UNIVERSITY of MARYLAND
SCHOOL OF MEDICINE

Clinical Applications of Big Data

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The Challenge

- Systems to enhance practice of medicine.
  - Physician-driven clinical challenges.
  - Deliver safer and more efficient care.
  - Enable decision support at the bedside.
- Strategic importance to the UMMC and UMSOM.
  - Enhance access to biomedical knowledge.
  - Strong theoretical basis in Computer Science.

Big Data - Clinical Decision-Making

- The practice of medicine.
  - "Medical practice" is "medical decision-making".
  - This is the defining skill of all physicians.
- "Diagnostic gap" in computations systems.
  - Many computational advances in healthcare.
    - Administrative, workflow, imaging, devices, etc.
  - Few advances in bedside clinical decision support.
    - Some success with alerts, calculators, and order sets.
    - But no computationally-enabled clinical decision support.

There are no practical systems to help doctors make clinical decisions.

Big Data - Challenges

- Accumulating data faster than we can analyze.
  - Clinicians require immediate access to 2-5 million facts.
  - Medical knowledge doubling every 5 years.
  - Clinical data doubling every 1-2 years.
- Analytical challenges.
  - Dimensionality, heterogeneity, interdependency, complexity.
  - Uncertainty, nonmonotonic, nondeterministic.
- Traditional statistical approaches to big data.
  - Efficiency and accuracy problems.
  - A priori models limit ability to find hidden patterns.

Big Data - Sources

- Department of Veterans Affairs repository (VINCI).
  - 15 years of clinical data from 150 hospitals and 800 clinics.
  - 20 million patients, 6 million currently active.
- Million Veteran Program (MVP).
  - Genomic sequences and markers, correlated with VINCI.
- Electronic Maryland EMS Data System (eMEDS).
  - Assessments, treatments, and dispositions for 400,000 priority medical EMS calls annually.
- GENEVA Consortium.
  - Secondary analysis of clinical and demographic data with high-dimensional genomic markers.

Big Data - Approach

- Semantic analysis.
  - Provide context and meaning to the clinical data.
- Machine learning.
  - Reduce intractable amounts of clinical data into a moderately-sized repository of medical facts.
- Pathophysiology.
  - Organize clinical knowledge according to physiologic relationships and evidence-based guidelines.
- Human factors.
  - Incorporate an understanding on the nature of clinical expertise in decision making.

Big Data - Areas of Research

- Dimensionality reduction.
- Biological enrichment (domain information).
- Discovery of relationships with genomic data.
- Knowledge extraction from unstructured text.
- Validation approaches.
- Rare event discovery.

Research Projects

- Knowledge Representation and Reasoning (KRR)
  - Disease, critical event, and treatment efficacy prediction.
- Patient Safety in Emergency Medicine
  - Identify patient safety indicators in emergency medicine.
- The Nature of Clinical Expertise
  - Elucidate the clinical decision-making process.
- Pre-Hospital Syndromic Surveillance
  - Risk analysis for obscure syndromes and toxidromes.
- Chronic Disease Prediction with Genomic Data
  - Genomic prediction models in pre-symptomatic individuals.
- Computational Image Classification
  - Cellular communications and surgical safety.

Research Projects - KRR

- Restructure data for bedside decision support.
  - Disease prediction.
  - Critical event prediction.
  - Treatment efficacy prediction.
- Focus on a small group of chronic diseases.
  - CAD, DM, CKD, COPD, AD, Prostate + Pancreatic CA.
  - Complex and multifactorial.
  - Leading causes of morbidity and mortality.
- Strategic collaborations.
- New computing facilities at the Baltimore VA.

Research Projects - KRR Clinical Narratives

- Semantic framework for clinical decision support.
  - Apply text analytics to clinical narratives.
  - I2B2 data set (www.i2b2.org).
  - Establish relationships between extracted terms using domain-specific medical ontologies.
  - Infer additional facts using OWL reasoner with clinical rules.
- Initial results.
  - Extract evidence-based risk scores from clinical narratives.
    - TIMI Risk Score for Acute Coronary Syndrome.
    - San Francisco Syncope Rule.
  - Great than 90% accuracy.

Research Projects - Patient Safety

- Patient safety is an essential health care challenge.
  - Reporting, analysis, and prevention of medical errors.
- Safety challenges in emergency medicine.
  - 100 million annual visits.
  - High-workload, time-sensitive, nondeterministic, information-poor, disconnected, life-critical care.
- Safety events difficult to measure.
  - Events resulting in harm just the “tip of the iceberg”.
  - Need to identify “submerged” events.
    - Near misses and events that did not result in harm.
    - Hard to find with self-reporting & with a priori models.

Research Projects - Clinical Expertise

- The nature of clinical expertise in decision making.
  - Information requirements (what, when, why).
  - Clinical guidelines, clinical prediction rules, online resources.
  - Effect of time pressure and patient acuity.
  - Impact of workflow and social interactions.
  - Inter-operator variability.
- Elucidate the clinical decision-making process.
  - Observational studies, simulations, and surveys.
- Use results to help with decision-support systems.
  - Empathic and user-driven approach to development.
  - Vetting and credentialing of decision-support systems.

