

Information: Broader Perspectives

Deepak Kumar
Bryn Mawr College

The General Definition of Information

Information = Data + Meaning

The information
went data way



General Definition of a Datum

$Dd =_{def} x$ being distinct from y

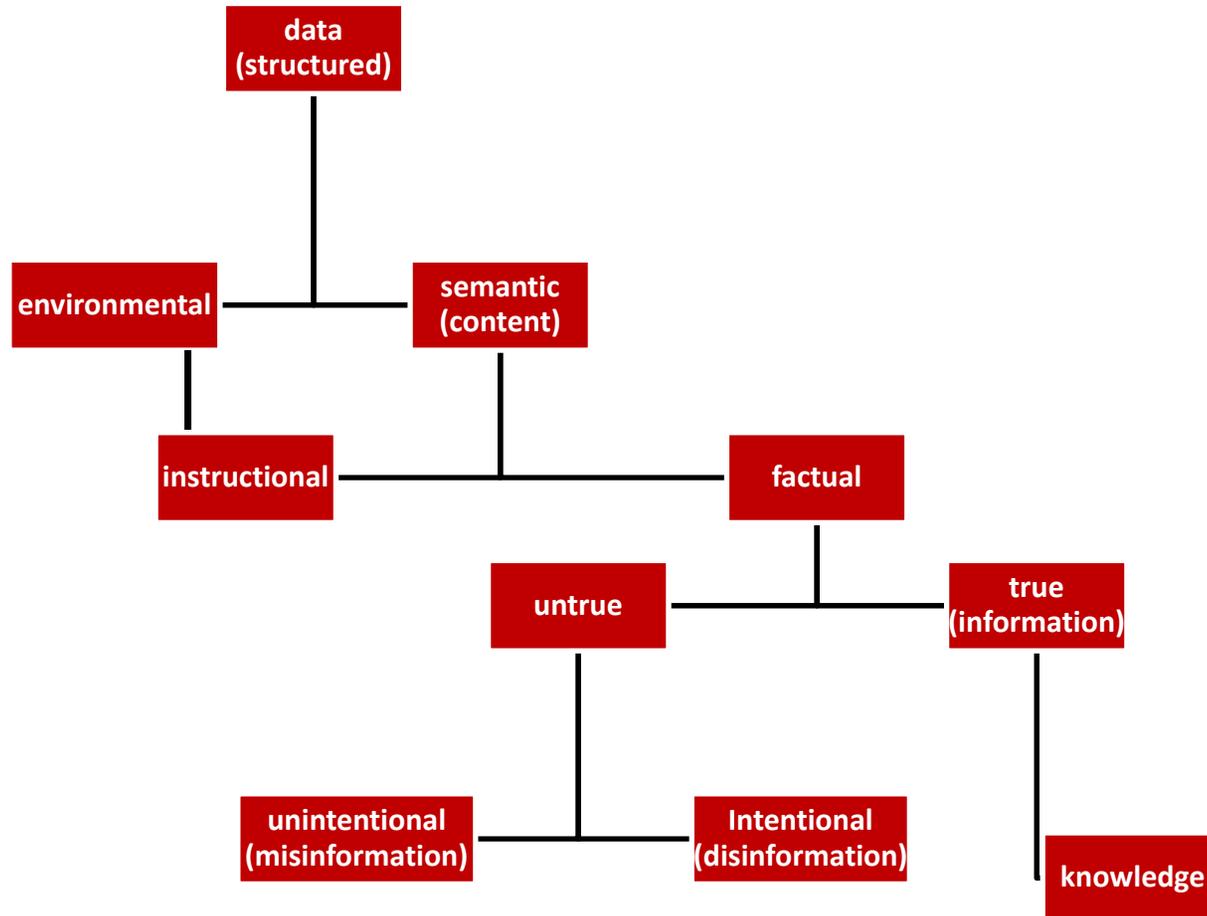
where the x and y are two un-interpreted variables and the domain is left open to further interpretation.

The General Definition of Information

Definition: σ is an instance of information, understood as semantic content, if and only if:

- 1) σ consists of n data, for $n \geq 1$;
- 2) The data are *well-formed*;
- 3) The well-formed data are *meaningful*.

Information: A Taxonomy



Luciano Floridi, *Information: A Very Short Introduction*, Oxford 2010.

