

# Syllabus of IA-1

## Data Science for Healthcare

- Introduction

A number of factors make data science indispensable to healthcare in the present day, the most important of them being the competitive demand for valuable information in the health market. The collection of patient data through proper channels can help provide improved quality healthcare to consumers. From doctors to health insurance providers to institutions, all of them rely on the collection of factual data and its accurate analysis to make well-informed decisions about patients' health situations.

Nowadays, diseases can be predicted at the earliest stage with the help of data science in healthcare, that too remotely with innovative appliances powered by Machine learning. Mobile applications and smart devices constantly collect data about heartbeat rates, blood pressure, sugar, and so on, transferring this data to the doctors as real-time updates, who can then devise treatments accordingly.

## Application and Use Cases of Data Science in Healthcare

1. Discovering drugs
2. Virtual assistance
3. Wearables
4. Tracking Patient Health
6. Predictive Analytics in Healthcare

## **Benefits Of Data Science in Healthcare**

### **1. Reduced failure in treatments**

Perhaps the most vital use of data science in healthcare is to minimize errors in treatment through accurate predictions and prescriptions. Since a substantial amount of data about the patient's medical history is collected by the data scientists, that stored data can be used to identify symptoms of illnesses and provide an accurate diagnosis. Since treatment options can now be personalized, and care is more informed, mortality rates are much lessened.

### **2. Facilitates drug development**

The development of medicines requires time and intensive research. However, both time and effort can be reduced by medical data science. Through the usage of case study reports, lab testing outcomes, prior medical data, and the effect of the drugs in clinical trials, machine learning algorithms can predict whether the drug is going to produce the desired effect on the human body.

### **3. Develops a specialized skill set**

For quality treatment to be administered, it is imperative to develop skillsets that can provide an accurate diagnosis. Using predictive analytics, one can predict which patients are at a higher risk and how to intervene early to prevent serious damage.

### **4. Minimizes healthcare expenses**

Electronic Health Records(EHRs) can be used by specialists of data science in the medical field to identify the health patterns of patients and prevents unnecessary treatment or hospitalization, thus reducing costs.

- **Healthcare Data Sources and Data Analytics for Healthcare**

Healthcare data sources are diverse and include various types of information generated and collected within the healthcare industry. These data sources provide valuable insights for healthcare professionals, researchers, policymakers, and analysts. Data analytics in healthcare involves using advanced techniques to process and analyze these data sources to derive meaningful insights and inform decision-making.

Here are some common healthcare data sources and an overview of data analytics in healthcare:

- **Healthcare Data Sources:**

**1. Electronic Health Records (EHRs):** Digital records of patient health information, including medical history, diagnoses, medications, treatment plans, lab results, and more. EHRs are maintained by healthcare providers and facilitate efficient patient care.

**2. Medical Claims Data:** Data generated from insurance claims, providing information about medical procedures, treatments, and costs. This data is crucial for billing and reimbursement processes.

**3. Clinical Trials and Research Data:** Data collected from clinical trials and research studies to evaluate the safety and effectiveness of medical interventions, drugs, and therapies.

**4. Health Registries:** Specialized databases that track specific health conditions, diseases, or populations, providing comprehensive information for research and monitoring.

**5. Health Surveys:** Surveys conducted to gather information about various health-related behaviors, risk factors, and demographics of populations.

**6. Wearable Devices and Health Sensors:** Data collected from wearable devices such as fitness trackers, smartwatches, and health sensors, providing real-time information about individuals' health and activity levels.

**7 Healthcare Imaging Data:** Medical imaging data such as X-rays, MRI scans, CT scans, and ultrasound images, used for diagnostics and treatment planning.

- **Data Analytics for Healthcare:**

Data analytics plays a crucial role in deriving insights and improving healthcare outcomes. Here are some key aspects of data analytics in healthcare:

**1. Descriptive Analytics:**

Descriptive analytics involves summarizing historical data to understand trends, patterns, and key metrics. It helps in assessing past performance and identifying areas for improvement.

