HAIMLC701 AI & ML in Healthcare

Module		Topics	Hours.
1.0		Introduction	04
	1.1	Overview of AI and ML,A Multifaceted Discipline, Applications of AI in Healthcare - Prediction, Diagnosis, personalized treatment and behavior modification, drug discovery, followup care etc,	
	1.2	Realizing potential of AI and ML in healthcare, Healthcare Data - Use Cases.	

CO Mapped : CO1-Understand the role of AI and ML for handling Healthcare data(L3)

Textbooks:

1. Arjun Panesar, "Machine Learning and AI for Healthcare", A Press.
2. Arvin Agah, "Medical applications of Artificial Systems ", CRC Press

References:

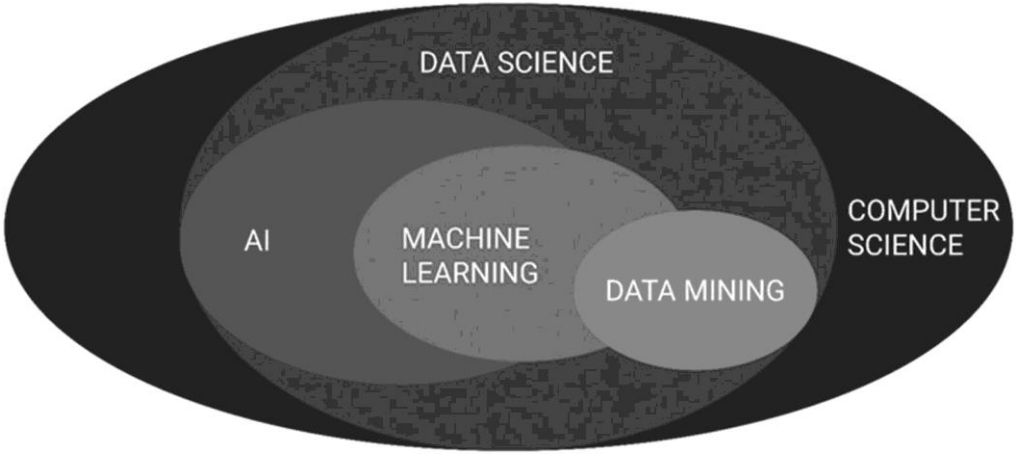
1. Erik R. Ranschaert Sergey Morozov Paul R. Algra, "Artificial Intelligence in medical Imaging-Opportunities, Applications and Risks", Springer
2. Sergio Consoli Diego Reforgiato Recupero Milan Petković,"Data Science for Healthcare-Methodologies and Applications", Springer
3. Dac-Nhuong Le, Chung Van Le, Jolanda G. Tromp, Gia Nhu Nguyen, "Emerging technologies for health and medicine", Wiley.
4. Ton J. Cleophas , Aeilko H. Zwinderman, "Machine Learning in Medicine- Complete Overview", Springer

