Rise of the Intelligent Machines in Healthcare
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Conflict of Interest

Kenneth A. Kleinberg, MA

Has no real or apparent conflicts of interest to report.
Agenda

• Roundtable Learning Objectives
• Overview of Intelligent Computing
• Use in Other Industries
• Uses in Health Care
• Challenges and Futures
• Roundtable Questions/Discussion
• Summary/Wrap-Up
Learning Objectives

• Identify what **advances in intelligent computing** are having the greatest effect on other industries such as transportation, retail, and financial services, and how these advances could be applied to healthcare
• Compare the **types of technological approaches** used in intelligent computing, such as inferencing, constraint-based reasoning, neural networks, and machine learning, and the types of problems they can address in healthcare
• Identify **examples of the application of intelligent computing in healthcare** and the **Internet of Things** (IoT) that are already deployed or are in development and the benefits they provide, such as robotic assistants, smart pumps, speech interfaces, scheduling systems, and remote diagnosis
• Recognize **the workflow, workforce, and cultural changes** that will need to occur in a world of intelligent machines, such as the morphing or elimination of job roles, comparisons of human to computer performance, and the reliance, risks and benefits of use of intelligent systems
• Discuss the **IT implications** and how healthcare industry professionals can prepare for and **take advantage** of these inevitable advances in intelligent computing
The Evolving Story of Intelligent Computing

**What**

Intelligent computing/AI uses algorithms, heuristics, pattern matching, rules, machine/deep learning, and cognitive computing to solve problems typically performed by humans, as well as complex problems difficult for humans.

**How**

Intelligent systems are often inspired by biology (parallel computation) and, through access to large data sets, get smarter with use.

**When**

AI has been in development for decades, but only recently gotten good enough for people to notice, mostly due to advances in other industries besides health care.

**Why**

The public perception of AI is often influenced by hundreds of sci-fi movies, fear of “bad robots,” and a general skepticism that “machines” will ever be able to master human capabilities that we hold so dear.

**Who**

The rise of intelligent machines is approaching; and the world, especially the health care industry, is far from prepared for what’s to come…
STEPS Benefits of Intelligent Computing

- Tasks get done faster and more consistently
- Enhances the abilities of human workers
- Interacting with AI can be fun!
- Clinicians have smart “assistants” they can query
- Stuff doesn’t fall “through the cracks”
- Larger and more complex data sets can be accessed
- Analytics can be made smarter
- Alerts and reminders can be more intelligent
- Supports more dynamic and adaptive patient engagement
- Catches problems and trends earlier
- Adapts education to the patient and context
- Reduces labor costs
- Operates continuously and with more capacity
- Becomes more effective over time
Some (Controversial) Definitions of Intelligent Computing/AI

**Intelligent Computing/AI**
(can learn and adapt)

**Cognitive Computing**
(simulates human thought processes)

**Statistics and Analytics**
- Regression
- Descriptive and inferential
- Bayesian networks
- Random forest
- Data mining
- Predictive analytics
- Computational learning

**Symbolic (Logical) Reasoning**
- Rule/Knowledge-based systems
- Induction and deduction
- Forward and backward chaining
- Fuzzy logic

**Bio-inspired Systems**
- Neural networks (multilayer, feedforward, recurrent, convolutional)
- Genetic algorithms
- Progeny clustering
- Machine learning
- Deep learning
IC/AI is Vastly More Powerful than Procedural Programming

When is it Intelligent Computing?

The less the statistician programmer researcher analyst clinician modeler has to determine the order of processing order of training data to apply factors to focus on steps to improve the model the more the system can be described as intelligent.

Typical Problem Types for Intelligent Computing

<table>
<thead>
<tr>
<th>Decision Making</th>
<th>Planning</th>
<th>Machine Vision/Perception</th>
<th>Knowledge Discovery and Data Mining</th>
<th>Optimization</th>
<th>Scheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td>What should we do?</td>
<td>What needs to happen in what order?</td>
<td>What do you see?</td>
<td>What relationships exist?</td>
<td>How can it be made better?</td>
<td>How can we accommodate these constraints?</td>
</tr>
<tr>
<td>Speech/NLP/Translation</td>
<td>Pattern Recognition Classification</td>
<td>Clustering</td>
<td>What class does something belong in?</td>
<td>How many different groups of similar objects?</td>
<td></td>
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How Fast Is IC/AI Advancing: Are We There Yet?

AI and intelligent computing advances are starting to accelerate.

**AI Winters**: AI has already gone through a few phases of hype and troughs of disillusionment (1974-80, and 1987-93).

**Unpredictable Timing**: Some advances seem to never arrive (speech recognition), while others come upon us **unexpectedly** (GPS driving directions).