**2. Predictive Analytics:**

Predictive analytics uses historical data to make predictions about future events. It's used for forecasting disease outbreaks, patient readmission rates, and treatment outcomes.

**3. Prescriptive Analytics:**

Prescriptive analytics combines historical data with optimization techniques to recommend actions that will optimize outcomes. It helps in making informed decisions for patient care and resource allocation.

**4. Machine Learning and AI:**

Machine learning algorithms are used to analyze large datasets and discover patterns that may not be apparent through traditional methods. AI-powered models can aid in diagnosing diseases, identifying risk factors, and recommending treatment plans.

**5. Population Health Management:**

Analytics is used to assess the health status of populations, identify at-risk individuals, and develop interventions to improve community health.

**6. Fraud Detection:**

Analytics helps identify fraudulent claims and billing patterns to prevent healthcare fraud and abuse.

**7. Natural Language Processing (NLP):**

NLP techniques are used to analyze and extract information from unstructured clinical notes and medical records, enabling better understanding of patient conditions.

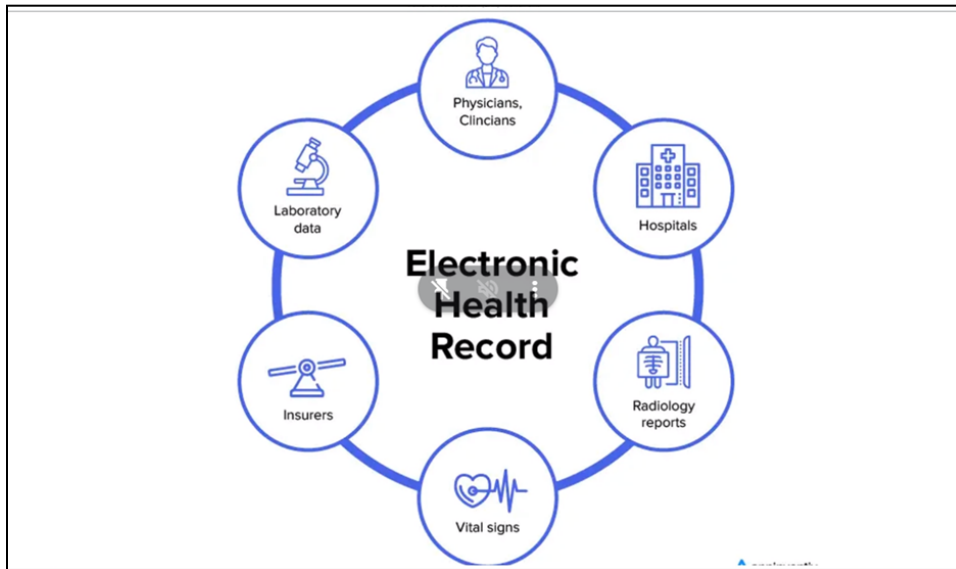
- Applications

1. **Healthcare Fraud Detection:** Data science techniques help identify unusual patterns and anomalies in medical billing and claims data, facilitating the detection of fraudulent activities and reducing healthcare fraud.
2. **Personalized Medicine and Treatment Plans:** By analyzing genomic data and patient records, data science can create personalized treatment plans that consider an individual's genetic makeup, medical history, and other relevant factors for more effective medical interventions.
3. **Drug Discovery and Development:** Data science is used to analyze molecular data, chemical properties, and clinical trial results to accelerate drug discovery and development processes. Machine learning models can predict the potential effectiveness of new compounds.
4. **Healthcare Imaging Analysis:** Data science enhances medical image analysis by automating the detection of abnormalities in X-rays, MRI scans, CT scans, and other imaging modalities. This improves diagnostics and speeds up the interpretation process.
5. **Remote Patient Monitoring:** Data science supports remote patient monitoring through wearable devices and sensors. It collects real-time health data, alerts medical professionals to potential issues, and facilitates timely interventions.
6. **Predictive Analytics for Disease Outbreaks:** Data science can analyze historical health data, environmental factors, and population demographics to predict disease outbreaks. This information is crucial for public health agencies to allocate resources and take preventive measures.

