THE ESSENCE PROJECT - TOWARD 'MEANING COMPUTING'

Michael Rovatsos
University of Edinburgh

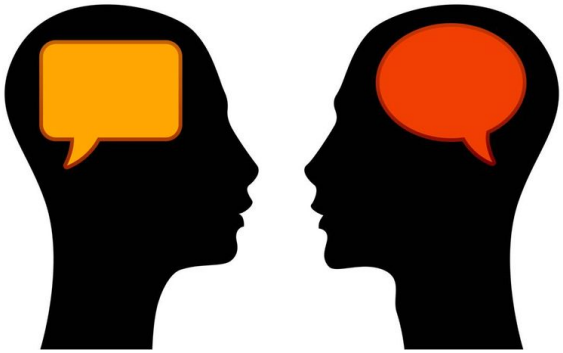
SWeL Seminar, Heriot-Watt University
26th October 2015

ESSENCE

- **Evolution of Shared Semantics in Computational Environments** (Nov 2013 – Oct 2017)
  - Funds 11 pre-doctoral and 4 post-doctoral researchers
- Partners:
  - Universities: Edinburgh (Coordinator), Amsterdam, Trento, Brussels
  - Labs/companies: CSIC-IIIA Barcelona, SONY Labs Paris, Taiger Madrid
- Associated partners:
  - Engineering SA (Italy), SELEX ES (UK), DSTL (UK), Safer Scotland (UK), Heriot-Watt University (UK)

Vision

- Human communication made possible through **negotiating** and **sharing** meaning
- Translating this ability to machines would massively improve their flexibility



Significance

- Database integration, data linkage
- Automated composition of web services
- Ad hoc coordination of robots
- Human-machine dialogue systems
- Tracking evolution of human communication

Methodology

1. Model communication as evolving process of **meaning negotiation**
2. Understand foundations of **reasoning, decision making**, and **learning** in communication
3. Develop and test **computational models** of evolving, shared semantics

Why ESSENCE?

- Enables specialist training at intersection of largely disconnected areas
  - Multiagent systems
  - Language evolution
  - Natural language processing
  - Semantic web & ontologies

Scientific Themes

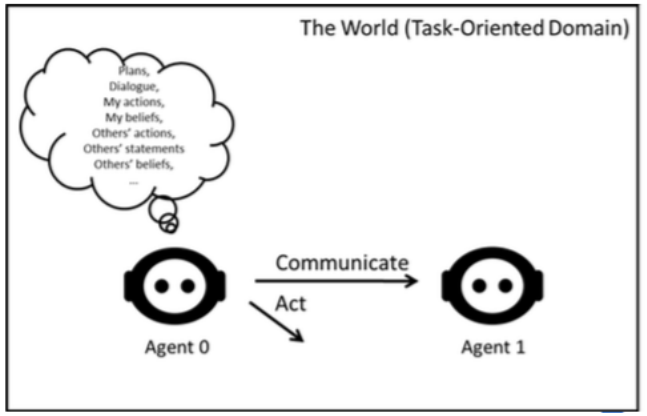
- Rational action and communication
  - How to make decisions about communication
- Representation and reasoning
  - How to represent meaning adequately
- Data and communication
  - How to extract meaning from data
- Human communication
  - How humans establish and evolve shared meaning

Individual Projects

Communication planning
Dynamic, focussed data matching
The ESSENCE Platform: Architecture
A collaborative platform for domain knowledge construction
An entity-centric crowdsourcing pipeline for large-scale up-to-date high quality knowledge
The ESSENCE Challenge
Concept convergence: argumentation and agreement over meaning
Advanced interaction-situated semantic alignment
The ESSENCE Platform: Integration
The social construction of conceptual space
Sociolinguistics and network games
The ESSENCE Model
Open-ended robot interaction
Robust communication and alignment of concept extensions
Co-evolution of grammar with open-ended meaning

Communication planning

- Domain-independent algorithm for scalable dialogue planning
- Uses symbolic planning approach
  - Initially two-layer architecture
  - Now exploring epistemic planning
- Emphasis on negotiation and mutual modelling



Sociolinguistics and network games

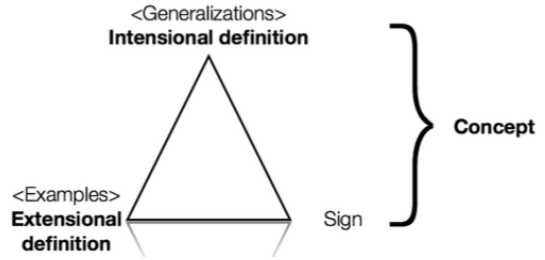
- How is common ground established in dialogue?
  - Common ground expands in absence of objections
- Developing formal semantics of these processes
- Emphasis on pragmatic meaning sharing strategies in dialogue