Three Types of Information

- **Syntactic Information**
Related to symbols from which **messages** are formed, and to their interrelations (structural)
- **Semantic Information**
related to the meaning of **messages**...
- **Pragmatic Information**
Related to the usage and effect of **messages**

Three Types of Information

- **Syntactic Information**
Related to symbols from which messages are formed, and to their interrelations (structural)
- **Semantic Information**
related to the meaning of messages...
- **Pragmatic Information**
Related to the usage and effect of messages

INFORMATION = MESSAGE?

Jan C. A. van der Lubbe, Information Theory, Cambridge 1997.

Two Traditions...

- Concerned primarily with semantic & pragmatic aspects of information.
- Concerned with syntactic aspects of information:
 - How do you measure syntactic information?
 - Limits on the amount of information which can be transmitted?
 - Limits on compression of information?
 - How to build information processing systems approaching these limits?

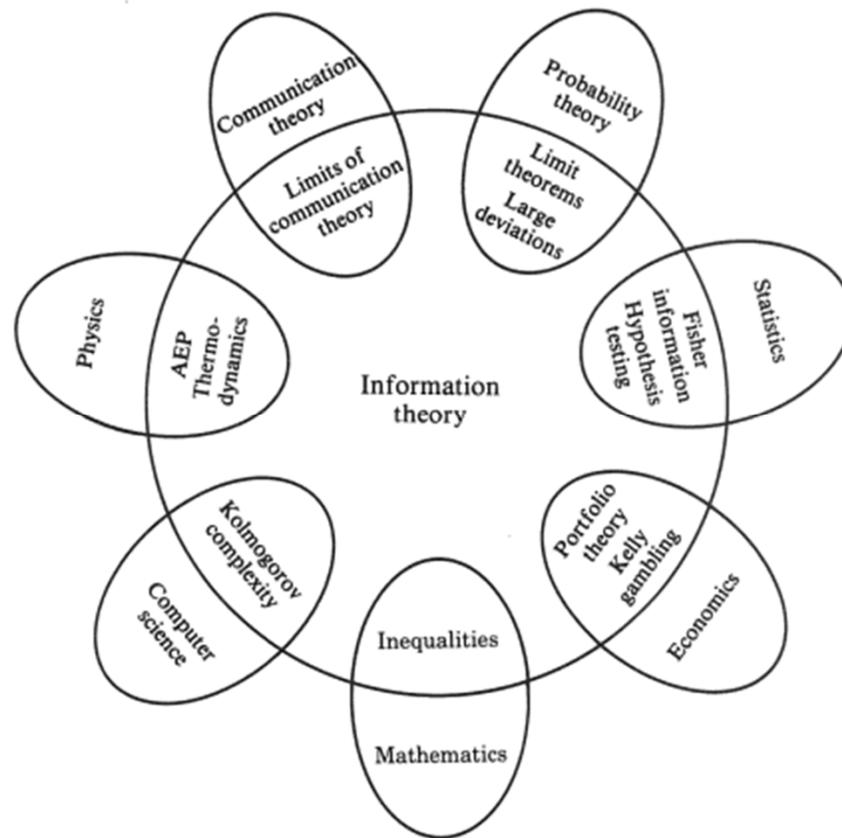
Classical Information Theory

- Concerned with syntactic aspects of information:
 - How do you measure syntactic information?
 - Limits on the amount of information which can be transmitted?
 - Limits on compression of information?
 - How to build information processing systems approaching these limits?

Classical Information Theory

- Concerned with syntactic aspects of information:
 - How do you measure syntactic information?
Answer: Entropy, H .
 - Limits on the amount of information which can be transmitted?
Answer: Channel Capacity, C
 - Limits on compression of information?
Answer: Entropy, H .
 - How to build information processing systems approaching these limits?
Answer: Fo' real!

Relationship with Other Fields



Thomas M. Cover & Joy A. Thomas, *Elements of Information Theory*, Second Edition, Wiley 1990.

Floridi's Roadmap

- **Mathematical Information**

Information Theory

- **Semantic Information**

- **Physical Information**

Universe is fundamentally composed of data, instead of matter or energy, with material objects as a complex secondary manifestation.

- **Biological Information**

Genetic Information, Neural Information, Computational Neuroscience, ...

- **Economic Information**

Commoditization of information, value of information, game theory, ...

- **Ethics of Information**

Five Fundamentals of Information

- **Entropy**

Information Theory, bits, bandwidth, codes,...

- **Economics**

Strategies for value: how information is produced, priced, and distributed, ...

- **Encryption**

Secure transmission, digital signatures, digital cash, ...

- **Extraction**

Data organization, storage, extraction, etc...

