Karlsruher Institut für Technologie

FINCA: Fast Inexact Combinatorial and Algebraic Solvers for Massive Networks

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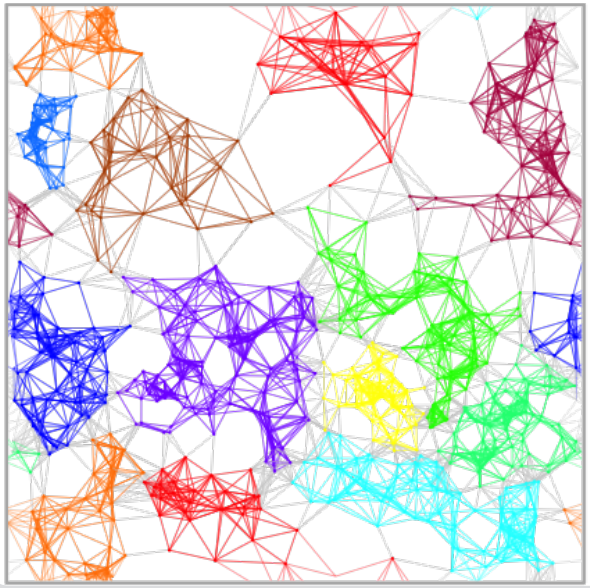
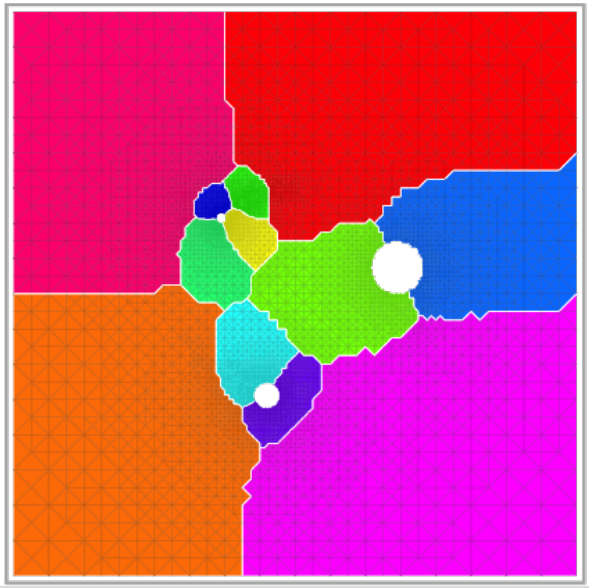
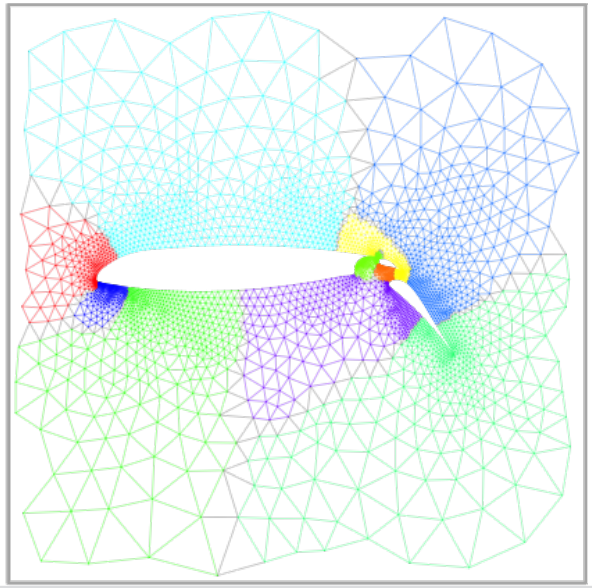


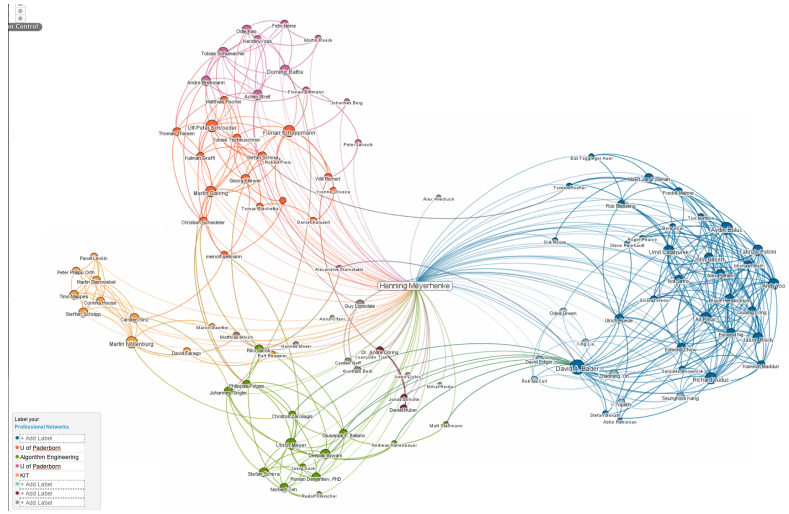




Context

Massive complex networks
are part of big data:

