

Revolutionizing Healthcare using Smart Computing

From Reactive to Predictive and Personalized Healthcare



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The Healthcare Challenges: Rising Chronic and Infectious Diseases



1 Non Communicable Diseases dominate mortality – 41M/year. Major contributors:

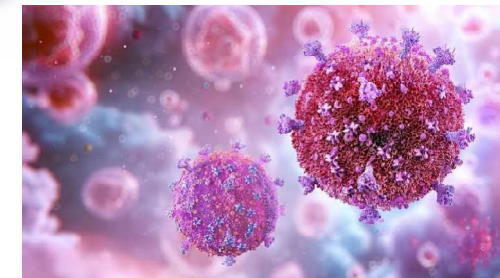
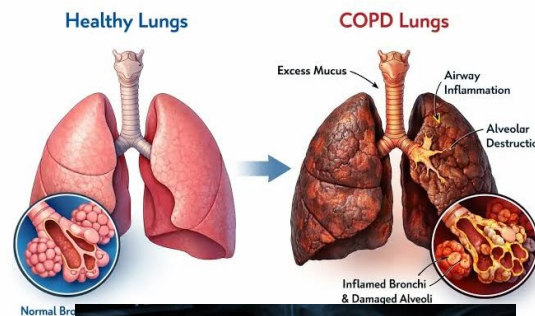
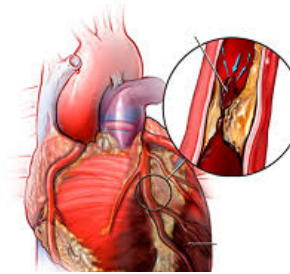
- Cardiovascular (CVD): ~17.9M/ Cancer: ~9.3M/ COPD: ~4.1M/ Diabetes: ~2.0M

2 Diabetes is rapidly expanding

- 529M globally in 2021. Projected to exceed 1.31B by 2050. (2.5 times)
- Type 2 diabetes 96% of diabetes cases in 2021.

3 Infectious diseases a major threat

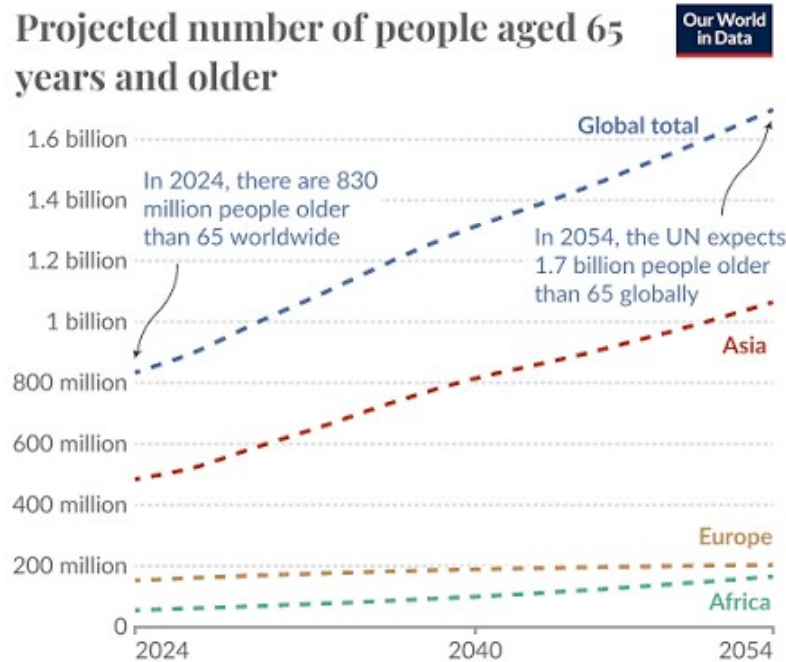
- 282M malaria cases estimated in 2024.
- 10.7M TB patient in 2024; 1.23M died from TB.
- 1.3M new HIV infections occurred globally in 2024.
- 1.41B people required treatment/care for neglected tropical diseases in 2024.



The Healthcare Challenges: Aging and Growing Population



Among the total global population 8.3B; Aged 60+ is ~1.4 Billion by 2030 and ~2.1 billion by 2050.



Data source: UN, World Population Prospects (2024)
Note: Projections from 2024 onwards are based on the UN's medium scenario.
OurWorldinData.org/population-growth | CC BY

India's rapidly growing elderly population

Senior citizens constitute about 10% of the population currently, but this will double by 2050

Share of elderly (60+) in population (%)



