Current Trends in Machine Learning for Signal Processing (MLSP)

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First, a very brief history...

- Started existence as the Technical Committee on *Neural Networks for Signal Processing* (NNSP) in 1990
- First NNSP Workshop September 1991, in Princeton, NJ
- First TC Chair, Fred B. H. Juang
- Yearly workshops since 1991

Yearly workshops since 1991

Workshops on Neural Network for Signal Processing

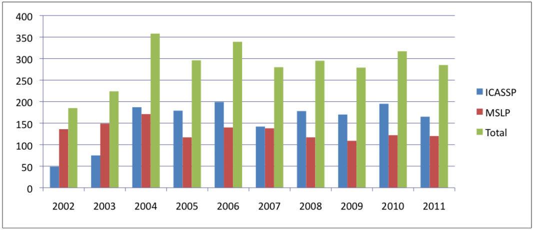
- NNSP 1991, September 30–Oct. 2, Nassau Inn, Princeton, New Jersey, USA
- NNSP 1992, August 31–September 2, Hotel Marienlyst, Helsingor, Denmark
- NNSP 1993, September 6–9, Linthicum, Maryland, USA
- NNSP 1994, September 6–8, Proto Hydra Resort Hotel, Ermioni, Greece
- NNSP 1995, August 31–September 2, Royal Sonesta Hotel, Cambridge, Boston, USA
- NNSP 1996, September 4–6, Keihanna, Seika, Kyoto, Japan
- NNSP 1997, September 24–26, Amelia Island Plantation, Florida, USA
- NNSP 1998, August 31–September 2, Newton Institute, Cambridge, England
- NNSP 1999, August 23–25, Madison, Wisconsin, USA
- NNSP 2000, December 11–13, Sydney, Australia
- NNSP 2001, September 10–12, Falmouth, USA
- NNSP 2002, September 4–6, 2002, Martigny, Valais, Switzerland
- NNSP 2003, September 17–19, 2003, Toulouse, France

Workshops on Machine Learning for Signal Processing

- MLSP 2004, September 29–October 1, 2004, São Luis, Brazil
- MLSP 2005, September 28–30 2005, Mystic, USA
- MLSP 2006, September 6–8, 2006, Maynooth, Ireland
- MLSP 2007, August 27–29, 2007, Thessaloniki, Greece
- MLSP 2008, October 16–19, 2008, Cancún, Mexico
- MLSP 2009, September 2–4, 2009, Grenoble, France
- MLSP 2010, August 29–September 1, 2010, Kittila, Finland
- MLSP 2011, September 18–21, 2011, Beijing, China

From NNSP to MLSP

- “Neural Network for Signal Processing” was deemed to be too narrow a scope by many
- Working with the IEEE SPS President at the time, Fred Mintzer, the TC approved the name: Machine Learning for Signal Processing which became the TC’s new name after approval by the BoG



Submissions to ICASSP in MLSP
and the MLSP Workshop since 2002

MLSP: What is the scope?

- The bridge between machine learning and signal processing
- *Learning* is the key aspect
- *Signal processing* defines the main applications of interest and the constraints
- Attractive solutions for traditional signal processing applications such as pattern recognition, speech, audio, and video processing
- Primary candidates for emerging applications such as BCI, multimodal data fusion and processing, behavior and emotion recognition, and learning in environments such as social networks

Current EDICS

- Applications of machine learning
- Bayesian learning; Bayesian signal processing
- Cognitive information processing
- Graphical and kernel methods
- Independent component analysis
- Information-theoretic learning
- Learning theory and algorithms
- Neural network learning
- Pattern recognition and classification
- Bounds on performance
- Sequential learning; sequential decision methods
- Source separation

Areas of activity, emerging trends

- Methods
  - Sparsity-aware learning
  - Learning in kernel spaces
  - Semi-supervised learning
  - Distributed learning
  - Subspace and manifold learning
  - Semi-blind data analysis, learning
- Besides learning, *integration* of approaches has been a key emphasis, making MLSP a natural home for
  - brain-computer interface
  - behavior and emotion recognition
  - multimodal data fusion and processing
  - multiple/joint data analysis
  - learning in environments such as social networks

Cognitive information processing represents a major paradigm shift in learning

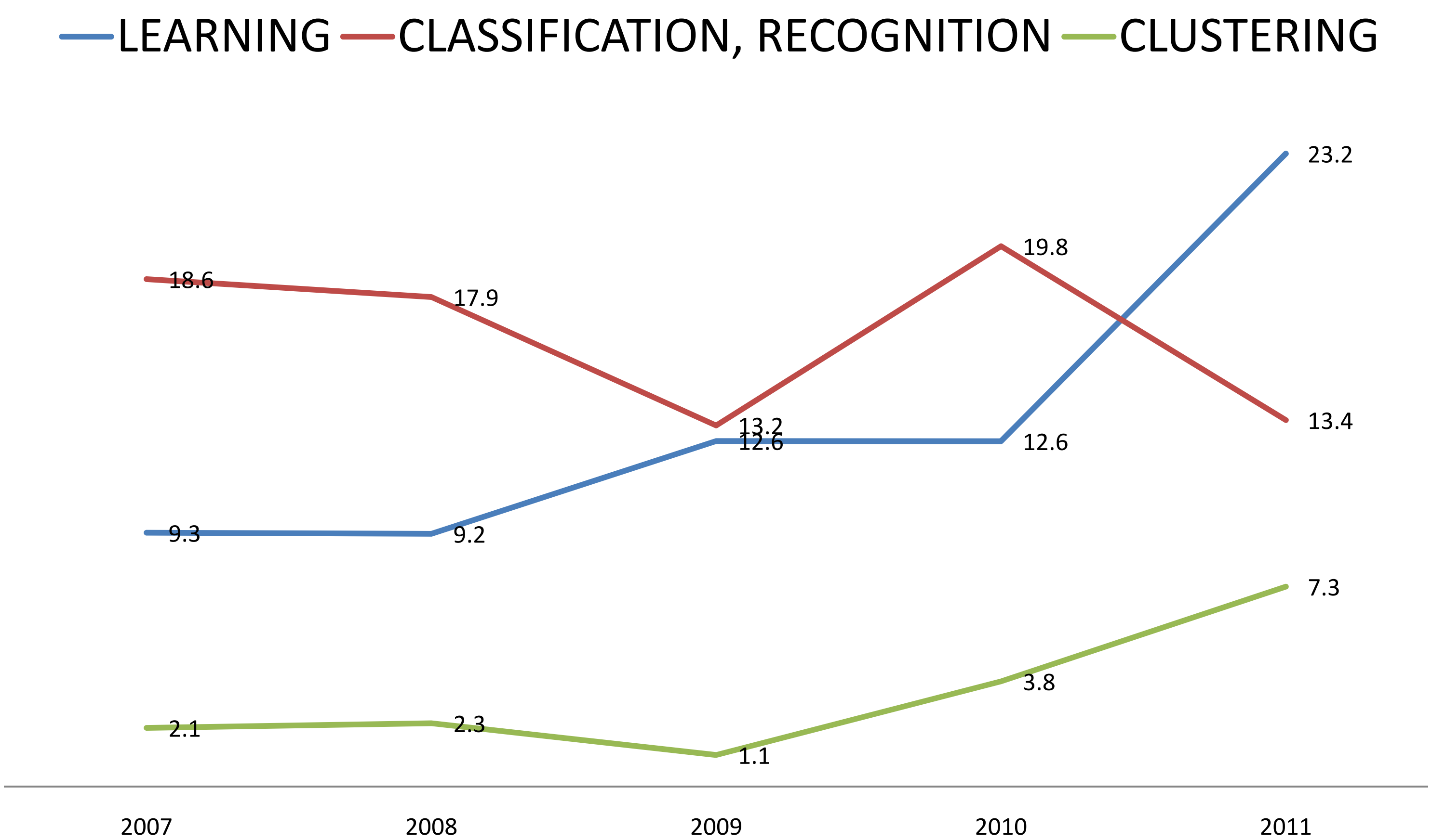
A dynamic system is called *cognitive* if it exhibits all four cognitive properties:

