Introduction

CHAPTER -01

Course Objectives

1 To understand the need and significance of AI and ML for Healthcare.

2 To study advanced AI algorithms for Healthcare.

3 To learn Computational Intelligence techniques .

4 To understand evaluation metrics and ethics in intelligence for Healthcare systems,

5 To learn various NLP algorithms and their application in Healthcare,

6 To investigate the current scope, implications of AI and ML for developing futuristic Healthcare Applications.

Course Outcomes

CO1. Illustrate the role of AI and ML in Healthcare Industry.

CO2.Apply AI algorithms for Healthcare problems.

CO3.Evaluate AI models for Healthcare systems.

CO4.Explore patient records for disease information.

CO5.Apply NLP techniques for Healthcare System.

CO6. Develop Healthcare applications using any AI and ML algorithms.

Textbook

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

Outline

- 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,
- Realizing potential of AI and ML in healthcare
- Healthcare Data - Use Cases

Introduction to AI

- The term AI was first coined in 1956 by Professor John McCarthy of Dartmouth College.
- Artificial intelligence is the simulation of human intelligence processes by machines, especially computer systems.
- It is a ability of machine that think and learn like humans do.
- Artificial Intelligence is an relative to more than one branch of knowledge field aiming at developing techniques and tools for solving problems that people are good at.
- AI is an umbrella term that encompasses a wide variety of technologies, including machine learning, deep learning, and natural language processing (NLP).
- Artificial intelligence is a software think intelligently, in the similar manner the intelligent humans think.
- AI is accomplished by studying how human brain thinks, and how humans learn, decide, and work while trying to solve a problem.
- Artificial intelligence can play a key role in the sectors like healthcare, agriculture, E-commerce, NASA, Robotics, transportation..

- The term AI was first coined in 1956 by Professor John McCarthy of Dartmouth College.
- Artificial intelligence (AI) technology allows computers and machines to simulate human intelligence and problem-solving tasks.
- The ideal characteristic of artificial intelligence is its ability to rationalize and take action to achieve a specific goal.
- Artificial intelligence makes it possible for machines to learn from experience, adjust to new inputs and perform human-like tasks.
- AI is an umbrella term that encompasses a wide variety of technologies, including machine learning, deep learning, and natural language processing (NLP).
- Using these technologies, computers can be trained to accomplish specific tasks by processing large amounts of data and recognizing patterns in the data.
- Most AI examples that you hear about today – from chess-playing computers to self-driving cars – rely heavily on deep learning and natural language processing.
- Artificial intelligence can play a key role in the sectors like healthcare, agriculture, E-commerce, NASA, Robotics, transportation.

A Multifaceted Discipline

- AI is a subset of computer science that has origins in mathematics, logic, philosophy, psychology, cognitive science, and biology, among others

