

Cognitive information processing

- an emerging trend for MLSP

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Why is it important?

VISION

What should we do?

MISSION

The legacy



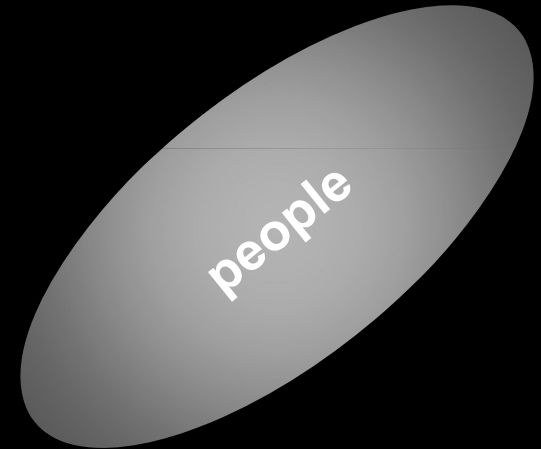
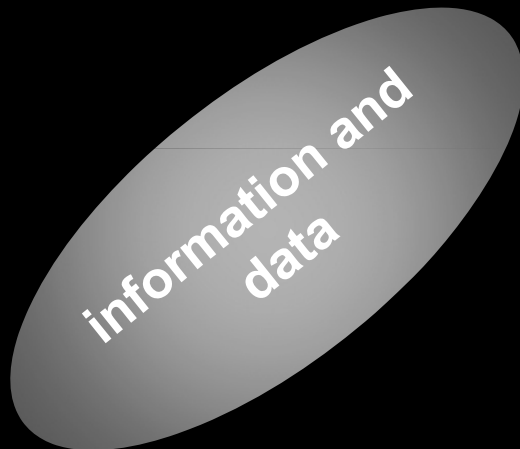
Allan Turing

Theory of computing,
1940'es



Norbert Wiener

Cybernetics
1948



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

How much is needed to qualify the system

robustness

A tiered capability framework to high-level capabilities

adaptivity

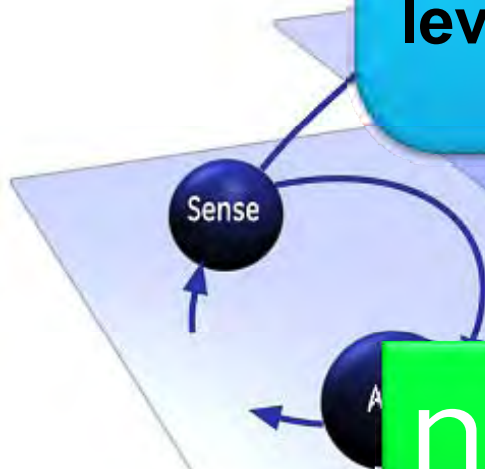
systems

efficiency

adaptive systems

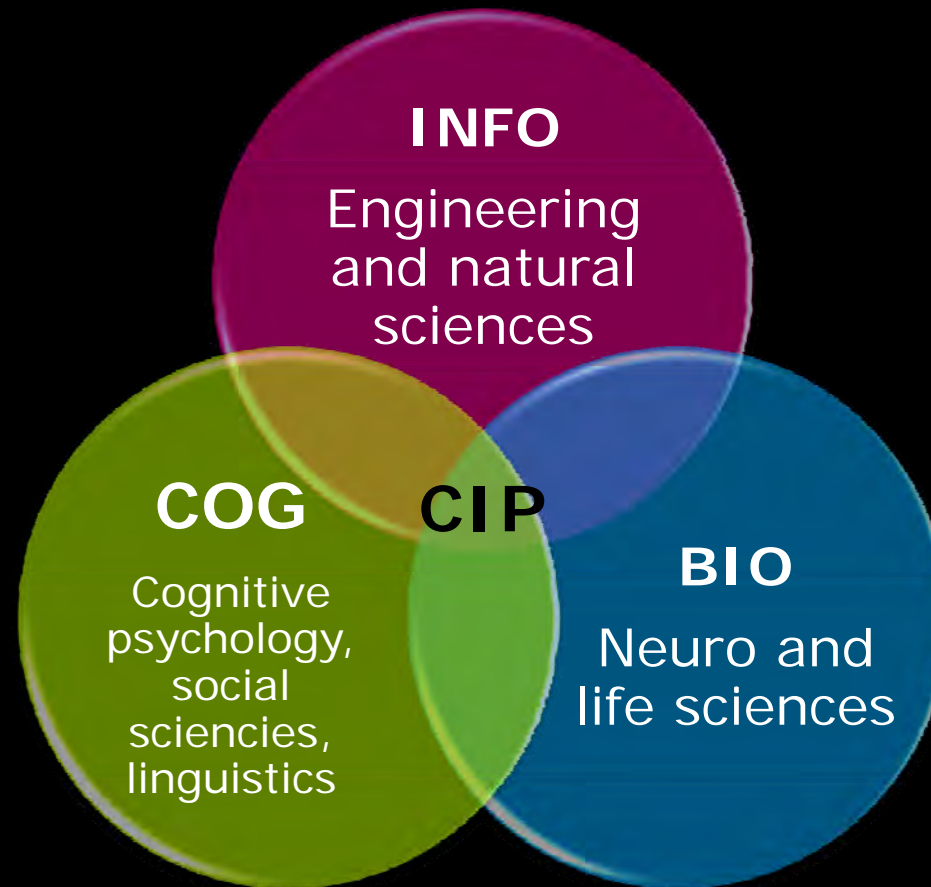
natural interaction

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 effectiveness 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