Source: World Population Prospects 2022
Graphic: Jaipal Sharma & Ankita Tiwari

The Healthcare Challenges: Healthcare Workforce Shortages

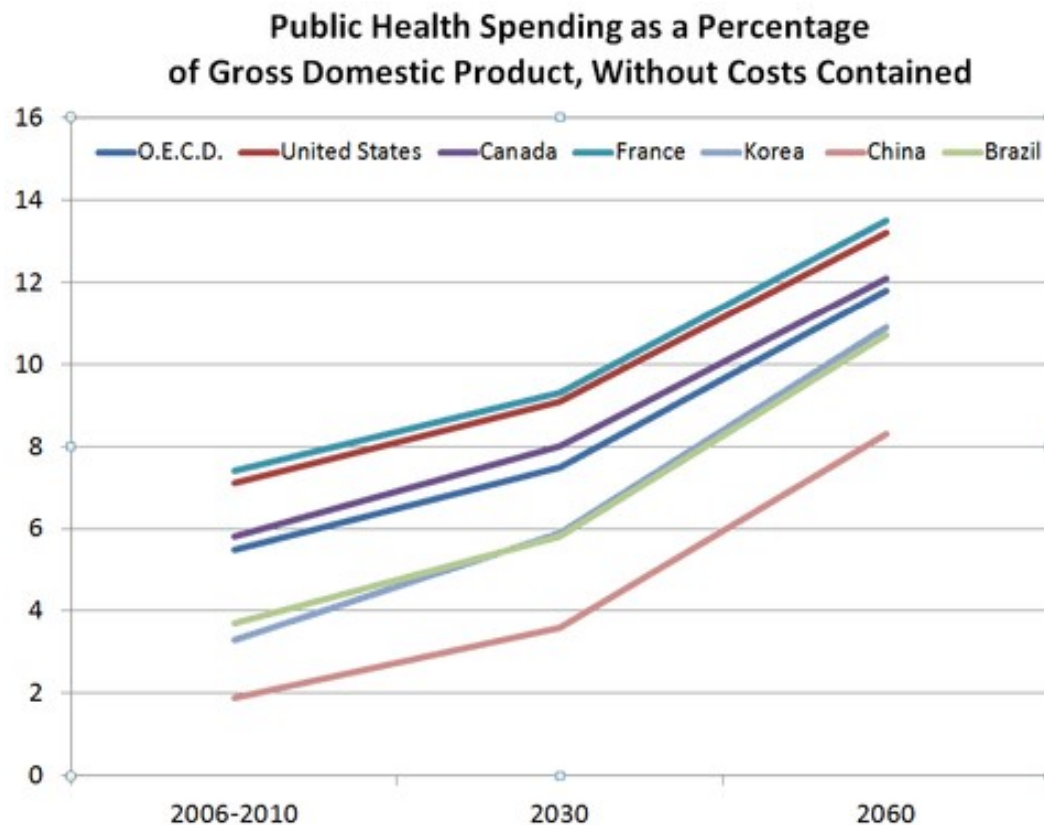
- WHO projects a global shortage of 18 million healthcare workers by 2030.
- India has ~73 health workers (~10 Docs/10 Nurs/8 Phs/~1 Midwifery) @ 10,000 population,
- Most of Developing countries like India is facing a critical requirement for millions of additional professionals to meet growing demands.



States that do not have a specialist in more than 65 per cent of the CHCs	A lot of States still do not have doctors in PHCs	In some States, most PHCs do not have a nursing midwife
Proportion of CHCs without a specialist doctor	Proportion of PHC without a doctor	Proportion of PHCs without an ANM
Sikkim 100.0	Chhattisgarh 43.0	Bihar 72.1
Madhya Pradesh 95.4	West Bengal 37.7	Himachal Pradesh 48.0
Bihar 87.3	Punjab 34.3	Punjab 44.4
Chhattisgarh 82.8	Bihar 32.8	Uttar Pradesh 33.8
West Bengal 79.6	Madhya Pradesh 30.7	Jharkhand 32.0

PHC: primary health centre CHC: community health centre Source: MoHFW, BL Analysis

The Healthcare Challenges: Escalating Healthcare Costs



Healthcare costs to rise at 13% in 2025, likely to beat global average

MANU KAUSHIK
New Delhi, April 6

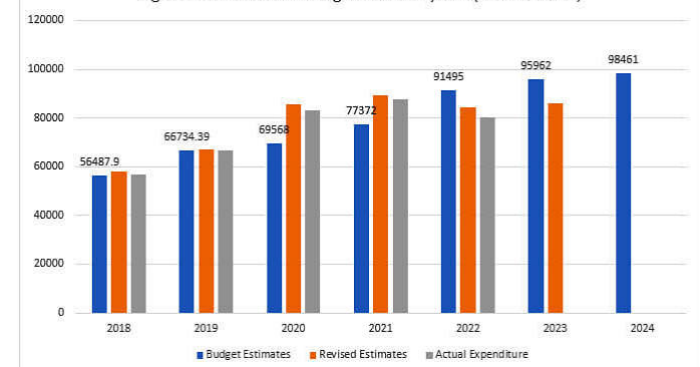
THE HEALTHCARE COSTS in India are projected to rise by 13% in 2025 — higher than both the global average of 10% and the 12% increase recorded in the previous year— according to Aon's Global Medical Trend Rates Report 2025.

The report attributes the rise in healthcare costs to increasing hospitalisation rates and the growing adoption of advanced medical treatments. "With healthcare inflation consistently outpacing general inflation, employers in India are under increasing pressure to design sustainable medical benefits for their workforce."

HEALTH INFLATION



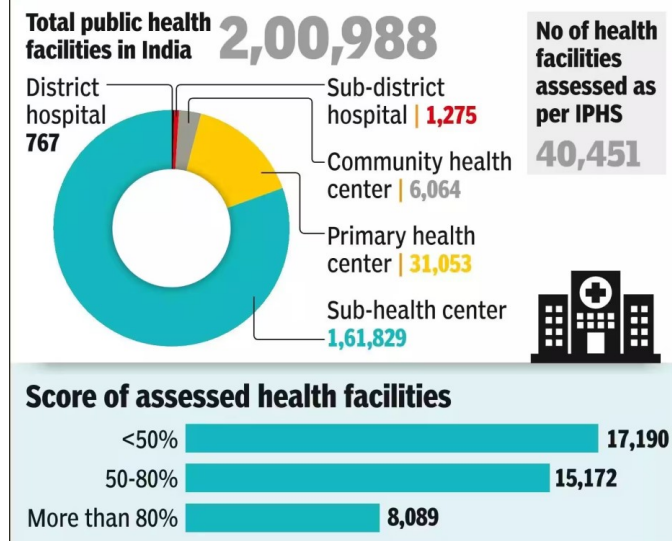
Figure 1: Total Health budget over the years (in nominal INR Cr.)