"People Learning" --- not just "Machine Learning"

Research Projects - Genomic Prediction

- Chronic disease prediction with genomic markers.
  - Leading causes of M&M.
  - Obscure patterns of inheritance.
  - Prediction in presymptomatic individuals = early intervention.

- Initial results.
  - Cluster models to combine relevant clinical and genomic features.
  - New genotype score comparable to clinical risk scores.
  - Demonstrated improvements in risk prediction using domain knowledge and feature selection.
  - Identified new genomic relationships using collaborative filtering and cosine similarity.

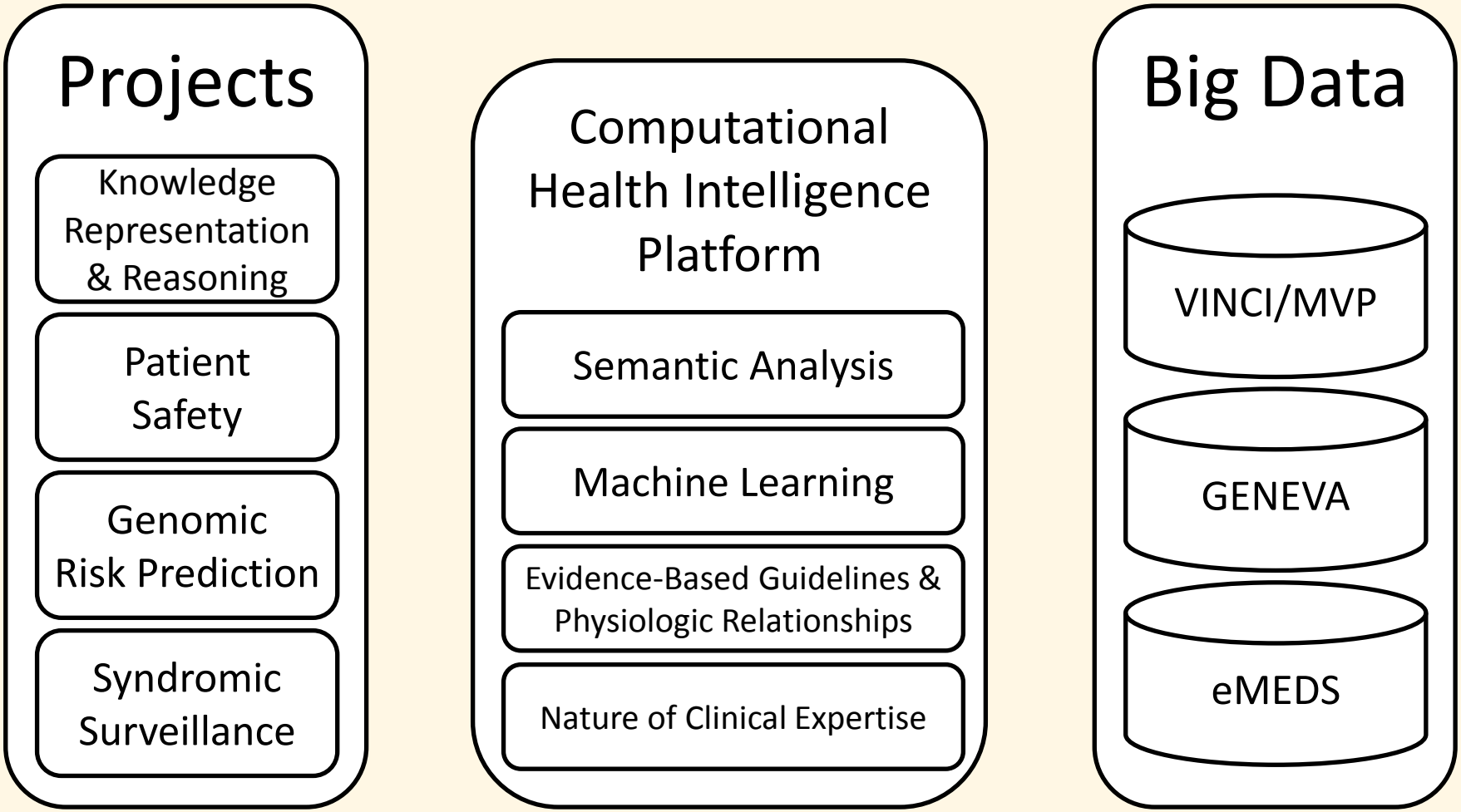
Research Projects - Syndromic Surveillance

- Early detection of disease outbreaks.
  - Biologic terrorism, disasters, or natural causes.
- Monitoring of pre-clinical data.
  - Electronic Maryland EMS Data System (eMEDS).
  - Complement with data from social media.
- Machine learning approach.
  - Identify obscure syndromes and toxidromes.
  - Predict hospital utilization requirements.

Computational Image Classification

- We experimented with image classifier techniques using machine learning algorithms.
- We developed a new approach to extract and map image features to biological characteristics.
  - Extracted image features from smooth muscle images.
  - Characterized cell-to-matrix interactions.
- We also applied this approach algorithm to laparoscopic surgery videos.
  - Identified critical surgical activities.
  - Recognized potentially unsafe actions.

Research Overview



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