- **Practical Systems for Healthcare.**

1. **Electronic Health Records (EHR) Systems:** EHR systems digitize patient health information, making it easily accessible to healthcare providers. They store medical history, diagnoses, medications, treatment plans, lab results, and more, enhancing patient care coordination and reducing paperwork.
2. **Clinical Decision Support Systems (CDSS):** CDSS provide healthcare professionals with evidence-based recommendations and alerts at the point of care. These systems help in diagnosing diseases, suggesting treatment options, and preventing medication errors.
3. **Telemedicine and Telehealth Platforms:** Telemedicine platforms enable remote consultations between patients and healthcare providers through video calls or messaging. These platforms facilitate healthcare access, especially in remote areas or during emergencies.
4. **Wearable Health Devices:** Wearable devices like fitness trackers and smartwatches monitor vital signs, activity levels, and sleep patterns. They provide real-time health data, enabling individuals and healthcare professionals to track health conditions.
5. **Health Information Exchange (HIE) Systems:** HIE systems facilitate the secure sharing of patient health information between different healthcare organizations, improving care coordination and reducing duplication of tests.
6. **Hospital Information Systems (HIS):** HIS manage various administrative, financial, and clinical aspects of a hospital. They include modules for patient registration, scheduling, billing, and electronic medical records.

- Electronic Health Records (EHR)



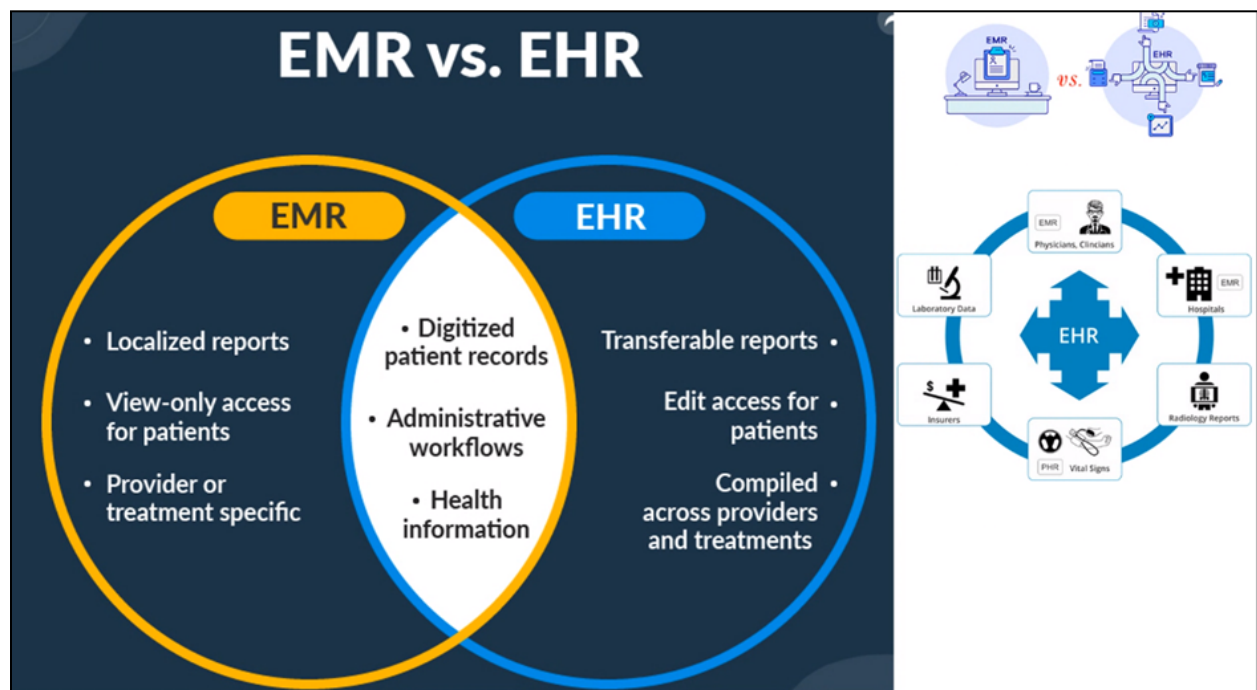
An electronic health record (EHR) is a **digital version of a patient's paper chart**. EHRs are real-time, patient-centered records that make information available instantly and securely to authorized users.