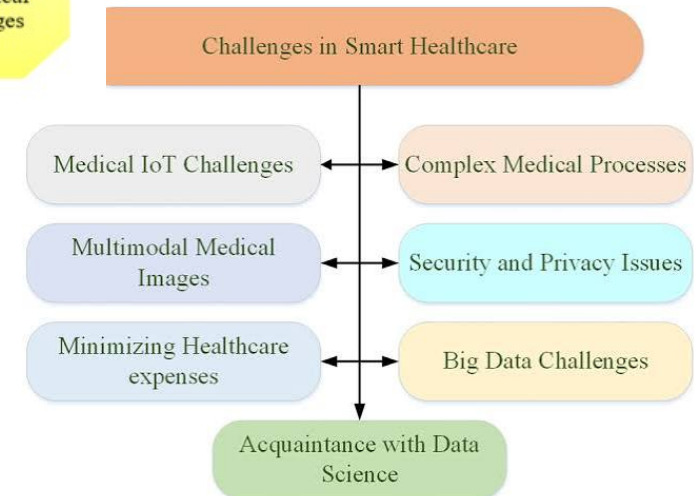
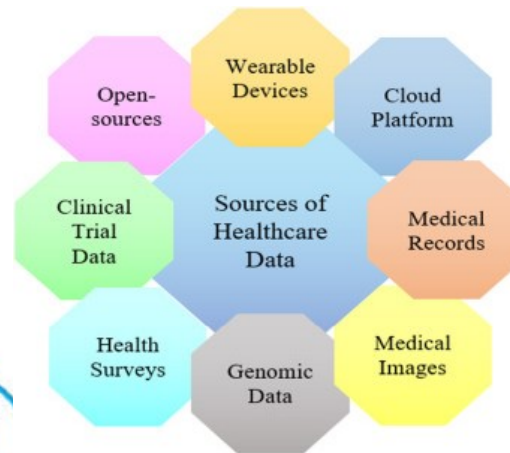
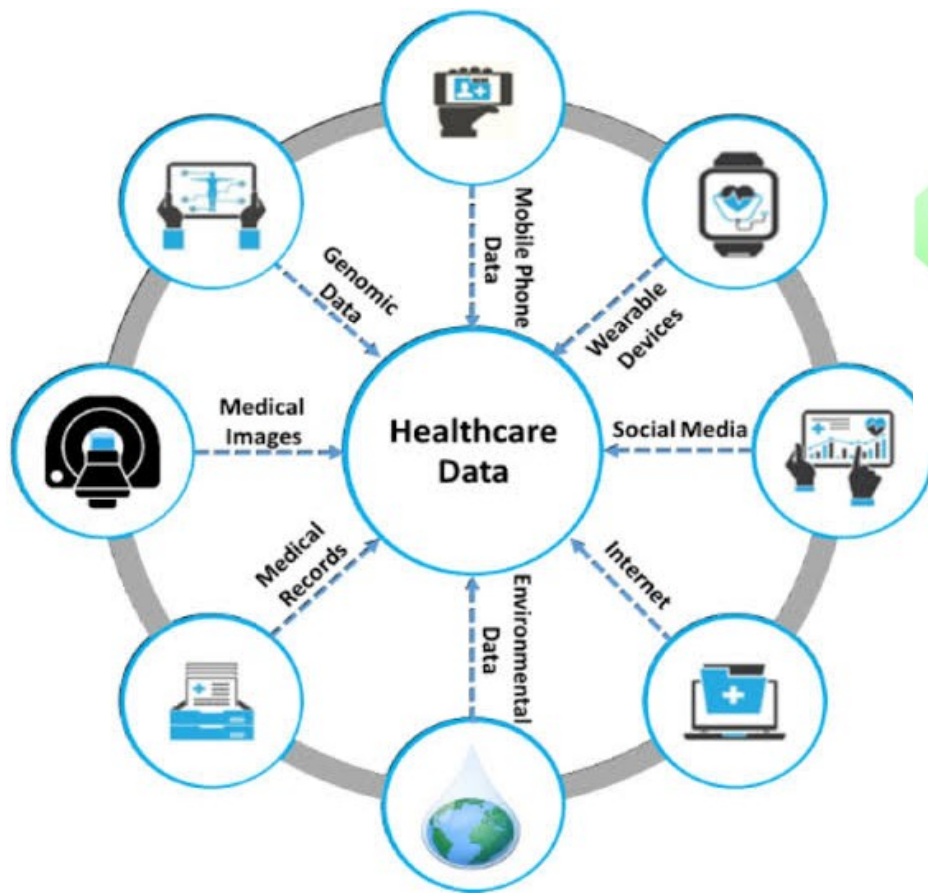
The Healthcare Challenges: Unequal Access to Quality Care



