AI and ML in Healthcare

Honor course: AI & ML

Artificial Intelligence and Machine Learning: Sem VII							
Course Code	Course Name	Teaching Scheme (Contact Hours)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
HAIMLC701	AI&ML in Healthcare	04	--	--	04	--	--	04

Module 1

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.	

Module 1

https://hms.harvard.edu/news/ai-predicts-future-pancreatic-cancer

https://interestingengineering.com/science/harvard-ai-tool-cancers-molecular

https://www.fda.gov/science-research/science-and-research-special-topics/artificial-intelligence-and-machine-learning-aiml-drug-development

https://www.facs.org/for-medical-professionals/news-publications/news-and-articles/bulletin/2023/june-2023-volume-108-issue-6/ai-is-poised-to-revolutionize-surgery/

https://aiforgood.itu.int/3-ways-ai-can-turn-mobile-phones-into-universal-healthcare-providers/

AI TERMINOLOGIES

- AI is a subset of computer science that has origins in **mathematics, logic, philosophy, psychology, cognitive science, and biology,**
- explosion of data through mobile devices, smartwatches, wearables, and the ability to access computer power cheaper than ever before
- With more mobile devices than people today, the future of health is wrought with data from the patient, environment, and physician. As a result, the opportunity for optimizing health with AI and machine learning is ripening
- Costs must typically be managed without negatively impacting patient access, patient care, and health outcomes.
- AI and machine learning is improving patient health, population health, and facilitating significant cost savings and efficiencies.
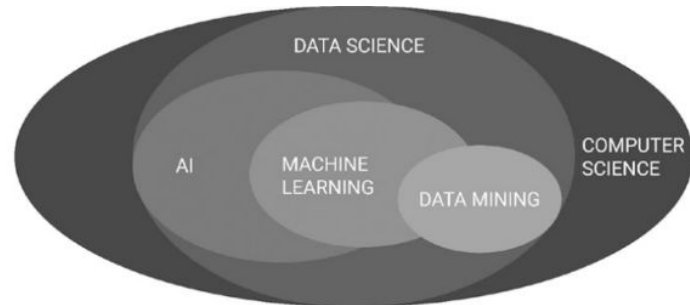
AI, ML TERMINOLOGIES

AI could be considered to comprise the following:
- **Getting a system to reason rationally.** Techniques include automated reasoning, proof planning, constraint solving, and case-based reasoning.
- **Getting a program to learn, discover and predict**. Techniques include machine learning, data mining (search), and scientific knowledge discovery. Getting a program to play games. Techniques include minimax search and alpha-beta pruning
- **Getting a program to communicate with humans.** Techniques include natural language processing (NLP).
- **Getting a program to exhibit signs of life.** Techniques include genetic algorithms.
- **Enabling machines to navigate intelligently in the world**
This involves robotic techniques such as planning and vision

Limited Memory—Systems That Think and Act Rationally

During observations, the system looks at items within its environment and detects how they change, then makes necessary adjustments.

This technology is used in autonomous cars.

Ubiquitous Internet access and IoT is providing an infinite source of knowledge for limited memory systems

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**. Although such AI is presently **limited,** it **could be used in caregiving roles such as assisting elderly or disabled people with everyday tasks.**
- a robot that is working with a theory of mind AI would be able to gauge things within their worlds and recognize that the people within the environments have their **own minds, unique emotions, learned experiences**, and so on.

Self-Aware AI—Systems That Are Humans

This most advanced type of AI involves machines **that have consciousness and recognize the world beyond humans. This AI does not exist yet,** but software has been demonstrated with desires for certain things and recognition of its own internal feelings.

- **the rigidity of the medical health sector has been duly grounded in the fact that peoples' lives are at risk. Medical services are more of a necessity than a consumer choice; so historically, the medical industry has had little to no threat that usually drives other industries to seek innovation.**
- **That has expedited a gap in what healthcare institutes can provide and what patients want—which subsequently has led to variances in care, in health outcomes, and a globally recognized medication-first approach to disease**

ML TERMINOLOGIES

- Machine learning was born from **pattern recognition and the theory that computers** can learn without being programmed to perform specific tasks. This includes techniques such as Bayesian methods; neural networks; inductive logic programming; explanation-based, natural language processing; decision tree; and reinforcement learning.
- This requires **knowledge acquisition, inference, updating and refining the knowledge base, acquisition of heuristics,** and so forth.