## What Are the Core Functions of EHRs?

- Health information and data.
- Results management.
- Order entry and management.
- Clinical decision support.
- Electronic communication and connectivity.
- Patient support.
- Administrative processes.
- Reporting and population health management.



- What are the objectives of electronic health records?
  - EHR should **allow for easy use of digital photography for patient identification as well as documentation of exam findings**. improvements in patient care as well as pay-for-performance goals. EHR should have easily generated reports of patients by diagnosis, visit type, demographics, etc.
- What is the difference between EMR and EHR?
  - The main difference between EMRs and EHRs is that **EHRs are maintained by multiple providers, while EMRs are only maintained by a single provider**. This means that an EHR contains more information than an EMR. Providers mainly use an EMR for diagnosis and treatment.





- Components and Benefits of EHR

## What are the components of an EHR system?

- **Electronic Health Records: The Basics**

- Administrative and billing data.
- Patient demographics.
- Progress notes.
- Vital signs.
- Medical histories.
- Diagnoses.
- Medications.
- Immunization dates.

## Advantages of Electronic Health Records

EHRs and the ability to exchange health information electronically can help you provide higher quality and safer care for patients while creating tangible enhancements for your organization.



- ☒ *Better Quality of Patient Care*
- ☒ *Better Emergency Care*
- ☒ *Security to Patients Data*
- ☒ *Reduction in Medical Errors*
- ☒ *Increased Efficiency & Productivity*
- ☒ *Cost Savings*

EHRs help providers better manage care for patients and provide better health care by:

1. Providing **accurate, up-to-date, and complete information about patients** at the point of care
2. Enabling quick access to patient records for more [coordinated, efficient care](#)
3. Securely **sharing electronic information** with patients and other clinicians
4. Helping providers more effectively [diagnose patients, reduce medical errors, and provide safer care](#)
5. Improving patient and provider interaction and communication, as well as [health care convenience](#)
6. Enabling safer, **more reliable prescribing**

7. Helping promote **legible, complete documentation** and accurate, streamlined coding and billing
8. Enhancing [privacy and security](#) of patient data
9. Helping providers **improve productivity** and **work-life balance**
10. Enabling providers to **improve efficiency and meet their** [business goals](#)
11. **Reducing costs** through decreased paperwork, improved safety, reduced duplication of testing, and improved health.

## Transformed Health Care



Electronic Health Records (EHRs) are the first step to transformed health care. The [benefits of electronic health records](#) include:

- **Better health care** by improving all aspects of patient care, including safety, effectiveness, patient-centeredness, communication, education, timeliness, efficiency, and equity.
- **Better health** by encouraging healthier lifestyles in the entire population, including increased physical activity, better nutrition, avoidance of behavioral risks, and wider use of preventative care.
- **Improved efficiencies and lower health care costs** by promoting preventative medicine and improved coordination of health care services, as well as by reducing waste and redundant tests.
- **Better clinical decision making** by integrating patient information from multiple sources.

