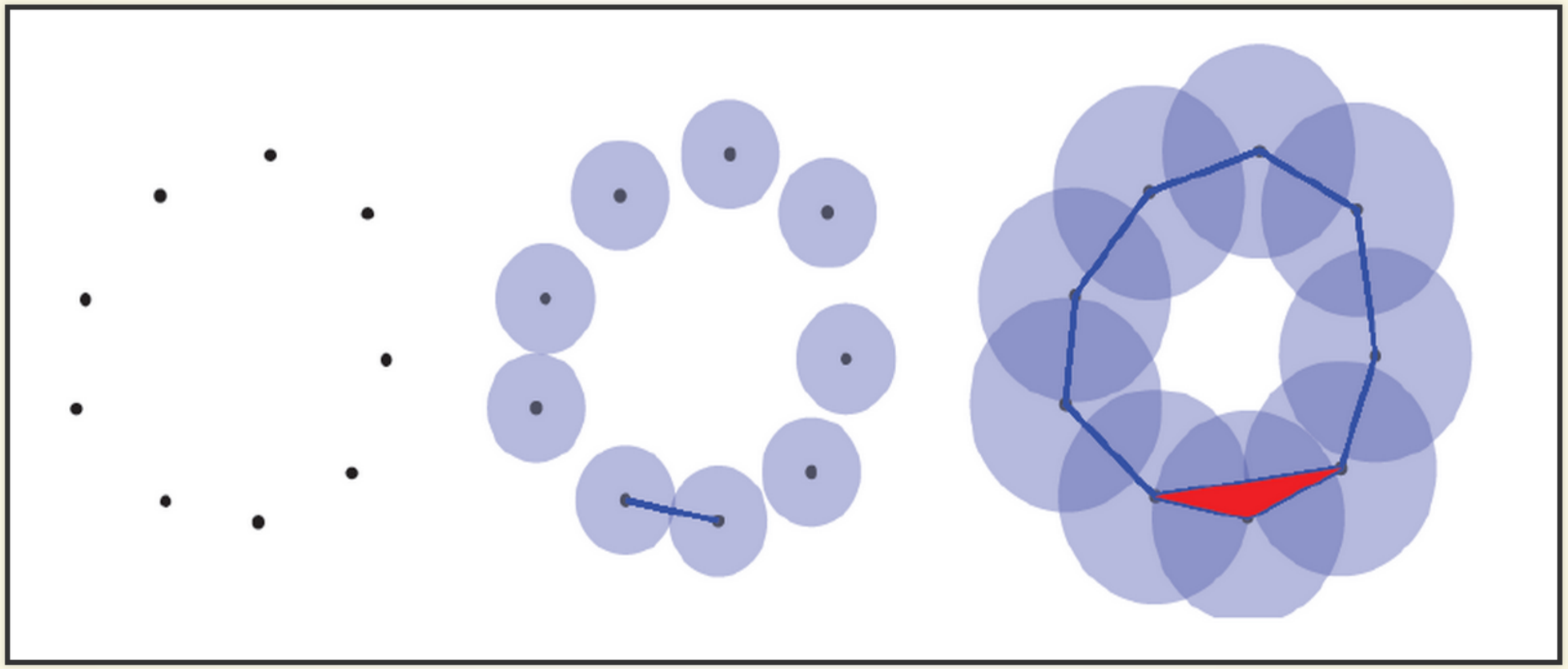
Periodicity

Recurrence

Conley Index

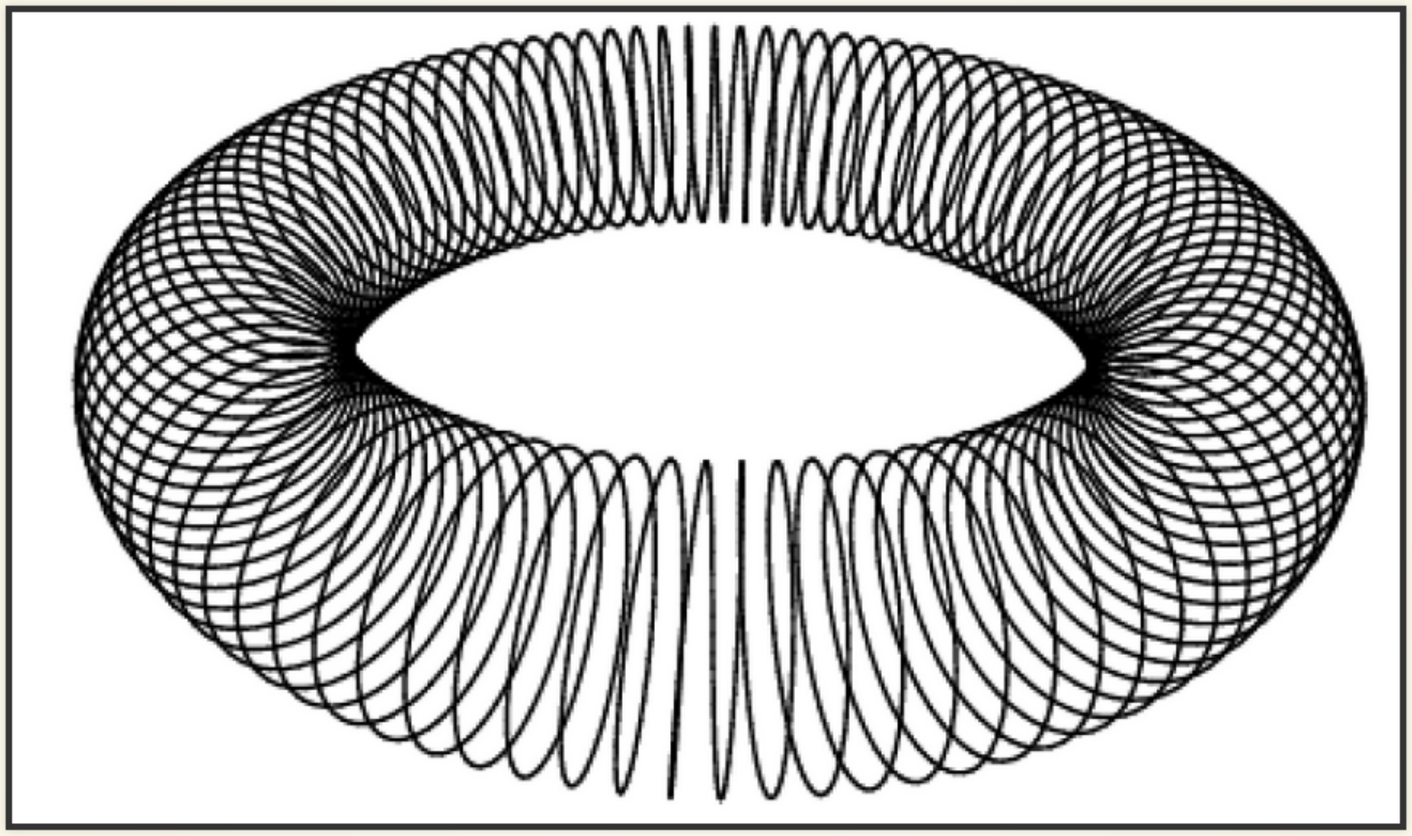
DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Choice of Scale



DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Choice of Scale

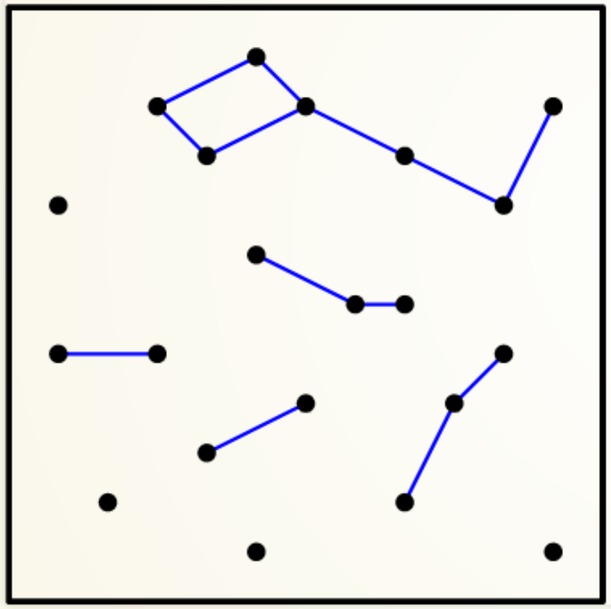


DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

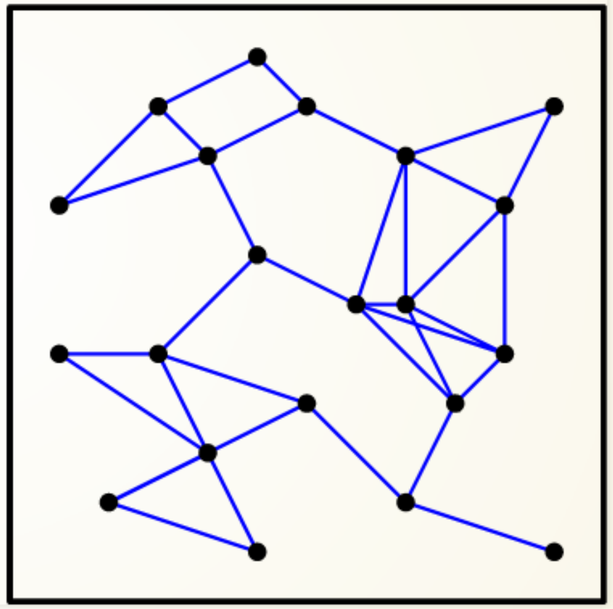
Choice of Scale

Emergent Behaviour

$r < O(\log n/n)$

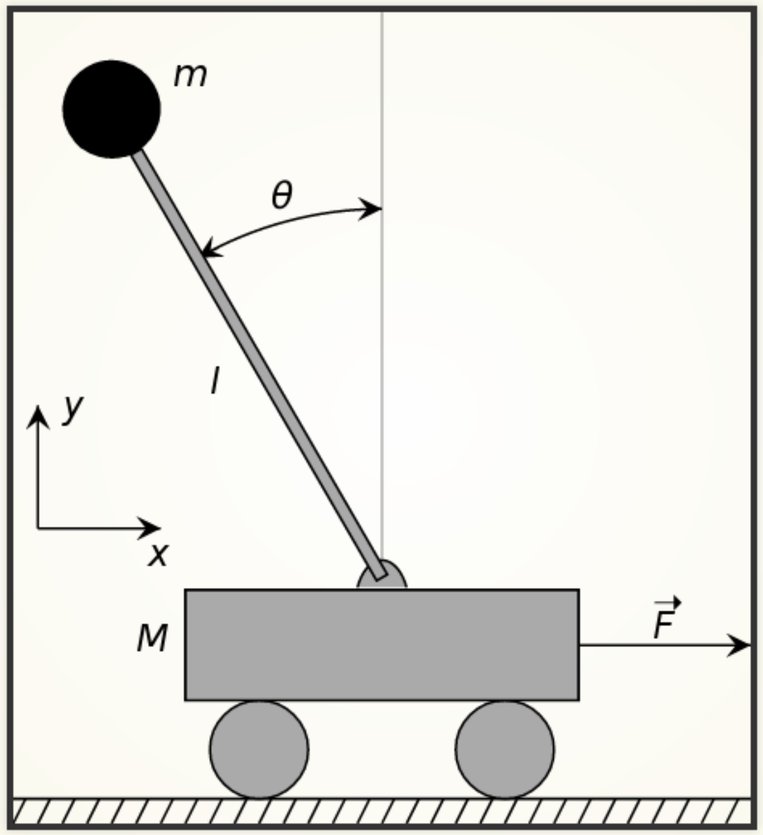


$r > O(\log n/n)$



DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

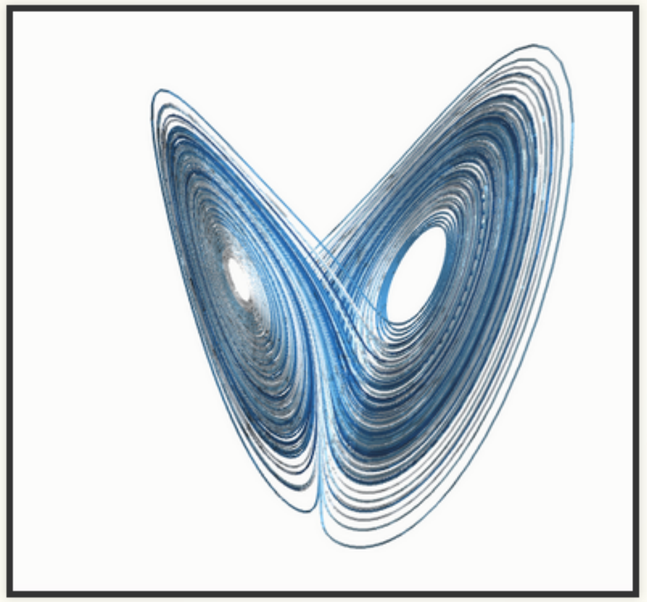
Nonlinear systems



DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Nonlinear systems

Chaotic systems

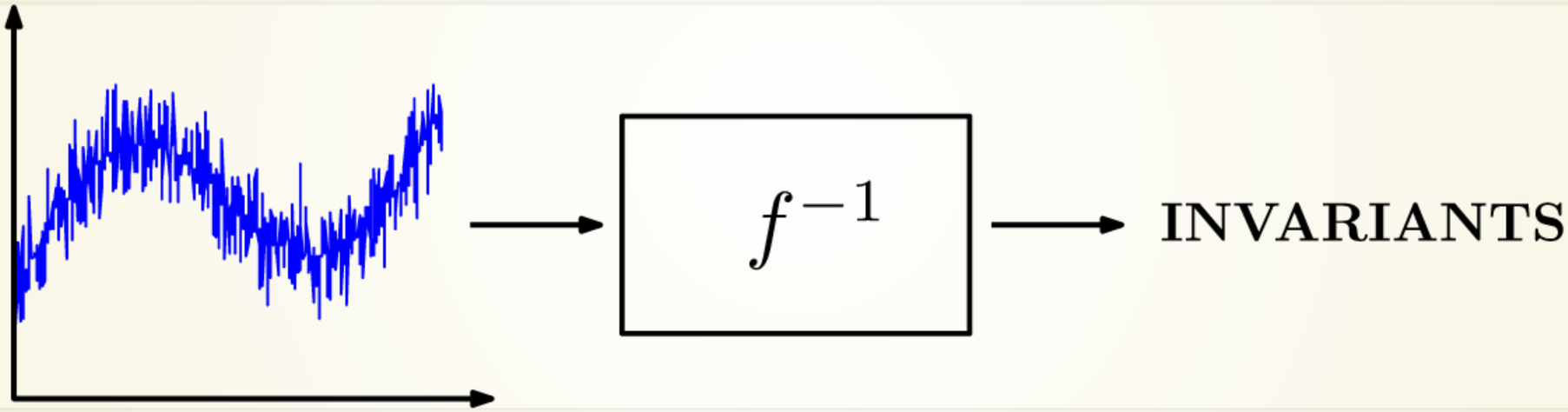


DYNAMICS OF MULTI-LEVEL COMPLEX SYSTEMS

Nonlinear systems

Chaotic systems

Systems without equations



COMPLEXITY SCIENCE

" A "complex system" is any system comprised of a great number of heterogeneous entities, where local interactions among entities create multiple levels of collective structure and organization"