DS TERMINOLOGIES

- Data science is a general term for the range of techniques used when trying **to extract insights (i.e., trying to understand) and information from data.**

In most business cases,
a data scientist or data engineer
will be required to perform many
technical roles related to the data
including **finding, interpreting, and managing data; ensuring consistency of data; building mathematical models using the data; and presenting and communicating data insights/findings to stakeholders**

- The data science team typically performs two key roles. First, beginning **with a problem or question, it is seeking to solve it with data**; and second, **it is using the data to extract insight and intelligence through analytics**
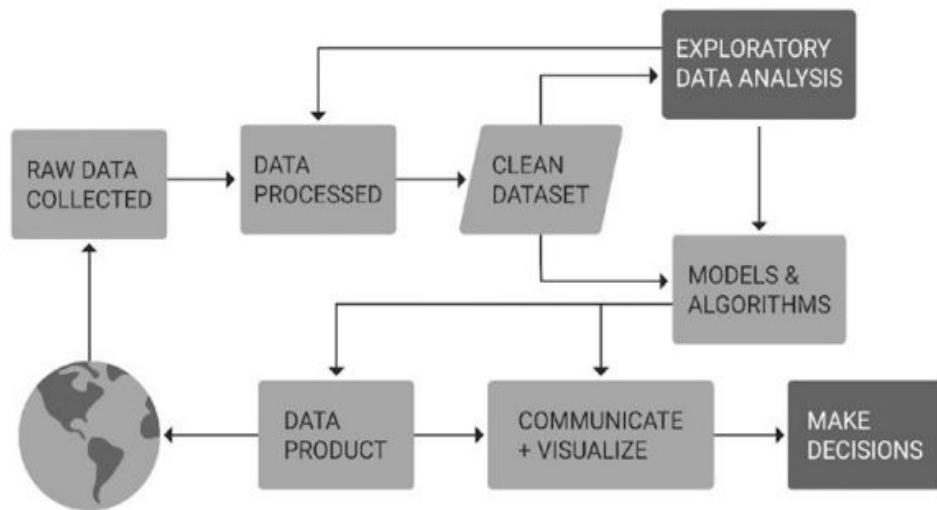
DS: Datafication

- Today, we have real-time, immediately accessible data and tools that enable rapid analysis. **Datafication refers to the modern-day trend of digitalizing (or datafying) every aspect of life**
- **Phones collect metrics such as blood pressure, geographical location; steps walked, nutritional diaries; and other unstructured data such as conversations, reactions, and images.**
- It's not just digital or clinical data either. **Data extraction techniques can be applied to paper documentation, or images scanned, to process the documents for synthesis and recall.**
- Healthcare professionals collect **health biomarkers** alongside other structured metrics. Regardless of the source of data, to learn, data must be turned into information.

