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Challenges

Modern clinical care units continuously monitor patient vital signs and labs, but this data is underutilized:

- Threshold alarms are overly simplistic, mostly limited to analyzing a single data stream.
- Tools for sophisticated on-line analysis are rare.
- Most systems do not provide patient information along with alarms or individual data streams to help clinicians contextize data.
- Access to recorded data is often difficult or impossible.
- The volume of data available can be overwhelming.

- We have attempted to overcome these challenges for a particular use-case by developing a tool to aid clinicians in detecting vasospasm, a dangerous narrowing of vessels in the brain, in post-surgical subarachnoid hemorrhage patients. We aimed to allow clinicians to accurately assess patients for vasospasm without invasive angiogram.

Integrated Decision Support

Clinical decision support systems provide the opportunity to overcome clinical data use challenges by:

- Utilizing a multitude of patient features from disparate sources in concert to produce a more complete picture of patient state.
- Allowing the clinician to perform statistical analysis on-line.
- Presenting patient summaries and other data to clinicians in an effective way.

Effective use of clinical decision support systems holds the promise of improved care, reduced mortality, and decreased healthcare costs.

- Clinical decision support systems have failed to see widespread use. To change this, we utilize:
  - A flexible, hospital independent framework to guide design and encourage component reuse (G-CDSA).
  - An analysis stage utilizing clinical guidelines, physician expertise, and data-driven models to provide increased transparency and trust.

Graphical user interface for the vasospasm clinical decision support tool. The user interface has been designed to emphasize both data visibility and simplicity, while reusing common medical symbolism to ease use.

In a clinical setting, this tool would be fed with a constant stream of real-time data, and would update continuously to serve as both an alert and a decision support system. For the purposes of this demo, retrospective patient data is used.

Three-Pronged Approach

Three-pronged approach to patient risk assessment:

- In the design of the analysis component of a decision support system, transparency and simplicity are key considerations, to turn clinician trust. To achieve this, we incorporate a three pronged approach:
  - Prong 1: Analysis of existing clinical care guidelines
    - Provides hospital-wide standard of care
    - Based on wide body of literature
    - Provides a "lower-bound" on system behavior
  - Prong 2: Survey of approach taken by physicians
    - Leverages extensive education, refined through experience
    - Could aggregate the opinions of many peers
    - Offers expert opinion when none is available
  - Prong 3: Statistical models trained on data from large patient populations.
    - Leverage large amounts of retrospective patient data as "experience"
    - Complexity allows them to capture nuance, subtle patterns
    - Potential to identify medically novel approaches to patient risk assessment

Development

- After aneurysmal subarachnoid hemorrhage, patients are kept in the ICU for up to fourteen days to monitor for vasospasm, which can lead to ischemia if untreated. While there are clinical factors which increase suspicion for vasospasm, the ability to define its onset is made difficult by poor sensitivity of available tests.
  - The only definitive measure of vasospasm is cerebral angiogram, which is invasive and resource-intensive.
  - Steps for development included:
    - Identification of patient features which were likely to be of use in risk assessment
    - Gathering these features from retrospective patient data stores (89 patients from between 2001 and 2011 were incorporated)
    - Surveys of clinical guidelines of the Hospital of the University of Pennsylvania, and physician interviews
    - Statistical testing using Weka®
  - Development of an intuitive user interface
Challenges

- Clinical data use challenges by:
  - Difficulty or impossibility to contextualize data.
  - Access to recorded data is often difficult or impossible.
  - Challenges to aggregate data streams to help clinicians.
  - The volume of data available can be overwhelming.
  - Few opportunities to perform statistical analysis on-line.

- Integrated Decision Support
  - Answer to these challenges is a heterogeneous approach to providing increased transparency and trust.

- Development
  - Development of an intuitive user interface for the vasospasm clinical decision support tool, which allows the clinician to perform retrospective patient data analysis.
  - Development of a three pronged approach:
    - Prong 1: Analysis of existing data helps to understand vasospasm,
    - Prong 2: Survey of approaches to aid the development of the tool,
    - Prong 3: Analytical modeling with potential to identify medically nuanced patterns.

- Three-Pronged Approach
  - The only definitive measure of vasospasm is narrowing of vessels in the brain, where vasospasm is most easily identified through angiogram.
  - While there are clinical factors which increase suspicion for vasospasm, the ability to define its onset and progression are kept in the ICU for up to fourteen days to monitor for a particular use-case by developing a tool to aid clinicians in detecting vasospasm, a dangerous complication following aneurysmal subarachnoid hemorrhage. This tool would be used to help clinicians in detecting vasospasm, a dangerous complication following aneurysmal subarachnoid hemorrhage. The tool would be fed with a constant stream of real-time data, and would update continuously to narrow the vascular tree.