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

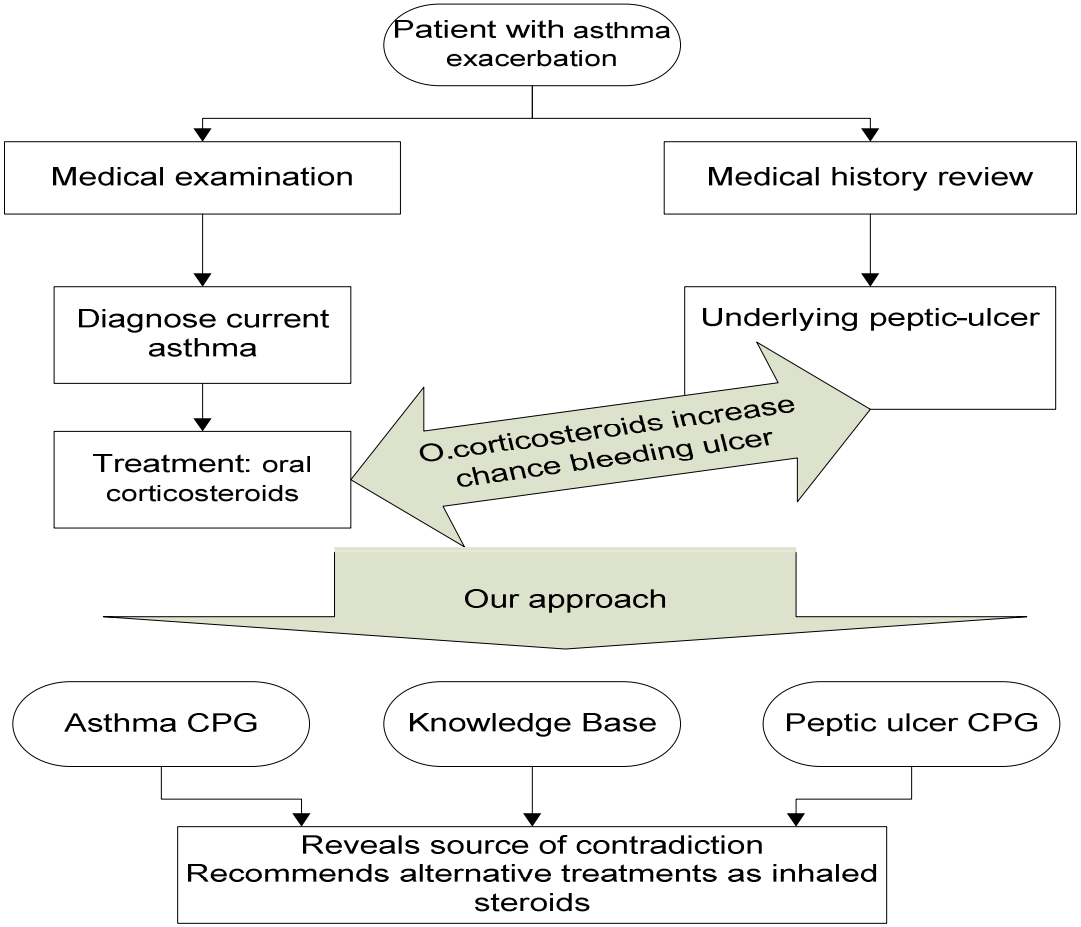
Marisela Mainegra Hing, Martin Michalowski, Szymon Wilk, Wojtek Michalowski, Ken Farion

MET Research Group, University of Ottawa
in collaboration with
Telfer School of Management
Adventium Labs
Poznan University of Technology
Children's Hospital of Eastern Ontario

Outline

- Motivating Example
- Clinical Practice Guidelines (CPGs)
- Background Research
- Managing Multiple CPGs
  - Constraint Satisfaction CPG Model
  - Identifying Points of Contention in Multiple CPGs
- Discussion and Future Work

Motivating Example



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

CPG Research

- 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 then 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)