Applications of AI in Healthcare
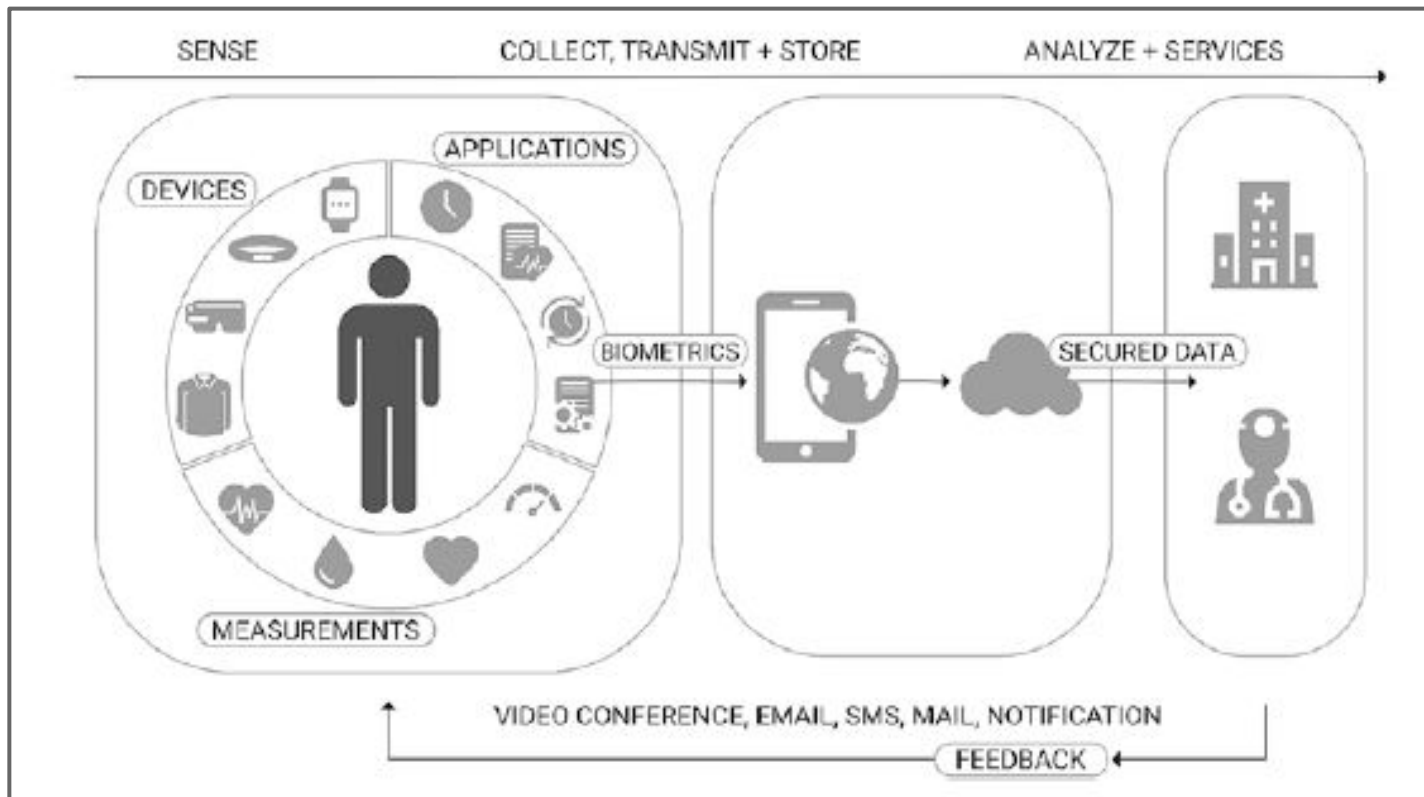
A data-driven, patient–healthcare professional relationship

Applications of AI in Healthcare

- Imagine a situation where you walk in to see your doctor with **pain around your heart**. After listening to your symptoms, she inputs them into her computer, which pulls up the **latest evidence base** she should consult to efficiently diagnose and treat your problem. You have a*n MRI scan, and an intelligent computer system assists the radiologist* in detecting any concerns that would be **too small for your radiologist's human eye to see.**
- Your *watch may have even been continuously collecting your blood pressure and pulse* while a *continuous blood glucose monitor had a real-time profile of your blood glucose readings.*
- Finally, your medical records and **family's medical history** is assessed by a computer system that suggests treatment pathways precisely identified to you.

Prediction and Diagnosis

- Technologies already exist that **monitor data to predict disease outbreaks.**
This is often done using real-time data sources such as **social media** as well as historical information from the Web and other sources.

Malaria outbreaks have been predicted with artificial neural networks, analyzing data including rainfall, temperature, number of cases, and various other data points.

- Many digital technologies offer an alternative to _non-emergency health systems._
Considering the future, **combining the genome with machine learning algorithms** provides the opportunity to learn about the **risk of disease, improve pharmacogenetics, and provide better treatment pathways for patients**

Personalized Treatment and Behavior Modification

A digital therapy from **Diabetes Digital Media, the <u>Low Carb Program</u>**, assists people with type 2 diabetes and prediabetes to reverse (i.e., **place into remission**) their condition.

The app provides _personalized education and integrated health tracking, learning from the user's and wider community's progress._

At the end of a year, most members who complete the program reduce medication dependency, saving over $1,015 per patient per year in medication **"deprescription."**

Drug Discovery

Used for initial screening of drug compounds to predicted success rate based on biological factors.
This includes **R&D discovery technologies like next-generation sequencing.**
Drugs do not necessarily need to be pharmacological in their appearance. The use of digital solutions and aggregation of real-world patient data are providing solutions to conditions once considered to be chronic and progressive.

The Low Carb Program 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

Follow-Up Care

Hospital re-admittance is a huge concern in healthcare.

Doctors, as well as governments, are struggling to keep patients healthy, particularly when returning home following hospital treatment.