Introduction

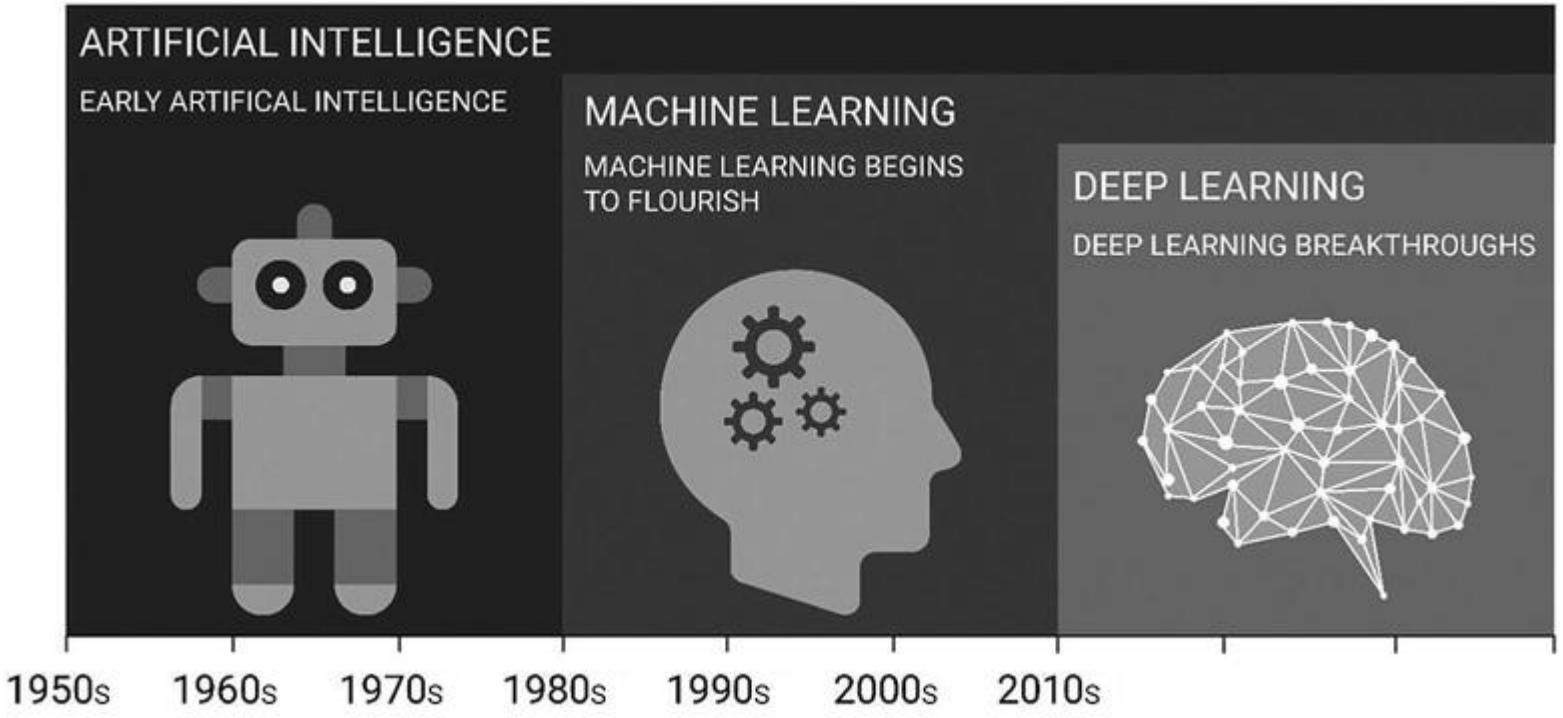
- What Is Artificial Intelligence?
  - Virtual assistants determines tastes
  - cars are now able to drive themselves
  - mobile apps can help reverse diseases once considered to be chronic and progressive
  - Today, data comes in real time -digital devices, wearables, and the Internet of Things (IoT)
- Agents developing traits including knowledge, reasoning, problem-solving, perception, learning, planning, and the ability to manipulate and move
- Data streaming in real time at a rapid pace, from a variety of sources, and with the demand for analysis and interpretable for better decisions
- *Whether AI will take over the earth in the next generation is unlikely, but AI and its applications are here to stay*

A Multifaceted Discipline

- In 1950 when British pioneer Alan Turing published “Computing Machinery and Intelligence” in which he asked, “Can machines think?”
- The Turing Test proposed a test of a machine's ability to demonstrate “artificial” intelligence, evaluating whether the behavior of a machine is indistinguishable from that of a human.
- It is estimated that there will be 150 billion networked measuring sensors in the next decade—which is 20 times the global population
- From smartphones to smart washing cars, smart homes, cities, and communities await



AI and its development



Four distinctive categories of AI:
1. Reactive Machines

- most basic AI
- respond in a current scenario, relying on taught or recalled data to make decisions in their current state
- perform the tasks well for what they are designed , but not others
- do not store memories or past experiences for future action
- Example:
  - Deep Blue, the chess-playing IBM supercomputer make predictions based on the chessboard
  - Deep Blue beat world champion chess player Garry Kasparov in 1996.
  - Google's AlphaGo

2. Limited Memory: Systems that Think and Act Rationally

- works on the principle of limited memory
- uses both preprogrammed knowledge and subsequent observations carried out over time
- During observations, the system looks at items within its environment and detects how they change and then makes necessary adjustments
- Example:
  - Self-driving cars can store recent speed of nearby cars, the distance of other cars, speed limit, and other information to navigate the road

3. Theory of Mind: Systems That Think Like Humans

- This kind of AI requires an understanding that the people and things within an environment can also alter their feelings and behaviors
  - Theory of Mind AI should understand the human emotions, beliefs, and be able to interact socially like humans
  - This type of AI machines are still not developed, but researchers are making lots of efforts and improvement for developing such AI machines
- Although such AI is presently limited, it could be used in caregiving roles such as assisting elderly or disabled people with everyday tasks
- Theory of mind AI can attempt to understand people's intentions and predict how they may behave

4. Self-Aware AI: Systems That Are Humans

- The future of Artificial Intelligence
- These machines will be super intelligent, and will have their own consciousness, sentiments, and self-awareness
- These machines will be smarter than human mind
- Self-Awareness AI does not exist in reality still and it is a hypothetical concept

What Is Machine Learning?