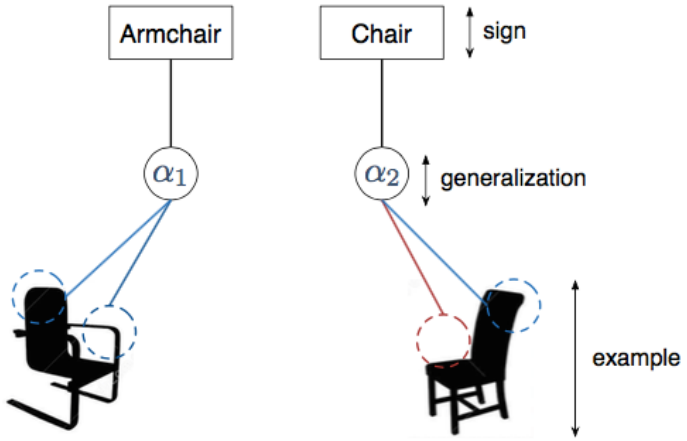
A: [That is] a docksider.
B: A what?
A: A kind of leather shoe, kinda pennyloafer.
B: Okay, got it.

π_1, π_2, π_3, s
$\pi_1 : [\![\text{docksider}]\!](s)$
$\pi_2 : ?[\![\text{docksider}]\!]$
$\pi_3 : [\![\text{pennyloafer}]\!](s)$
$[\![\text{docksider}]\!] = [\![\text{pennyloafer}]\!]$

Concept Convergence: Argumentation and agreement over meaning

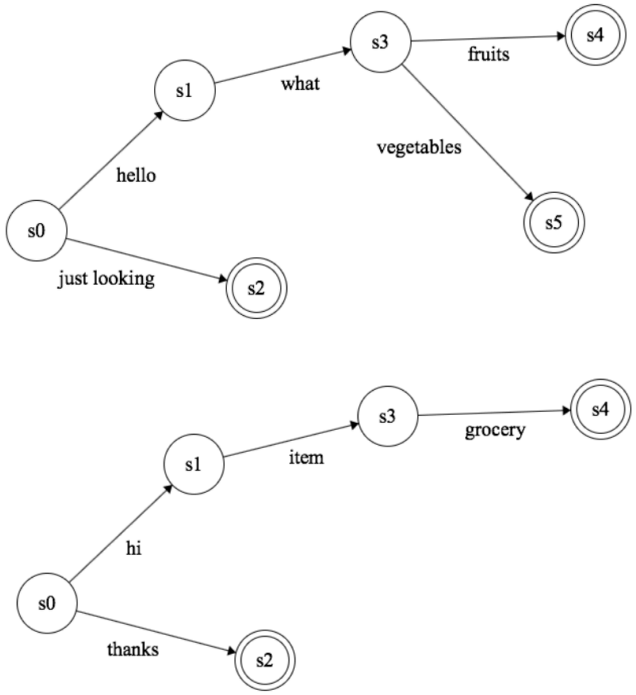
- Semiotic approach to meaning representation
- Argumentation among agents used to reach agreement
- Emphasis on meaning convergence and learning





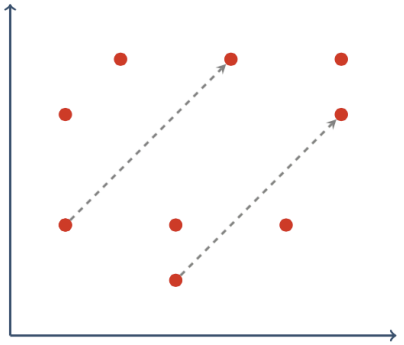
Advanced interaction-situated semantic alignment

- Examines relationship between meaning and interaction
- Interaction context guides ontology alignment activities
- Emphasis on sharing meaning in interaction