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Any large-scale distributed system

COMPLEXITY SCIENCE

" A "complex system" is any system comprised of a great number of heterogeneous entities, where local interactions among entities create multiple levels of collective structure and organization"

Any large-scale distributed system

Global structures arising from local behaviour

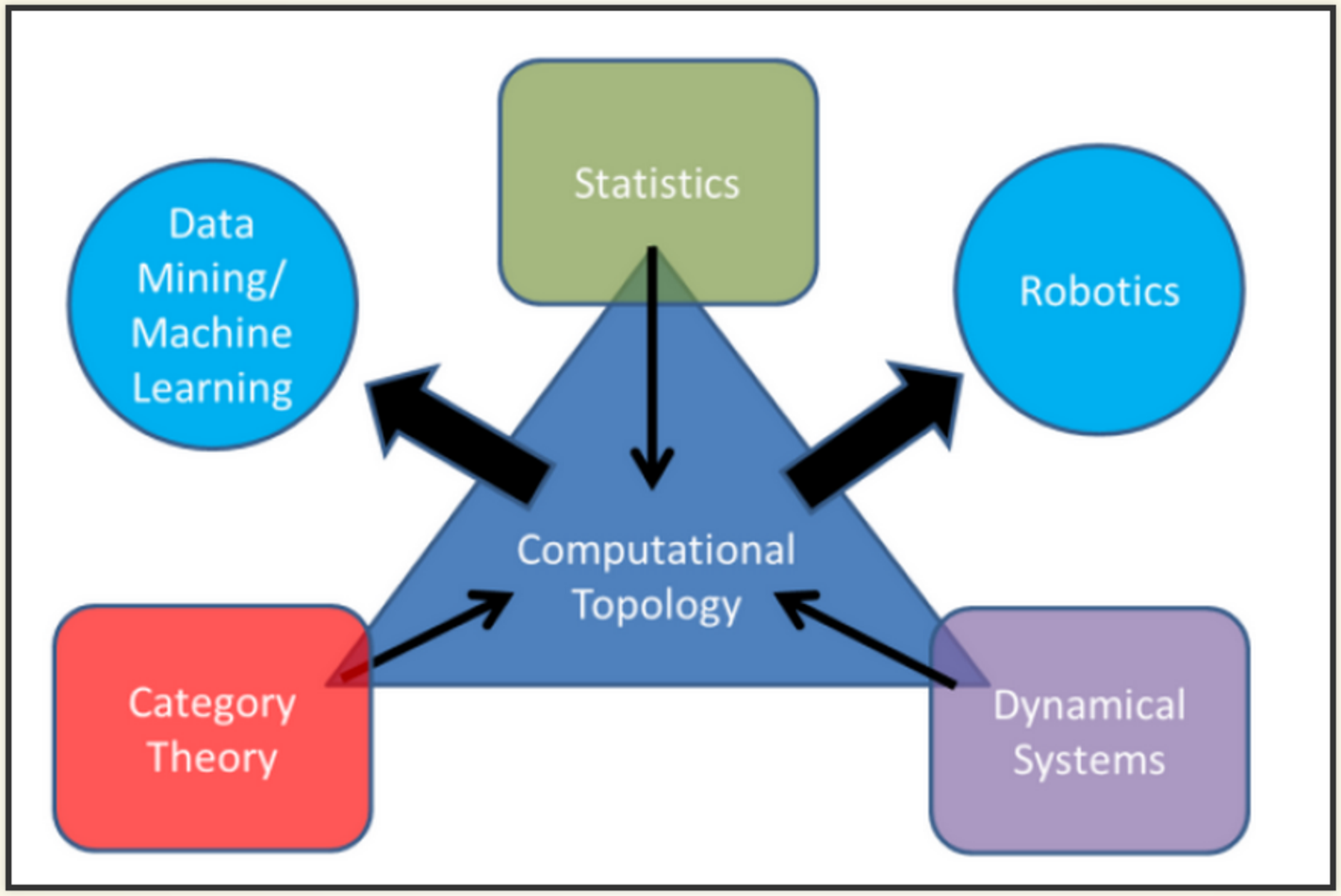
COMPLEXITY SCIENCE

Analysis inspired from physics

Different analogies for different systems

Lack of unified framework

BIG PICTURE


Statistics
Data Mining/ Machine Learning
Robotics
Computational Topology
Category Theory
Dynamical Systems

AREAS

- Dynamical Systems
- Statistics
- Category Theory

- Machine Learning
- Robotics

AREAS

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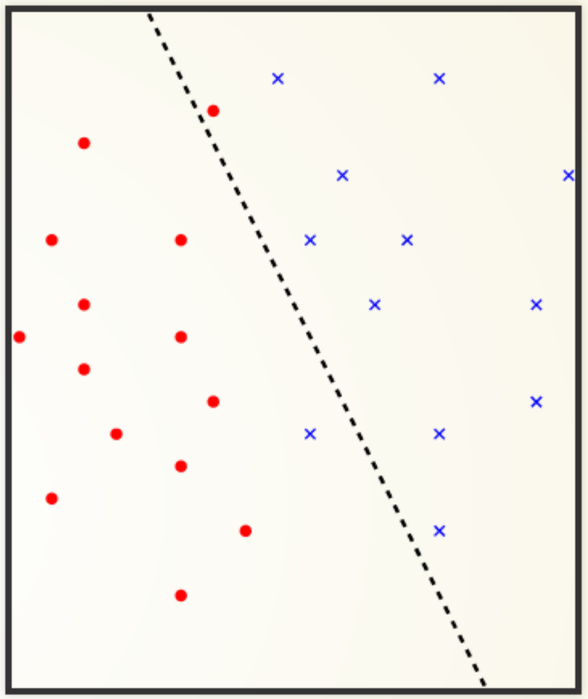
MACHINE LEARNING

