CWI Centrum Wiskunde & Informatica

Algorithms & Complexity
PNA 6

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(2.6 fte)

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Themes in PNA 6

- PNA 6.1 [Buhrman/de Wolf]
  - Quantum computing
- PNA 6.2 [Grünwald/Vitanyi]
  - Learning theory
- PNA 6.3 [Buhrman/de Wolf/Vitanyi]
  - Complexity & information theory
- PNA 6.4 [Buhrman]
  - Computational biology

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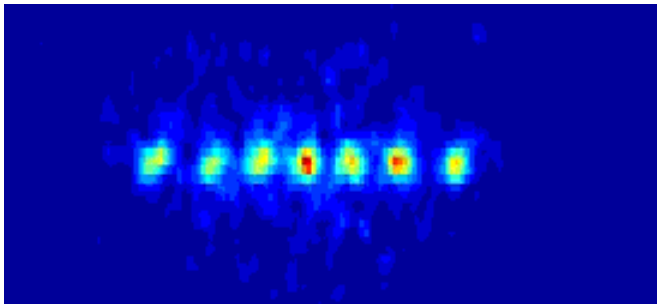
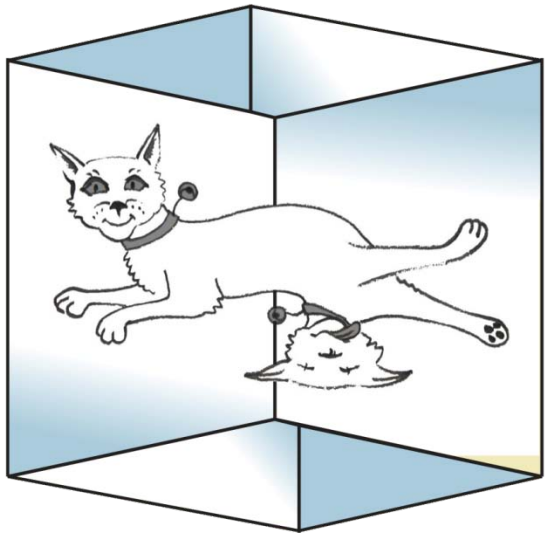
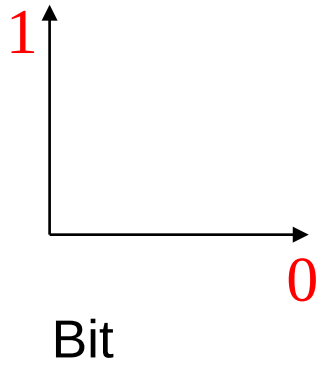
PNA 6.1
Quantum Computing



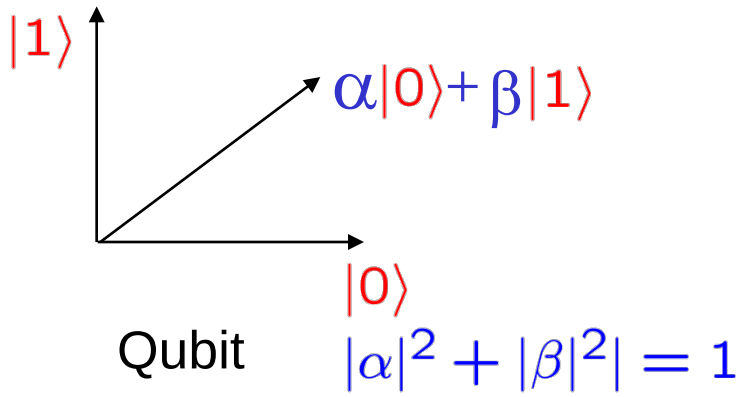


Quantum Computing

Bit: **0** or **1**



Qubit: superposition of **0** and **1**



- Algorithms: factoring, search …
- Quantum communication, crypto …

Highlights of PNA 6.1

- Fault-tolerance threshold (with PNA1)
- Quantum communication complexity
- Quantum non-locality & functional analysis
- Classical theorems via quantum techniques