**Exponential growth**: Will AI take off thanks to network effects and disruptive innovations, or will it only make modest advances for the next decades?

**Surpass human intelligence**: Some predict we’ll see the “singularity” of machine intelligence in the next few decades.

50s 60s 70s 80s 90s 2000 2010 2020 2030 2040 2050
IC/AI Being Used Successfully in Other Industries “Under the Covers”

**Transportation**
Autopilots, self-driving cars, space vehicles, complex scheduling
Example: American Airlines Sabre System

**Financial Services**
Auto-trading, check cashing, fraud detection, market prediction
Example: Securities Observation, News Analysis, and Regulation System (SONAR)

**Retail and Manufacturing**
Shopping assistants, product launches, logistics, robotic factories
Example: Amazon Machine Learning Service

**Security, Crime Prevention, Military**
Identification, case analysis, logistics
Example: Avigilon

**Emergency Response**
Biohazard response, environmental changes, police/military presence
Example: DigitalGlobe’s Tomnod

**Service and Support**
Booking assistants and tech support
Examples: USAA’s Military Veterans Advisor

**Gaming and Simulation**
Video games, entertainment, simulations, education/training
Example: Computer Go

**Commonalities**
- Complex challenges with lots of data
- Speed and consistency are important
- Resistance from existing workers
- A gradual adoption over years (or longer)
- Eventually it’s no longer considered AI
Applications of Intelligent Computing in Health Care

Six Related Categories of Application Development and Use

1. Intelligent Information Gathering and Sensing (IoT)
   What do we know about the patient and his changing environment to aid in his health?

2. Intelligent Interaction and Service
   How can we communicate with our systems in a more natural manor?

3. Intelligent Diagnosis and Care Plans
   What’s wrong with the patient and what type of evolving treatment plan would be most effective?

4. Intelligent Medical Devices
   How can we automate and adjust medical devices to be more real-time, accurate, and responsive?

5. Robotics
   What roles can robots take on to assist with the mundane, dangerous, or complex jobs of humans?

6. Advanced BI/Analytics
   What can we learn from our data, and how can we predict future states and act on that knowledge?
Enabling Situational Awareness and Action with IoT

Frameworks + AI-based Tools + Progressive Providers

"Ambiant" agent and machine intelligence-based platform provides alerting and workflow management processes

“Code Blue”
- How is it triggered (connected medical devices?)
- Who is it sent to (who is on the care team?)
- Who is nearest with the right skills (and able to respond?)
- When will they arrive?
- Who needs to bring what devices (crash cart) or medical supplies (and where are these items?)
- Who else needs to be notified and what are the ripple effects?

Source: CGI; ThoughtWire; Mackenzie Innovation Institute; Humber River Hospital
Intelligent Medical Devices: Reducing Workloads

Case in Brief: Artificial Pancreas and Smart Infusion Pumps—Medtronic MiniMed Connect

- SMARTGUARD mimics some functions of a healthy pancreas; predicts low glucose levels in advance and stops pump
- Insulin pump and continuous glucose monitoring can talk directly to smartphone
- Partnered with Samsung

Case in Brief: Anesthesiology Automation—Johnson & Johnson Sedasys

- FDA approval in 2013 for “narrow use” with expert available (uses propofol)
- In use at four U.S. hospitals for colonoscopies and endoscopies
- Business case: Anesthesiologist requires four years of medical school and a median salary of $277K per year
- Now being tested for heart and brain surgery

Source: Medtronic; Johnson & Johnson
Robotics: To Serve (and More)

Forecasted Impact from Robotics

$67B  Spending on robots in 2020
22%  Reduction in U.S. labor costs in by 2025

Hospital-Based Robots

University of California San Francisco at Mission Bay uses 25 TUG Robots by Aethon. They travel 481 miles per day in 1,300 trips, equating to a time savings of 315 hours.

Similarly, Yujin Robots can deliver drugs, linens, and meals, and also cart away medical waste, soiled sheets, trash.

Robotic Assistants

Developed in Japan, the latest generation of the Robobear medical assistant can lift patients into and out of beds, help position humans into sitting and standing positions, and lift patients from wheelchairs.

Telepresence

Partner’s HealthCare uses Vecna’s VGo robots to provide remote care to children in their homes. The robot can do “rounds” on the patient every day, taking pictures and gathering data to track progress.

Home Assistants

GiraffPLUS, from the European Union, combines a network of sensors that collects physiological and environmental data with a telepresence robot for social interaction. The data is fed wirelessly to doctors and utilizes Skype to conduct remote doctor consultations. It’s geared toward older patients who live alone.

Pets

Huggable is a collaboration between Boston Children’s Hospital and MIT. The social robot prototype recently started a 90-person study to determine whether it has therapeutic value for children enduring long hospital stays.