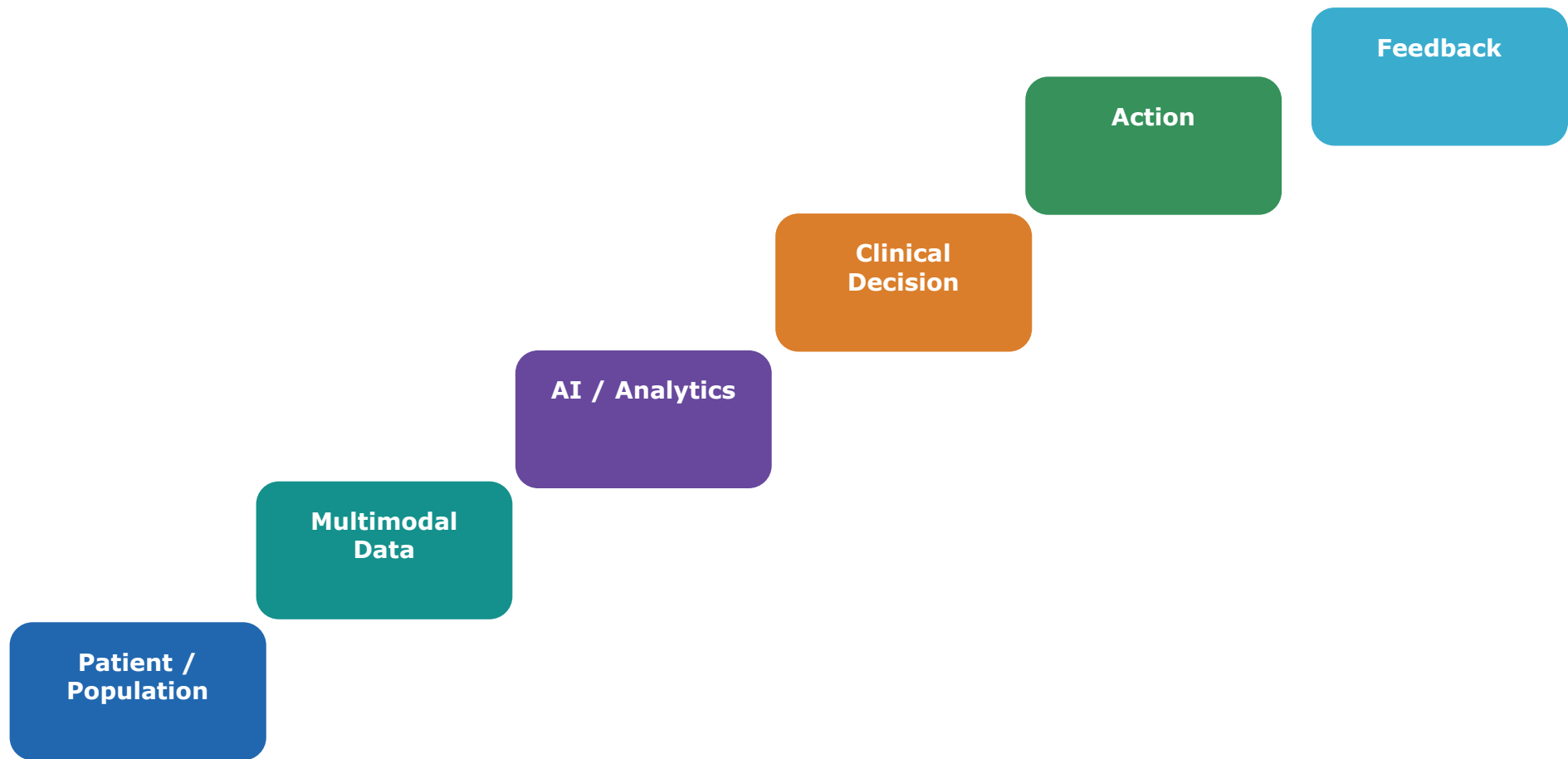
HEALTH REPORT CARD



The Healthcare Challenges: Increasing Complexity of Medical Data



Smart Computing Revolution in Healthcare



Artificial Intelligence Basics

HUMAN

RATIONAL

THOUGHT

Systems that think like humans...*Machine with minds* (Haugeland 1985)

Systems that think rationally.. Study of mental faculties using computational models. (Charniak et al. 1985)



Alan Turing 1930



John McCarthy 1956

BEHAVIOUR

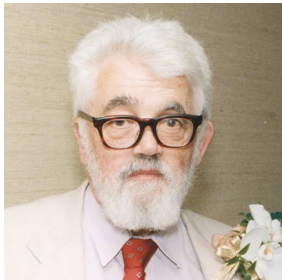
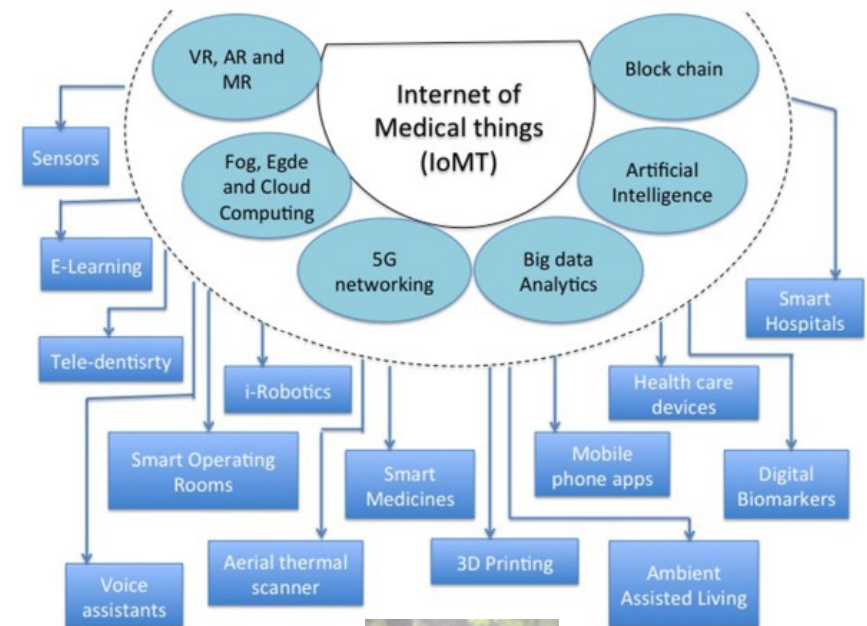
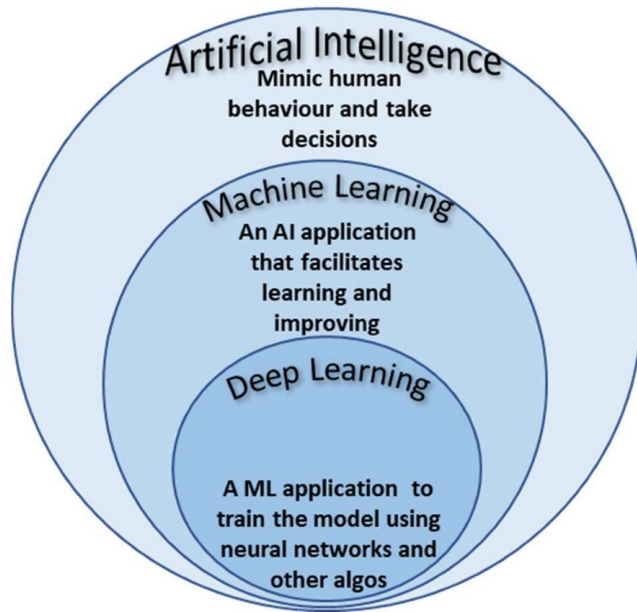
Systems that act like humans.. art of creating machines that perform functions that require intelligence when performed by people" (Kurzweil, 1990)

Systems that act rationally.. emulate intelligent behavior in terms of computational processes" (Schalkol, 1990)

AI is an art of creating the machines intelligent.