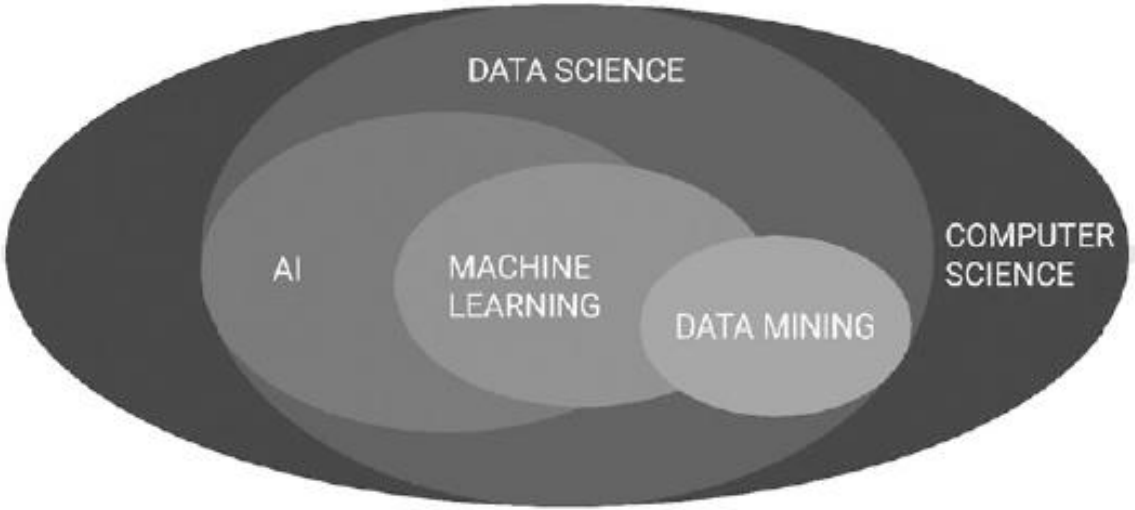


Figure 1-1. *AI, machine learning, and their place in computer science*

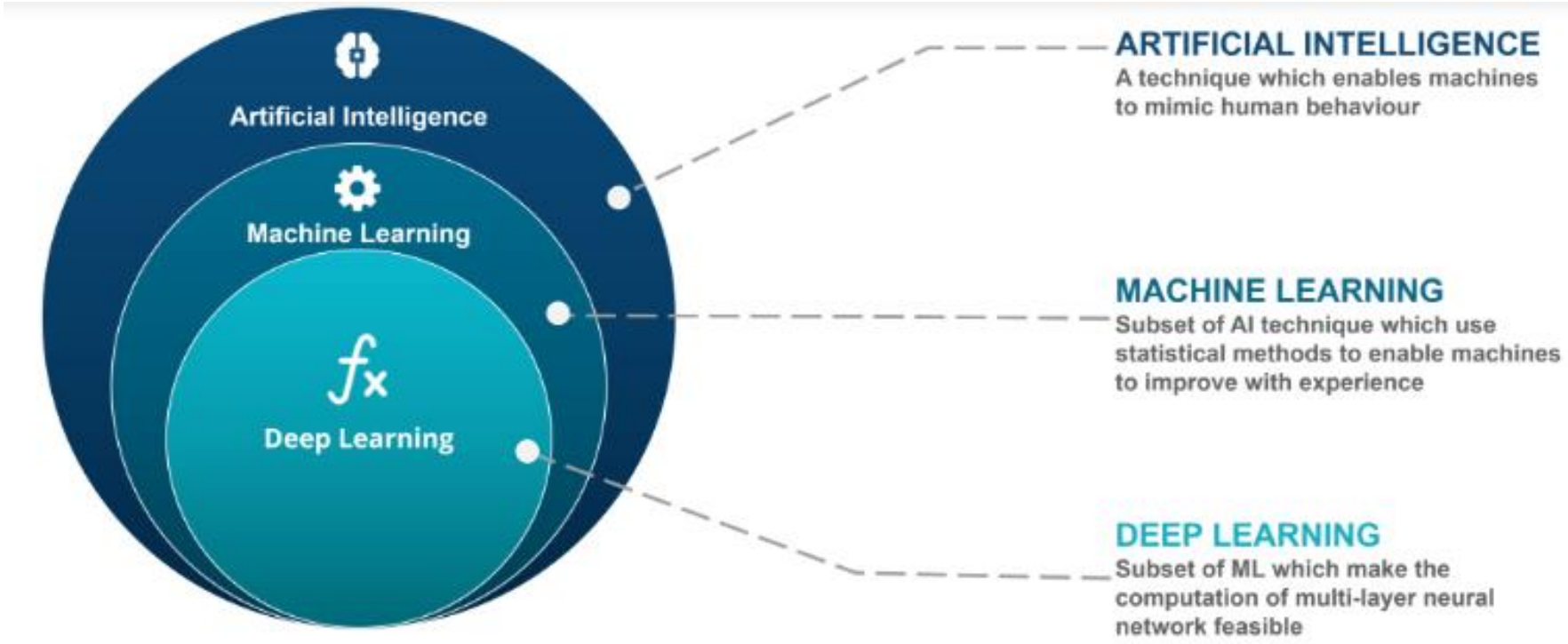
Examining Artificial Intelligence

- **Reactive Machines:** Reactive machines perform the tasks they are designed for well, but they can do nothing else. This is because these systems are not able to use past experiences to affect future decisions. These AI systems have no memory and are task specific.
- Reactive AI is a type of Narrow AI that uses algorithms to optimize outputs based on a set of inputs. Chess-playing AIs, for example, are reactive systems that optimize the best strategy to win the game. Reactive AI tends to be fairly static, unable to learn or adapt to novel situations.
- **Limited Memory—Systems That Think and Act Rationally:** AI that works off the principle of limited memory and uses both preprogrammed knowledge and subsequent observations carried out over time.
- These AI systems have memory, so they can use past experiences to inform future decisions. Some of the decision-making functions in self-driving cars are designed this way.
- **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. It could be used in caregiving roles such as assisting elderly or disabled people with everyday tasks.
- **Self-Aware AI—Systems That Are Humans:**This most advanced type of AI involves machines that have consciousness and recognize the world beyond humans. Machines with self-awareness understand their own current state.This type of AI does not yet exist.

Overview of AI and ML

- Artificial intelligence or AI refers to **the simulation of human intelligence in machines that are programmed to think and act like humans.**
- Machine learning or ML is **a field of artificial intelligence that allows systems to learn and improve from experience without being explicitly programmed .**