- Perception-action cycle, which produces information gain about the environment, obtained from one cycle to the next
- Memory, which predicts the consequences of action on/in the environment
- Attention, which is responsible for the allocation of available resources
- Finally, intelligence provides the basis for decision-making whereby intelligence choices are made in the face of environmental uncertainties

Trends in Machine Learning for Signal Processing

Kostas Diamantaras
TEI of Thessaloniki, Greece

Data collected from paper titles appearing in ICASSPs (MLSP track) and MLSP workshops between 2007-2011



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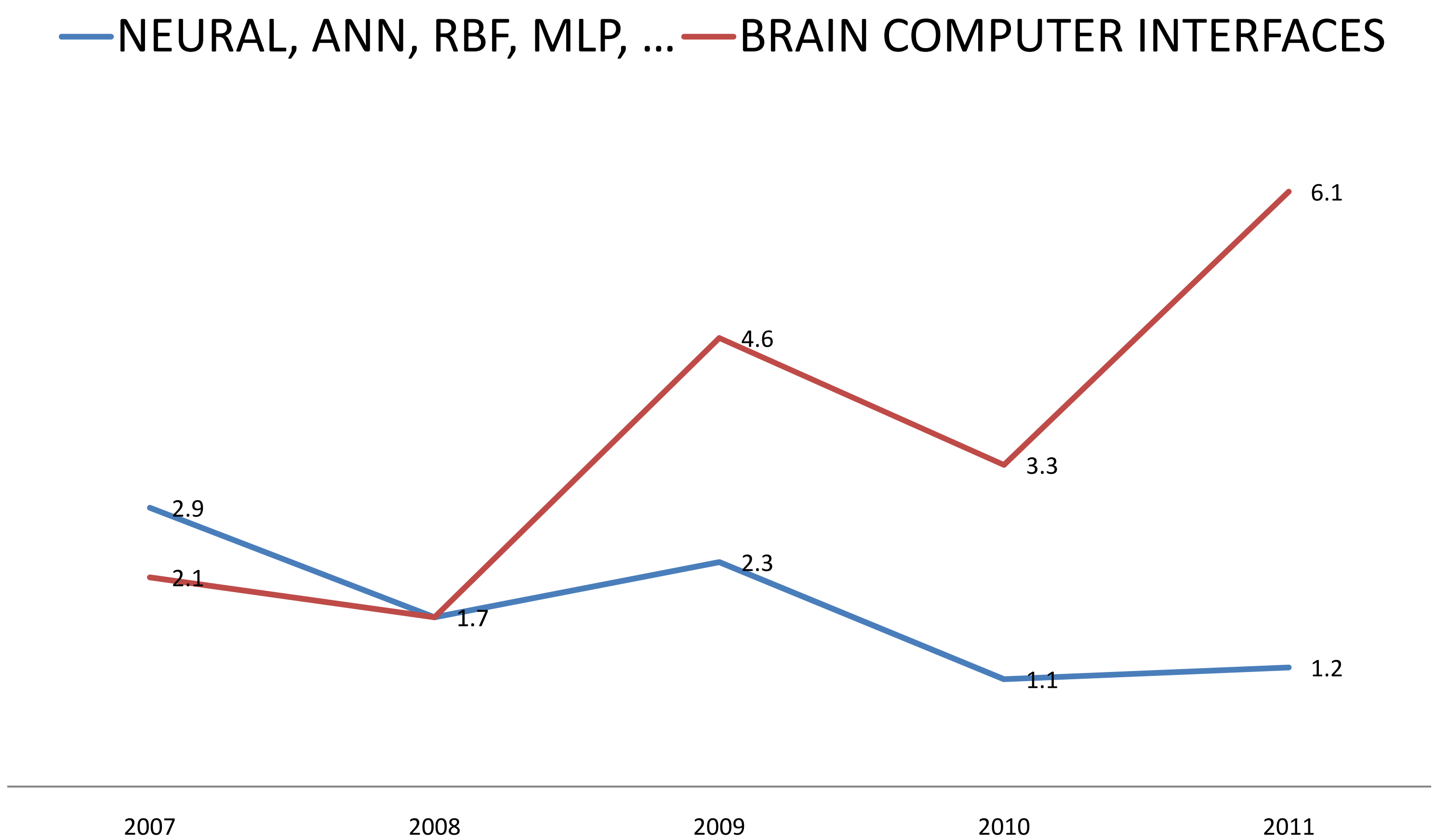

