Intelligent Clinical Decision Support with Probabilistic and Temporal EHR Modeling

Overview and Motivation

- Clinical decision-support systems (CDSS) have potential to exploit the wealth of clinical data in EHRs in addition to expert recommendations.
- New AI techniques needed to plan chronic and multi-stage treatments: compute patient-specific, temporal, statistically-justified treatment plans.
- Balance costs vs patient outcomes, reason with uncertainty.
- Hypothesis: CDSS can improve state of current clinical practice by providing outcome-driven and cost-driven optimized decisions.

Overview of envisioned CDSS

- SRL (Statistical Relational Learning) identifies clinically relevant features.
- POMDP (Partially Observable Markov Decision Processes) provides rules & corrective feedback.
- Intelligent Clinical Decision Support System (ICDSS)

SRL for medical prediction tasks

- Model: mixtures of relational probabilistic decision trees
- Learning: Relational Functional Gradient Boosting (RFGB)

POMDP models in chronic depression treatment

- Predictive model: Dynamic Bayesian Network
- Prediction horizon: 8
- Clinical variable: treat / not treat
- Outcome variables: self-reported survey (CDOI), treatment cost
- Objective function: tradeoff between CDOI and SS5 (clinician-selected weight)

Existing and Ongoing Work

- Simulations over 5,807 IN/TN patients
  - >50% improvement in cost effectiveness
  - >30% improvement in outcomes beyond existing fee-for-service model

Progress & Expected Outcomes

Cardiology domain

- Developing SRL methods to learn likelihoods of future adverse medical events
  - CARDIA 20 year longitudinal dataset (N=5115)
  - Preliminary results suggest high predictive power @ year 20
  - Future: use POMDP to suggest lifestyle changes (smoking, exercise), medications

Stroke domain

- 3 observation, 2 decision points:
  - Admission (t=0): demographics, symptoms observed, medical administered
  - Discharge (t=2 weeks): test results, diagnosis, possible change of treatment, long-term prescription
  - Follow up (t=6 mo): death, long term dependency

ER domain

- Regenstrief PHESS: 65 million records across Indiana
  - Identify high utilizers: significant source of waste

Two promising AI techniques: SRL and POMDP

- Statistical Relational Learning (SRL): learning probabilistic models from datasets with relational structure
  - Handles linked datasets, incomplete/missing data, noise
  - Excellent for EHR data

- Partially Observable Markov Decision Processes (POMDP): learning probabilistic models from datasets with relational structure
  - Handles linked datasets, incomplete/missing data, noise
  - Excellent for EHR data

With clinical partners:

*Indiana University School of Informatics and Computing
† Indiana University School of Medicine, Regenstrief Institute