Organizations such as **NextIT have developed [digital health coaches](#)**, similar to a virtual customer service representative on an e-commerce site.
The assistant prompts questions about the patient's medications and reminds them to take medicine, queries them about their condition symptoms, and conveys relevant information to the doctor.

Realizing the Potential of AI in Healthcare

Understanding Gap

There is a 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 AI and machine learning in healthcare. Encouraging the **adoption of data-driven strategies** 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. The approach required is one of investment in data. Improving value for both the patient and the provider requires data and hence data science professionals.

Fragmented Data

There are many hurdles to be overcome.
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.
At no point in the patient experience is this data combined.
Nor do infrastructures exist to parse and analyze this larger set of data in a meaningful and robust matter.
In addition, electronic health records **(EHRs)**, which at present are **still messy and fragmented across databases, require digitizing** in a mechanism that is available to patients and providers at their convenience.

Realizing the Potential of AI in Healthcare

Appropriate Security

Organizations face **challenges of security and meeting government regulation** specifically with regards 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 the wrath of the ransomware WannaCry in 2017. The ransomware, which originated in America, scrambled data on computers and demanded payments of $300 to $600 to restore access

Hospitals and GP surgeries in England and Scotland were among over 16 health service organizations hit by the "ransomware" attack. The impact of the attack wasn't just the cost of the technological failure: it had a bearing on patients' lives. Doctors' surgeries and hospitals in some parts of England had to cancel appointments and refuse surgeries. In some areas, people were advised to seek medical care in emergencies only.

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 conducted in 2016 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.

Healthcare organizations require **modernization of network infrastructure** to ensure they are appropriately prepared to provide the best patient care possible.

The case for this is highlighted by the fact that the bulk of NHS computers in 2018 use Internet Explorer 8 as their default Internet browser - which was first launched almost a decade ago

Realizing the Potential of AI in Healthcare

Bias

A significant problem with learning is bias.

As AI becomes increasingly interwoven into our daily lives—integrated with our experiences at home, 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 to.

It's not until algorithms are used **in live environments that people discover built-in biases,** which are often amplified through real-world interactions.
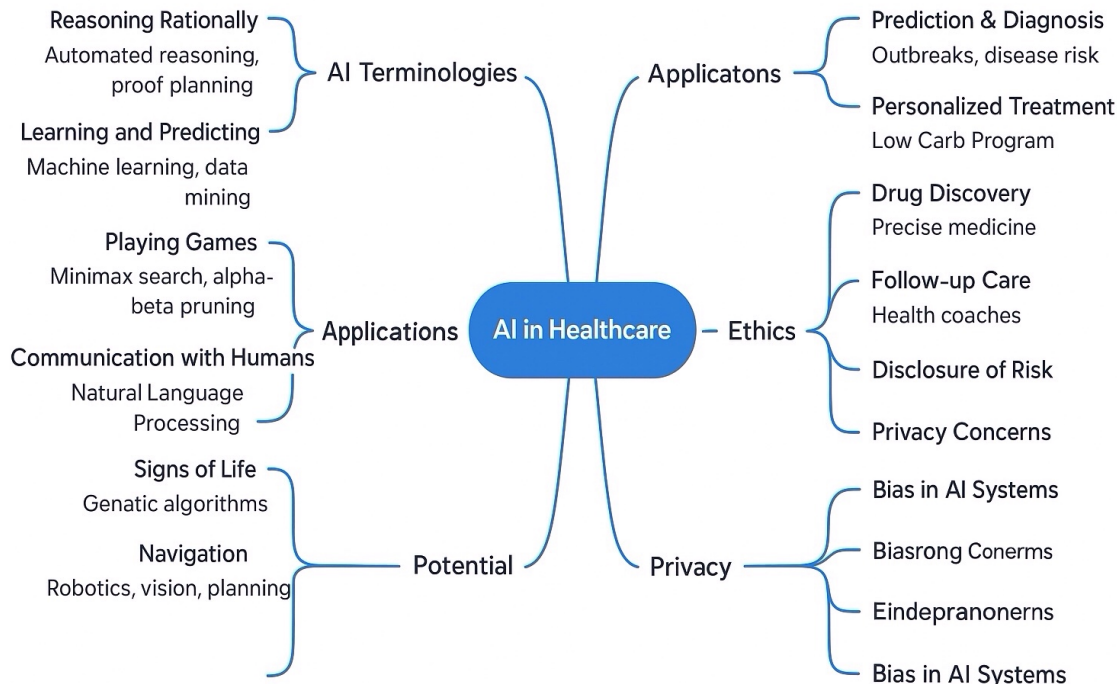
This has expedited the growing need for more transparent algorithms to meet the stringent regulations on drug development and expectation. **Transparency is not the only criteria; it is imperative to ensure decision-making is unbiased to fully trust its abilities**. People are given confidence through 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.