- **Emission**

Frequency, modulation, radio, TV, phones, networks, ...

Towards a Science of Information

- Information Theory needs to meet new challenges of current applications in *biology, communication, knowledge extraction, economics, ...*
- Understand new aspects of information in **structure, time, space, and semantics.**
- PLUS...dynamic information, limited resources, complexity, representation-invariant information, and cooperation & dependency



Center for Science of Information

NSF Science and Technology Center



Google™ Custom Search

Search

[Home](#)

[About Us](#)

[Research](#)

[Education](#)

[Diversity](#)

[Knowledge Transfer](#)

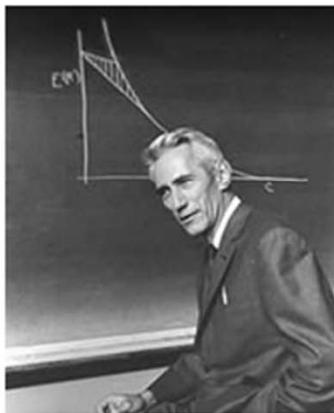
[News & Events](#)

[Blog](#)

[Wiki](#)

ADVANCING NEW FRONTIERS

Our mission is to advance science and technology through a new quantitative understanding of the representation, communication, and processing of information in biological, physical, social, and engineered systems.



Video: [Watch this introductory video about our Center](#)

CSOI CHANNEL SCHOLARS



PURDUE
UNIVERSITY

UCSanDiego

PRINCETON
UNIVERSITY

Introducing the 2012-13 CSol Channels Scholars Cohort

UPCOMING EVENTS & ACTIVITIES

[Bryn Mawr to host AALAC/Mellon 23 Working Group on Information](#)

through Saturday, October 27, 2012

[CS Theory/Math Seminar, Douglas Comer, Purdue University](#)

Monday, October 29, 2012

Lawson 3102

NEWS & ANNOUNCEMENTS

[Kumar receives prestigious ACM SIGMOBILE Outstanding Contribution Award](#)

Monday, September 24, 2012

[CSol's Shankar Subramaniam, UCSD bioengineers to play a central role in new NIH program to accelerate metabolomics](#)

Monday, September 24, 2012

Some Challenges...

- **Structure**

Measures are needed for quantifying information embodied in structures (e.g., information in material structures, nanostructures, biomolecules, gene regulatory networks, protein networks, social networks, financial transactions).

- **Time**

Delay (e.g., information arriving late may be useless or has less value).