Overview of AI and ML



Machine Learning

- Machine learning is a term credited to Arthur Samuel of IBM, who in 1959 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 can be understood as an application of AI.
- Systems that have hard-coded knowledge bases will typically experience difficulties in new environments.
- Certain difficulties can be overcome by a system that can acquire its own knowledge.
- This capability is known as machine learning.

Data Science

- The term data science was phrased by William Cleveland in 2001 to describe an academic discipline bringing statistics and computer science closer together.
- All AI tasks will use some form of data.
- Data science is a growing discipline that encompasses anything related to data cleansing, extraction, preparation and analysis.
- Data science is a general term for the range of techniques used when trying to extract ɔm data.

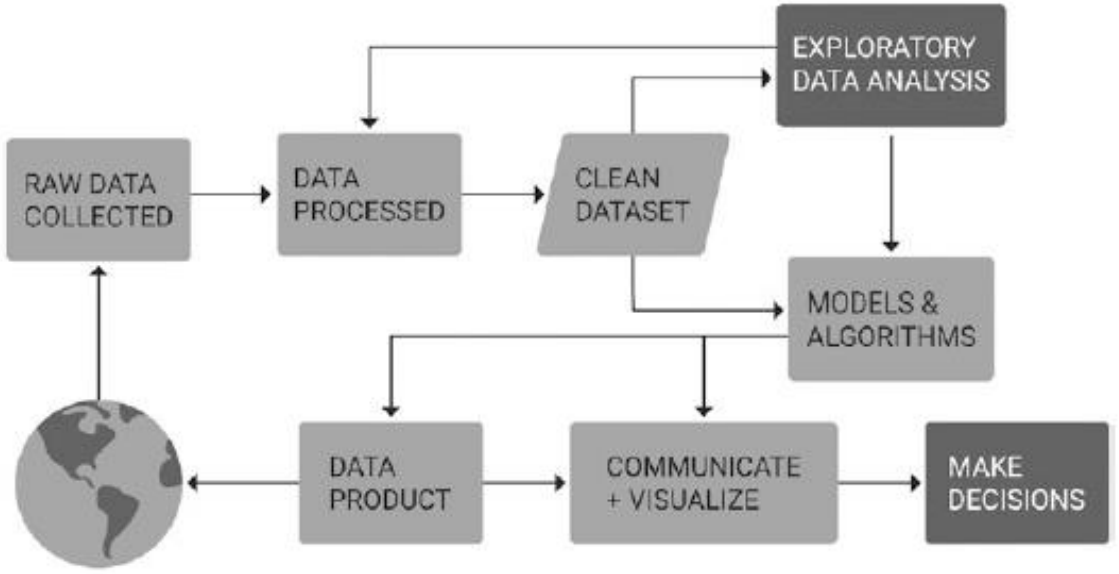


Figure 1-3. Data science process

AI in Health Care

- AI is also playing an increasingly important role in healthcare.
- AI-powered tools can help doctors diagnose diseases, develop new treatments, and provide personalized care to patients.
- The healthcare sector is one of them that AI is going to play a main role to improve the treatment process more independently and with better results in terms of disease diagnosis and medical care assistance.
- The increasing availability of healthcare data and rapid development of big data analytic methods has made possible the recent successful applications of AI in healthcare.
- AI is also used in fitness tracking devices that monitor heart rates, sleeping patterns, and walking activities, helping users to generate alerts and exercise accordingly.
- In future AI can do all major operations.