- **Barriers to Adopting EHR**

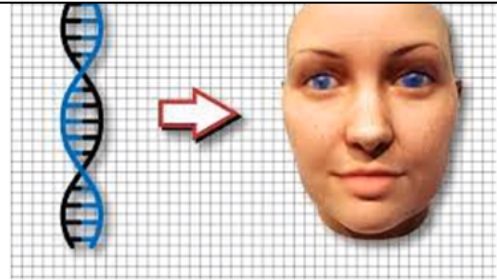
1. **Financial Costs:** Implementing and maintaining an EHR system can involve significant upfront and ongoing costs, including software licenses, hardware, training, customization, and support. Smaller healthcare organizations or practices might struggle to allocate the necessary resources.
2. **Complexity and Training:** Transitioning from paper-based records to electronic systems requires staff to learn new software and workflows. Training can be time-consuming and might require additional resources, leading to resistance from staff members.
3. **Change Management and Resistance:** Healthcare professionals and staff members who are accustomed to paper-based processes might resist the changes introduced by EHR systems. Overcoming resistance and managing the cultural shift can be challenging.
4. **Data Security and Privacy Concerns:** Healthcare data is sensitive and subject to strict privacy regulations. Concerns about data breaches, unauthorized access, and patient privacy can impede EHR adoption.
5. **Workflow Disruption:** Implementing an EHR system can disrupt established workflows and processes, causing short-term productivity declines. Ensuring a smooth transition and minimizing disruptions is essential.
6. **Data Entry Burden:** Healthcare professionals might perceive data entry as time-consuming and burdensome, affecting their ability to provide direct patient care. This can result in incomplete or inaccurate records.  
**Lack of IT Expertise:** Smaller healthcare organizations might lack in-house IT expertise required for EHR implementation, leading to challenges in system setup, maintenance, and troubleshooting.
7. **Data Migration:** Migrating existing paper-based or electronic records to the new EHR system can be a complex process, requiring careful data validation and quality assurance.

- **Challenges of using EHR data**

1. **Data Quality and Accuracy:** EHR data can be prone to errors, inconsistencies, and missing information. Inaccurate or incomplete data can lead to incorrect diagnoses, treatments, and medical decisions.
2. **Interoperability Issues:** EHR systems from different vendors might not be fully interoperable, making it challenging to exchange patient information seamlessly between healthcare settings. Lack of standardized data formats and terminology can hinder data sharing.
3. **Data Fragmentation:** Patient information might be scattered across different EHR systems, departments, and providers, resulting in fragmented records that can lead to incomplete patient profiles.
4. **Data Entry Burden:** Healthcare professionals often find data entry time-consuming and disruptive to their workflow. This can lead to data entry errors, missing information, and potential burnout among healthcare staff.
5. **Data Privacy and Security:** EHR data contains sensitive patient information, and maintaining data privacy and security is critical. Breaches or unauthorized access can have serious legal, ethical, and reputational implications.
6. **Data Standardization and Terminology:** Lack of standardized data formats and consistent medical terminology can result in confusion and inconsistency when recording and interpreting patient information.
7. **Usability and User Experience:** EHR systems with poor usability can lead to frustration among healthcare professionals, impacting data entry accuracy and overall system adoption.

- Phenotyping Algorithms.