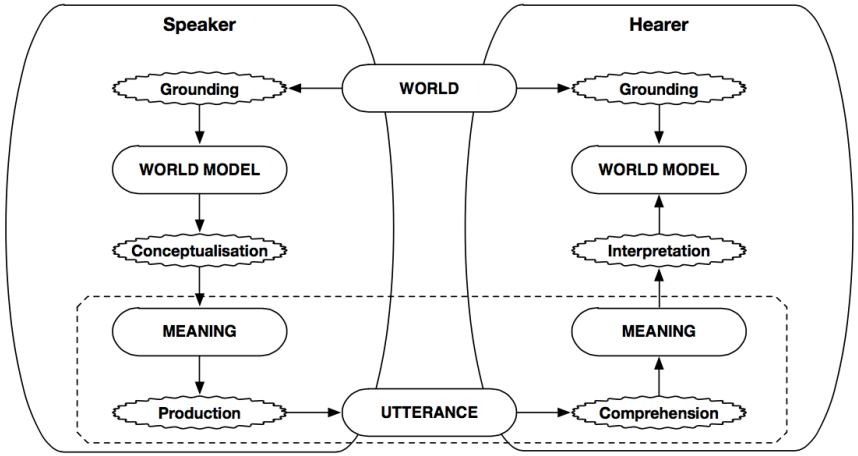
The social construction of conceptual space

- Use of compositionality and ambiguity in response to communicative pressures
  - Provide scaffolding for conventionalised meaning and to convey novel meaning
- Combination of language games and learning dynamics
- Emphasis on repurposing and recombination of meaning



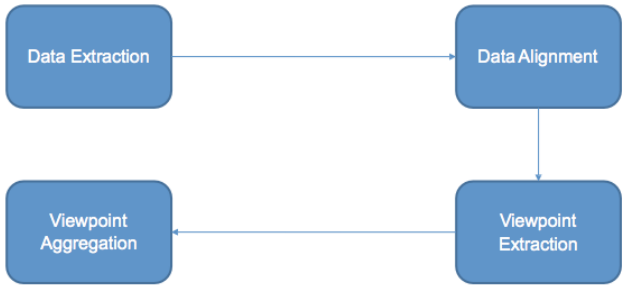
Co-evolution of grammar with open-ended meaning

- Investigates minimal conditions for complex grammatical structures to emerge
  - Specifically tense-aspect-mode structures
- Evolutionary agent-based simulation approach
- Emphasis on emergence of complex semantic structures



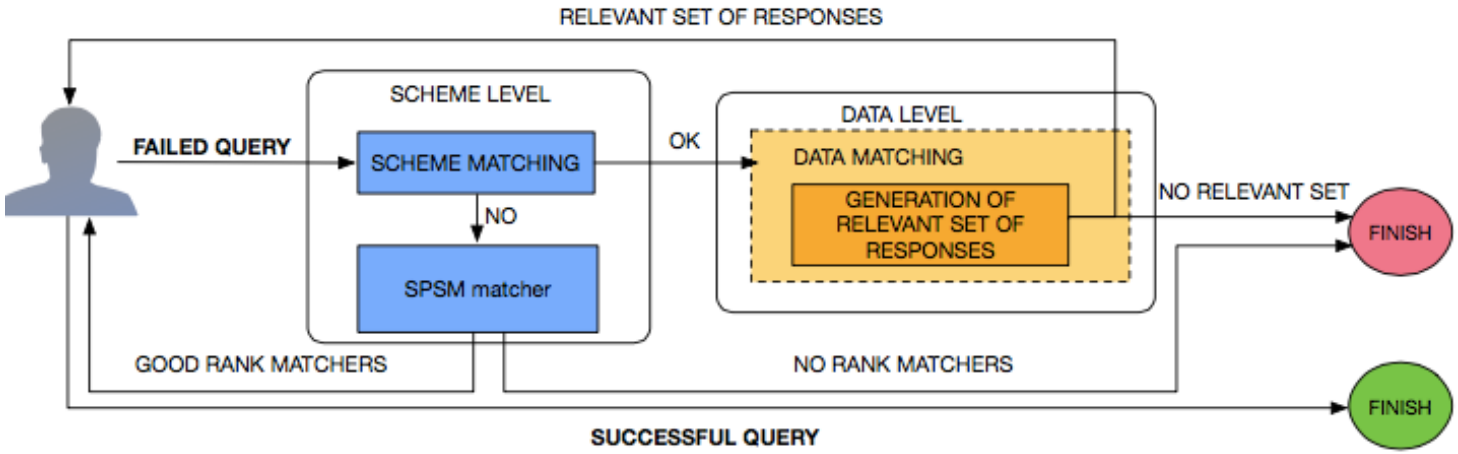
Robust communication and alignment of concept extensions

- Collaborative systems focus on aggregating opinions, not detecting divergence
- How do we disentangle subjective opinion from divergence in semantics?
- Emphasis on identifying divergent semantic viewpoints in data