List of companies using AI in health care

- **Google Health/Deep Mind:**Google Health was established in 2006 to provide Person al Health Record(PHR) services by connecting to doctors and hospitals as well as ph armacies directly.
- It was one of the Artificial Intelligence companies in healthcare to provide information about medical conditions, directions to hospitals, medicine reminders, and fitness progress.
- It used AI to assist in diagnosing cancer, predicting patient outcomes, preventing blindness, etc., and the ways to explore patient care by using tools that were used by physicians.

List of companies using AI in health care

- **IBM Watson Health:**IBM Watson Health is one of the leading healthcare AI companies to have committed to building smarter healthcare systems with a simple process, better care, faster breakthrough, and improved experiences for people around the world.
- Through Artificial Intelligence, Cognitive computing, analytics, cloud storage, and 3D printing, the healthcare system is undergoing a dramatic transformation.
- They can assist with healthcare consulting services by evolving healthcare organizations into integrated ecosystems of providers, payers, and researchers.
- IBM also interacts with patients, caregivers and with the help of technology they focus on affordable healthcare at a large scale.

List of companies using AI in health care

- **Oncora Medical:**Oncora Medical is a digital healthcare company that uses adaptive data captive technology to identify and collect the data of each patient naturally in the physician's workflow.
- It uses real-world data to fight cancer by improving quality and outcomes for cancer patients.
- Their software technology allows to collect data and apply to all healthcare-related decisions for the benefit of the patient.

List of companies using AI in health care

- **Cloud MedX Health:**Cloud MedX Health is a healthcare AI company that aims for affordable, accessible, and standardized healthcare for all patients and doctors.
- It uses NLP (Natural Language Processing) and deep learning to extract key medical concepts for EHR and serve them to physicians and hospitals to improve clinical operators, documentation, and patient care.
- The process is automated and repetitive. It turns qualified doctors, nurses, coders, billers, and staff into data entry personals.
- It has built an AI assistance with an aim to help physicians and patients own data to data-driven decisions.

List of companies using AI in health care

- **Babylon Health:**Their AI technology can understand and recognize the unique ways humans expressing their symptoms.
- Babylon Health's Knowledge Graph is one of the largest structured medical knowled ge bases in the world.
- It attempts to capture human knowledge on modern medicine and encoded it for machines.
- They follow NLP to interrupt, understand and use human language and patterns.

List of companies using AI in health care

- **Corti:**Corti mainly focuses on top medical organizations around the world with a motive to help them improve in their decision-making.
- It also helps medical professionals diagnose illness and provides prompts for effective ac tion by utilizing cutting-edge machine learning.
- Corti isn’t designed for signals but trains itself by listening to sound from the huge set of calls to identify and improve its model as it works.
- Its real-time AI-powered decision-making system identifies significant factors in ongoing conversations and alerts healthcare or medical professionals in urgent instances like Cardiac arrest.

List of companies using AI in health care

- **Butterfly Network:** Butterfly Network, Inc. is an AI company located in Connecticut, United States of America. It was founded in 2011 with a motive to provide healthcare by making medical imaging accessible to everyone around the world.
- Butterfly IQ uses healthcare AI by providing Ultrasound tools that help make better deci sions right beside the bed as patient care is foremost than just capturing an image.

List of companies using AI in health care

- **Arterys:** Arterys is a Medical Imaging Cloud AI company with AI-powered technology to transform the workflow with faster diagnosis and better outcomes.
- They concentrate where clinical care is data-driven, intelligent, and patient-focused.
- Arterys work to transform healthcare by reducing subjectivity and variability in clinical diagnosis.