Smart Computing in Healthcare:

AI • ML • IoMT • Cloud • Big Data • Robotics



Arthur Samuel



Yoshua Bengio



Geoffrey Hinton



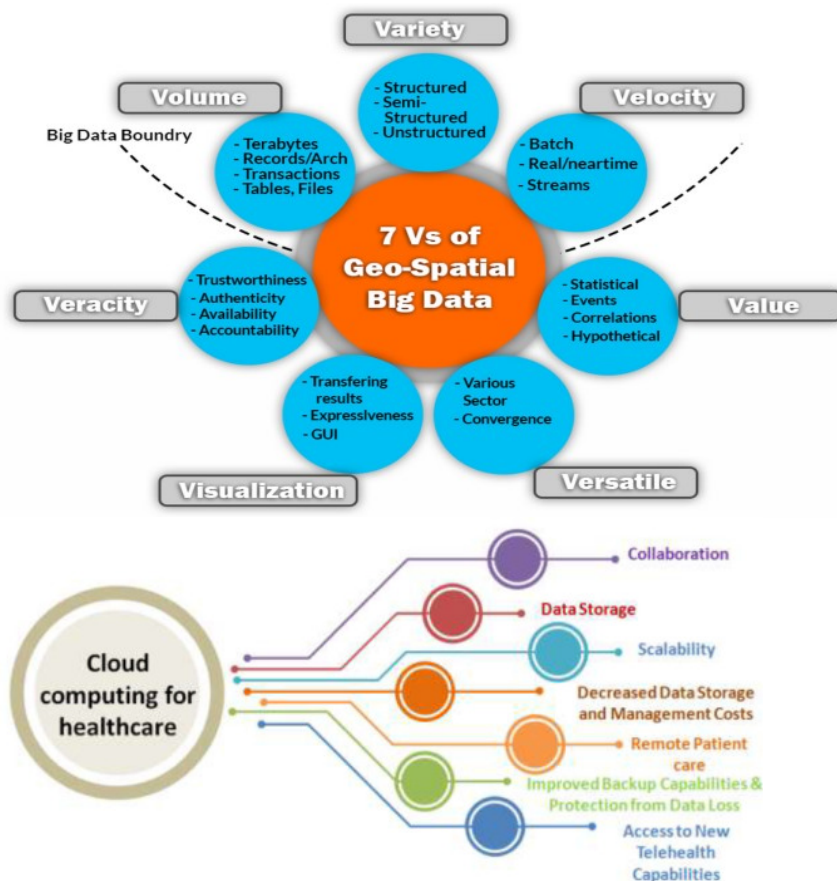
Yann LeCun



Kevin Ashton

Smart Computing in Healthcare:

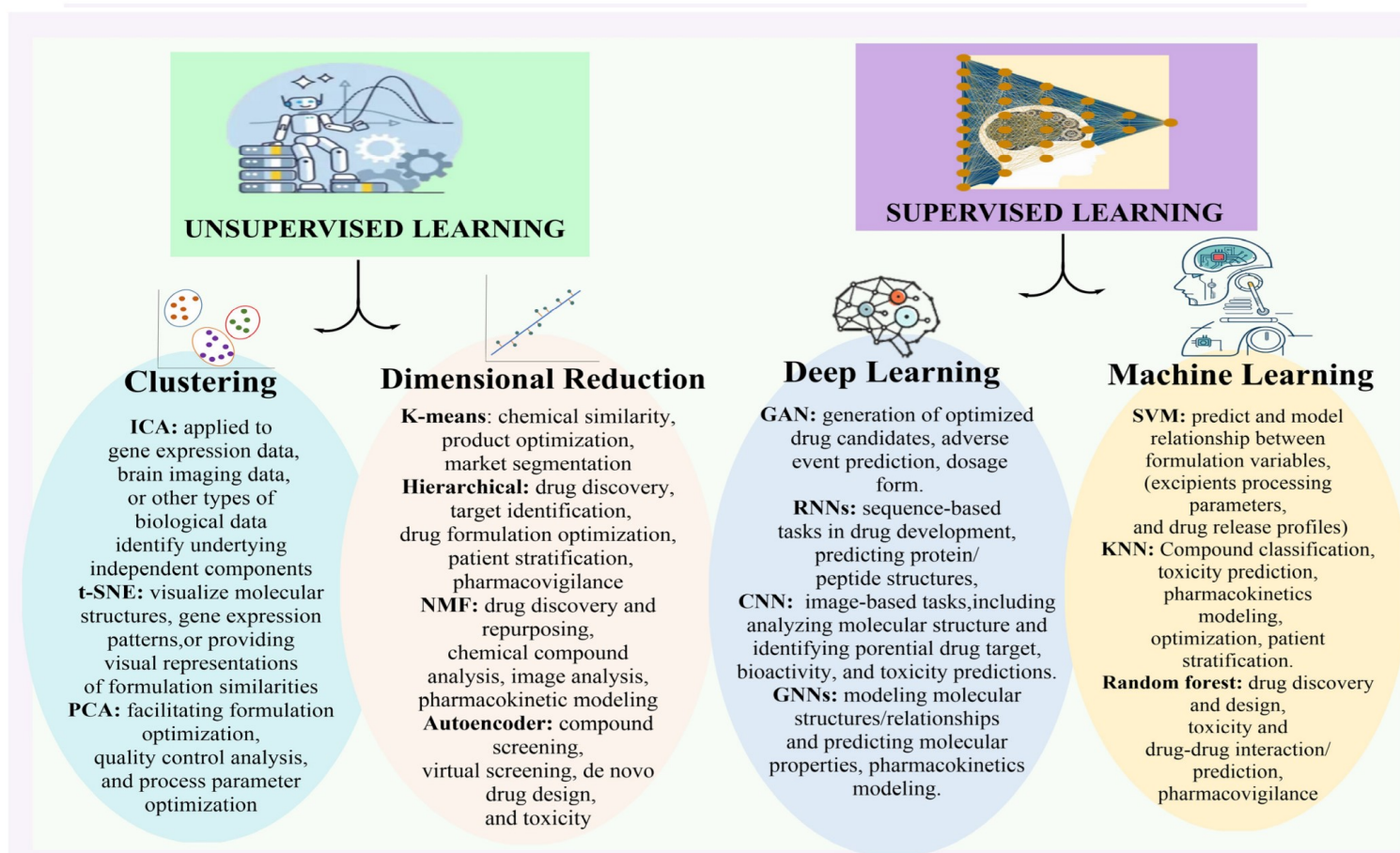
AI • ML • IoMT • Cloud • Big Data • Robotics