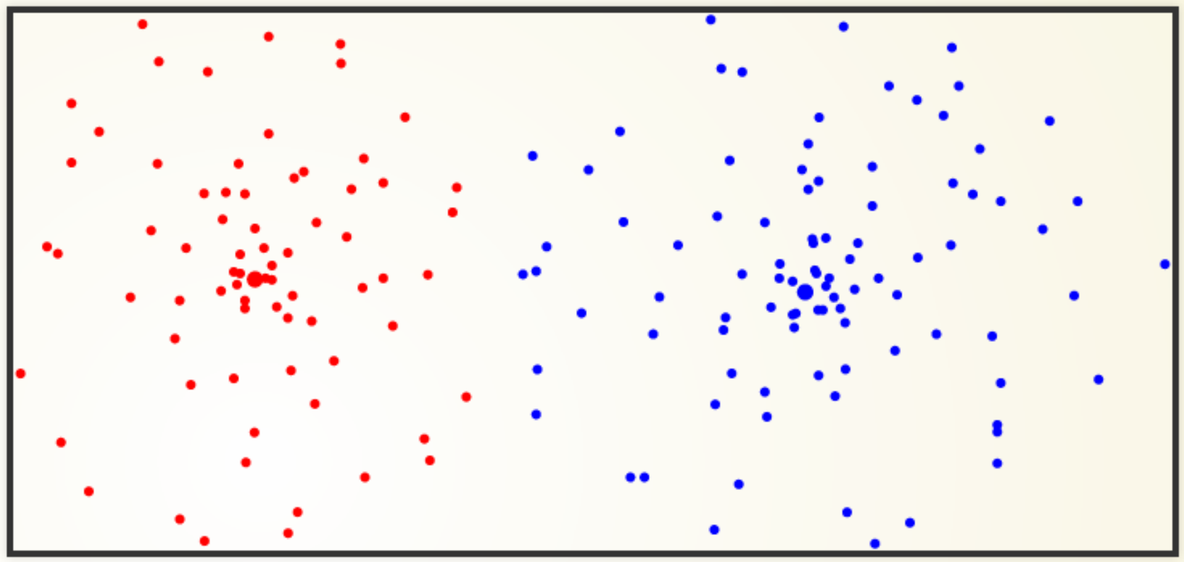
MACHINE LEARNING

Classification,



MACHINE LEARNING

Classification,
clustering



MACHINE LEARNING

Classification,
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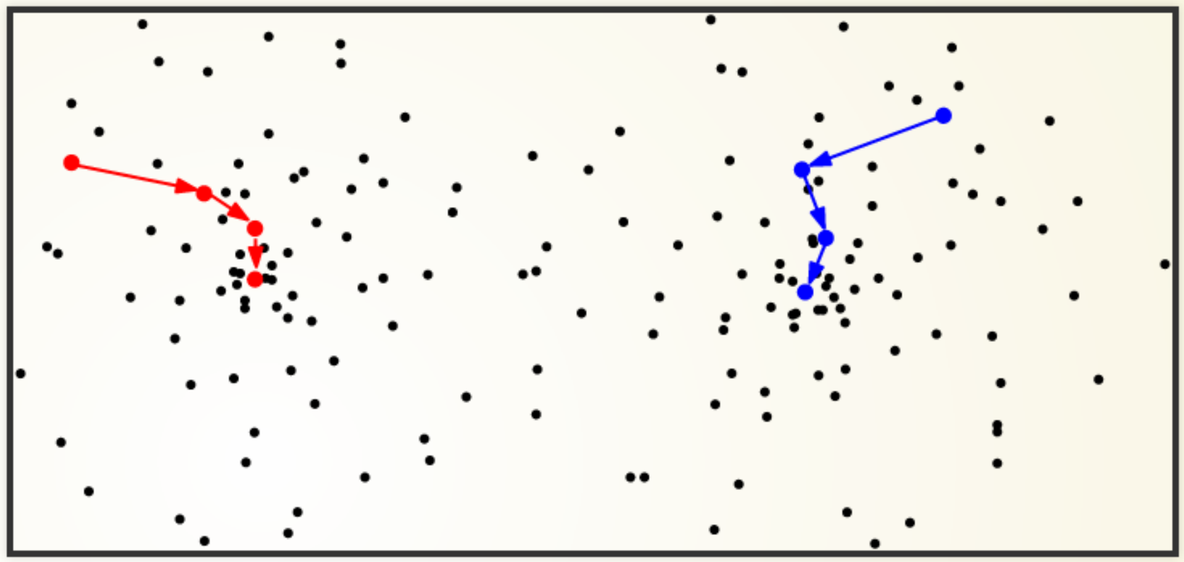