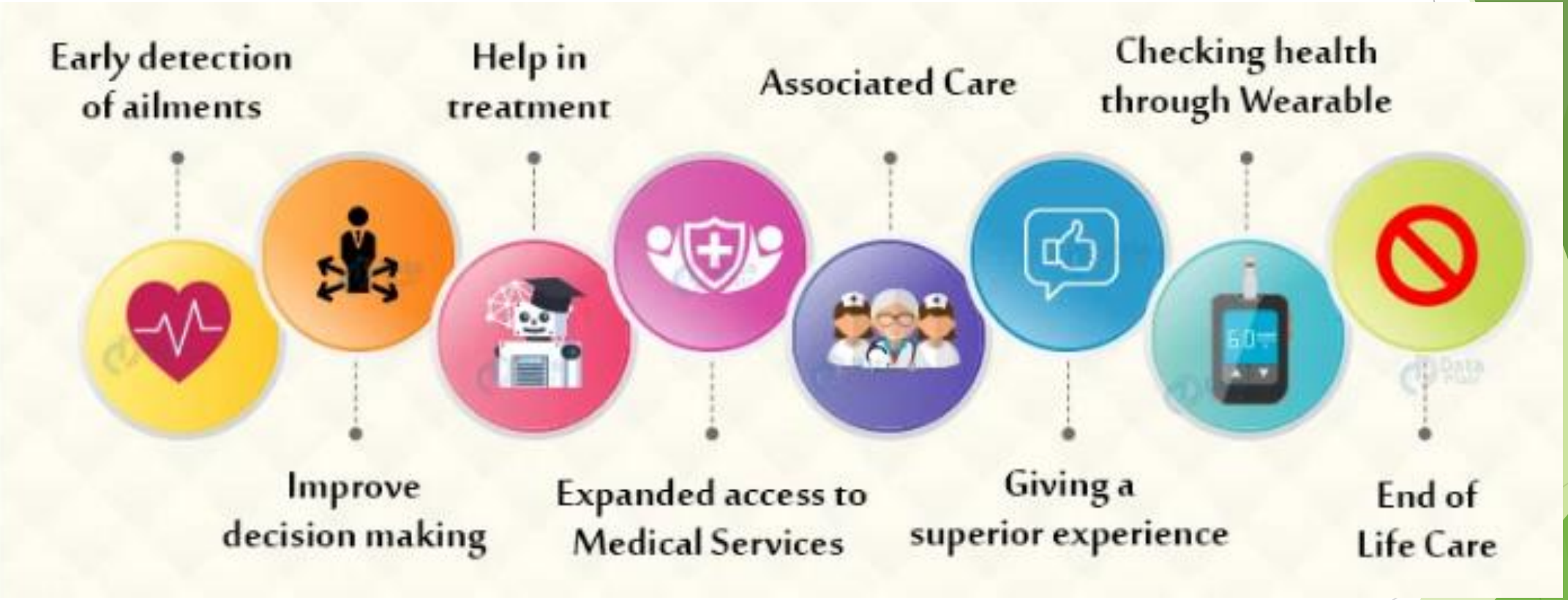
List of companies using AI in health care

- **Caption Health:**Caption Health was founded in 2013 to empower healthcare providers with new capabilities to acquire and interpret ultrasound exams.
- Caption Health is the first and only healthcare AI company to be FDA authorized and AI-guided medical imaging acquisition system.
- Their concept is to transform diagnostic healthcare by expanding access to highly qualified medical imaging in order to improve patient care and reduce cost.
- The Caption Guidance Software uses AI to provide real-time guidance and allow healthcare providers to capture diagnostic quality images to bring more benefits of Ultrasound to patients.

List of companies using AI in health care

- **Enlitic:**Enlitic was founded in 2014. It builds AI deep learning technology for streaming radiologists' workflow and upgrades healthcare diagnoses.
- Enlitic is molding the next generation of diagnostic healthcare tools for patients around the world.
- It also helps radiologists identify diseases and other medical issues more accurately.