## Phenotyping

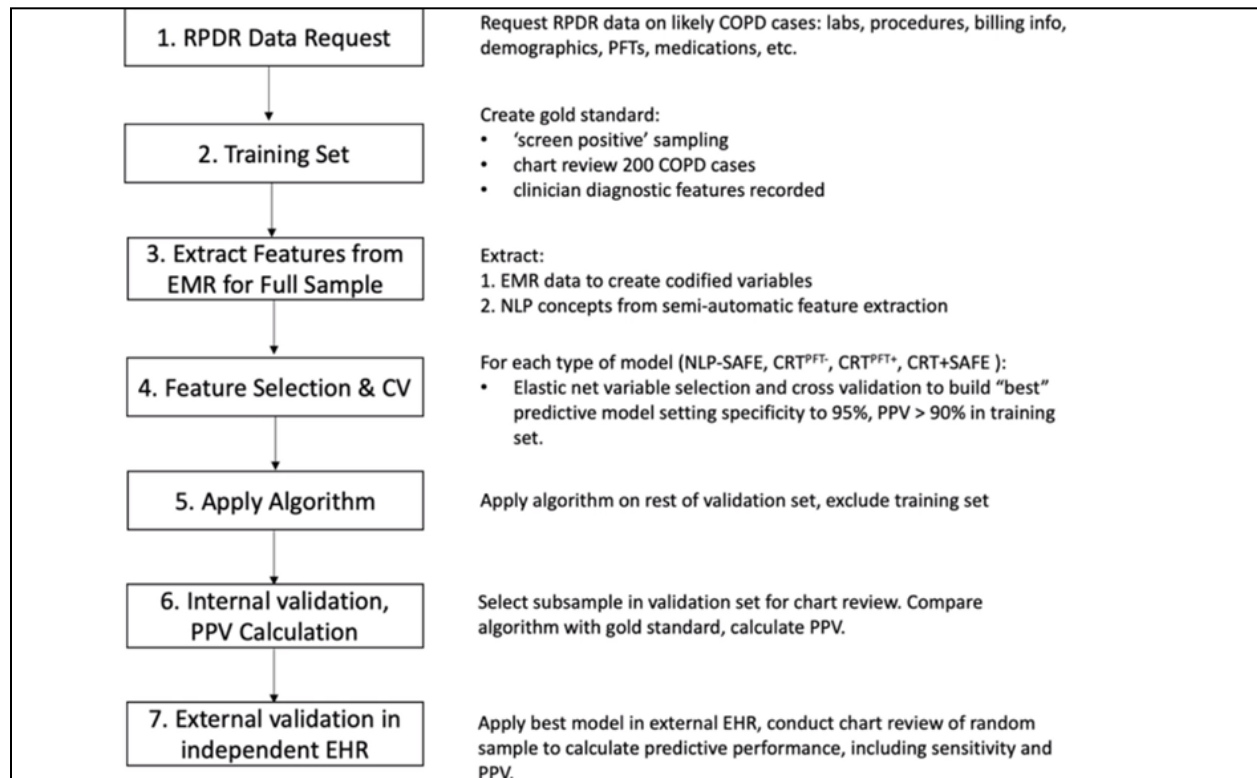


Phenotyping is **the practice of developing algorithms designed to identify specific phenomic traits within an individual**. These algorithms are created using multiple variables, thus enabling researchers to accurately identify traits and perform analyses.

- What is computational phenotyping?
  - Computational Phenotyping: **Using Models to Understand Individual Differences in Personality, Development, and Mental Illness.**
- What is data phenotyping?
  - Digital phenotyping refers to **new approaches to measure behavior through the collection of biometric and personal data in situ from digital devices, such as smartphones, wearables, or social media.**
- What is phenotyping in EHR?
  - In the context of electronic health records (EHRs), a "computable phenotype," or simply "phenotype," is a clinical condition or characteristic that can be ascertained by means of a computerized query to an EHR system or clinical data repository using a defined set of data elements and logical expressions.
- What is phenotyping used for?
  - DNA phenotyping is used **to predict an organism's physical characteristics by using information collected from its genetic code.**
  - The sequence of genomes in any person's DNA can indicate possible observable traits, such as hair color, eye color, face shape, skin color, sex, and more.

# What is image based phenotyping?

- A cell's phenotype is the culmination of several cellular processes through a complex network of molecular interactions that ultimately result in a unique morphological signature. Visual cell phenotyping is **the characterization and quantification of these observable cellular traits in images.**