- **SaaS** – on-demand hosted services to healthcare businesses, allowing instant access to business applications and CRM
- **IaaS** – provide medical facilities with on-demand computing and massive storage
- **PaaS** - provide a secure environment for web-based services and cloud application deployment

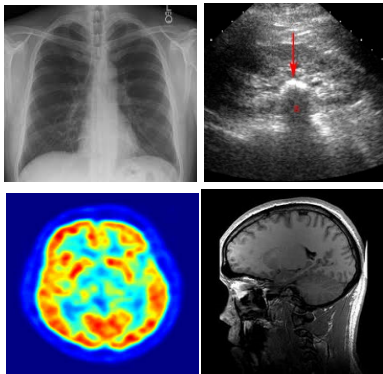
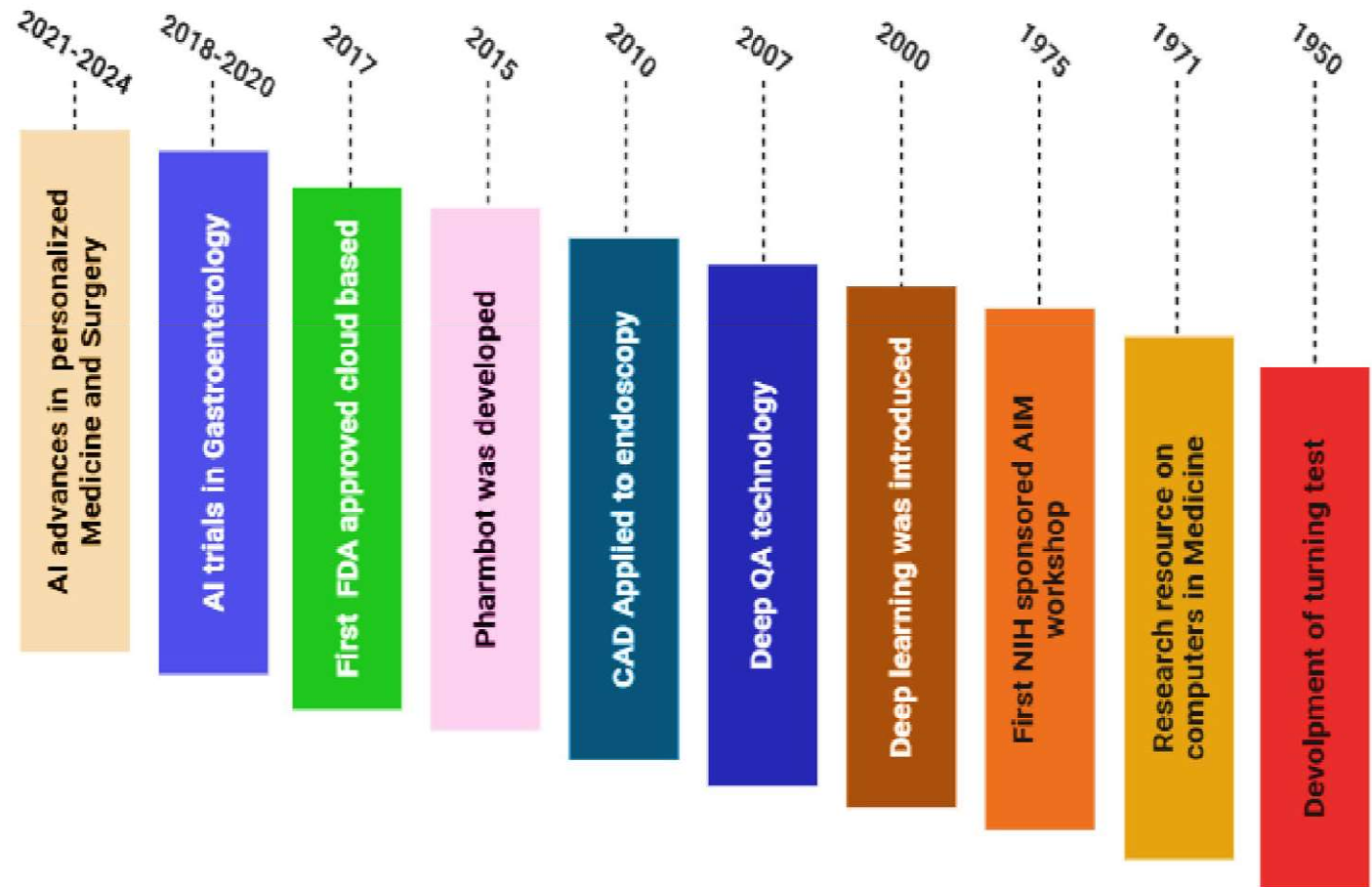
AI • ML • Deep Learning Techniques

