Identifying Inconsistencies in Multiple Clinical Practice Guidelines for a Patient with Co-morbidity

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Outline

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- Managing Multiple CPGs
  - Constraint Satisfaction CPG Model
  - Identifying Points of Contention in Multiple CPGs
- Discussion and Future Work
Motivating Example

Patient with asthma exacerbation

Medical examination

Diagnose current asthma

Treatment: oral corticosteroids

Medical history review

Underlying peptic-ulcer

O. corticosteroids increase chance bleeding ulcer

Our approach

Asthma CPG

Knowledge Base

Peptic ulcer CPG

Reveals source of contradiction
Recommends alternative treatments as inhaled steroids
Clinical Practice Guidelines (CPGs)

- Motivation for the CPG development and use: medical errors (IOM Study, 2001); need to practice evidence-based medicine; improve patient outcomes; control costs

- CPG: *systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific clinical circumstances*

- CPG in this study: set of decision steps of varying level of abstraction and detail for diagnosis and/or management of patients who have specific clinical condition
Some of CPG models/formalisms:

1. Arden syntax: Medical Logic Modules that include set of logical expressions implemented as production rules; has no execution standards

2. GLIF: a flowchart translated into object-oriented model; GLEE execution engine under development

3. PROforma: knowledge composition language for expert system-like use where CPG is modeled as a plan consisting of tasks; execution using Prolog-like interpreter

4. Asbru: time-oriented CPG representation as a set of skeletal plans; executed mostly as a visualization tool
Gaps in CPG Research

- Most of the attention has been paid to representing CPGs as models rather than executing them.

- Usability issues include:
  - How to customize CPG to local practice?
  - How to use CPG with missing or uncertain data?
  - How to integrate CPG with a decision support function?
  - How to adjust CPG to different levels of decision making expertise?
  - How to manage multiple CPGs at one time?

Research question: How to use CPGs for a patient with co-morbidity (multi-system diseases)?
Patient with Co-morbidity: Managing Multiple CPGs

- Three step process
  - Modeling individual CPG as constraint satisfaction problem
  - Amalgamating individual models into a combined model
  - Solving combined model and finding points of contention (infeasibilities)

- Importance of reconciliation of multiple treatments in the face of ever increasing instances of co-morbidity among patient population
**Constraint Satisfaction Problem (CSP)**

- **Definition**
  - **Given** \( P = (V, D, C) \)
    - \( V \) is a set of variables, \( V = \{V_1, V_2, ..., V_n\} \)
    - \( D \) is a set of variable domains (domain values), \( D = \{D_{V_1}, D_{V_2}, ..., D_{V_n}\} \)
    - \( C \) is a set of constraints, \( C = \{C_1, C_2, ..., C_l\} \)
      \( C_{V_a, V_b, ..., V_i} = \{(V_a, V_b, ..., V_i)\} \subseteq D_{V_a} \times D_{V_b} \times ... \times D_{V_i} \)
  - **Query**: Find a value for each variable such that all constraints are satisfied

- Useful for modeling and solving combinatorial problems
Modeling the CPGs

- Transform a graphical representation into a CPG-CSP model
  - Variables represent patient state and treatments
  - Constraints impose restrictions on variable/value combinations for a given disease

- Solving a CPG-CSP model provides
  - Missing values
  - Deduces a patient’s state from limited information
  - Can identify inconsistencies in a patient’s recorded state
Graphical Representation of Peptic Ulcer CPG

Based on the UHMS Peptic Ulcer Guideline
From Graphical Representation to a CSP-CPG Model

\[ \mathcal{V} = (U, NS, F, E, HP, C, S, NT, A, D) \]
\[ \mathcal{D} = \{D_1, \ldots, D_{10}\}, \text{ where } D_i = \{true, false\} \forall i = 1..10 \]
\[ U \rightarrow S \equiv true, \sim U \land NS \land F \rightarrow NT \equiv true \]
\[ \sim U \land NS \land \sim F \rightarrow A \equiv true, \]
\[ \sim U \land \sim NS \land E \rightarrow S \equiv true \]
\[ \sim U \land \sim NS \land \sim E \land \sim HP \rightarrow D \equiv true \]
\[ \sim U \land \sim NS \land \sim E \land HP \land C \rightarrow S \equiv true \]
\[ \sim U \land \sim NS \land \sim E \land HP \land \sim C \rightarrow NT \equiv true \]
Points of Contention

- Contractions introduced because of the amalgamation of multiple CPGs

- Two types of points of contention
  - Implicit
    - A contradiction cannot be identified from the CPG and its establishment requires additional knowledge that goes beyond that encapsulated in a CPG
  - Explicit
    - A class of treatments that are inadmissible according to a treatment plan defined by another CPG

- Identify treatments that need to be replaced or modified
Addressing Points of Contention

- Combined CPG-CSP model is solved
  - If solution exists it represents a treatment for co-morbidity patient
  - Infeasibility identifies point of contention that needs to be resolved

- Resolving points of contention can be done by:
  - Replacing variables (alternative treatment plans)
  - Removing variables (abandoning treatment)
  - Leaving resolution to the physician
Discussion and Future Work

- Proposed a new way to model CPGs and reconcile them for co-morbidity patient
  - Constraint programming method for finding treatments and points of contention

- Future work
  - Exploring other ways of handling points of contention
  - Incorporating external knowledge (i.e. drug-disease interactions database)
  - Tagging models with meta-constraints for easier revisions