Another example is Paro, the roboseal, developed by the Japanese firm AIST.

**IBM Watson Health Launched in 2015**

- **Cognitive Computing**

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### Company in Brief: IBM Watson Health (Part of IBM Watson Group)

#### Technical Approach
- Uses hundreds of computational techniques, including machine learning; conducts NLP queries on structured and unstructured data; generates hypotheses, scores evidence, and returns answers
- Uses IBM DeepQA software, Apache UIMA Architecture, clusters of Linux servers, and Hadoop

#### Key Factors for Success
- Focuses on breadth and depth scale, combination of approaches, and parallel processing
- Supports partner development with APIs, offers cloud capabilities

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<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
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| 2011 – 2012 | Feb 2011: Nuance, Columbia University, University of Maryland  
Oct 2012: Cleveland Clinic, Case Western Reserve University |
| 2013 – 2014 | Feb: Memorial Sloan Kettering, WellPoint, Maine Center for Cancer Medicine  
Oct: MD Anderson’s Moon Shot Program  
Jun 2014: GenieMD |
| H1 2015 | Mar: Modernizing Medicine  
Apr: IBM Watson Health established; Apple, Johnson & Johnson, Medtronic; acquires Explorys, Phytel |
| H2 2015 | Jul: CVS  
Aug: Acquires Merge Healthcare  
Sep: Boston Children’s Hospital, Columbia University Medical Center, ICON plc, Sage Bionetworks, Teva Pharmaceuticals |

*Source: IBM*
Major Challenges to IC/AI in Health Care

Business Challenges

- **Complexity**: Medical issues don’t appear in isolation and coordination of care is difficult.

- **Threat to human jobs**: Strong fear associated with technology displacing human workers.

- **Cost**: The high costs for developing, testing, certifying, and implementing can be a barrier.

- **Workflow**: How do AI solutions fit into existing workflows? How much effort is required to use it? Does it interfere or annoy unnecessarily?

- **Competing Priorities**: EHRs, portals, Meaningful Use, Payment Report, ACOs.

Legal and Ethical Challenges

- **Regulation**: Health IT regulations are hotly debated at the national level. Finding the right balance of public health protection and fostering innovation is key.

- **Legal**: Juries still award large sums when health care is not applied properly or expected outcomes are not achieved.

- **Liability**: How do we deal with computer failings? It raises the issue of data de-identification, privacy, security, and espionage.

- **Human Touch**: How will we interact with AI? How strongly will we require the human touch and human compassion in health care?
<table>
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<tr>
<th>AI Ubiquitous: All Major Corporations</th>
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<tbody>
<tr>
<td><strong>Every Company Loves You</strong></td>
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<tr>
<td>“Do they have your best interests in mind?”</td>
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<td><strong>Battle of the Giant Intelligences</strong></td>
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<tr>
<td>Which AI-run governments, corporations, and systems will dominate?</td>
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<td><strong>Promises, Promises</strong></td>
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Intelligent Computing Roundtable Discussion Topics

1. What types of health care problems do you believe are most amenable to intelligent computing in the short term (now)? Data gathering/filtering, intelligent interaction, diagnosis/decision support, intelligent medical devices, robotics, analytics?

2. Which job functions do you think are most at risk for being eliminated by intelligent computing/AI? Support personnel, nurses, general practitioners, specialists, radiologists, surgeons, care managers?

3. Which intelligent computing techniques do you believe will be the most successful over the next 10 years? Statistical-based, logical reasoning-based, or bio-inspired?

4. What do you see as the largest barriers to IC/AI success in health care? Technical, Clinical, Costs, Skills, Regulation, Legal. Ethical?

5. Do you believe that we will see intelligent systems more capable than humans/physicians in diagnosis and treatment plans within the next 10, 20, or 30 years?

6. Are you concerned about the rise of intelligent machines in your lifetime, or do you believe that the technologies will never be sophisticated or autonomous enough to pose a real threat to humanity? Yes, or No?
Summary/Key Takeaways

Steps to Intelligent Computing/AI Success

- **Satisfaction**
  
  Focus on the advantages of intelligent computing – these systems should be viewed as assistants, not threats

- **Treatment/Clinical**
  
  Combine the experience, knowledge, and human touch of clinicians with the power of intelligent computing to achieve more than either alone

- **Electronic Information/Data**
  
  Use intelligent computing to tackle the complexity and expanse of new data sources to push the boundaries of precision medicine and population health

- **Prevention and Patient Education**
  
  Use Intelligent Computing to provide higher levels of patient engagement and education, such as adaptive, personalized response and gaming

- **Savings**
  
  Use IC to reduce labor costs, increase consistency, discover new clinical knowledge, and offer scalable return on investment for value- and risk-based care
Thank You!

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