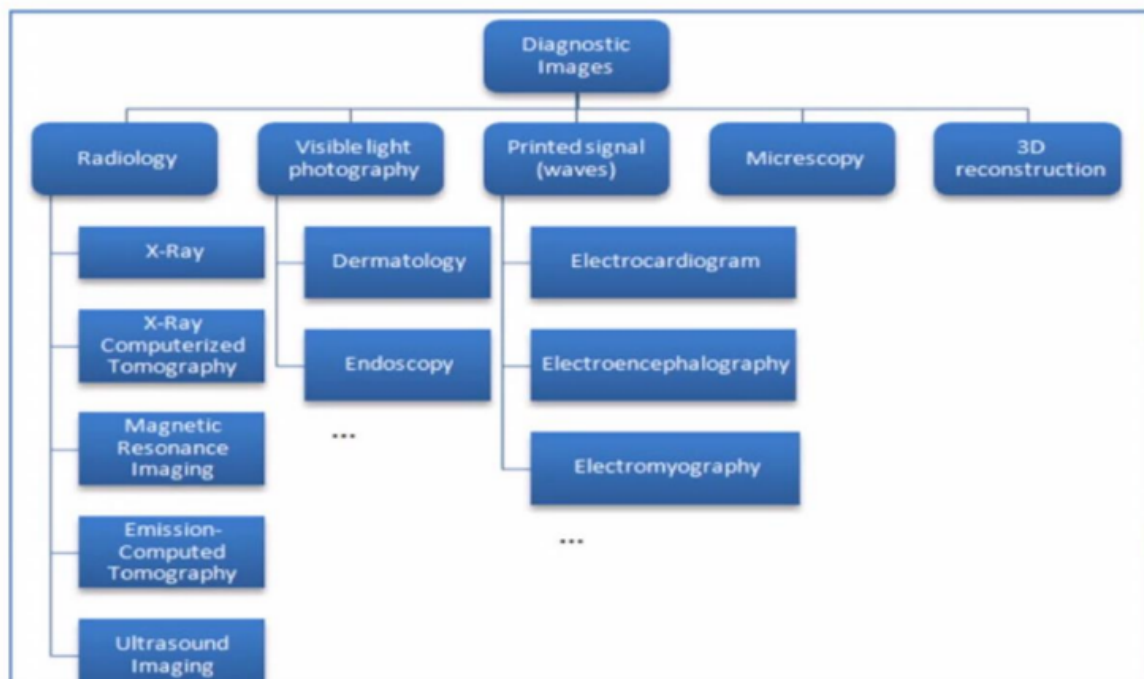


## Biomedical Image Analysis

- Biomedical Imaging Modalities

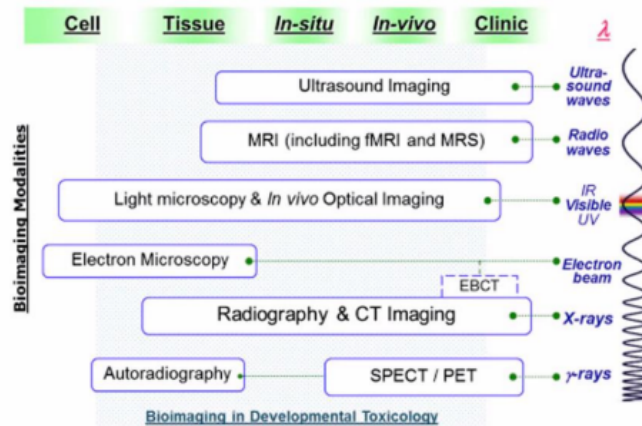
- Biomedical images are measurements of the human body on different scales (i.e. microscopic, macroscopic, etc.).
- They come in a wide variety of imaging modalities (e.g. a CT scanner, an ultrasound machine, etc.) and measure a physical property of the human body (e.g. radiodensity, the opacity to X-rays).
- These images are interpreted by domain experts (e.g. a radiologist) for clinical tasks (e.g. a diagnosis) and have a large impact on decision making of physicians.

## Biomedical Imaging Modalities



## What is biomedical imaging modalities?

In biomedical imaging, the **application of most digital filters** is generally empirical and aims at enhancing visual perception to improve the detection or characterization of a particular lesion.