Grand Challenges PNA 6.1

- New quantum algorithms
- Applications physics/math/CS
- Quantum crypto

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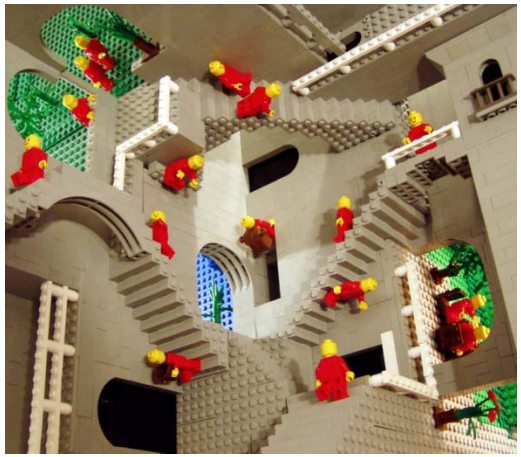
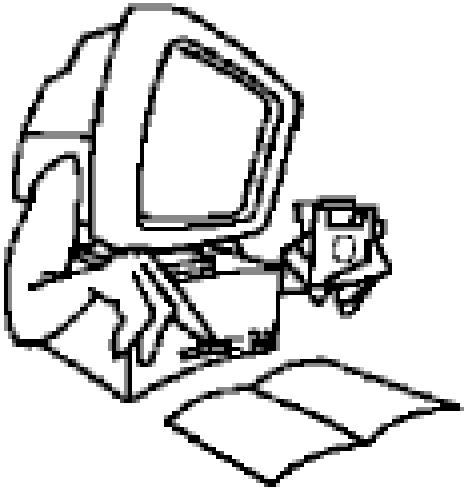
PNA 6.2
Learning theory



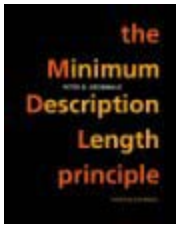


Learning Theory

- Information theoretic methods for learning from data
- Learning when all models are wrong
- Minimum Description Length (MDL)
- Forensic statistics

Highlights PNA 6.2

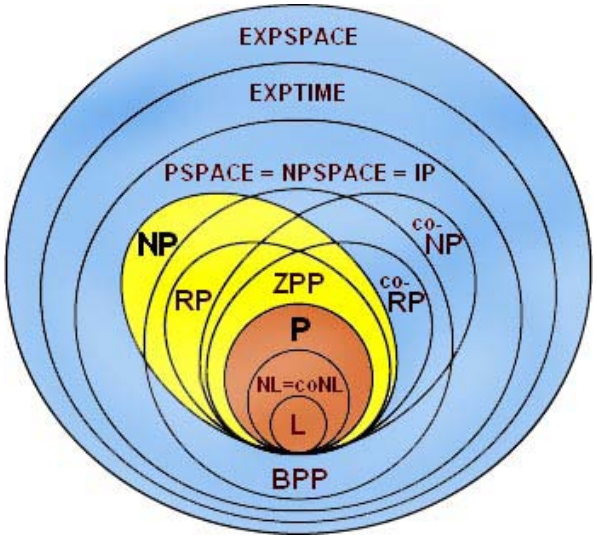
- MDL is suboptimal in classification
  - MDL can overfit
- Switch distribution
  - Prediction method outperforms Bayes when models wrong
- Standard book on MDL (Grünwald)

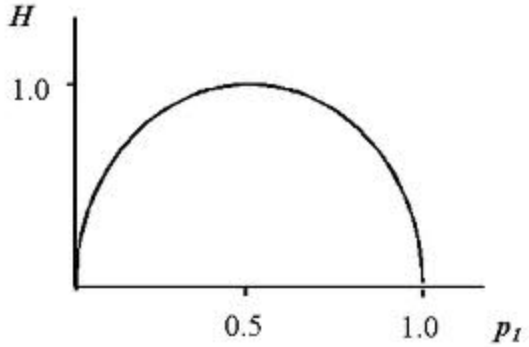


Grand Challenges PNA 6.2

- Learning when all models are wrong
  - Generalization of MDL avoids overfit
  - Unify Vapnik's learning theory and MDL
  - Application in forensic statistics