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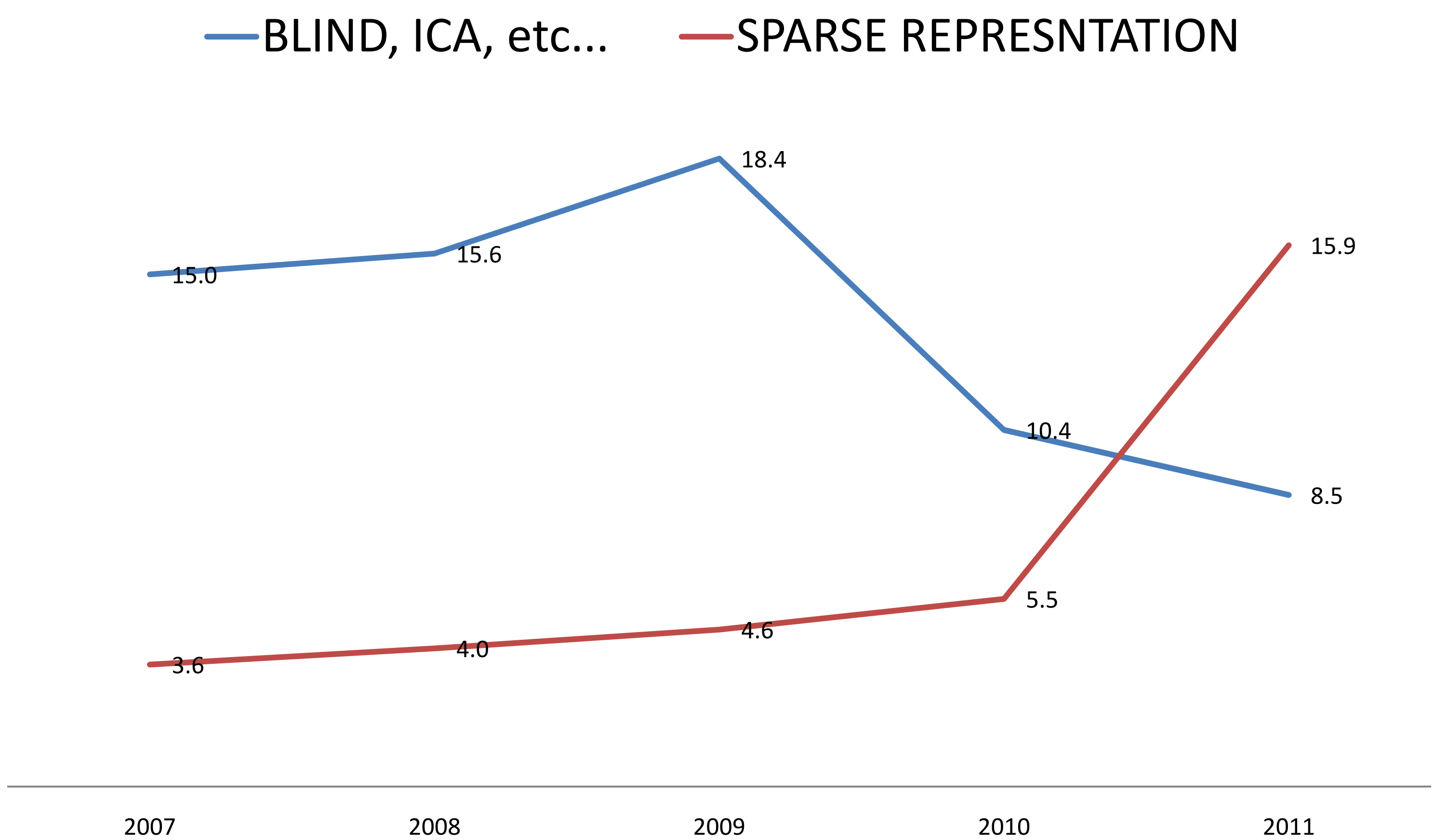

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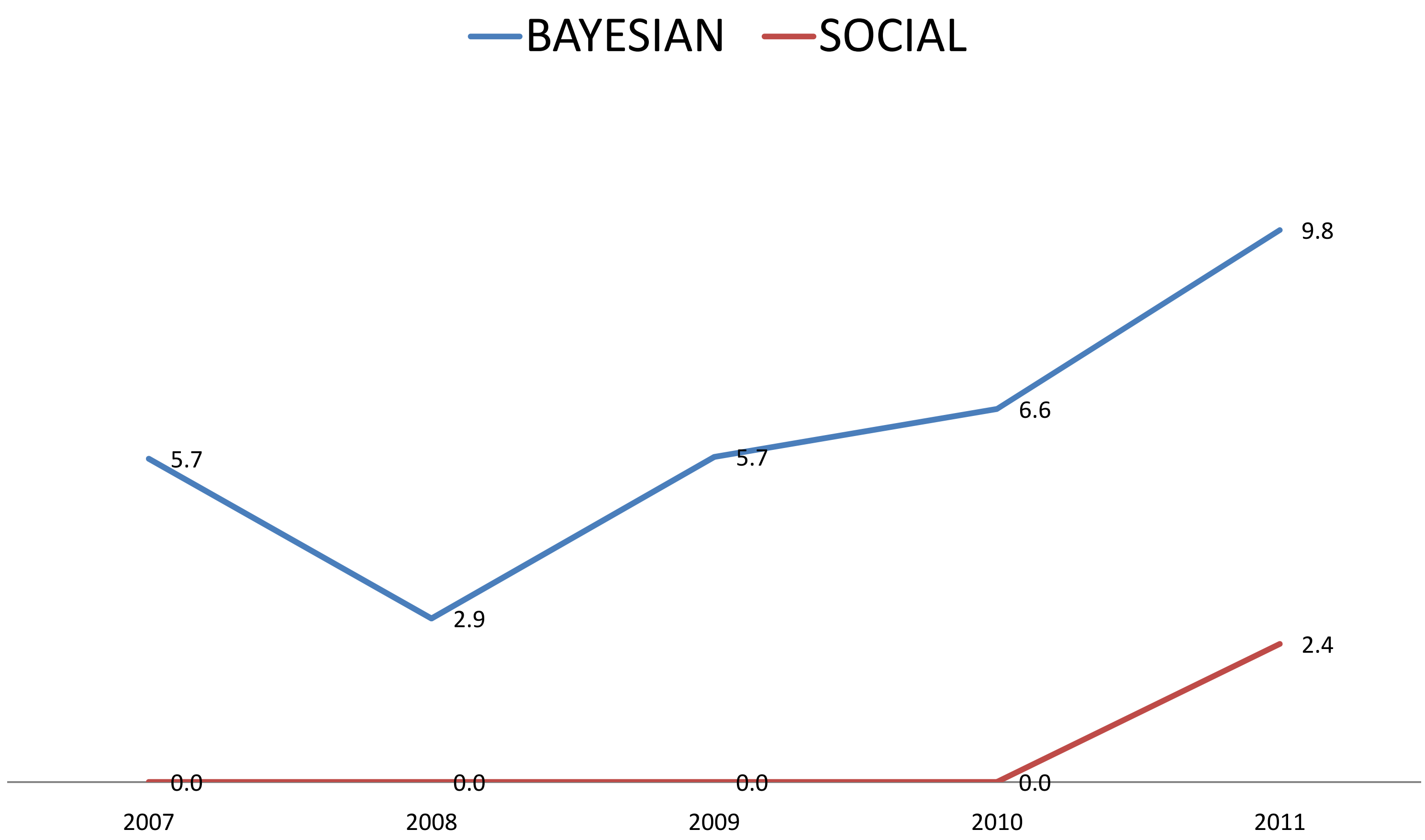