MACHINE LEARNING

- Ill-defined inverse problems

MACHINE LEARNING

- Ill-defined inverse problems
- Applications of mathematical representations

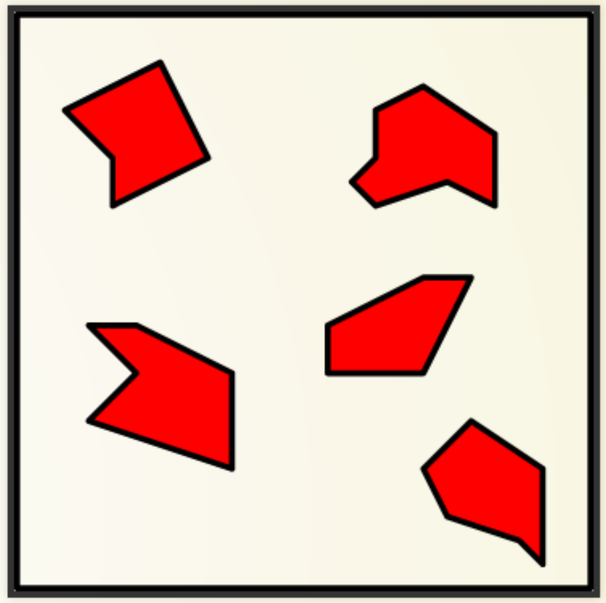
ROBOTICS

Complex yet testable systems

ROBOTICS

Complex yet testable systems

high dimensional
configuration spaces,

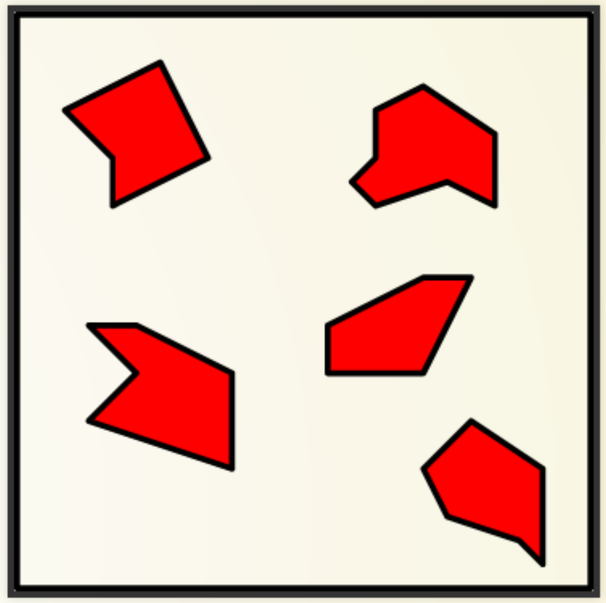


ROBOTICS

Complex yet testable systems

high dimensional
configuration spaces,

measurement errors,



ROBOTICS

Complex yet testable systems

high dimensional
configuration spaces,

measurement errors,

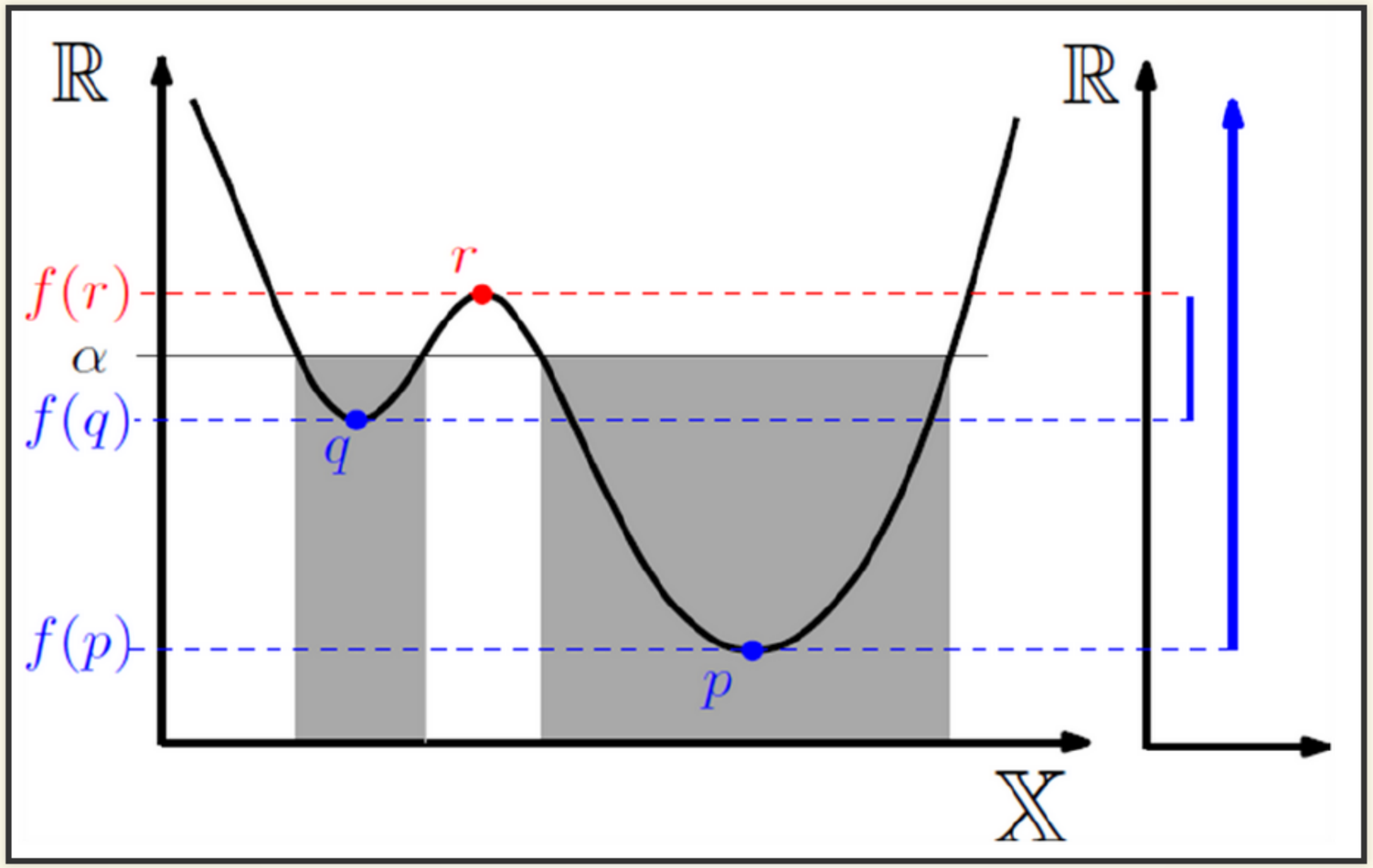
physical systems

WORK PACKAGES

- Persistence of Maps
- Multiscale Statistics
- Categorical Systems
- Validation and Applications

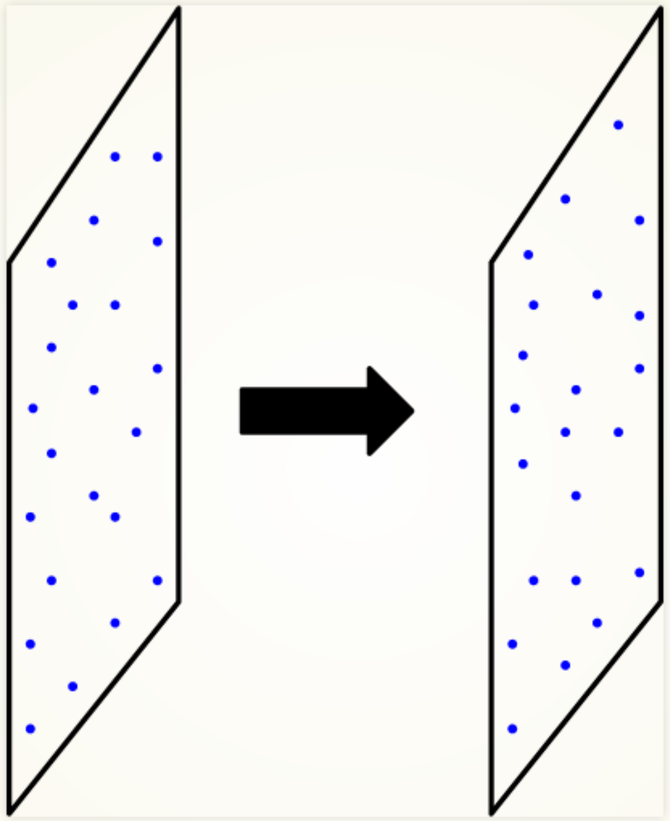
PERSISTENCE OF MAPS

Usually, we look at spaces



PERSISTENCE OF MAPS

Look at dynamics (described by maps)