- Arthur Samuel of IBM in1959 proposed that it may be possible to teach computers to learn everything they need to know about the world and how to carry out tasks for themselves
- Machine learning was born from pattern recognition and the theory that computers can learn without being programmed to perform specific tasks
  - Techniques such as Bayesian methods, neural networks, inductive logic programming, explanation-based natural language processing, decision tree, and reinforcement learning

What Is Data Science?

- Data science is an interdisciplinary field that uses statistics, scientific computing, scientific methods, processes, algorithms and systems to extract or extrapolate knowledge and insights from noisy, structured, and unstructured data

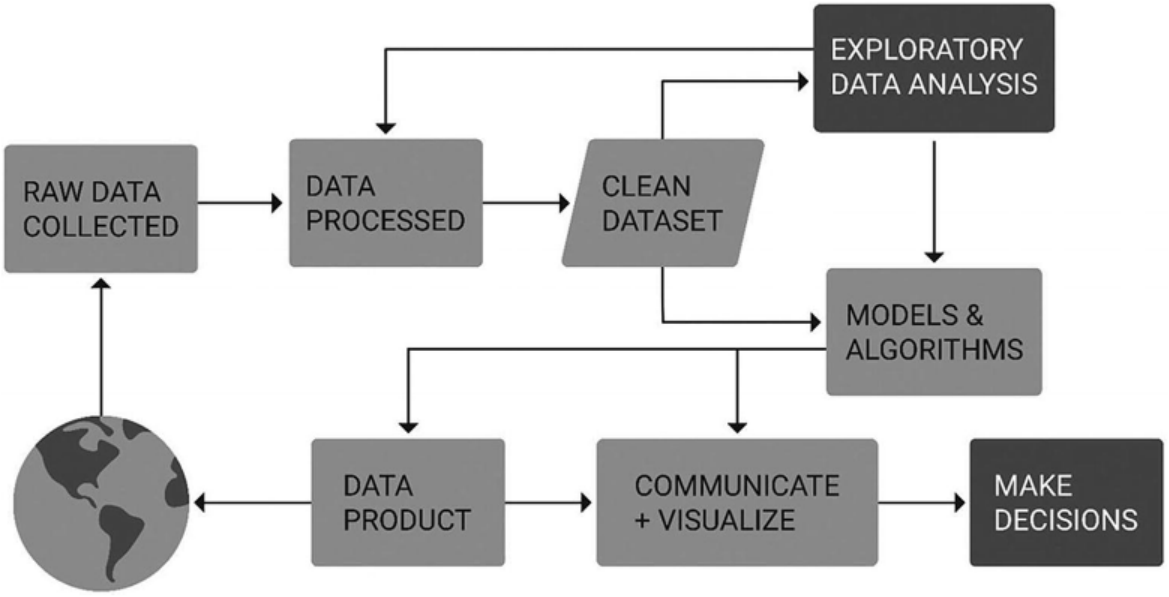


Figure 1-3 Data science process

Data Science

- real-time, immediately accessible data and tools that enable rapid analysis
- Both patients and healthcare professionals generate a tremendous amount of data
  - Phones collect metrics such as blood pressure, geographical location, steps walked, nutritional diaries, and other unstructured data such as conversations, reactions, and images

Digital Health Devices

1. Detecting Arrhythmias-

   Kardiamobile personal EKG monitor

2. Detecting emergencies:

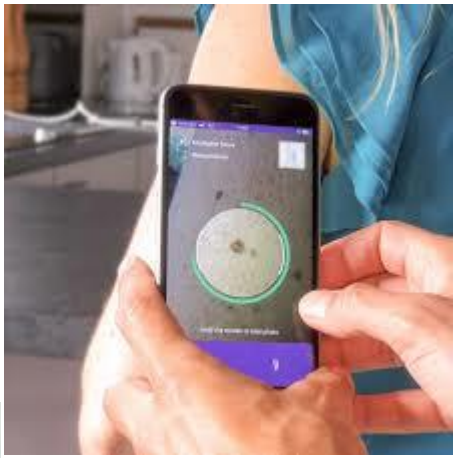
   Detecting sepsis- Sepsis happens when an infection you already have triggers a chain reaction throughout your body.