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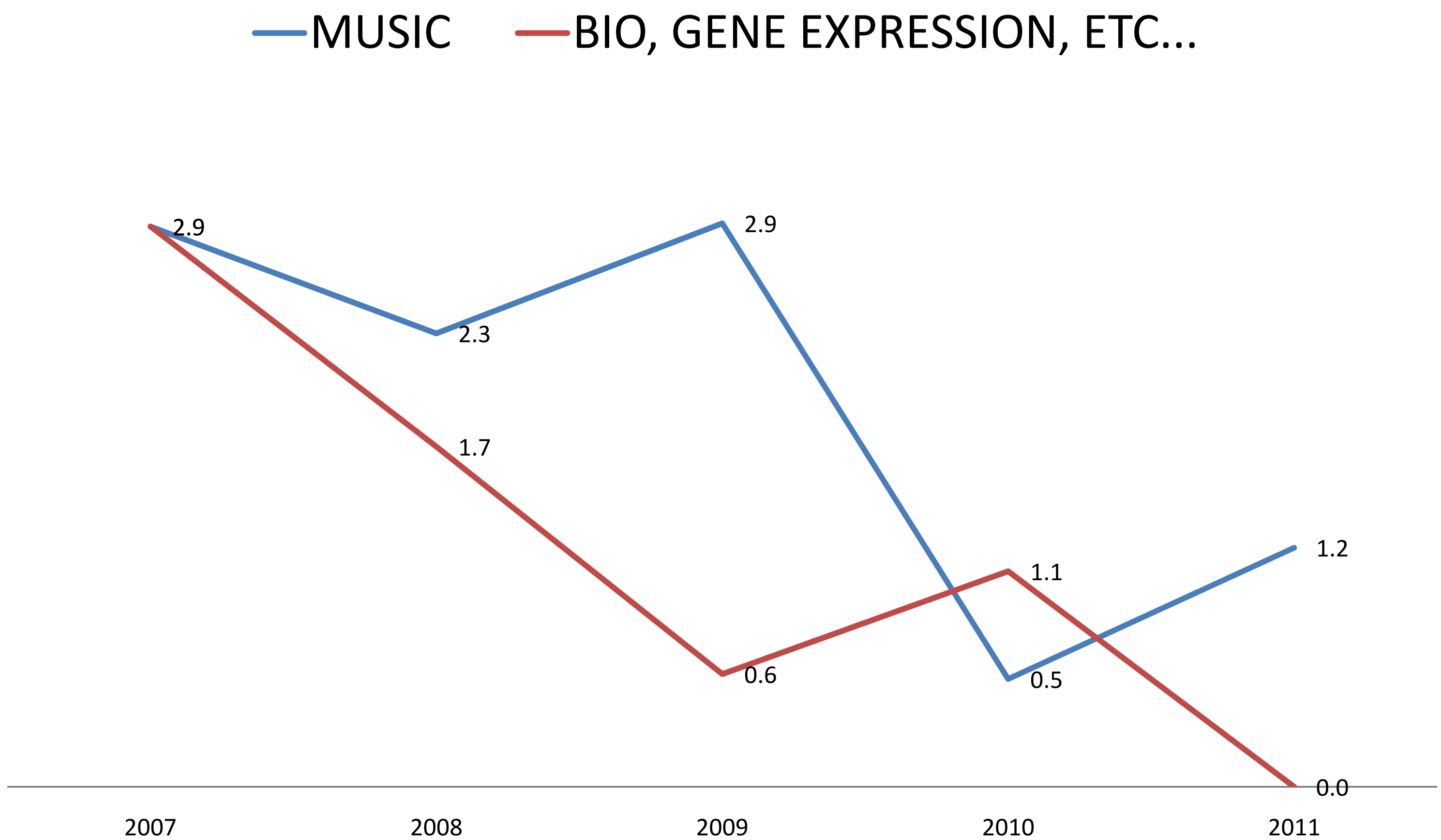