Application of AI in Health Care



https://data-flair.training/blogs/wp-content/uploads/sites/2/2020/05/Role-of-AI-in-Healthcare-DF.jpg

Application of AI in Healthcare

- Disease Identification/Diagnosis
- Personalized Treatment/Behavioral Modification
- Drug Discovery/Manufacturing
- Robotic Surgery
- Clinical Trial Research
- Doing Repetitive Jobs
- Follow-Up Care

Disease Prediction :

- 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.

Disease Identification/Diagnosis :

- AI can be used to analyze patient data & identify patterns that may indicate a disease.
- This can help doctors diagnose diseases earlier & more accurately.
- Computer algorithms to detect disease easily based up on the Symptoms to be answering on the chatbots but they must be developed and applied with care.
- AI can diagnosis the heart disease and lung cancer more accurately.
- An AI computer algorithm using high quality data proved more consistent and accurate.
- Pathology is the medical specialty that is concerned with the diagnosis of disease based on the laboratory analysis of such as blood, urine and tissues.

Personalized Treatment/Behavioral Modification

- A personal approach is crucial in medicine.
- Each person can be considered as a unique dataset.
- AI makes work with this data more sophisticated and precise.
- Algorithms can accurately analyze genetic information and medical history to tailor separate and individual treatment plans.
- They can also recommend specific medications, minimizing adverse effects by accounting for patient-specific factors.

Drug Discovery/Manufacturing

- The usual drug discovery process is complicated and time-consuming.
- AI algorithms reduce the time needed to identify drug candidates and make predictions.
- AI is speeding up this process by helping design drugs, predicting any side effects and identifying ideal candidates for clinical trials.
- The success of AI in drug discovery is largely due to deep learning.
- Many of the top pharmaceutical companies have only relatively recently made serious efforts to apply AI to drug discovery.
- IBM's own health applications has had initiatives in drug discovery since it's early days.

Robotic Surgery

- AI-powered robotic surgery with AI algorithms bring a significant advancement in surgical precision.
- Surgeons can remotely control robotic arms equipped with AI algorithms, enhancing accuracy during complex and risky procedures.
- Eg. The da Vinci robot has got the bulk of attention in the robotic surgery space.
- The machine has four arms, which are freely moving and regular than a human and a high definition display for showing surgeons X-Ray during procedures.
- Robot-assisted surgeries, considered generally safe & have led to fewer surgery-related complications, less pain and a quicker recovery time.

Clinical Trial Research

- Clinical trials are a type of research that studies new tests and treatments and evaluates their effects on human health outcomes.
- People volunteer to take part in clinical trials to test medical interventions including drugs, cells and other biological products, surgical procedures, radiological procedures, devices, behavioural treatments and preventive care.
- Artificial Intelligence in helping shape and direct clinical trial research.
- AI can also be used for remote monitoring and real-time data access for increased safety.
- For example monitoring biological and other signals for any sign of harm or death to participants.

Doing Repetitive Jobs

- Analyzing tests, X-Rays, CT scans, data entry, and other tasks can all be done faster and more accurately by robots.
- Cardiology and radiology are two disciplines where the amount of data to analyze can be large amount and time consuming.
- Cardiologists and radiologists in the future should only look at the most complicated cases where human supervision is useful.

Follow-Up Care

- 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.

Realizing the Potential of AI in Healthcare

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.
- 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.
- Example: WannaCry in 2017- The ransomware, which originated in America, scrambled data on computers and demanded payments of $300 to $600 to restore access.

Realizing the Potential of AI in Healthcare

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.

Bias:

- A significant problem with learning is bias.
- 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.
- 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.

Healthcare Data—Little and Big Use Cases

- Healthcare stakeholders understand they are surrounded by masses of data from patients, professionals, and transactions.
- It is key to know how to drive value and meet KPIs (key performance indicators).
- The following are a selection of exciting healthcare data use cases.

Predicting Waiting Times

- In Paris, France, four of the hospitals that comprise the Assistance Publique-Hôpitaux de Paris (AP-HP) teamed up with Intel and used data from internal and external sources, including 10 years of hospital admissions records, to determine day- and hour-based predictions of the number of patients expected to enter their facility.
- This data was made available to all surgeries and clinics and demonstrates an immediate way data could be used to improve efficiency and empower stakeholders.