3. Detecting seizures

   A seizure is a burst of uncontrolled electrical activity between brain cells that causes temporary abnormalities in muscle tone or movements , behaviors, sensations or states of awareness.

Digital Health Devices

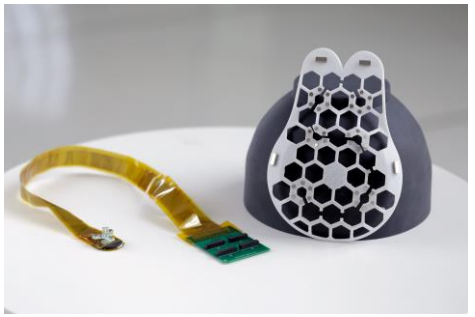
4. Skin checking apps- allows users to take pictures of suspicious regions -provide the preliminary diagnosis



5. Stroke detection

(head band to find stroke

during sleep)



6. Breast cancer detection- deep learning models + human pathologists diagnosis improves results (ultrasound scanner wearable in pic)

7. Drug discovery---cheaper, new drugs without clinical trials with less cost…

(Animation robotics for drug discovery)

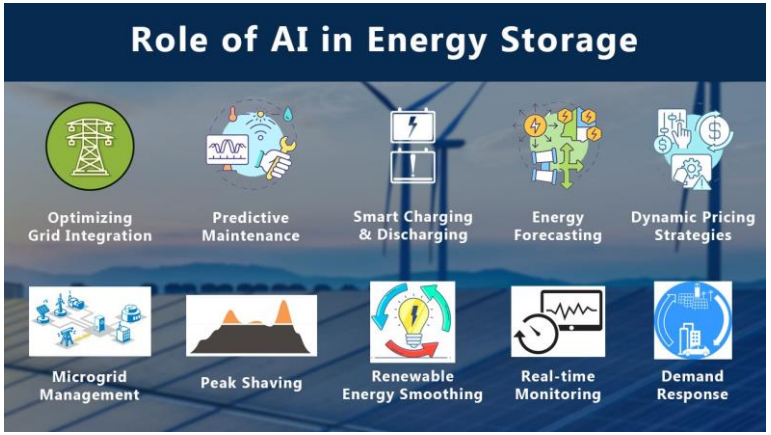
Healthcare has been slow to adopt the benefits of big data and AI, especially when compared to transport, energy, finance etc..

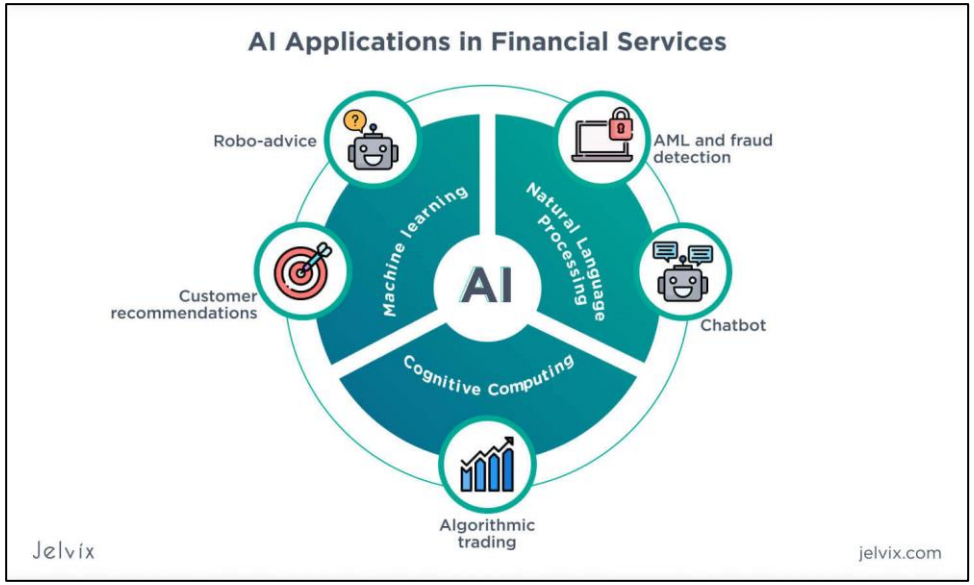
Why??