Emphasis on Pharmaceuticals





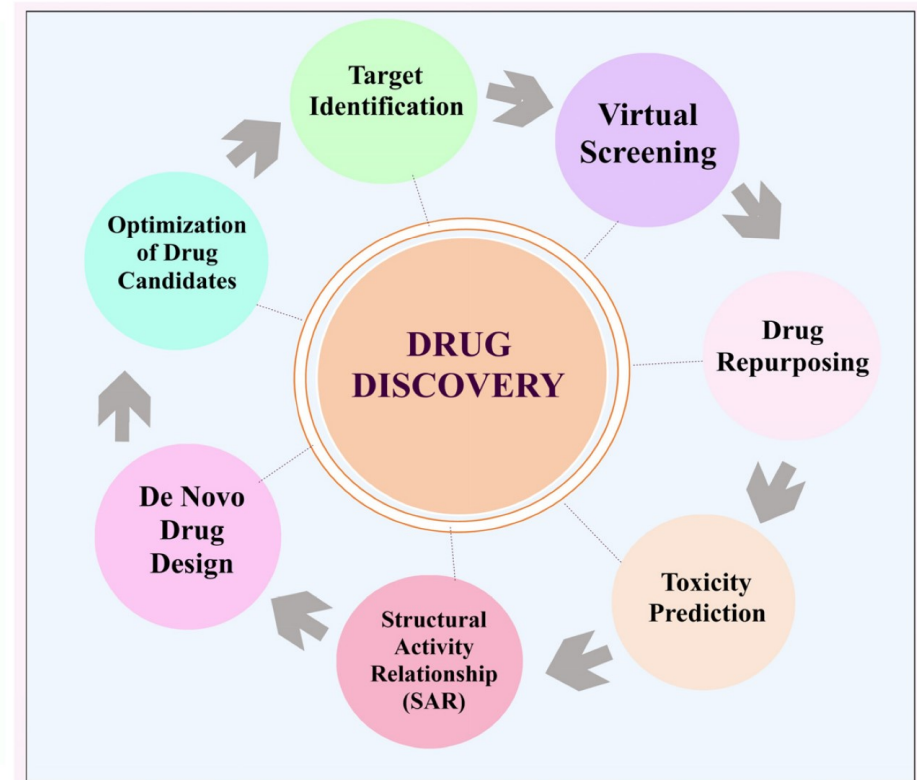
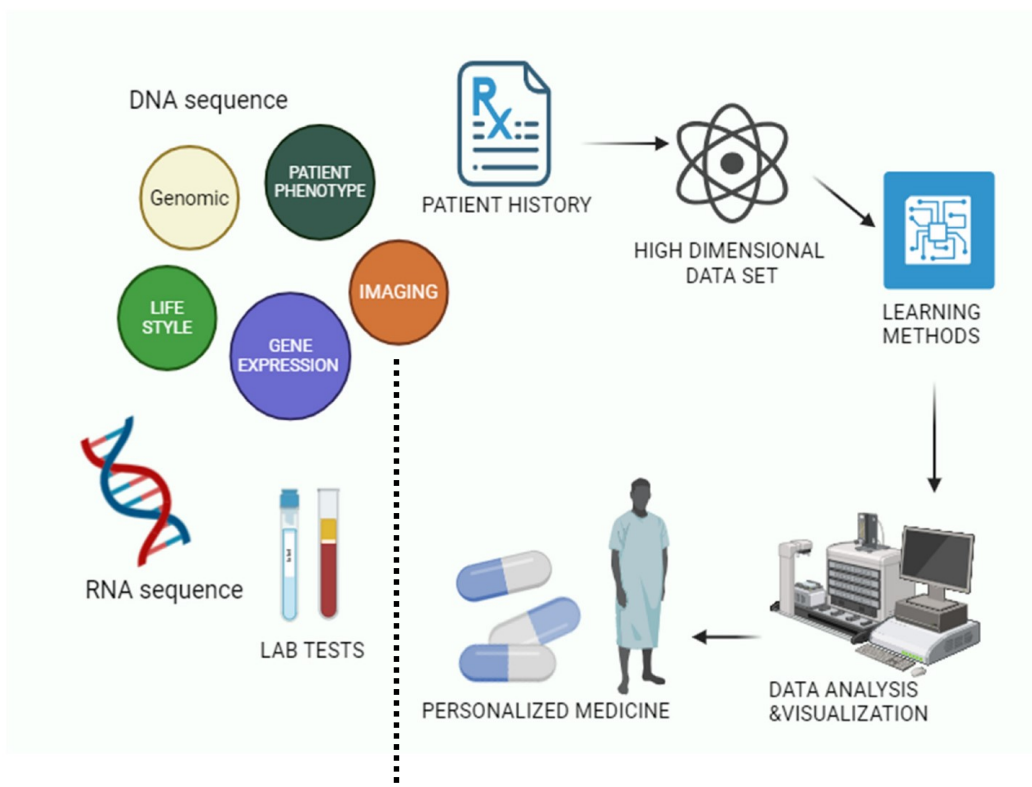
AI in Healthcare: Key Milestones