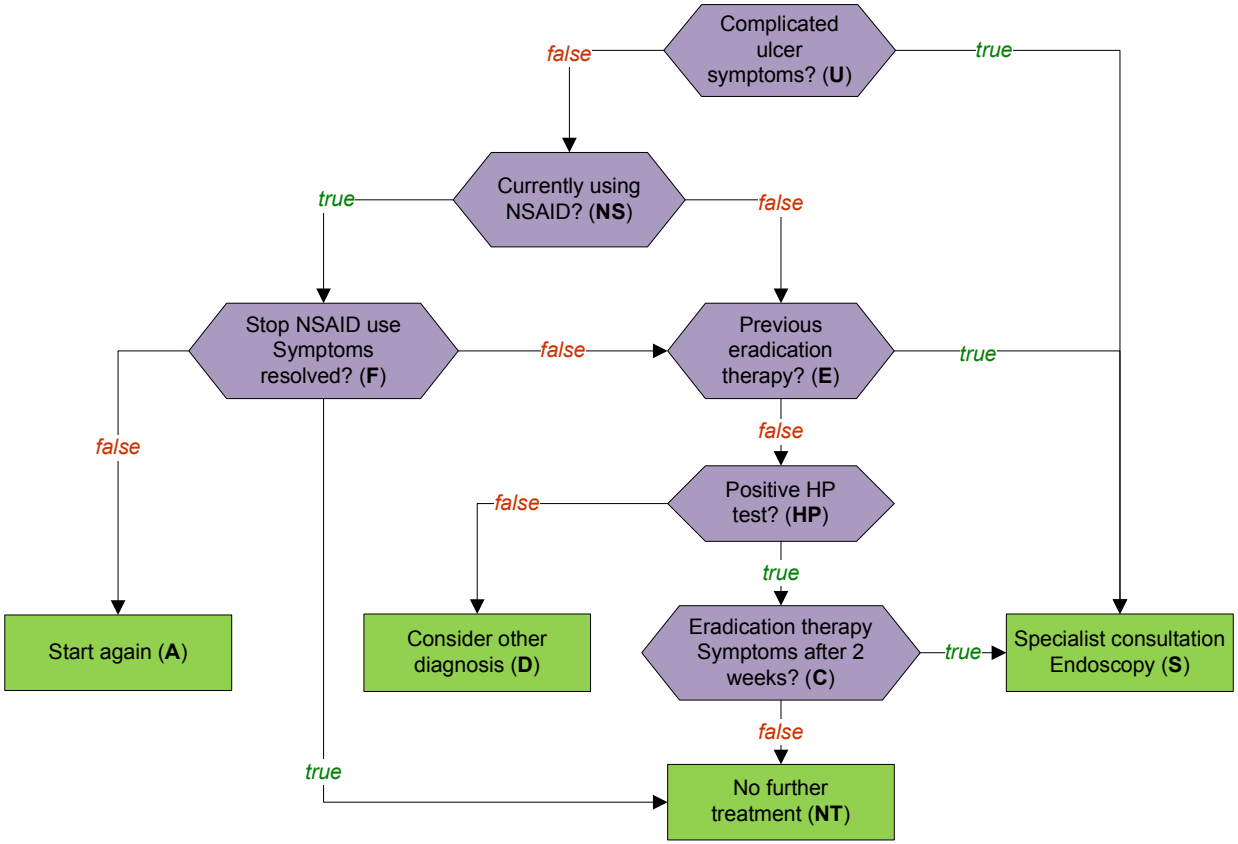
- Definition
  - **Given *P* = (*V*, *D*, *C*)**
    - ***V*** is a set of variables,
      $\boldsymbol{V} = \{V_1, V_2, \ldots, V_n\}$
    - ***D*** is a set of variable domains (domain values),
      $\boldsymbol{D} = \{D_{V1}, D_{V2}, \ldots, D_{Vn}\}$
    - ***C*** is a set of constraints, $\boldsymbol{C} = \{C_1, C_2, \ldots, C_l\}$
      $C_{Va,Vb,\ldots,Vi} = \{(V_a, V_b, \ldots, V_i)\} \subseteq D_{Va} \times D_{Vb} \times \ldots \times D_{vi}$
  - **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

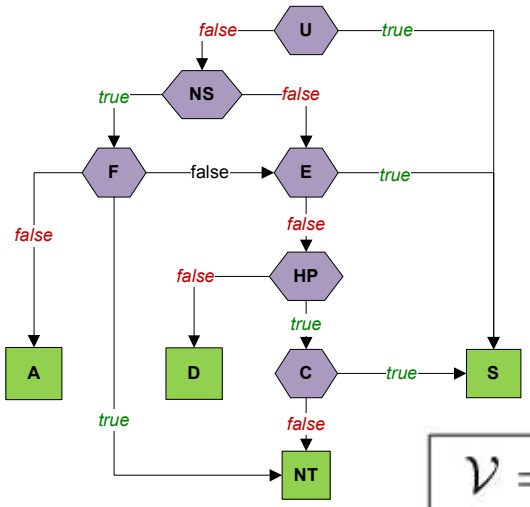
- Solving a CPG-CSP model provides
  - Missing values
  - Deduces a patient's state from limited information
  - Can identify inconsistencies in a patient's recorded state

Graphical Representation of Peptic Ulcer CPG



Based on the UHMS Peptic Ulcer Guideline

From Graphical Representation to a CSP-CPG Model



$$\mathcal{V} = (U, NS, F, E, HP, C, S, NT, A, D)$$

$$\mathcal{D} = \{D_1, .., D_{10}\}, \text{ where } D_i = \{true,\ false\}\ \forall i = \overline{1..10}$$

$$\mathcal{C} = \left\{ \begin{array}{c} U \rightarrow S \equiv true, \tilde{}U \wedge NS \wedge F \rightarrow NT \equiv true \\ \tilde{}U \wedge NS \wedge \tilde{}F \rightarrow A \equiv true, \\ \tilde{}U \wedge \tilde{}NS \wedge E \rightarrow S \equiv true \\ \tilde{}U \wedge \tilde{}NS \wedge \tilde{}E \wedge \tilde{}HP \rightarrow D \equiv true \\ \tilde{}U \wedge \tilde{}NS \wedge \tilde{}E \wedge HP \wedge C \rightarrow S \equiv true \\ \tilde{}U \wedge \tilde{}NS \wedge \tilde{}E \wedge HP \wedge \tilde{}C \rightarrow NT \equiv true \end{array} \right\}$$

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

MET Research @ uOttawa

www.mobiledss.uottawa.ca