Transport

Traffic Flow Analysis
Automatic Traffic Incident Detection
Parking and Traffic Regulation Enforcement
Automated License Plate Recognition
Autonomous Vehicles
Delay Predictions
Road Condition Monitoring
Driver Monitoring

Energy

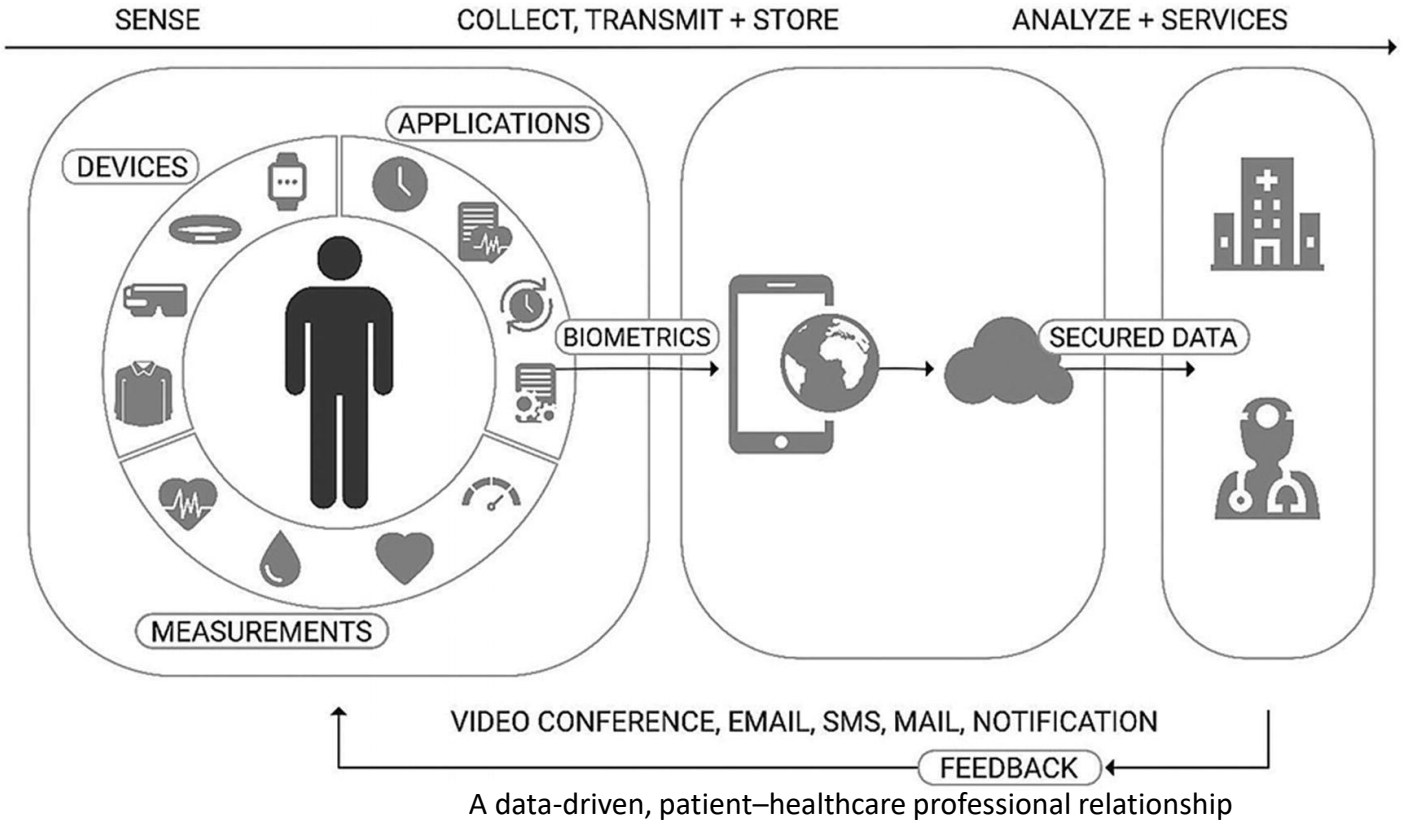




Applications of AI in Healthcare

- Highly unlikely that AI agents will ever completely replace doctors and nurses, but machine learning and AI are transforming the healthcare industry and improving outcomes

