Artificial Intelligence Methods for Theme 1 Workflow Management

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Overview

- Hyunggu Jung (completed Masters Aug 2011)
  - reasoning about bother, interaction (ER)
- John Champaign PhD Student
  - intelligent peer-based tutoring for home healthcare
  - current research: annotations, corpus division, error in assessment, lesson time

Overview (continued)

- Hadi Hosseini PhD Student
  - multiagent resource allocation (ER)
  - current research: multilevel queues, multiple resources, negotiation
- John Doucette Masters Student (NSERC-funded)
  - multiagent resource allocation (ER)
  - current research: pre-emptive costs, bothering users
- Atif Khan PhD Student (course project with Doucette)
  - ontologies to facilitate time-critical answers to questions

hSITE Themes and Contexts

- Champaign: Right Information, Home Healthcare
- Jung: Right Person, Right Time (ER)
- Hosseini: Right Person, Right Time (ER)
- Doucette: Right Person, Right Time (ER)
- Khan: Right Information, Decision Making

Motivation and Approach

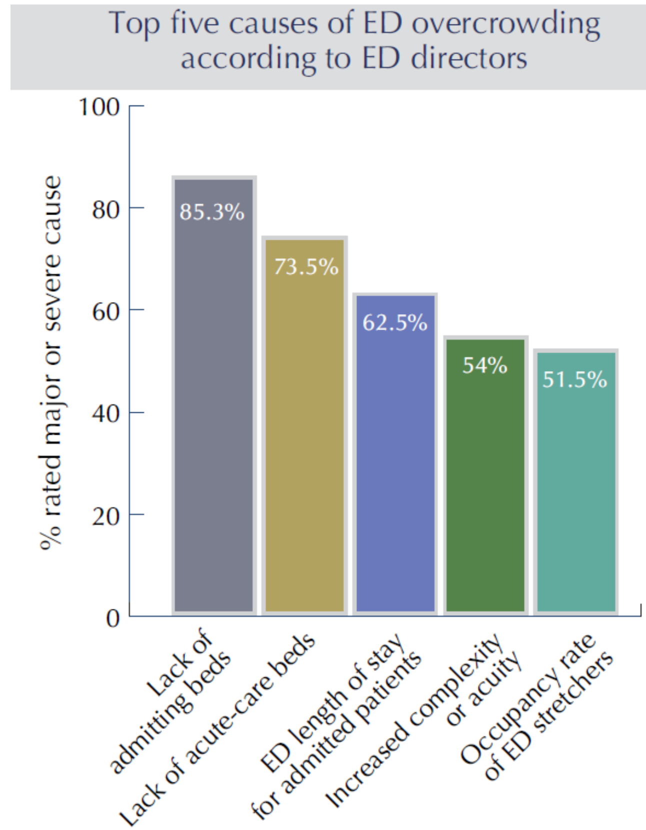
- Allowing patients or caregivers to learn how to manage health
  - through learning objects in repositories of knowledge
  - using experiences of and advice from peers
  - a style of peer-based intelligent tutoring
- Example: patient trying to manage diabetes
- Find appropriate peers and learning objects
- Approach: similarity of peers, past benefits to peers, allow peer contributions to the repository

Models and Solutions

- Curriculum Sequencing
  - Ordering of learning objects based on experiences of similar peers (presented at FLAIRS 2010)
- Annotations
  - Intelligently showing messages left by previous students
  - modeling reputation of annotation and annotator
  - validated by simulations: even when poor annotators are present
- Corpus Divisions
  - peers can propose new, divided learning objects
  - validated: those preferring shorter objects, even if poor dividing skill

Motivation: Connections to hSITE

- Pivot role in Theme 1:
  - *"….systematically modeling clinical workflows, in order to identify sources of inefficiencies and threats to patient safety, and explore ways in which advanced clinical information infrastructures could improve on these inefficiencies and optimize quality of care…."*
- Resource allocation
  - *"…some applications in real-time resource allocation methods within a hospital have been reported, in which workflow models help in allocating rooms, clinicians and equipment."*
- According to the annual ED census (CADTH, 2005)
  - 25,000 patients to 210,000 patients
  - Median: 60,000 patients → 7 patients/hour
  - 7 < Service rate < 10 P/hr
  - Mean service rate: 4 Hr/P
  - ED Patient arrival, service rate



