KNOWLEDGE REPRESENTATION

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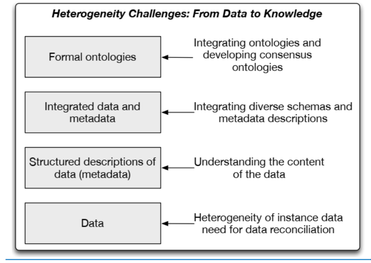
CHALLENGES

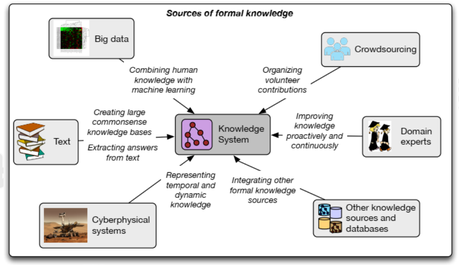
KR Languages & Reasoning

- *Hybrid KR*
  - using 1 language limits us to the problems
  - combining 2 languages results in an increase in the complexity of reasoning
  - produce combination systems, ranging from issues of allocating resources to issues related to characterization of the capabilities of the combination
- *Representing inconsistency, uncertainty & incompleteness*
- *Challenges in reasoning*
  - the worst-case complexity is dismal
  - improving expected performance remains a vital issue in reasoning
- *Lightweight KR*
  - need the principled development of lightweight languages, algorithms & tools
  - develop knowledge modeling languages & interfaces which have a light-weight appearance

Deal with heterogeneity of data & knowledge



Knowledge capture



Make KR accessible to non-experts

- turn data to knowledge easily & to see at least the initial benefits quickly
- visualize & explore the massive quantities of data

OPPORTUNITIES

Scientific discovery

- *Environmental sustainability*
  - motivate the development & use of standardized terminologies for the Earth Sciences
  - Earth Science researchers employ a number of different statistical & modeling approaches to investigate & predict a huge range of natural phenomena by using KR techniques
- *Biomedical & pharmaceutical research*
  - use of ontology in biomedical research for enrichment analysis
  - with > 30,000 terms & millions of genes & proteins, localization & biological processes, the Gene Ontology has been used to bring insight into thousands of scientific experiments

GENEONTOLOGY
Unifying Biology

- *Advancing healthcare*
  - aggregate information and match automatically patients and patients to clinical trials
  - develop personalized treatment plans, identify individuals with similar rare diseases, leverage data from tests, literature and common practice

Education

Intelligent tutoring systems, fueled by substantial knowledge bases that incorporate both specialist knowledge & commonsense knowledge, could revolutionize education

Robotics, sensors, computer vision

- *Household robots*
  - 3 critical areas:
    - methods for representing knowledge
    - methods for updating the robot's internal KR based on percepts & actions
    - methods for planning, execution, and execution monitoring
  - Reasoning about actions
    - investigate & develop knowledge processing methods that, given a vague task, are capable of inferring the information needed to do in the appropriate way
  - Uncertainty
    - a mixed continuous-discrete state space
    - the dimensionality of which is unbounded, substantial uncertainty about the current state of the world and about the effects of actions
    - very long time-horizons for planning
- *Understanding spatial and spatio-temporal data*
  - use of qualitative spatial representations
    - provide some relief from both the volume & noisiness of such data
    - enable integration of different kinds of spatial knowledge (topological, orientation, size, distance...)

Question answering systems

- application
  - analysis of intelligence documents
  - answer questions with respect to medical transcripts or research literature
  - look for answers from past law cases & find answers from patent databases
- build natural language understanding systems
  - translate text to a KR formalism
  - augment it with various kinds of knowledge
  - reason with all of them to form answers
- formulate answers to questions
  - formalize what answers to such questions are
  - answering "Why", "How" & "What-If" questions remains a challenge

Why KR?

What Does Formal Knowledge Representation Bring?

- **Reasoning**
  - Inferring new facts from explicitly asserted data and knowledge
  - Reasoning about actions and objects in the outside world (robotics, computer vision)
  - Hierarchical inference
  - Query expansion and query answering from heterogenous data sources
- **Ontologies and other formal domain models**
  - Explicit and unambiguous domain descriptions for knowledge sharing
  - Reuse and comparability of models, analyses, and interpretations
  - Domain models for natural-language understanding
  - Ontology-based data access for heterogeneous data sources
- **Advanced KR languages and techniques**
  - Formal representation of both domain knowledge and students in education systems
  - Use of knowledge representation in machine learning
  - Understanding text and extracting explicit knowledge from it
  - KR as "lingua franca" for diverse knowledge resources