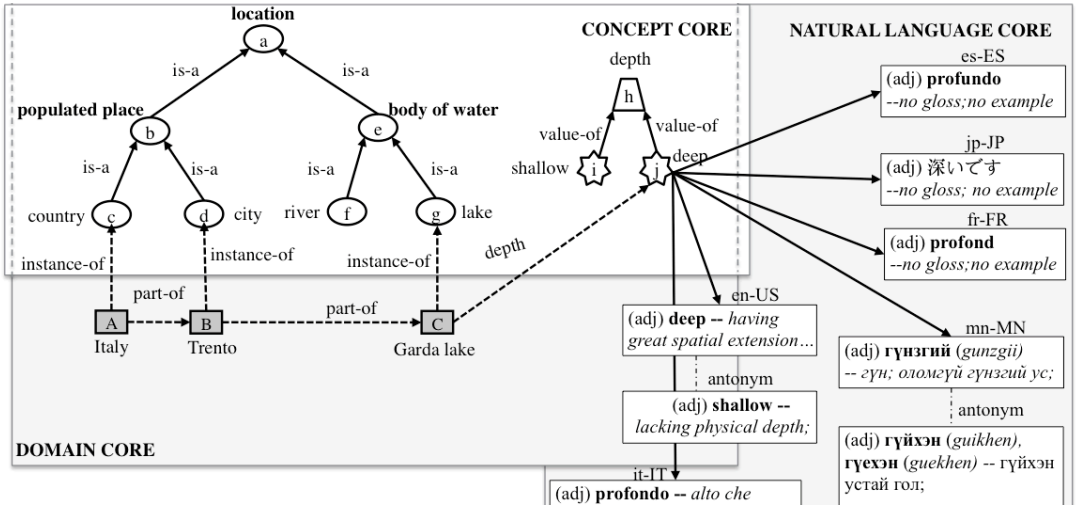
Dynamic, focussed data matching

- Retrieve and match data from heterogeneous information sources at run-time
- Human-in-the-loop approach
- Emphasis on resolving semantic conflicts



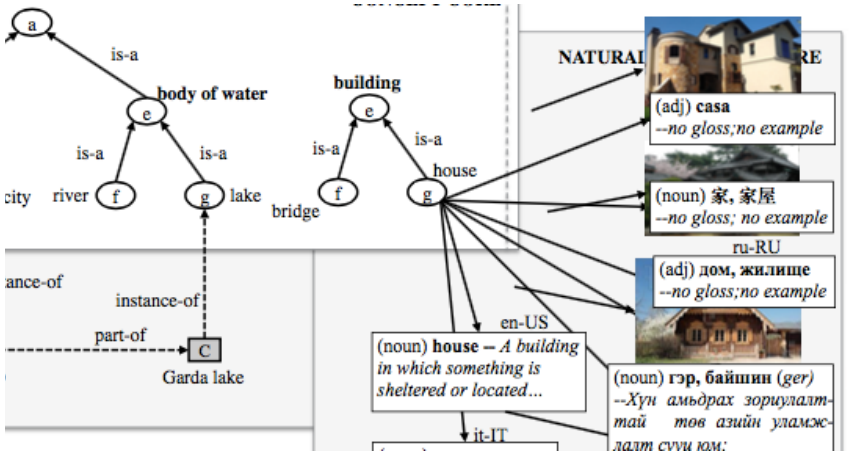
A collaborative platform for knowledge construction

- Crowdsourcing a multi-lingual lexical-semantic knowledge base
  - Interplay between experts and non-experts
- Emphasis on joint meaning negotiation



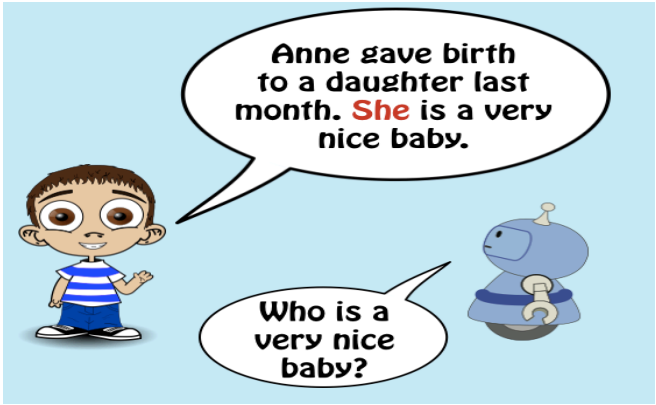
A large-scale multicultural knowledge resource