However, algorithms that "learn" can be developed in most languages, including Perl, C++, Java, and C.

AI in Healthcare

AI Terminologies
- Reasoning Rationally — Automated reasoning, proof planning
- Learning and Predicting — Machine learning, data mining

Applications
- Playing Games — Minimax search, alpha-beta pruning
- Communication with Humans — Natural Language Processing

Potential
- Signs of Life — Genatic algorithms
- Navigation — Robotics, vision, planning

Applicatons
- Prediction & Diagnosis — Outbreaks, disease risk
- Personalized Treatment — Low Carb Program

Ethics
- Drug Discovery — Precise medicine
- Follow-up Care — Health coaches
- Disclosure of Risk
- Privacy Concerns

Privacy
- Bias in AI Systems
- Biasrong Conerms
- Eindepranonerns
- Bias in AI Systems

AI in Healthcare – One Page Summary

1. AI, ML, DS Basics

AI — Machines that can reason, learn, predict, communicate, evolve, and navigate

ML — Machines learn from patterns in data

DS — Extracts insights from data Roles. solving problems and analytics

Datafication — everyday activities (steps, BP, GPS, diet, conversations) into data

2. Types of AI

- **Reactive Machines** — No memory, simple responses
- **Limited Memory** — Uses 'recent data eno
- **Theory of Mind** — Understands emotion, beliefs, intentions carec
- **Self-Aware AI** — Future At- conscuosnes and self-awareness

3. Applications in Healthcare

- **Prediction & Diagnosis** — Outbreaks, early disease risks, malaria prediction
- **Personalized Treatment** — Low Carb Program app diabetes remiss
- **Drug Discovery** — AI screens commounds speeds R&D
- **Follow-up Care** — Digital health coaches remind medication

4. Challenges in Realizing Potential

- **Understanding gap** between doctors and AI experts
- **Fragmented data**, scattered across apps, EHRs, hospitals
- **Security** riveers sanes ransomware attacks (NHS WannaCry 2017)
- **Data Governance** privacy, outdated infrastructure
- **Bias** algorithms inherit training data bias

Mnemonics to remember entire Module

AI Terminoologies	RLP-CNS	Reasoning, Learning 🗑 **Privacy**
Types of AI	ReLiToSe	Reactive, Limited Memory, Theory
Applications	PPDF	Prediction & Diagnosis, Personalized
Challenges	UF-SDB	Drug Decovery, Folow- ure Care

Conclusion

- **Intelligent systems can help us reverse disease, detect our risk of cancers, and suggest courses of medication based on real-time biomarkers.**
With this also comes tremendous responsibility and questions of wider morality.
As a result, the **ethics of learning is a fundamental topic for consideration.**

On the basis that an intelligent system can detect the risk of disease, should it tell the patient it is tracking the impending outcome? If an algorithm can detect your risk of pancreatic cancer—an often-terminal illness—based on your blood glucose and weight measurements, is it ethical to disclose this to the patient in question? Should such sensitive patient data be shared with healthcare teams - and what the unintended consequences of such actions?

- And if **a patient opts out of sharing data,** is it then ethical to generalize based on known data to predict the same illness risk? And what if I **can't get life insurance wi**thout this pancreatic cancer check? There are considerable privacy concerns associated with the use of a person's data and **what should be private or not,** and equally as to what data is useful.
- the more data available the more precise a decision can be made—but exactly how much it too much is another question

The **ethics of AI are currently without guidelines, regulations, or parameters on how to govern the enormous treasure chest of data and opportunity**. AI algorithms are only as fair and unbiased as the learnings, which come from the environmental data: learning on health data is revealing **new ethical dilemmas for consideration.**

- Data governance and disclosure of such data still requires policy, at the national and international level:

Would it be ethical for a doctor to decide whom to treat based on the reading from two patients' Apple Watches?

- *With the future of medicine grounded in data and analytics, it begs the question as to whether there will ever be enough data?*

23