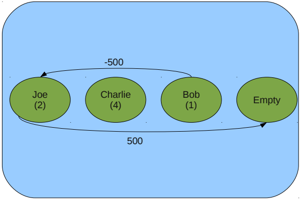
- Adopted from Canadian Agency for Drugs and Technologies (CADTH)
  - http://www.cadth.ca/media/pdf/320a_overcrowding_tr_e_no-appendices.pdf

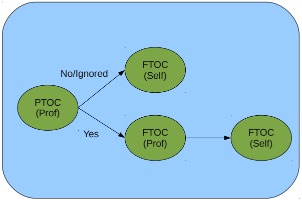
Approaches, Future Plans

- Solutions:
  - Increasing the number of personnel, beds, rooms → needs infrastructure
  - Optimizing the throughput of the system → better scheduling, higher satisfaction
- Issues involved in patient scheduling
  - Real-time nature of emergency departments, patient arrivals
  - Priorities, fairness
  - Treatment and diagnosis durations are unknown
- Right person, Right time:
  - Goals: Decreasing average waiting time, Decreasing average idle time
  - Important measures: cost, overall health care delivery, satisfaction (personnel, patients)
  - Queuing-theoretic model
  - Decentralized Markov Decision Processes: patients are self-interested agents maximizing their local utility function
  - Auction-based system to promote interdependencies whilst providing coordination
- Future plans:
  - Combinatorial auctions → bundle of resources
  - Mechanism design → eliciting preferences, priorities
  - Exchanges

Optimal Doctor/Patient Assignments

- Finding optimal assignment: NP-Hard
- Multi-Agent heuristic methods approximate costs of preemption under *worst case* assumptions.
- Transfer of Control Strategies can provide a better approximation. (Cohen, Jung, Fleming and Cheng 2010)





Optimal Doctor/Patient Assignments?

Work in Progress:

- Model design and foundations ✓
- Simple implementations ✓
- More detailed implementations
  - bother/transfer costs
  - YLL and other real-world measures of utility
  - real-world triage systems
- Theoretical proof of convergence
- Simulations with real-world data (if available)

Motivation:

Patient specific, evidence based decision making under constrained conditions

- knowledge, time

Methodology:

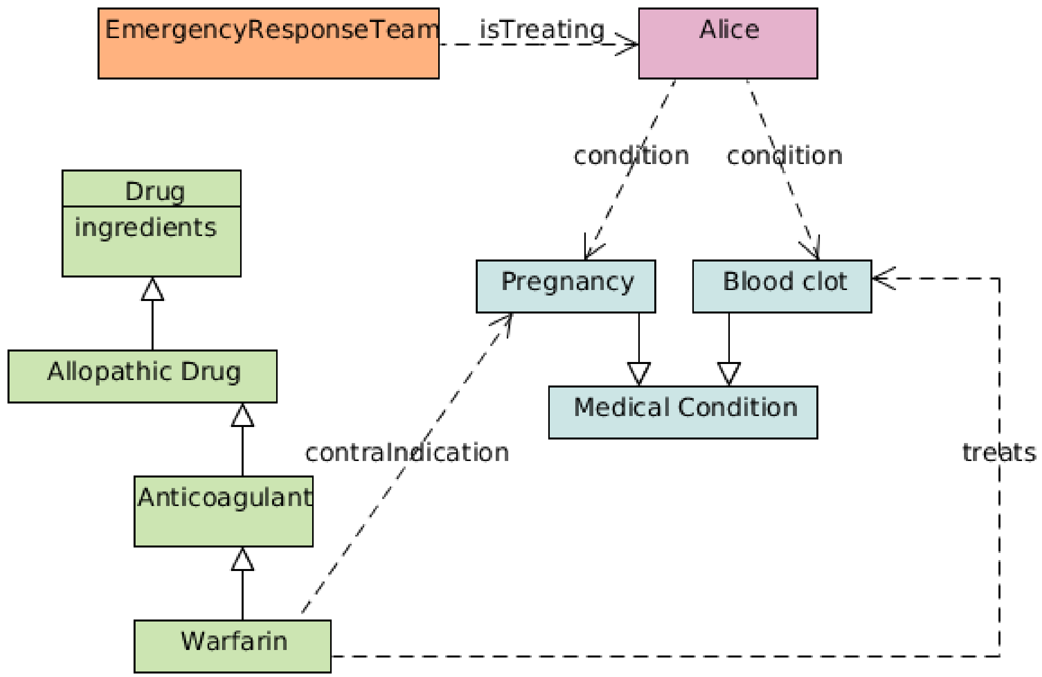
1. Semantic knowledge representation
   - represent knowledge with meaning (machine processable)
2. Knowledge discovery via logical reasoning
   - inference (making implicit knowledge explicit)