- Grounding diverse knowledge in non-linguistic data
- Extending multi-linguistic resources by images
- Emphasis on knowledge structures that capture diversity of meaning



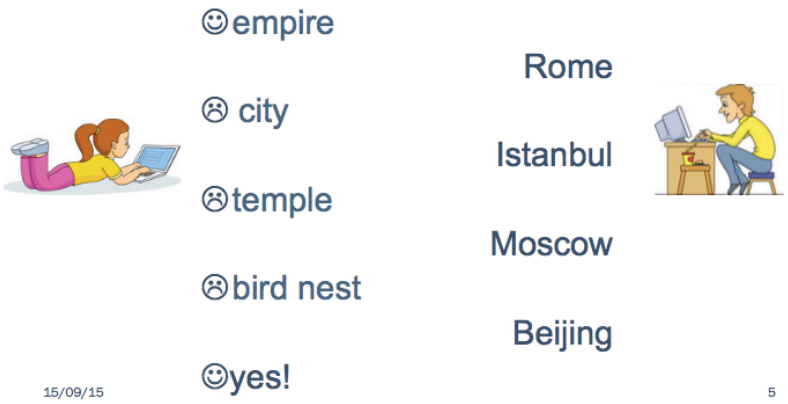
Winograd Schema Challenge

- Tests ability to resolve referential ambiguity
- Requires deep semantic understanding

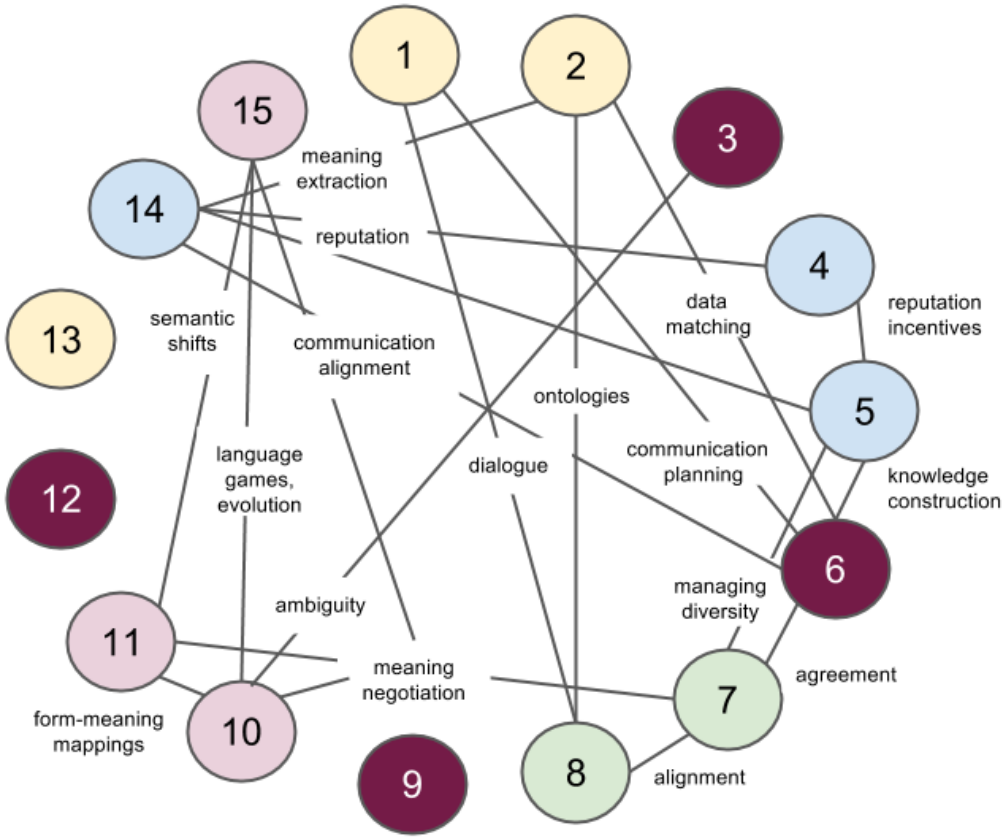


Taboo Challenge Competition

- Tests ability to guess described entitites
- Requires knowledge and dialogue strategy