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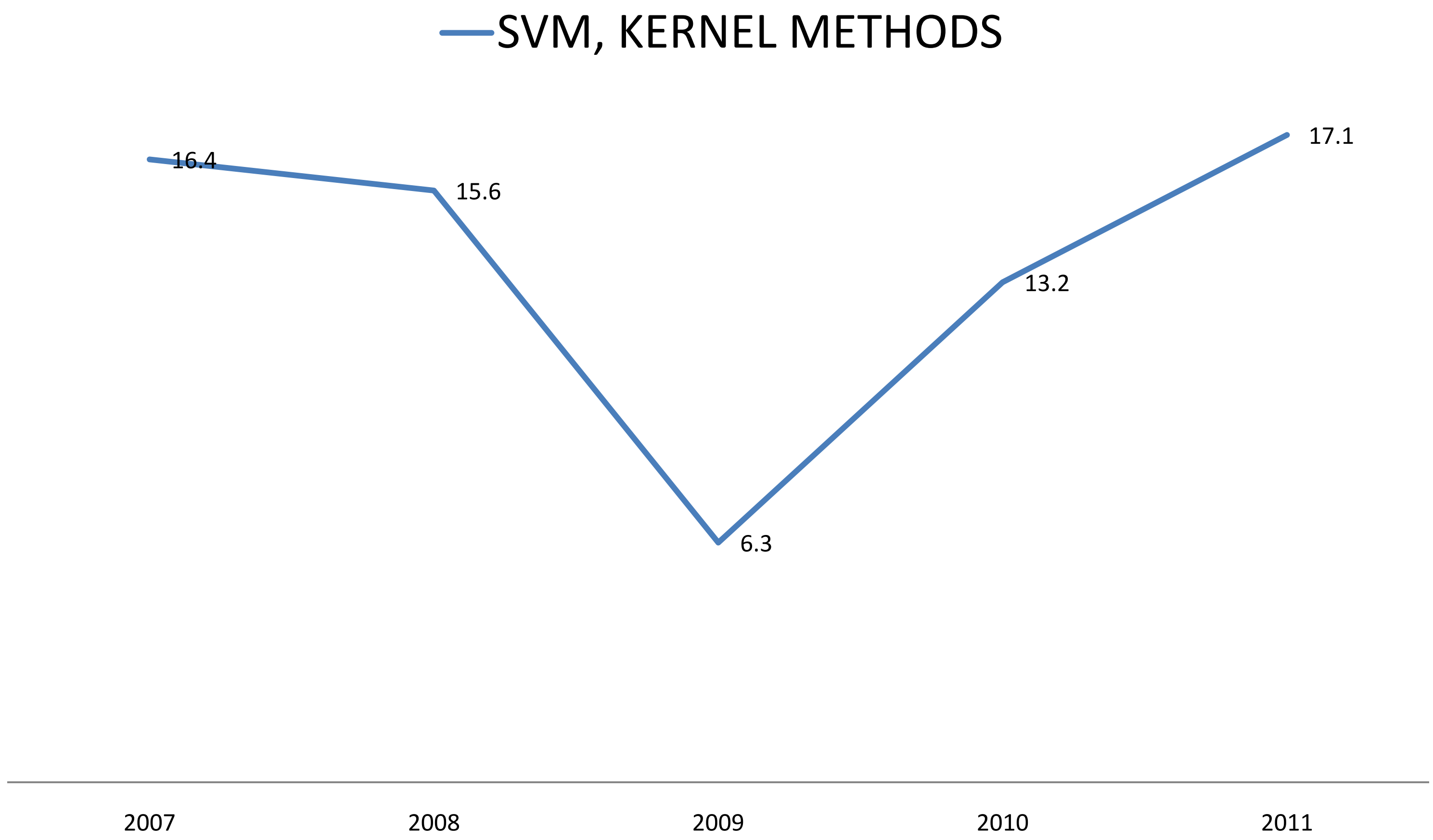

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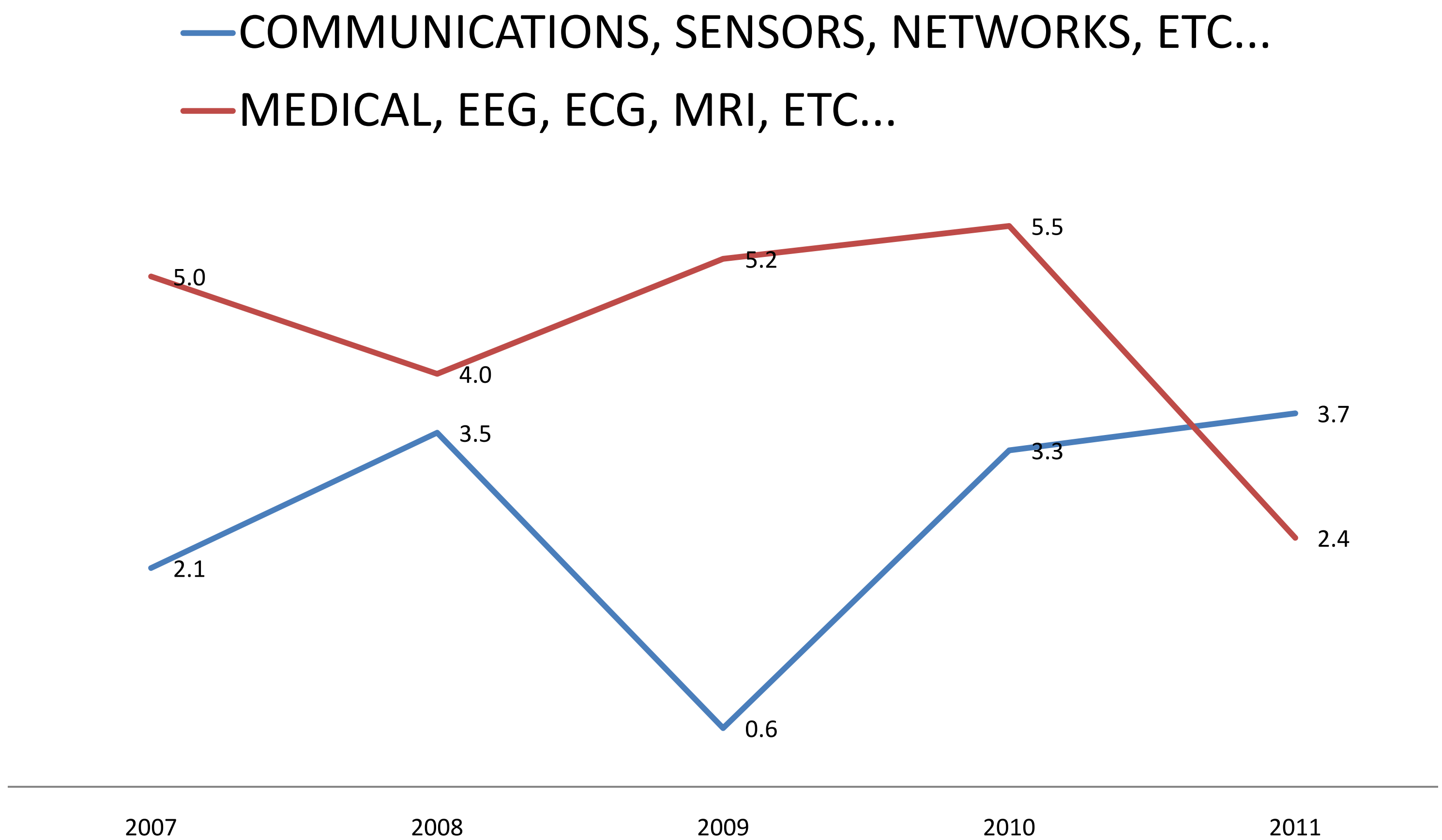