Reducing Readmissions

Using data analytics, at-risk patient groups can be identified based on medical history, demographics, and behavioral data.

This can be used to provide the necessary care to reduce readmission rates.

At UT Southwestern hospital in the United States, EHRs analytics led to a drop in the readmission rate of cardiac patients from 26.2% to 21.2% through successful identification of at-risk patients.

Predictive Analytics

- In the United States, Optum Labs has collected the 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 provide allows models to be trained and validated to find people who fit predictive risk trends for certain diseases such as hypertension, type 2 diabetes, heart disease, and metabolic syndrome.

Electronic Health Records

- Every patient has a digital health record consisting of their details, demographics, medical history, allergies, clinical results, and so forth. Records can be shared, with patient consent, via secure computer systems and are available for healthcare providers from both public and private sectors.
- In the United States, Kaiser Permanente has implemented a system that shares data across all their facilities and made it easier to use EHRs. 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. The data sharing system improved outcomes in cardiovascular disease.

Value-Based Care/Engagement

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. The aim is to help improve performance in disease prevention and care coordination.

Healthcare IoT—Real-Time Notifications, Alerts, Automation

- Millions of people use devices that datafy their lives toward the quantified self. Devices connected to the Internet currently include weighing scales; activity monitors (such as Fitbit, Apple Watch, Microsoft Band) that measure heart rate, movement, and sleep; and blood glucose.
- The data recorded could be used to detect the risk of disease, alert doctors, or request emergency services depending on the biometrics received.

Movement Toward Evidence-Based Medicine

- Evidence-based medicine is a term denoting treatment given based on proven scientific methods in pursuit of the best possible outcomes.
- With growing datafication, there is also increasing “real-world evidence” or data, which can be analyzed at an individual level to create a patient data model and aggregated across populations to derive larger insights around disease prevalence, treatment, engagement, and outcomes.
- This approach improves quality of care,transparency, outcomes, value, and at its core, democratizes healthcare delivery.

Public Health

- Analysis of disease patterns and outbreaks allows public health to be substantially improved through an analytics-driven approach.
- 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.
- 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.

Descriptive Analytics

- Descriptive analytics brings insight to the past, focussing on the question of what happened, through analyzing data from history. Descriptive analytics uses techniques such as data aggregation and data mining to provide historic understanding. There is much to be learned from descriptive analytics.

- Limitations of descriptive analytics are that it gives limited ability to guide decisions because it is based on a snapshot of the past. Although this is useful, it is not always indicative of the future.

Diagnostic Analytics

Diagnostic analytics is a form of analytics that examines data to answer the question of why something happened. Diagnostic analytics comprises of techniques such as decision trees, data discovery, data mining, and correlations.

Predictive Analytics

- Predictive analytics allows us to understand the future and predict the likelihood of a future outcome. Predictive analytics uses the data that you have at your disposal and attempts to fill in missing data with best-guess estimates.
- Predictive analytics remains elusive, as it requires access to real-time data that allows near real-time clinical decision-making. To support this medical sensors and connected devices must be fully integrated to provide up-to-the-moment information on patient health.

Prescriptive Analytics

Prescriptive analytics strives to make decisions for optimal outcomes: that is, to use all available data and analytics to inform and evolve a decision of what action to take—that is, smarter decisions.

Prescriptive analytics predicts not only what will happen but also why it will happen to provide recommendations regarding actions that will take advantage of the predictions.

Examples: Personalized care, Patient Monitoring in Real Time

Realizing Personalized Care

Metabolic health has been demonstrated to influence the risk of a variety of health conditions, including type 2 diabetes, hypertension, some dementias, and some cancers. While acting as a digital intervention for type 2 diabetes, the Low Carb Program app used a variety of features in the form of health biomarkers and demographics including blood glucose, weight, gender, and ethnicity to score a patient's metabolic health. As the app expanded to integrate with wearable health devices, increased weight and blood glucose data enabled the algorithm to extend to determine the likely risk of pancreatic cancer. This is communicated to patients with their healthcare team where relevant and is referenced through cohort data comparison.