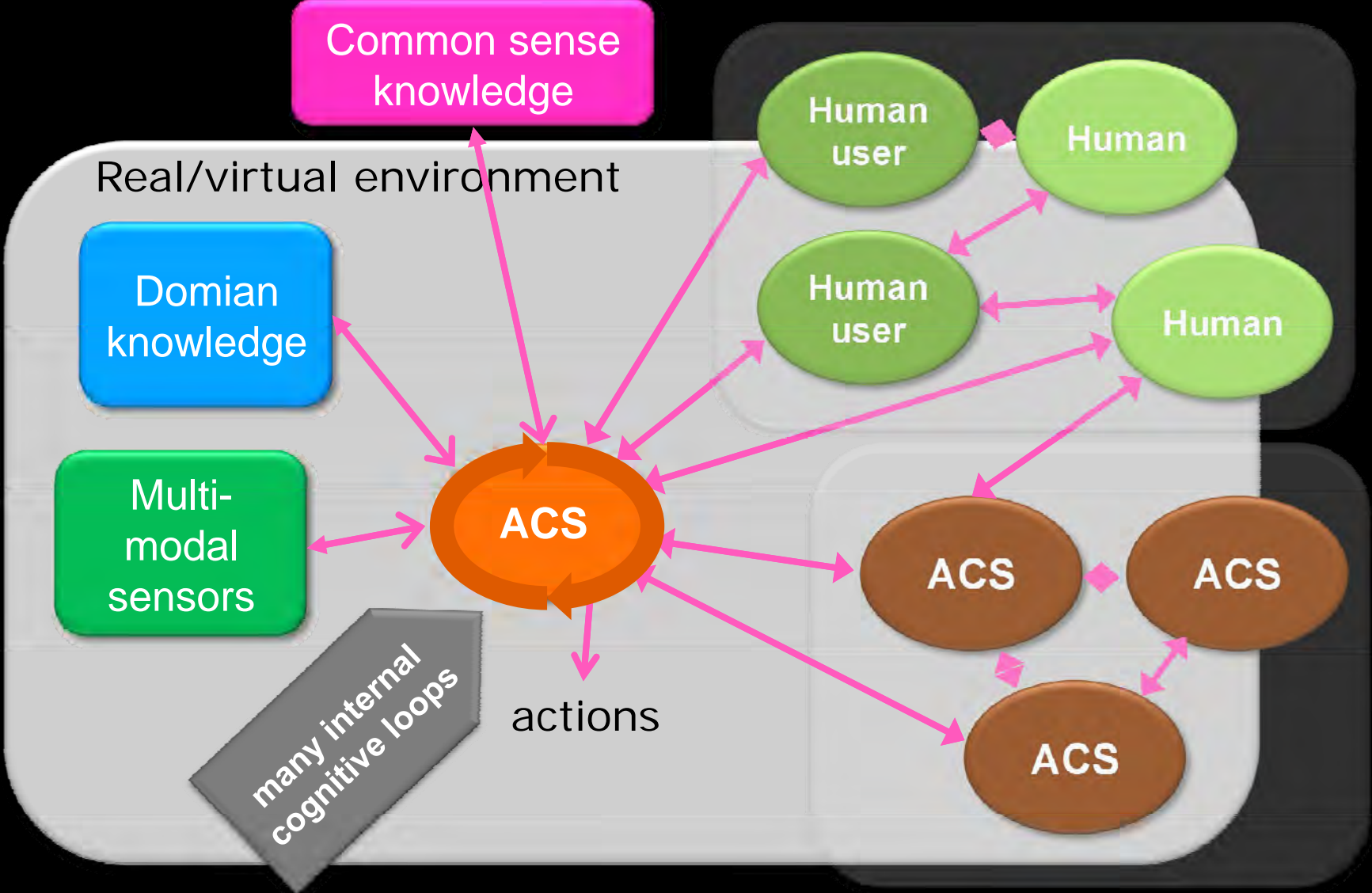
Ref: A. Halevy, P. Norvig, F. Pereira: The unreasonable effectiveness of data, IEEE Intelligent Systems, March/April, pp. 8-12, 2009.

Mission

A cognitive information processing system should optimize itself according to:

The statistical model of the domain, the psychophysical 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-dimensional 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