An Architectural Approach to Statistical Relational AI

Paul S. Rosenbloom
Department of Computer Science and Institute for Creative Technologies
University of Southern California

Architecture

- Hypothesis about fixed structure underlying intelligence
- Mechanisms for memory, learning, interaction and decisions
- Also possibly perception, motor control, reflection, motivations, emotions, etc.
- Yields intelligent behavior when combined with knowledge
- May model human cognition and/or produce AI

Relationship to StarAI

- Drive exploration of StarAI across AI capabilities and applications
  - Focus on what is common rather than what distinguishes
  - Focus on integration rather than optimization in isolation
- Drive development of broader yet simpler architectures
  - Understand and rationalize current architectures
  - Build new generation of architectures
- Architectures provide tools and languages, but may also
  - Embody hypotheses about necessity/minimality and sufficiency/completeness
  - Constrain how models/systems are built

Graphical Architecture

- Base architectures on graphical models
  - Particularly intriguing for architectures because of how produce
    SOA algorithms across symbols, probabilities & signals from a
    single representation & reasoning algorithm (summary product)
    - E.g., Rete match algorithm (symbol), loopy belief propagation (probability),
      Kalman filters and forward-backward in HMMs (signal)
  - Standard paradigm for probabilities (BN) & signals (MRF/CRF)
    - Not yet as well explored for symbols (modulo constraint processing)

What Exists

- A hybrid mixed memory architecture based on Soar 9 and ACT-R
  - Procedural (rules) and declarative (semantic/facts and episodic)
  - But also constraints
- Based on factor graphs
  - Undirected, bipartite graphs with nodes for variables and factors
  - Functions/messages are piecewise linear over rectilinear N dimensional regions
- Memory elements defined by generalized conditionals
  - Conditions, actions, conducts, and functions
  - Variations based on directionality of message flow, open/closed world, and
    normalized/unnormlized variables

Towards architectures that are simpler yet more functional than today’s best