$$f : \mathbb{X} \to \mathbb{Y}$$

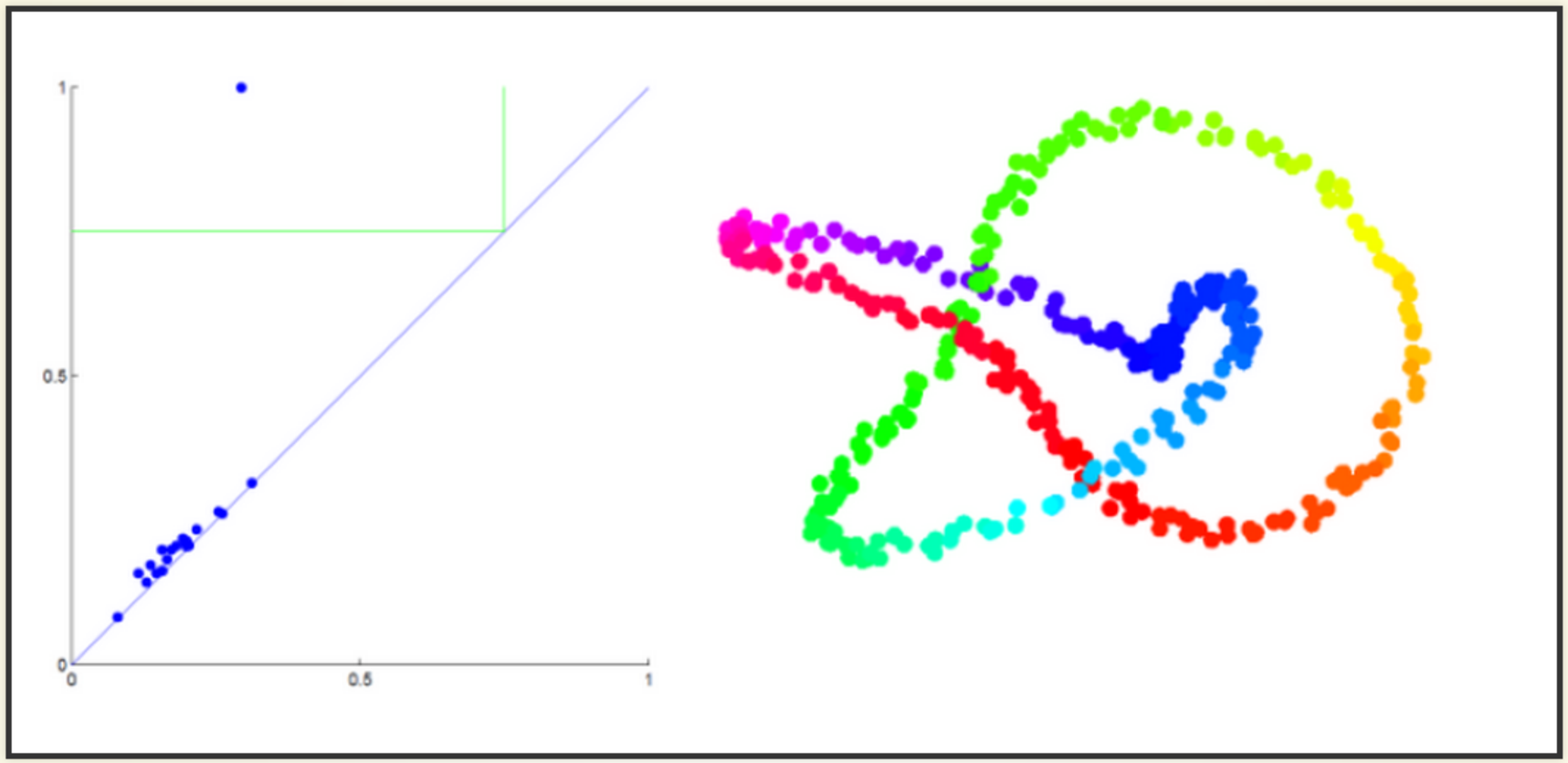
PERSISTENCE OF MAPS

Jordan forms of homologies

“A vector space with an endomorphism (loop quiver) has a Jordan block decomposition”