PNA 6.3
Complexity & Information Theory

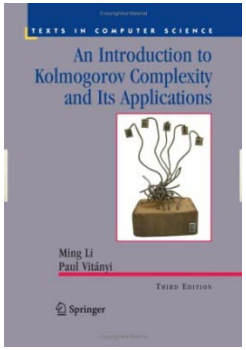




Complexity & Information Theory

- Computational complexity
- Kolmogorov complexity
- Distributed computing
- Property testing

Highlights PNA 6.3



- Third edition Kolmogorov complexity book (Li-Vitanyi)
- Exponential density of NP-hard sets under reasonable assumption: co-NP not in NP/poly
- New bounds for testing Isomorphism of Boolean functions

Grand Challenges PNA 6.3

- New non-relativizing separations
  - Separations a la P vs NP
- Time-limited Kolmogorov Complexity
  - Characterization of random strings
- Connection with quantum computing

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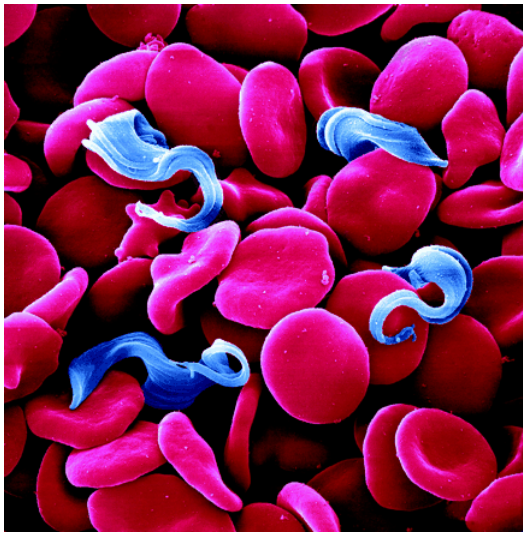
PNA 6.4
Computational Biology



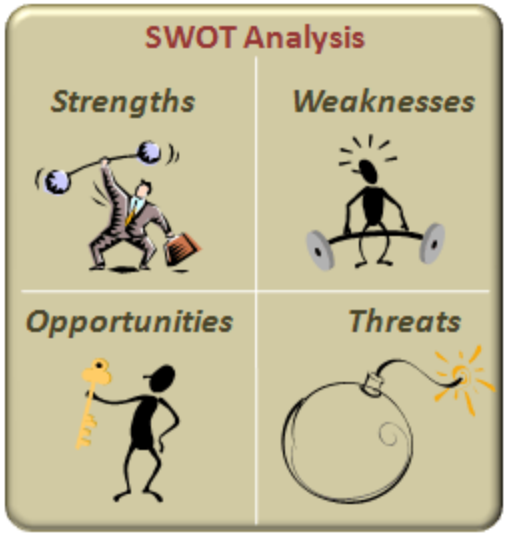
Highlights PNA 6.4

- Model optimization of genetic code
  - Why is the code unique?
- Model evolutionary advantage of pan editing in trypanosomatids
- Theory of early peptides

Grand Challenges PNA 6.4

- Apply techniques from math/CS to modeling of (early) evolution
- Apply techniques from quantum computing to simulate bio-systems
- Apply clustering techniques based on Kolmogorov complexity to biological systems/pathways

SWOT analysis
PNA 6



Strengths

- Strong, international reputation in many mainstream areas
- Amply funded & prizes: Veni, Vidi, Vici, EU, van Dantzig prijs
- Many publications in top journals and conferences
- Successful PhD students

Weakness

- E pluribus unum: federation of research areas
- Distance from practice?

Opportunities

- Quantum: coop. with physics (U of A, Delft) & math (PNA 1, 2 & 5)
- Learning: forensics & decline effect
- Complexity: link quantum computing
- Bio: coop. MAC 4

Threats

- Competition with major North American universities for PhD's & postdocs (MIT/Berkeley etc.)
- Diminishing funding opportunities

Strategy

- Preserving our strength in diversity
- Cooperation with PNA1, 2, 5 & MAC4
  - Joint project on QC & combinatorics PNA1
- Cooperation with physics, math & bio
- Growing the bio-computing branch