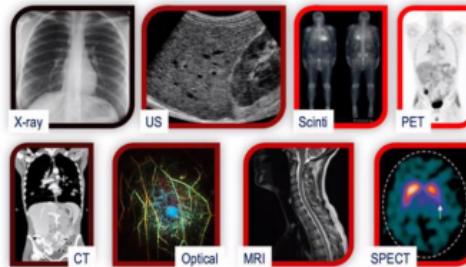


## What are the 5 medical imaging modalities?

1. Ultrasound.
2. X-Ray Imaging.
3. Computer Tomography (CT)
4. Magnetic Resonance Imaging (MRI)
5. Positron Emission Tomography (PET)

## What is medical image modality?

- The imaging modalities used in biology and medicine are **based on a variety of energy sources, including light, electrons, lasers, X-rays, radionuclides, ultrasound and nuclear magnetic resonance.**



- The images produced span orders of magnitude in scale, ranging from molecules and cells to organ systems and the full body



When this question is asked

physical mechanism that affect anatomical structure combo of visualization and physical

eg : are the example OF TECH

MOST COMMON :

ultrasonic SCAN /PET SCAN

best imaging modality :- MRI Is better a soft tissue hence its it best tha is more powerful than any other modality

cross question is mri imaging modality :

mri doesn't use Xray / any radition but use image moadality and is ore MRI  
FMRI – a bigger cost

Safest Imaging Modality :

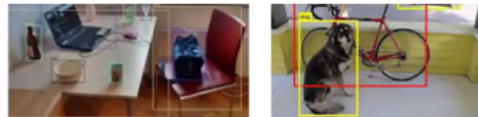
ultra soun : safest

can be used by any patient : lesser risk

- Object detection, Image segmentation

Image recognition	Object Recognition
Image recognition predicts the class of an image or video as a whole.	Object recognition identifies multiple objects in an image or video with defined labels.
It bundles image class and descriptive integers together to display key output.	It bundles together, class, location, frequency, and other factors of objects.
Users can scan a quick response (QR) code to anchor digital content on an image.	Users can slide a camera or smartphone to label real-world objects in real-time.
A list class is fed into the training model to identify images.	Powerful machine learning algorithms detect unknown features to identify objects.
The model is trained on the <u>K-nearest neighbor</u> algorithm	Each object is assigned a bounding box that predicts a confidence score.
In the supply chain, it is used to identify certain goods and classify them as defective or not defective.	It helps in performing facial recognition across domains to detect trespassers and alarm the concerned team.

## Object detection



- Object detection is a **computer vision technique for locating instances of objects in images or videos**. Object detection algorithms typically leverage machine learning or deep learning to produce meaningful results.

### What algorithm is used for object detection?

- The Fast R-CNN technique, or Fast Region-Based Convolutional Network method, is a training algorithm for detecting objects.

- **Object recognition is the area of artificial intelligence (AI)** concerned with the abilities of robots and other AI implementations to recognize various things and entities.
- Object recognition allows robots and AI programs to pick out and identify objects from inputs like video and still camera images.

## What is the object detection process?

- The process of object detection involves two main steps: **object localization and object classification**.
- Localization aims to determine the location and boundaries of the object within the image, usually by drawing bounding boxes around the objects.
- Object detection in OpenCV refers to the process of **identifying and locating specific objects within an image or a video**.

## Which language is best for object detection?

- C++ is considered to be the fastest programming language, which is highly important for faster execution of heavy AI algorithms.

Tensor flow also

## What algorithm is used for object detection?

- Popular algorithms used to perform object detection include **convolutional neural networks (R-CNN, Region-Based Convolutional Neural Networks), Fast R-CNN, and YOLO (You Only Look Once)**.
- The R-CNN's are in the R-CNN family, while YOLO is part of the single-shot detector family.
- **YOLO is a popular object detection algorithm** that has revolutionized the field of computer vision. It is fast and efficient, making it an excellent choice for real-time object detection tasks.

## Types of Image Segmentation



SEMANTIC IMAGE  
SEGMENTATION



INSTANCE  
SEGMENTATION



PANOPTIC  
SEGMENTATION

- Image Registration, Feature Extraction
- Mining of Sensor data in Healthcare
- Challenges in Healthcare Data Analysis.