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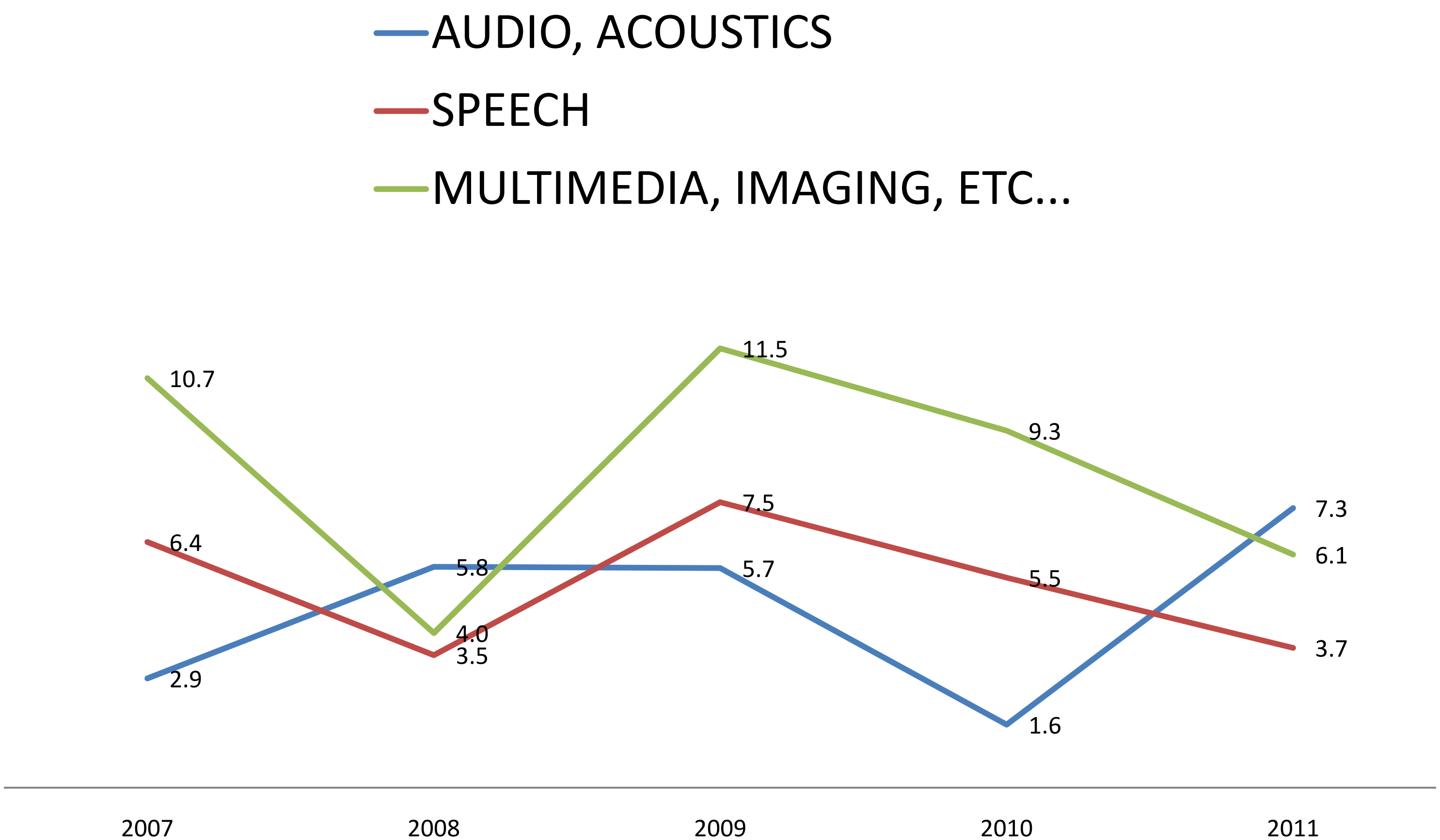