Machine learning is improving diagnostics, predicting outcomes, and beginning to scratch the surface of personalized care



A data-driven, patient–healthcare professional relationship

Applications of AI in Healthcare

- Prediction
  - Malaria outbreaks predicted with artificial neural networks (ANNs)
- Diagnosis
  - to learn about the risk of disease, improve pharmacogenetics, and provide better treatment pathways for patient
- Personalized Treatment and Behavior Modification
  - Diabetes Digital Media
    - Gro Health-Education -support in the areas of nutrition, activity, sleep, and mental health are powered by AI to tailor experience to user goal and focus, disease profile, ethnicity, age, gender, and location with remote monitoring support used in population health management

Applications of AI in Healthcare

- The use of digital therapeutics and aggregation of real-world patient data are providing solutions to conditions once considered to be chronic and progressive
- The Low Carb Program (LCP) app, for example, used by over 300,000 people with type 2 diabetes places the condition into remission for 26% of the patients who complete the program at 1 year

- Drug Discovery
  - initial screening of drug compounds based on biological factors
  - next-generation sequencing
    - massively parallel sequencing technology that offers ultra-high throughput, scalability, and speed used to determine the order of nucleotides in entire genomes or targeted regions of DNA or RNA

Applications of AI in Healthcare

- Follow-Up Care
  - Digital health coaches aid care, similar to a virtual customer service representative on an ecommerce site
  - Assistants can prompt questions about the patient's medications and remind them to take medicine, query them about their condition symptoms, and convey relevant information to the doctor
  - By setting up Zoom calls or other services, enable patients to engage with their healthcare team, removing any inertia in the process

Realizing the Potential of AI in Healthcare

- For AI and machine learning to be fully embraced and integrated within healthcare systems, several key challenges must be addressed
  - Understanding Gap
  - Fragmented Data
  - Appropriate Security
  - Data Governance
  - Bias
  - Software

1. Understanding Gap

- Huge disparity between stakeholder understanding and applications of AI and machine learning
  - Communication of ideas, methodologies, and evaluations are pivotal to the innovation required to progress
  - Data, including the sharing and integration of data, is fundamental to shift healthcare toward realizing precision medicine
  - Developing data science teams, focused on learning from data, is key to a successful healthcare strategy

Fragmented Data

- Data is currently fragmented and difficult to combine
- Patients collect data on their phones, Fitbits, and watches, while physicians collect regular biomarker and demographic data
- Electronic health records (EHRs),are still messy and fragmented across databases, require digitizing to patients and providers at their convenience
- COVID-19 expedited the linking of data sources; however in real-life, useful data fabric is still in infancy
- Data fabric -unified environment comprising architecture, technologies, and services to help an organization manage and improve decision-making
- Health apps and services use secure, cloud-based hosting providers : AWS, Microsoft Azure Cloud, and GC. Linkage by vendors to create a data fabric, for instance, may be closer than we think

Appropriate Security

- Organizations face challenges of security and meeting government regulation specifically with regard to the management of patient data and ensuring its accessibility at all times
- Many healthcare institutions are using legacy versions of software that can be more vulnerable to attack
- The NHS (National Health Service) digital infrastructure was paralyzed by the wrath of the ransomware WannaCry.
  - The ransomware, which originated in America, scrambled data on computers and demanded payments of $300–600 to restore access
  - claimed to have infected computers in 150 countries
  - The impact of the attack wasn't just the cost of the technological failure; it had a bearing on patients' lives

Data Governance

- Medical data is personal and not easy to access
  - It is widely assumed that the general public would be reluctant to share their data because of privacy concerns.
  - However, a Wellcome Foundation survey on the British public's attitude to commercial access to health data found that 17% of people would never consent to their anonymized data being shared with third parties
  - Adhering to multiple sets of regulation means disaster recovery and security is key, and network infrastructure plays a critical role in ensuring these requirements can be met