- Social networks



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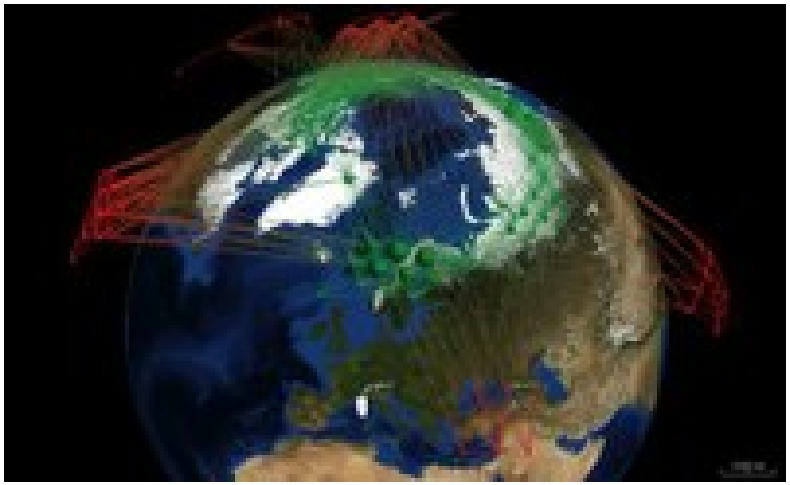

Image source: PIK Potsdam

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- Climate networks
- Biological networks
- ...

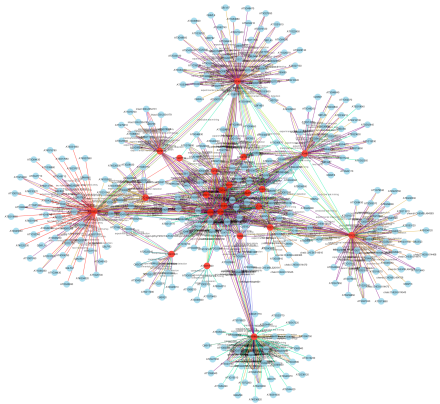

Image source: shgmo.org

Context

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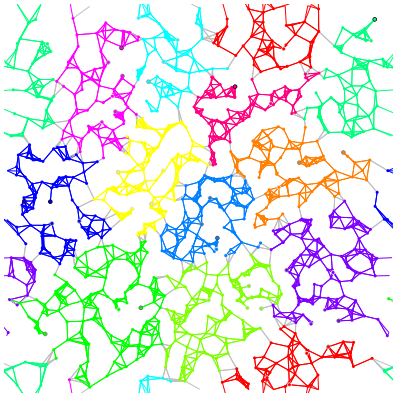
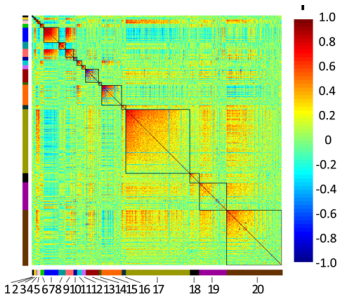
Network analysis

- **What:** Extract info from network structure and/or data stored within
- **Why:** Analysts/scientists need **information** for decisions!
- **How:** FINCA: Parallelism, approximation algorithms, heuristics

Objectives



- Make recent theoretical results usable in practice:
  - Sparsification of dense graphs
  - Low-rank approximation of matrices
  - Approximate maximum network flow



Img. source: E. A. Stone, J. F. Ayroles

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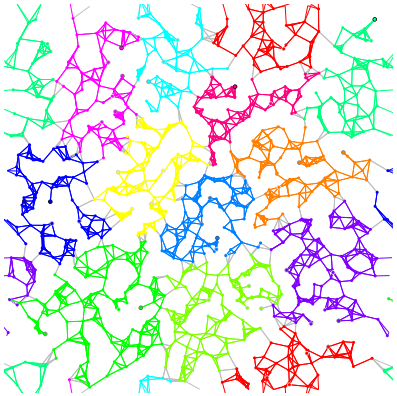

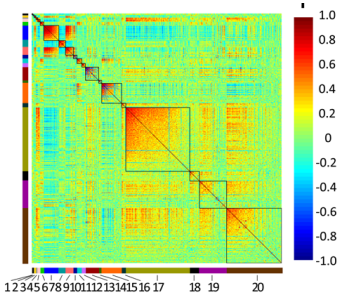

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  - Clustering dense graphs derived from correlation data
  - Graph drawing for massive complex networks
  - Network flow
  - Generation of massive dynamic complex networks