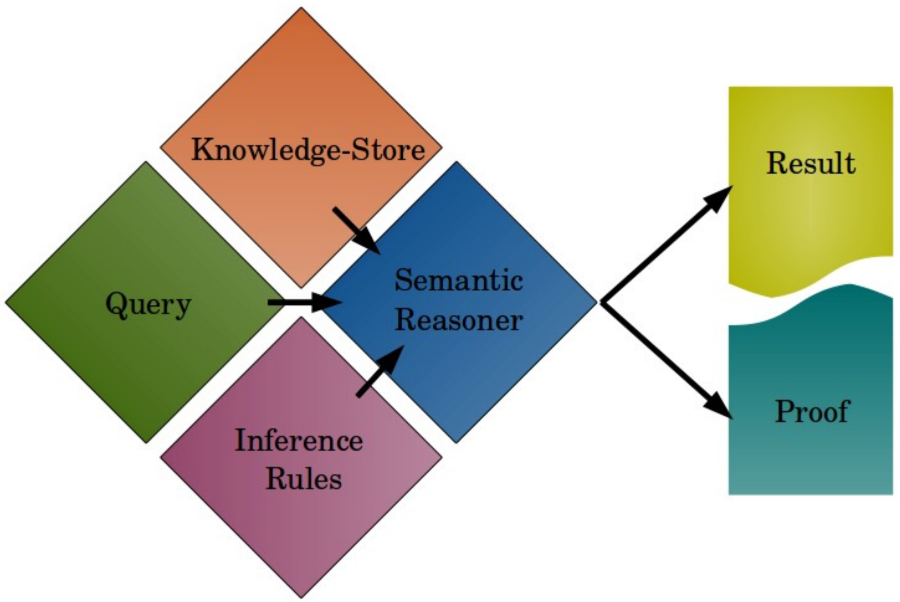
Different from traditional probabilistic approach.

Motivational Example:

An EMR person is about to administer an anti-coagulant agent to a patient. Patient is pregnant, condition not known to the EMR person (**knowledge constraint**). Given the critical situation, the EMR person has to make a decision about administrating the drug right away (**time constraint**).

How can the EMR person make the **best decision** for patient?





Query	:Alice :canNotBeGiven :Warfrain.
Inference Rule	{?PATIENT :condition ?CONDITION. ?DRUG :contraIndication ?CONDITION. } => {?PATIENT :canNotBeGiven ?DRUG}.
Proof	{{:Alice :condition :Pregnancy} e:evidence <knowledge-base#_27>. {:Warfrain :contraIndication :Pregnancy} e:evidence <knowledge-base#_22>} =>
Result	{{:Alice :canNotBeGiven :Warfrain} e:evidence <rules#_9>}. # Proof found in 3 steps (2970 steps/sec) using 1 engine (18 triples) }.

Connections within Theme 1

- John Champaign
  - using Diane Doran's home healthcare nurses for a user study
  - providing an information source for Diane's home healthcare nurses (clinical information systems on handheld devices)
- Hadi Hosseini
  - providing deeper reasoning towards ER solutions to combine with the data analysis of Mike Carter for more efficient ER handling
- John Doucette
  - providing more complex reasoning for Mark Chignell's intelligent notification project (e.g. bother costs, who to contact)
  - providing more complex reasoning for Mike Carter's ER solutions

Connections to Theme 2 and Theme 3

- sensing provides parameter values to model patients and clinicians (Jung, Hosseini, Doucette)

- networking enables communication flow (Champaign, Jung, Hosseini, Doucette)