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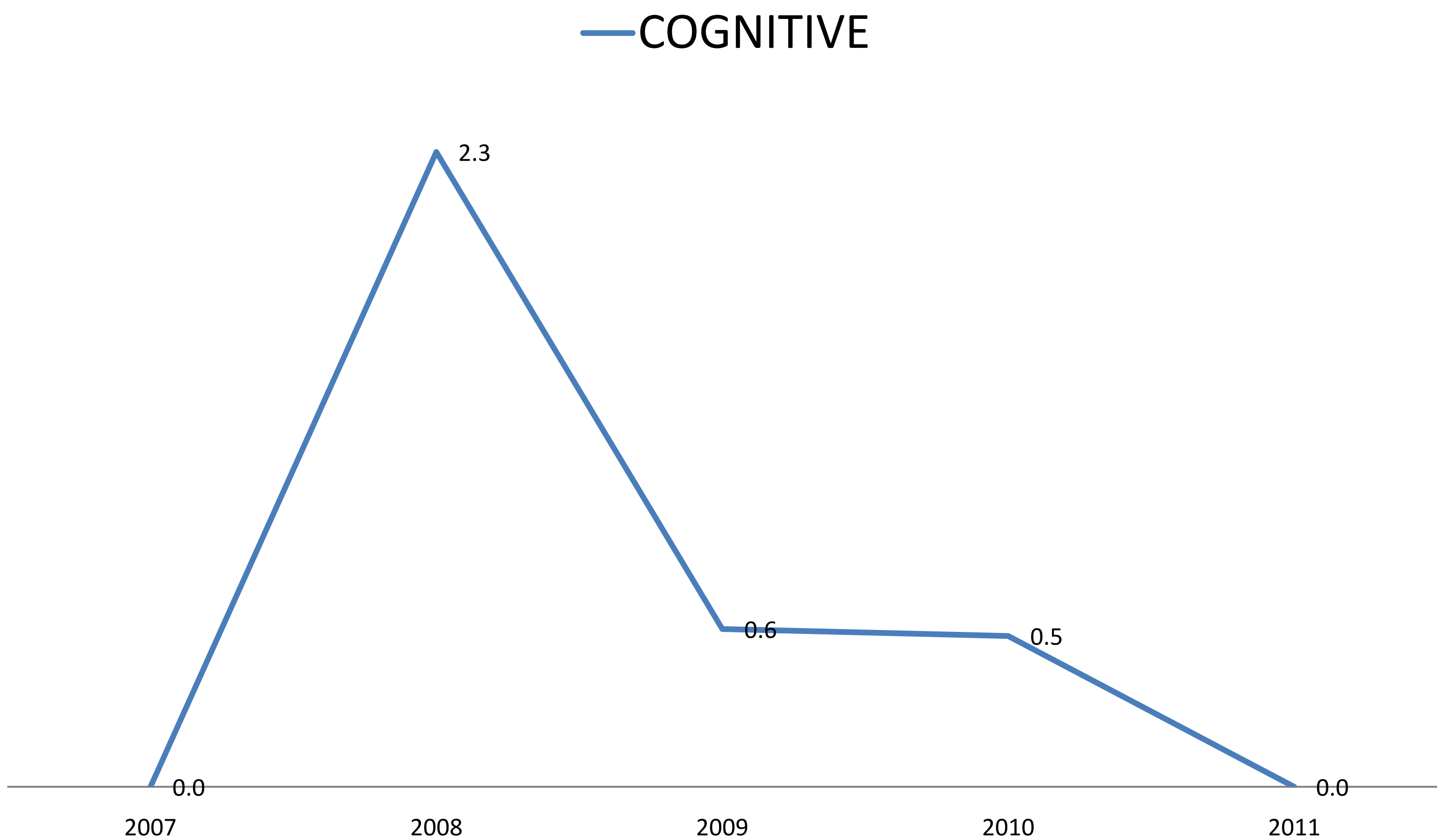

Cognitive information processing

- an emerging trend for MLSP

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Why is it important? VISION

What should we do? MISSION

The legacy

Allan Touring

Theory of computing, 1940'es

Norbert Wiener

Cybernetics

1948

processing → adaption → under-standing → cognition

information and data

people

Vision

Cognition refers to the representations and processes involved in thinking and decision making. Cognitive information processing integrate information processing in brains and computers for collaborative problem solving in open-ended environments

The vision is to design and implement profound cognitive information processing systems for augmented human cognition in real-life environments

Disentanglement of confusing, ambiguous, conflicting, and vast amounts of multimodal, multi-level data and information

Visnevs h

How much is needed to qualify the system

A tiere o high-level ca

robustness

adaptivity

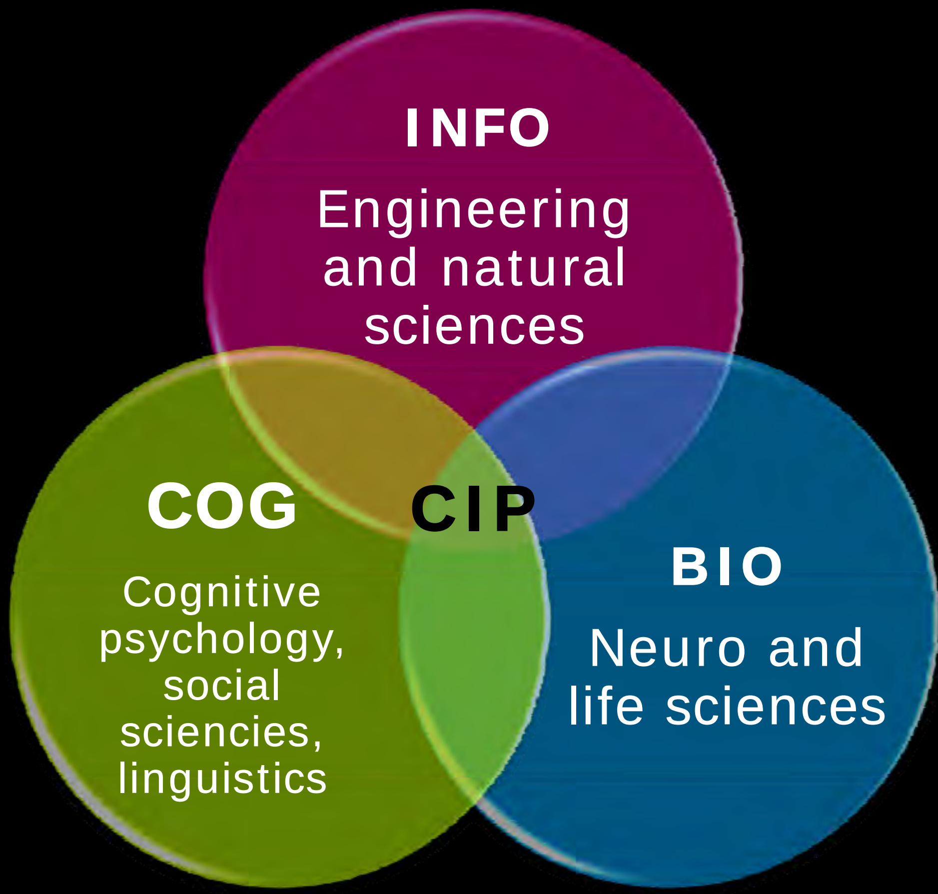
efficiency

natural interaction

emergent properties

Ref: N.A. Visnevski and M. Castillo-Effen: A UAS capability description framework: Reactive, adaptive, and cognitive capabilities in robotics, 2009 IEEE Aerospace Conference, pp. 1-7, 2009.