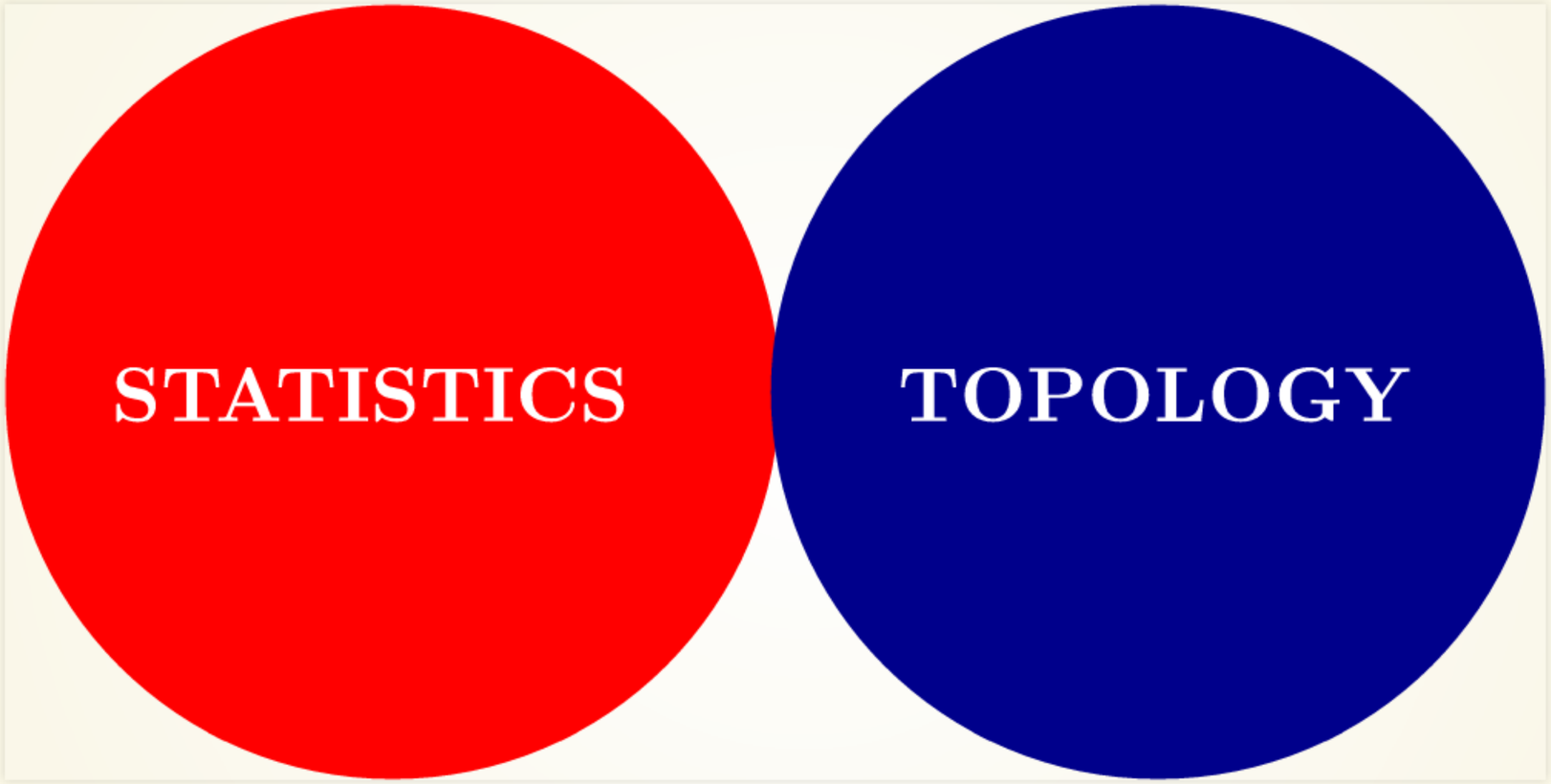
PERSISTENCE OF MAPS

Cohomology of recurrent systems



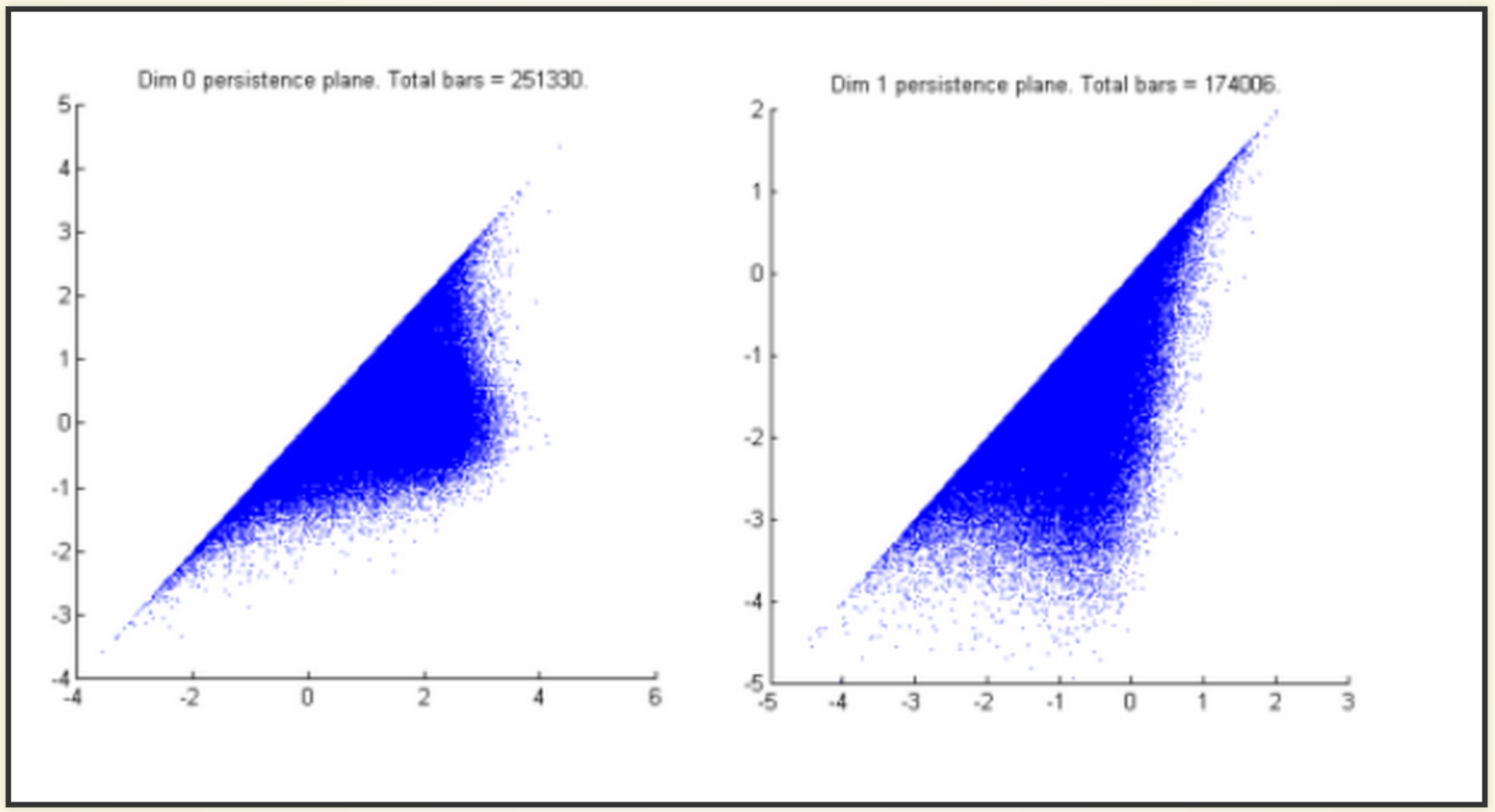
MULTISCALE STATISTICS

Statistics and topology



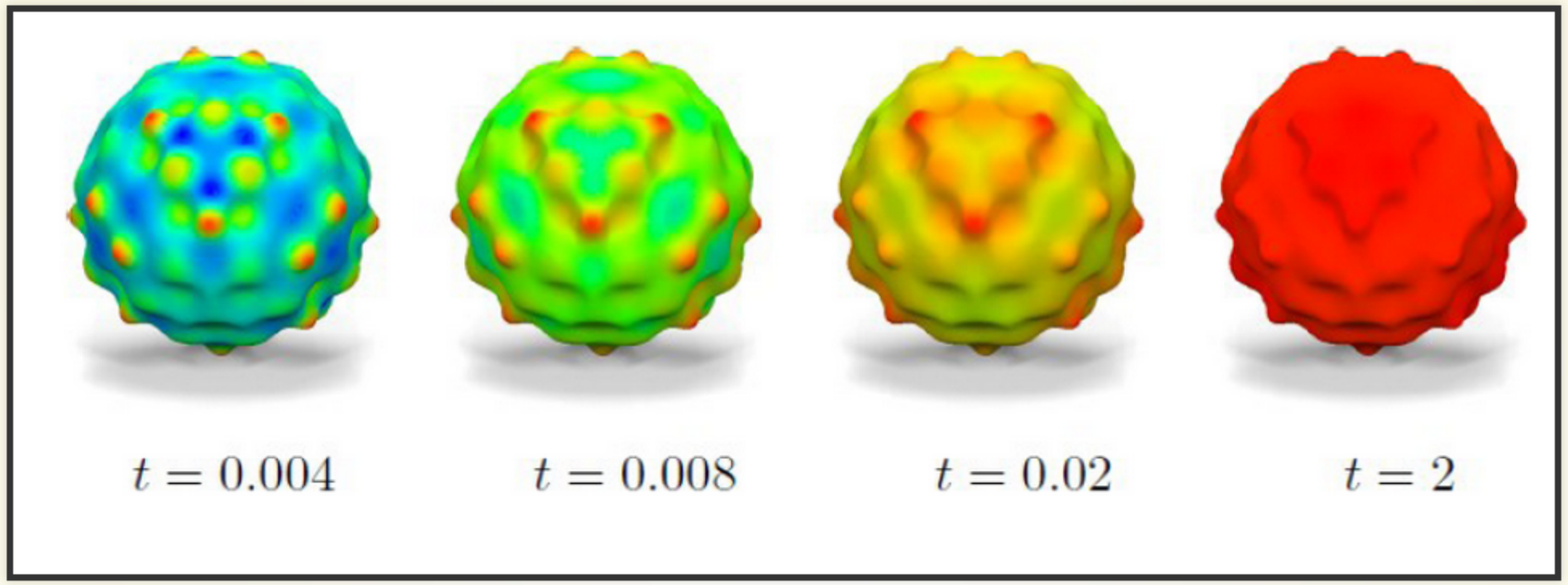
MULTISCALE STATISTICS

Topological noise



MULTISCALE STATISTICS

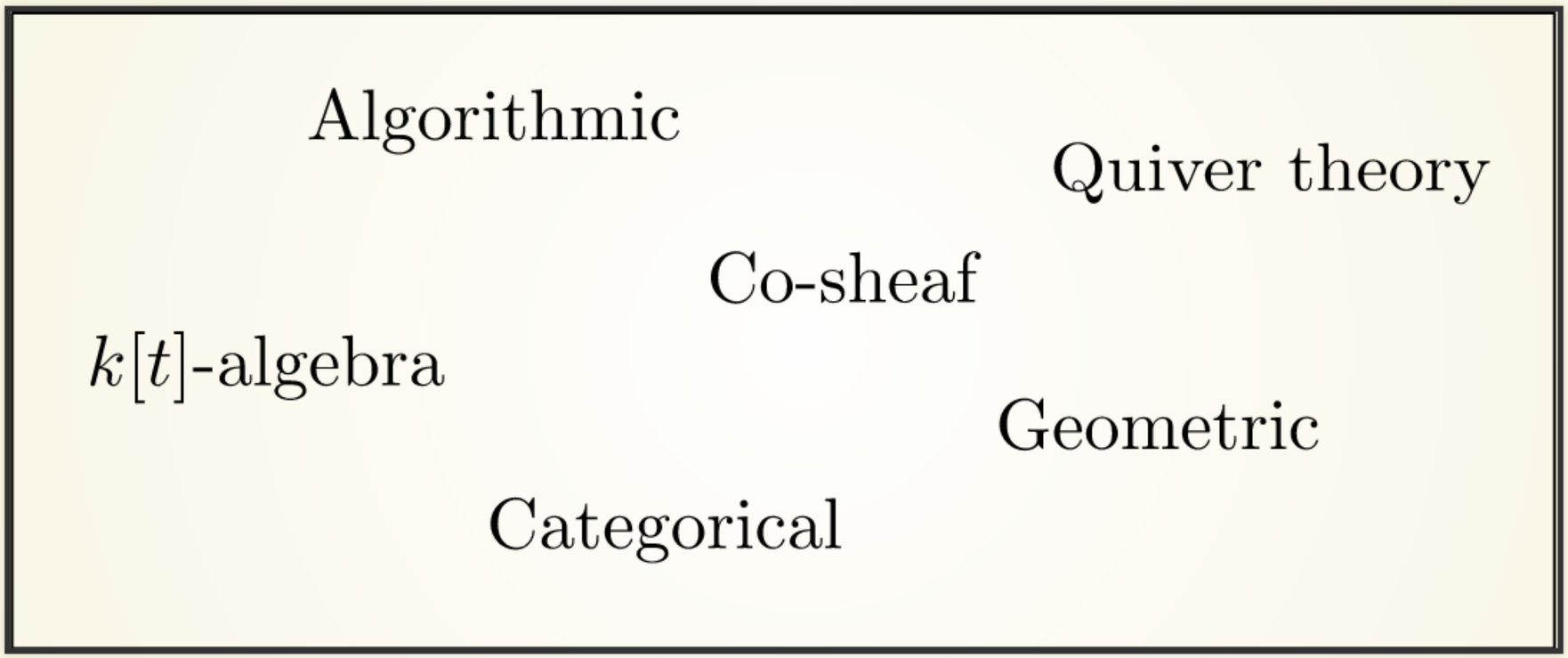
Effects of smoothing



$t = 0.004$ $t = 0.008$ $t = 0.02$ $t = 2$