Bias

- A significant problem with learning is bias
- As AI becomes increasingly interwoven into our daily lives—integrated with our experiences at home, at work, and on the road—it is imperative that we question how and why machines do what they do
  - Within machine learning, learning to learn creates its own inductive bias based on previous experience
  - Essentially, systems can become biased based on the data environments they are exposed
  - This has expedited the growing need for more transparent algorithms to meet the stringent regulations on drug development and expectation
    - Transparency is not the only criteria; it is imperative to ensure decision-making is unbiased to fully trust its abilities
    - People are given confidence through the ability to see through the black box and understand the causal reasoning behind machine conclusions

Software

- Traditional AI systems had been developed in Prolog, Lisp, and ML
- Most machine learning systems today are written in Python due to many of the mathematical underpinnings of machine learning that are available as libraries
- Algorithms that “learn” can be developed in most languages, including Perl, C++, Java, and C

Healthcare Data –Use Cases

- Predicting Waiting Times
- In Paris, France, four hospitals -Assistance Publique-Hôpitaux de Paris (AP-HP) used data from internal and external sources of 10 years of hospital admissions records, to determine day- and hour-based predictions of the number of patients expected to enter their facility
- Time series analysis techniques were used to predict admission rates at different times
  - This data was made available to all surgeries and clinics and demonstrates an immediate way
  - Most, if not all, clinics across the world have access to similar data, which demonstrates just how healthcare is only beginning to scratch the service of data's application

Healthcare Data –Use Cases

- Predictive Analytics
- In US, Optum Labs collected EHR for over 30 million patients, creating a database for predictive analytics tools to improve the delivery of care
    - The intention is to enable doctors to make data-driven, informed decisions with proximity and therefore improve patients' treatment
- The robustness that 30 million health records allows models to be trained and validated to find people who fit predictive risk trends for diseases such as hypertension, type 2 diabetes, heart disease, and metabolic syndrome
- By analyzing patient data including age, social, economic demographics, fitness, and other health biomarkers, providers can improve care at both an individual and population level through not only predicting risk but through the delivery of treatments for optimal patient outcomes

Healthcare Data –Use Cases

- **Analyze Electronic Health Records (EHRs)**
  - one of the most common use cases for big data in healthcare
  - EHRs track and record patient's health data like pre-existing conditions and allergies, reducing the need for unnecessary tests and the associated costs
  - Records can be shared, with patient consent, via secure computer systems and are available for healthcare providers
  - Each record comprises one modifiable file, which means that doctors can implement changes over time with no danger of data replication or inconsistencies
  - Sharing patient data between healthcare providers as they treat patients can reduce duplicate tests and improve patient care

Healthcare Data –Use Cases

- **Analyze Electronic Health Records (EHRs)**
- EHRs make perfect sense; however, complete implementation across a nation is proving a task
- In the United States, up to 94% of hospitals use EHRs according to HITECH research
- A McKinsey report highlighted how the data sharing system achieved an estimated $1 billion in savings as the result of reduced office visits and lab tests (cardiovascular disease)
- The EHR is evolving into the blockchain, which seeks to decentralize and distribute access to data

Healthcare Data –Use Cases

- **Deploy Evidence-Based Medicine**
  - When a patient is admitted to a hospital, doctors usually run a battery of tests to identify the symptoms and the underlying disease
  - Evidence-based medicine enables healthcare providers to gather evidence of a patient's health and compare the symptoms to a bigger patient database, enabling faster, more accurate, and effective diagnosis and treatment
  - Big data helps consolidate and analyze information from this large patient database generated from multiple, disparate sources
- **Reduce Hospital Readmissions**
  - Hospitals' costs increase due to high patient readmission rates within a month of release
  - Using big data, healthcare providers can identify at-risk patients based on patient trends, medical history, diagnostic information

Healthcare Data –Use Cases

- Value-Based Care/Engagement
- Healthcare engage patients in their health, healthcare decision-making, care, and treatment through digital means
- Note that patient engagement is not to be confused with patient experience, which is the pathway (journey) a patient may take
- One of the key drivers of data-driven solutions is the demand for patient engagement and the transition toward value-based care
- Better patient engagement enhances trust between patients, treatment providers, and bill payers which leads to better health outcomes and cost savings
- Blue Shield of California is improving patient outcomes by developing an integrated system that connects doctors, hospitals, and health coverage to the patient's broader health data to deliver evidence-based, personalized care to improve performance in disease prevention and care coordination