It takes cross-disciplinary effort to create a cognitive system



Ref: EC Cognitive System Unit http://cordis.europa.eu/ist/cognition/index.html

Revitalizing old visions through cognitive information processing systems by means of enabling technologies

Computation
distributed (grid,cloud) and ubiquitous computing

Connectivity
internet, communication technologies and social networks

Pervasive sensing and data
digital, accessible information on all levels

New theories of the human brain
Neuroinformatics, brain-computer interfaces, mind reading

New business models
Free tools paid by advertisement, 99+1 principle: 99% free, 1% buys, the revolution in digital economy

The unreasonable effectiveness of data

- E. Wigner 1960: The unreasonable efffectiveness of mathematics in the natural sciences.
- Simple linear classifiers based on many features from n-gram representations performs better than elaborate models.
- Unsupervised learning on unlabeled data which are abundant
- The power of linking many different sources
- Semantic interpretation
  - The same meaning can be expressed in many ways – and the same expression can convey many different meanings
  - Shared cognitive and cultural contexts helps the disambiguation of meaning
  - Ontologies: a social construction among people with a common shared motive
  - Classical handcrafted ontology building is infeasible – crowd computing / crowdsourcing are possible

Ref: A. Halevy, P. Norvig, F. Pereira: The unreasonbale effectiveness of data,

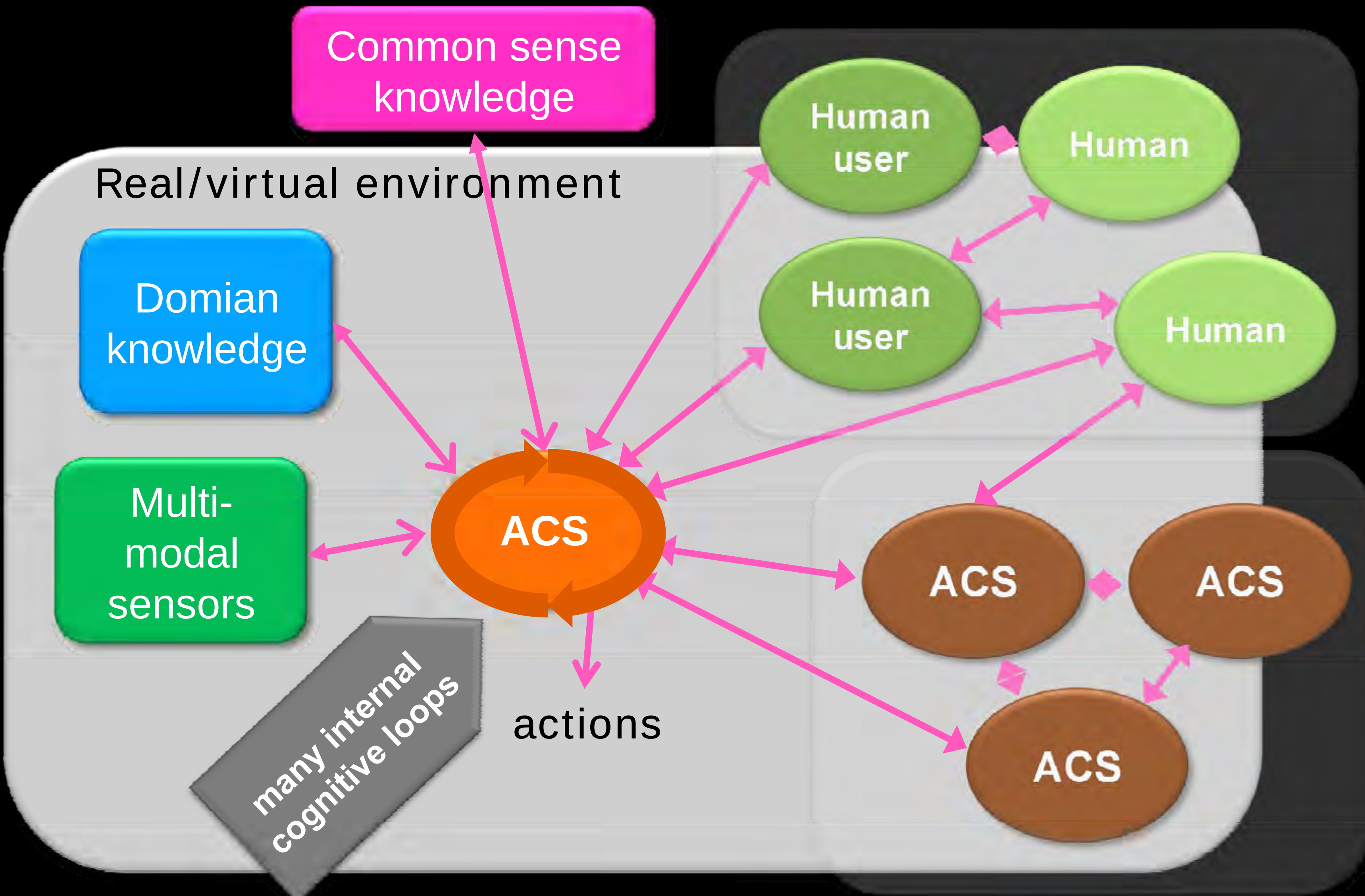
IEEE Intelligent Systems, March/April, pp. 8-12, 2009.

Mission

A cognitive information processing system should optimize itself according to:

The statistical model of the domain, the psycho-physical model of the users, the social context, and the computational resources in time and space

The cognitive information processing system and its world



Information processing and computing

Dynamical, multi-level, integration and learning of

- heterogeneous,
- multi-modal,
- multi-representation (structured/unstructured),
- multi-quality (resolution, noise, validity)
- data, information and human interaction streams

with the purpose of

- achieving relevant specific goals for a set of users,
- and ability to evaluate achievement of goals

using

- new frameworks and architectures and
- computation (platforms, technology, swarm intelligence, grid/cloud computing, crowd computing)

Examples of state of the art along diverse dimensions

- Cognitive radio networks
- Cognitive radar
- Cognitive components
- (Cognitive) sensing networks
- (Cognitive) social network models
- (Cognitive) information retrieval and content management engines

What could the MLSP community contribute

- Bayesian learning as the fundamental learning and information fusion principle
- Nonparametric Bayes
- Signal representation and features
- Sparse models for high-dimensinal data
- Dedicated, efficient, robust on-line algorithms for large scale data
- Engineering and demonstration of cognitive information processing platforms

We can only see a short distance ahead, but we can see that there is much to be done

Alan Turing, 1950