Cross-Project Links



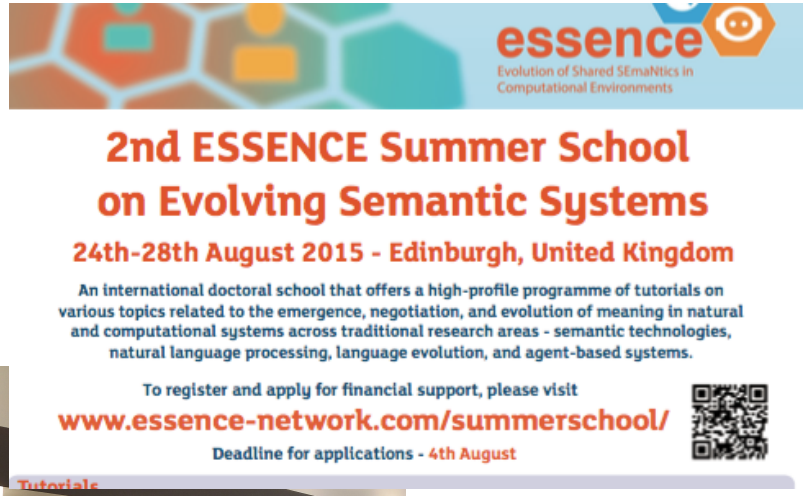
Training Events

Main Training Events & Conferences	Venue
Workshop 1: Exploring the ESSENCE space	Edinburgh
Workshop 2: Ad Hoc Approaches to ESSENCE problems	Ischia
1st Summer School: Theoretical Foundations	Ischia
First Coding Camp: ESSENCE "Hackathon"	Sant Feliu
2nd Summer School: Computational Models	Edinburgh
Workshop 3: Algorithms for Processing Meaning	Barcelona
Second Coding Camp: Components & Benchmarks	Barcelona
3rd Summer School: Man-Machine Meaning	Amsterdam
Workshop 4: Integration of ESSENCE Methods	Amsterdam
Third Coding Camp: Toward a ESSENCE software platform	Barcelona
Workshop 5: ESSENCE Challenge Competition	Barcelona
Final ESSENCE conference	Edinburgh

Second Summer School

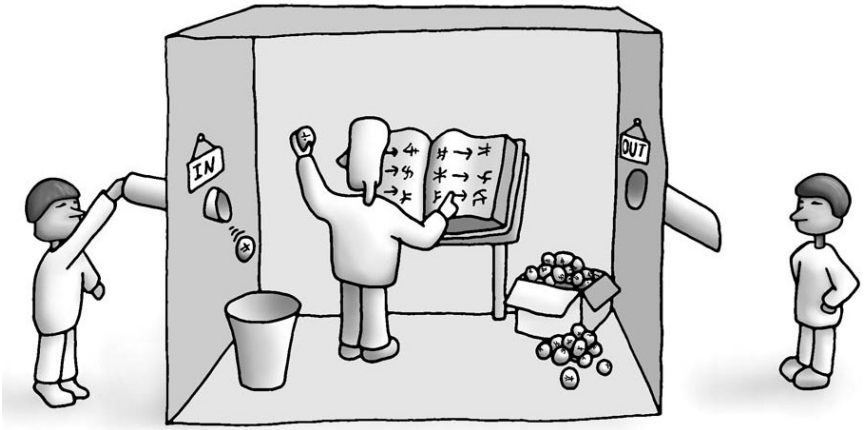
Week-long school with 13 tutorials & public lecture

- 10 external speakers
- 48 external attendees



Toward “meaning computing”?

- Common-sense reasoning is a hot topic in AI (again)
  - Watson, Siri, etc
- Is a purely “task-rational” approach condemned to the Chinese Room?
  - Account for a broader range of aspects of meaning
  - Focus on communication, interaction, and man-machine aspects



Toward “meaning computing”?

- Construction of meaning
  - Dialogical interaction, observation of communication, data collection, knowledge resources, human annotation
- Representation of meaning
  - Intensional, extensional, social, temporal, contextual and compositional dimensions
- Propagation of meaning
  - Through individual learning, interactive negotiation, collaborative discourse, formal standardisation, social influence
- Usage of meaning
  - Individual inference, mutual understanding, joint task coordination, joint inference, creative concept invention

CONCLUSIONS

Conclusions

- ESSENCE addresses very broad range of computational approaches to meaning
- Opportunities for cross-fertilisation, and maybe for going beyond current limitations
- Second half of the project duration will focus on integration of individual approaches
- Get involved!
  - Subscribe to essence-info@inf.ed.ac.uk
  - Visit www.essence-network.com


essence
Evolution
of Shared
SEmaNtics in
Computational
Environments

THANK YOU!