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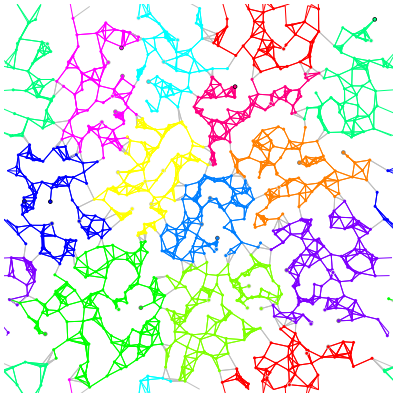

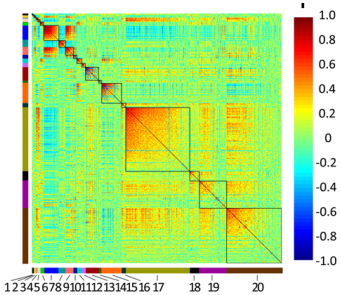

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- Improve applications from bioinformatics:
  - Gene expression profiling
  - Molecular distance geometry
  - Image segmentation tasks in biology

Methods

Clustering and drawing graphs

Clustering dense networks

- Sparsen dense graphs based on different edge importance measures
- Approximation/estimation of edge importance measures
- Integration into multilevel clustering algorithm
- Clustering dynamic/streaming networks

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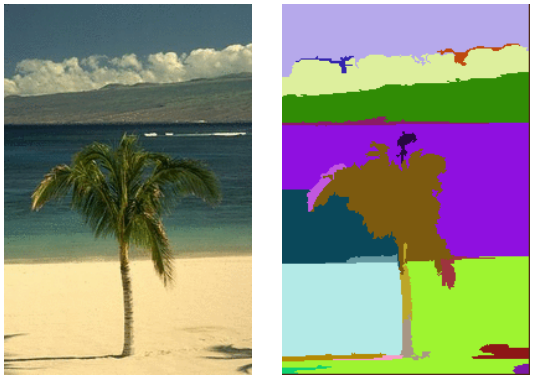
Drawing massive complex networks

- Entropy-stress model for GD
- Parallel implementation (ongoing work with C. Schulz and M. Nöllenburg)
- Integration of clustering concepts and edge importance measures
- Application to molecular distance geometry

Methods

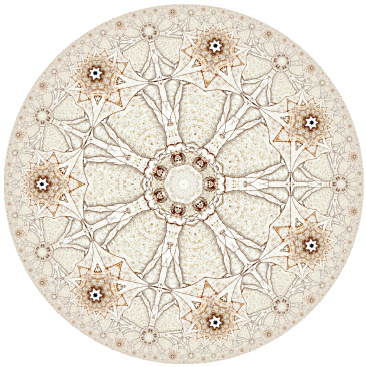
Approximate network flow and network generation



Img. source: Felzenszwalb, Huttenlocher

Approximate network flow

- Sparsification
- Low-rank approximation
- Combinatorial linear solvers
- Possible application: Image segmentation



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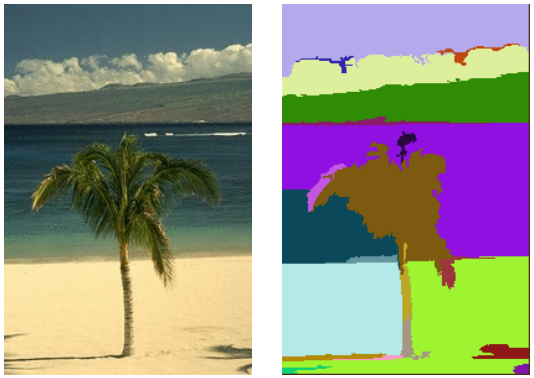

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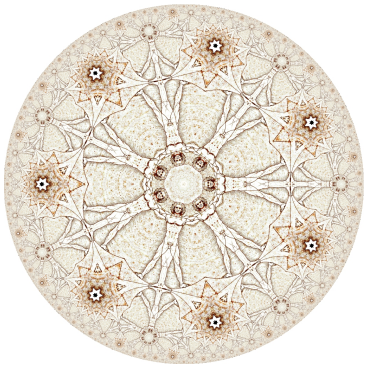

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Massive dynamic complex networks

- Hyperbolic geometry
- Space-partitioning data structures
- Dynamics

Nucleation points for cooperation

NetworKit tool suite

- Fast interactive network analysis (C++ with OpenMP, Python)
- Focus on massive networks
- Open source (MIT license)
- Used by several national and international projects
- Info, talk, docu, code: `http://www.network-analysis.info`

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FINCA connections to other projects

- Graph generator will be made available for all projects
- **Brandes/Wagner:** Backbones / sparsification
- **Koch/Mutzel:** Motifs / clustering, drawing
- **Zweig:** Centrality, clustering, motifs