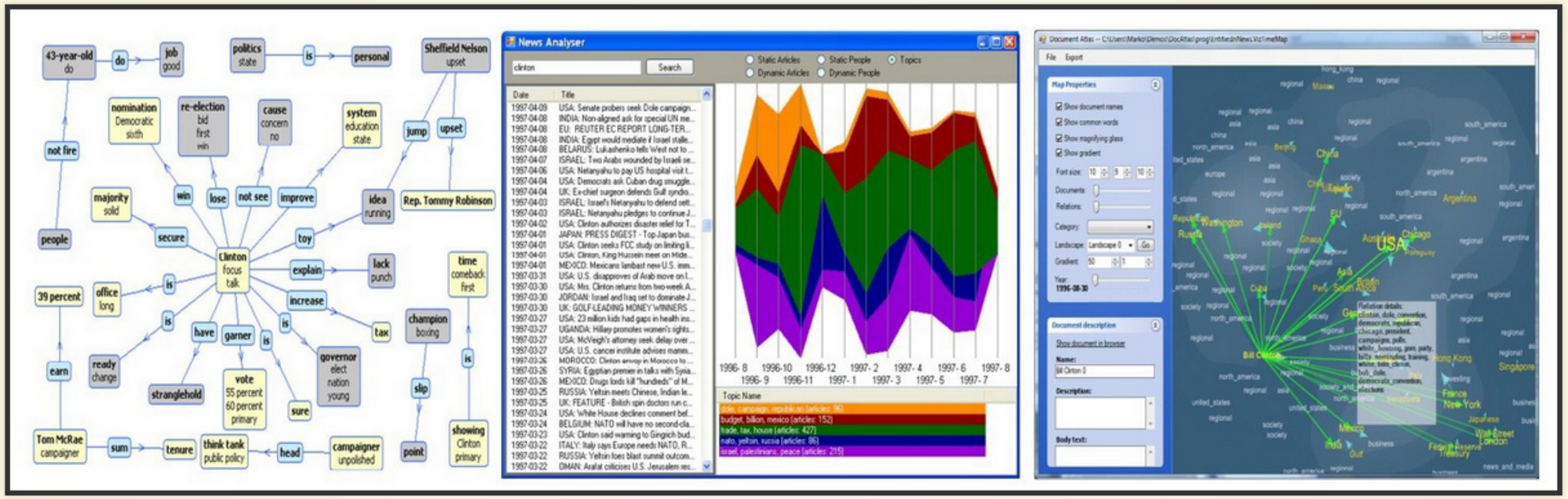
CATEGORICAL SYSTEMS

Unifying the various views of persistence



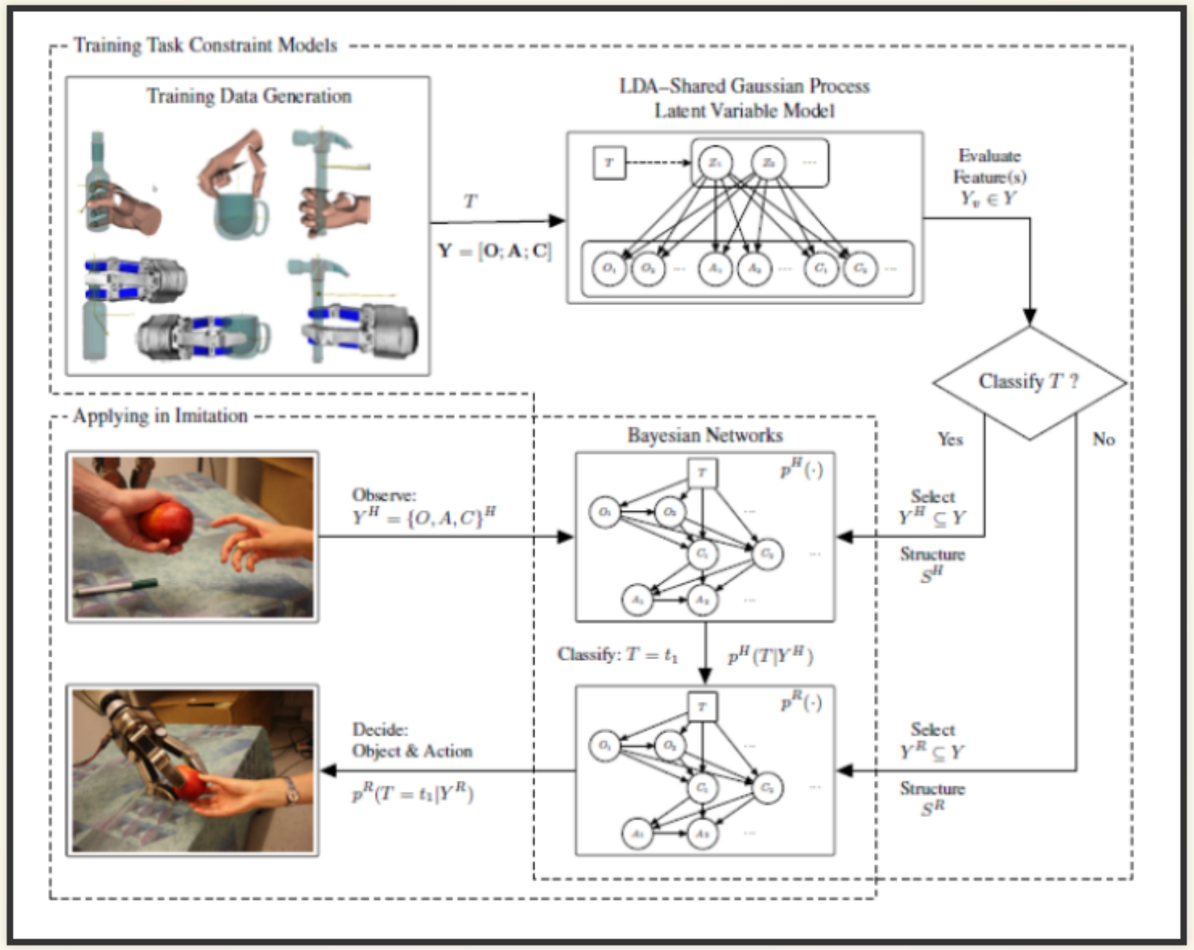
APPLICATIONS

Social Media



APPLICATIONS

Robotics



APPLICATIONS

Other data sources

- Sensor networks
- Financial data
- Biological data

MAILING LIST

toposys@ijs.si

PLAN FOR TODAY AND TOMORROW

- Introductions
- Administrative Details

- Discussions