Healthcare Data –Use Cases

- **Detect and Prevent Fraud**
  - Fraud in healthcare can range from genuine errors in billings to false claims that result in wrong payments
  - Due to the volume, velocity, and variety of data, claim verification and processing could take weeks or months
  - Detecting fraud and collecting evidence for legal action also take a long time and could result in huge financial losses for the organization
  - Big data analytics can help detect anomalies much faster and notify you instantly, significantly reducing the potential for healthcare fraud

Healthcare Data –Use Cases

- Healthcare IoT—Real-Time Notifications, Alerts, Automation
- Physicians need access to real-time information about their patients to improve patient care – including their visits to an emergency room, length of hospital stay, new diagnoses, progress in treatment, etc.
- Using big data and advanced analytics, we can analyze real-time information to enable proactive patient care and ensure data-driven decision-making, improving the quality of care, and lowering costs

Healthcare Data –Use Cases

- Healthcare IoT—Real-Time Notifications, Alerts, Automation

- Devices connected such as weighing scales; activity monitors (such as Fitbit, Apple Watch, Microsoft Band) measures heart rate, movement, and sleep; and blood glucose meters: all of which send metrics in real time and track user behavior in up-to-the-second fashion
- Early 2018 even saw the first fetal heartbeat wearable
- The data used to detect the risk of disease, alert doctors, or request emergency services depending on the biometrics received
- Many integrated devices are going beyond pulse and movement to measure sweat, oxidation levels, blood glucose, nicotine consumption,and more
- In another use case, University of California, Irvine, gave patients with heart disease the opportunity to return home with a wireless weighing scale and weigh themselves at regular intervals
    - Predictive analytics algorithms determined unsafe weight gain thresholds and alerted physicians to see the patient proactively before an emergency readmittance was necessary

Healthcare Data –Use Cases

- Healthcare IoT—Real-Time Notifications, Alerts, Automation

- According to several randomized trials, Fitbit wearers do exercise more, but not enough to guarantee weight loss and improved fitness
- A Cleveland Clinic study in 2016 found that heart rate monitors from four brands on the market were reporting inaccurate readings 10 to 20% of the time
- EHRs can also trigger warnings, alerts, and reminders for when a patient should get a new lab test; or track prescriptions

Healthcare Data –Use Cases

- Public Health
- By mapping patient location, it would be possible to predict outbreaks, such as influenza, that could spread within an area, making it easier to formulate plans for dealing with patients, vaccinations, and care delivery
- In West Africa, mobile phone location data proved invaluable in tracking the spread of the population—and as a result, helped to predict the Ebola virus's expanse
- After the Haiti earthquake in 2010, a team from Karolinska Institute in Sweden and Columbia University in the United States analyzed calling data from two million mobile phones on the Digicel Haiti network
- Phone records were used to understand population movements and for the United Nations to allocate resources more efficiently
- The data was also used to identify areas at risk of the subsequent cholera outbreak

Healthcare Data –Use Cases

- **Optimize Supply Chain Processes**
- Hospitals spend almost one-third of their overall operating expenses on managing their supply chains
- Big data plays a major role across the healthcare supply chain from placing the order, to order fulfillment and invoicing
- Real-time visibility into supply chain operations can help hospitals avoid supply round-tripping and wastage that are both expensive and affect care delivery
- Analyzing supply chain data can also help automate routine procurement tasks to free up staff to focus on strategic initiatives

Summary

- The potential applications of machine learning in healthcare are vast and exciting
- Intelligent systems can help us reverse disease, detect risk of cancers, and suggest courses of medication based on real-time biomarkers
- With this also comes tremendous responsibility and questions of wider morality
- We don’t yet fully understand what can be learned from health data. As a result, the ethics of learning is a fundamental topic for consideration

Summary

- Invariably, the more data available, the more precise a decision can be made—but exactly how much is too much is another question. The driving factor is determining the value of data
- The ethics of AI are currently without significant guidelines, regulations, or parameters on how to govern the enormous treasure chest of data and opportunity
- Data governance and disclosure of such data still require policy, at the national and international levels
- In the future, driverless cars will be able to use tremendous amounts of data in real time to predict the likelihood of survival if involved in a collision
- Would it be ethical for the systems to choose who lives or dies or for a doctor to decide whom to treat based on the reading from two patients' Apple Watches?