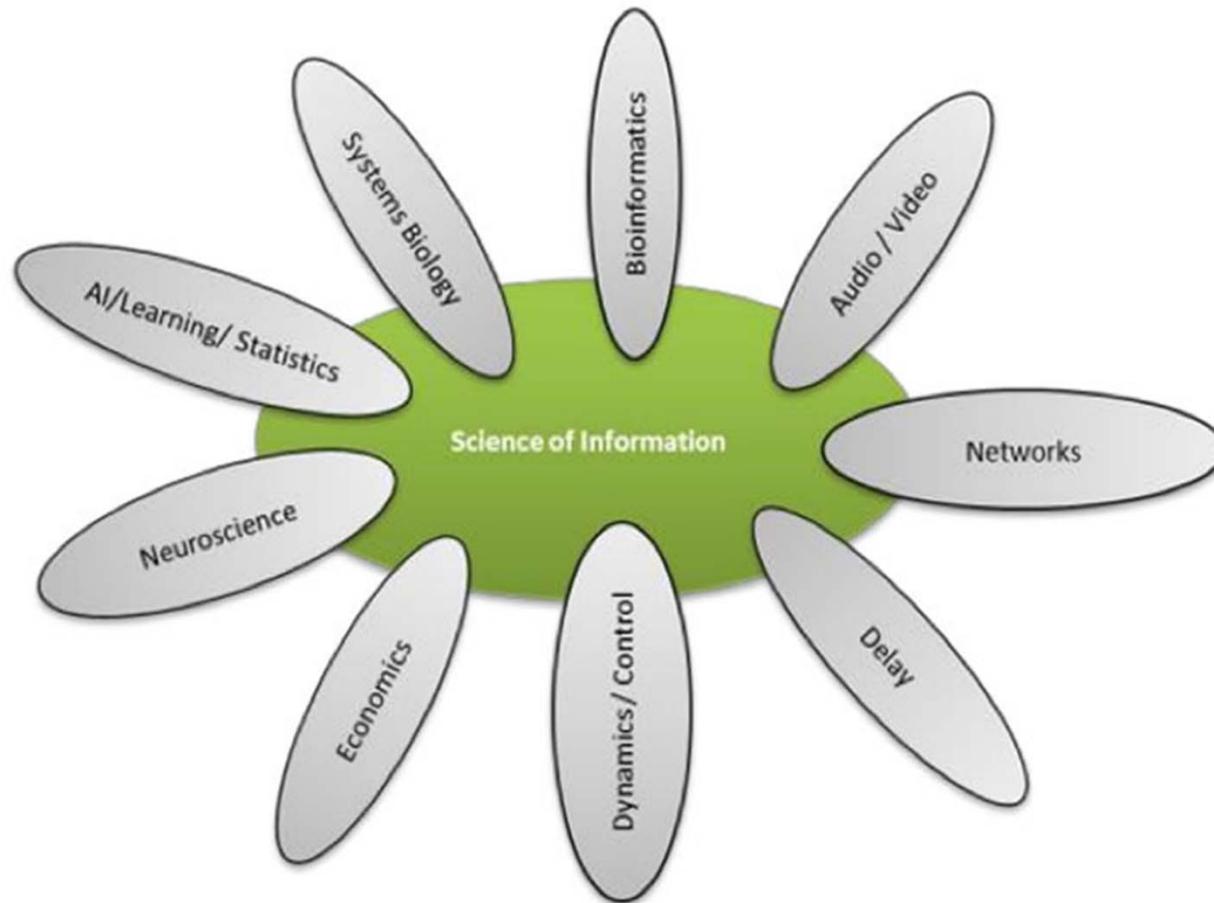
- **Semantics**

Is there a way to account for the meaning or semantics of information?

- **Knowledge Extraction**

Data driven science focuses on extracting information from data. How much information can actually be extracted from a given data repository? How?

Science of Information



Center for Science of Information (soihub.org->Research Overview), 2012.

Emerging Frontiers of Sol

	Information Theory & Communications		Biology		Knowledge Extraction		Economics	
	Traditional	Quantum	Molecular	Neuroscience	Big Data	Semantics	Theory	Applications
Fundamentals								
Structure								
Time								
Space								
Semantics								

Our Sol Roadmap

- **Foundations of Information Theory**

Entropy, codes, compression, channels, ...

- **Communications**

Voice, data, ...

- **Biological Information**

Bioinformatics, proteomics, epidemiology, neuroscience,...

- **Information Extraction**

Big data, storage, processing, IR, indexing, search engines, visualization,...

- **Economic Information**

Dynamic economic theory, behavior of continuously optimizing agents in markets, ...

- **Quantum Information**

How “dirty” do we want to get?

- Information Theory needs to meet new challenges of current applications in *biology, communication, knowledge extraction, economics, ...*
- Understand new aspects of information in structure, time, space, and semantics.
- PLUS...dynamic information, limited resources, complexity, representation-invariant information, and cooperation & dependency

- **Foundations of Information Theory**

Entropy, codes, compression, channels, ...

- **Communications**

Voice, data, ...

- **Biological Information**

Bioinformatics, proteomics, epidemiology, neuroscience,...

- **Information Extraction**

Big data, storage, processing, IR, indexing, search engines, visualization,...

- **Economic Information**

Dynamic economic theory, behavior of continuously optimizing agents in markets, ...

- **Quantum Information**

- **Mathematical Information**

Information Theory

- **Semantic Information**

- **Physical Information**

Universe is fundamentally composed of data, instead of matter or energy, with material objects as a complex secondary manifestation.

- **Biological Information**

Genetic Information, Neural Information, Computational Neuroscience, ...

- **Economic Information**

Commoditization of information, value of information, game theory, ...

- **Ethics of Information**

- **Entropy**

Information Theory, bits, bandwidth, codes,...

- **Economics**

Strategies for value: how information is produced, priced, and distributed, ...

- **Encryption**

Secure transmission, digital signatures, digital cash, ...

- **Extraction**

Data organization, storage, extraction, etc...

- **Emission**

Frequency, modulation, radio, TV, phones, networks, ...

Our Sol Roadmap

- **Foundations of Information Theory**

Entropy, codes, compression, channels, ...

- **Communications**

Voice, data, ...

- **Biological Information**

Bioinformatics, proteomics, epidemiology, neuroscience,...

- **Information Extraction**

Big data, storage, processing, IR, indexing, search engines, visualization,...

- **Economic Information**

Dynamic economic theory, behavior of continuously optimizing agents in markets, ...

- **Quantum Information**