NLP Applications for Enhancing Clinical Decision Making

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April 24, 2012

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Much information that could support CDS is textual and therefore cannot be leveraged by a CDS system without NLP.
My journey in and perspectives of the two areas
Two years prior to admission the patient was diagnosed with hepatitis. The patient had a liver transplant on June 7, 1992. He underwent a t-tube study, and now presents with a fever of 101°F lasting more than two days.

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**Zhou L, Friedman C, Parsons S, Hripcsak G. System architecture for temporal information extraction, representation and reasoning in clinical narrative reports. AMIA Annu Symp Proc :869-73.**
Clinical Decision Support

- CDS Interventions: reminders, alerts, infobutton, order sets, etc.
- Inpatient/outpatient EHRs: CPOE/e-prescribing, eMAR, etc.
- Structured knowledge representation and knowledge sharing
- Service-oriented architecture
Where will NLP have an impact in CDS?

- Improving patient safety
  - Improving medication management

- Enhancing EHR functions
  - Facilitating computerized provider order entry

- Reducing health care cost
  - Identifying high-risk, high-cost patients prospectively
Medication errors can cause injuries, are common, and are very costly.

- Adverse drug events and medication errors are estimated to cost the US health care system $177 billion annually.

Medication lists within patients’ EHRs are often outdated, incomplete or inaccurate, which is a major cause of medication errors.

- Active medications are often not added in a timely manner to the structured medication list.
  - Wagner and Hogan found discrepancies between the number of medications that patients reported taking (5.7) and those listed in their EHRs (4.7).
- Outdated medications are frequently not deleted.
  - 67.4% of medications were still active one calendar day after their inactive status was documented in the clinic notes.
Medication Reconciliation

- Trend impact analyses


Poon et al. Design and implementation of an application and associated services to support interdisciplinary medication reconciliation at discharge. JAMIA. 2006;13(6):581-92.
30% of active medications mentioned in notes were missing from patients’ medication list.
- e.g., “trazodone and paxil prescribed by psychiatrist”.

Clinicians often need detailed or additional information beyond the medication list in order to make judgments, changes and other decisions.
- e.g., history and progress of the disease, consultation notes from medical specialists.
Medications from NLP Output

NLP in CDS

Possible Missing Meds  High -Alert Meds Found!

Zhou et al. Improving Medication Reconciliation Using Natural Language Processing. The 2011 AHRQ Annual Conference, September 2011, Bethesda, MD
Integrate/couple NLP with CDS

Data interoperability / terminology standard

- Medication list may be coded using an institutional or commercial terminology; most existing NLP systems encode clinical text using standard terminologies
- Code information using multiple medical terminologies
- Conduct dynamic or static mapping as needed

System / data integration

- Integrate NLP system with other EHR applications
- Conduct data integration, aggregation and summarization

Conduct reasoning (inference)

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Free-text Order Entry

- 7.1% of medication order entries are free-text
- 9.3% (2,412 out of 26,001) hypoglycemic medication orders were entered using free-text for 2,091 patients
- 75.2% of these free-text entries have an exact name match in the medication dictionary
- the remaining 24.8% of the free-text entries could be coded if specific formulation information was also provided
- 17.4% of free-text hypoglycemic medication order entries included misspellings
  - e.g., “Glimepiride”, “Glipizide”, “Glyburide”, “Humalog”, “Humulin”

Free-text Order Entry - CDS

- CDS is not triggered when a medication order is entered as free-text
  - 92 drug-drug interaction (DDI) alerts were not triggered due to free-text entries, affecting 84 different patients
  - 196 patients who had a free-text hypoglycemic order entry also had the same exact drug entered as a structured and coded order during the study period
    - 10% had identical drug entries active in their medication list at the same time
- Only 25.9% of these patients had diabetes recorded in their problem list
- These CDS aspects are critical to patient safety
  - If unintentionally bypassed due to free-text medication order entries may result in potential harm to the patient
NLP ---> CPOE/CDS

- Advanced search function
  - It should not be limited to only detecting exactly spelled medication name
  - It should provide a relevant and smart list (not just a long list to sort through)

- Spelling error detection / correction
  - e.g., suggest a correction, autocorrect

- Efficient user-interface to address workflow issues
  - Auto-fill features
  - “Favorite” list or pick-list (where free-text entries should be monitored)
  - Avoid navigating through multiple screens

- Speech recognition
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There is a great need to minimize the cost of care delivered while still meeting quality incentives

- 5% of patients generally account for up to 50% of costs
- e.g., prevent readmissions by identifying high-risk, high-cost patients prospectively

How will NLP help?

- Most current risk assessment methods use claims and structured data
- Clinical narrative reports contain rich information, but are untapped
- Combine structured data with data extracted from free-text using NLP to identify target patients
- Employ machine learning methods (classification techniques and other probabilistic models) to stratify patients
- Provide CDS and make recommendations
Summary and Discussion

Many opportunities to apply NLP to enhance CDS

- Little things can make a big difference
  - Usability matters a lot
  - Make it easy for clinicians to do the right thing

Many challenges to tackle

- Speed is everything (subsecond “screen flips”)
  - If it takes too long to work, it will be useless
  - Optimize system performance, particularly speed

- Anticipate needs and deliver in real time
  - Bring information from free-text to clinicians at the time they need it

- Fit into the user’s workflow
  - e.g., develop an efficient user interface to present NLP output

Many challenges to tackle (cont.)

- Standards and system interoperability
- Service oriented architecture
- Others: organizational issues; diverse clinical domains; users with diverse roles, background and needs

Other requirements

- Simple interventions work best
  - Simplify and condense NLP output and make it useful
  - Continuous monitor impact, receive feedback and make improvement

Thanks!

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