AI Patient Data Analysis

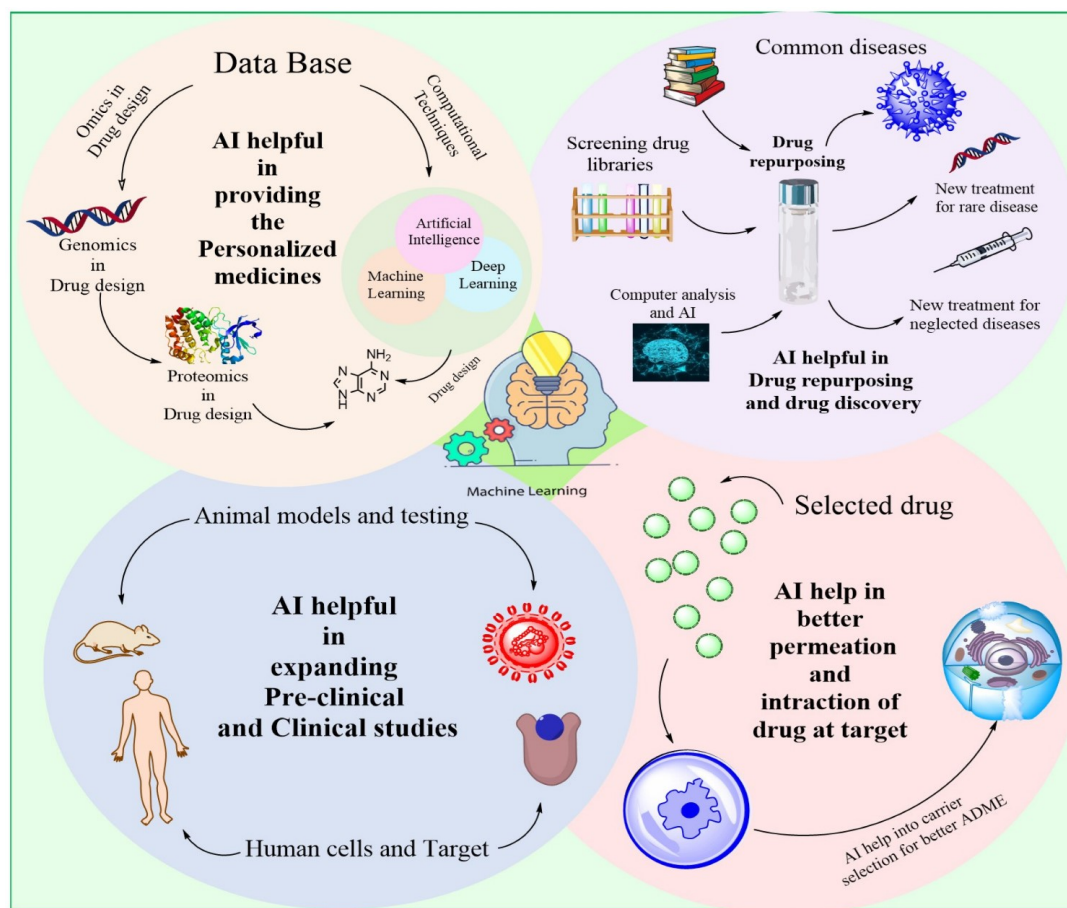
Drug Discovery

AI in acquiring and analyzing data of a patient in personalizing the treatment.



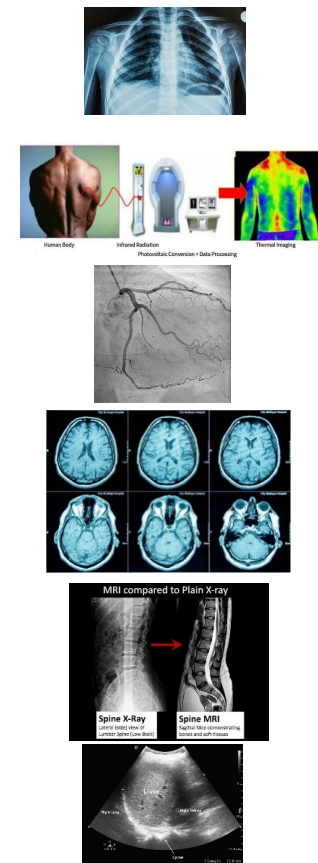
AI Patient Data Analysis

Drug Discovery...



Diagnostic Imaging in Medicine

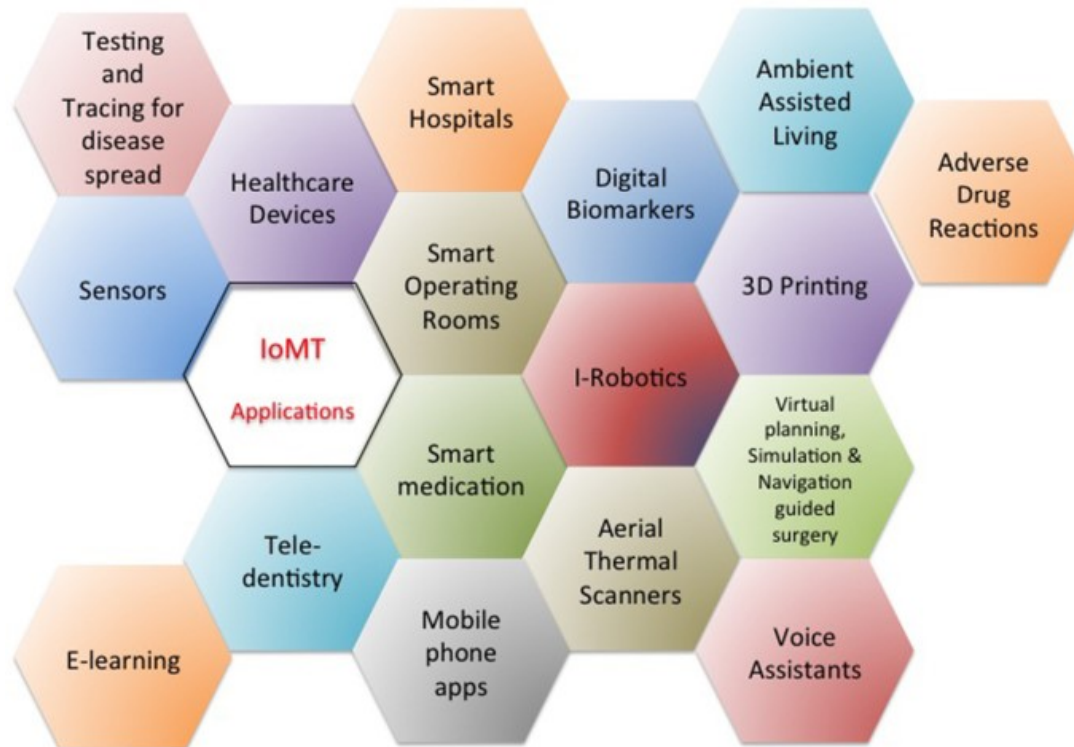
S.N	Imaging Type for Medical Purposes	Detailed Description
1.	X-rays (radiographic imaging)	Uses X-rays and other forms of ionising electromagnetic energy to produce images of things.
2.	Infrared imaging	Builds low-quality moving projection images of the physical internal structures in real time by repeatedly exposing them to X-rays at a reduced dose rate.
3.	Coronary angiography	Applied for the diagnosis of aortic aneurysms, stenosis, blockages, new vascular formation, and stent and catheter implantation.
4.	DEXA	The osteoporosis test uses Dual X-ray Absorptiometry, which is also called bone densitometry.
5.	CT Scan (Computed tomography)	Uses a computer and a lot of ionising radiation to create pictures of both solid and delicate tissues.
6.	MRI (Magnetic resonance imaging)	Imaging of the body made possible by a powerful magnet and radiofrequency waves; used in medical diagnostics.
7.	Ultrasound imaging	Makes use of broadband, sound waves with high frequencies reflected off of tissues to generate three-dimensional pictures.
8.	Bone scan	A method of monitoring bone repair that makes use of a radioactive substance.
11.	Magnetic resonance angiography scans	Draws blood vessel structures in the body with remarkable clarity.





Applications of IoMT in Healthcare

Internet of Medical Things (IoMT) is a connected network of medical devices, sensors, software applications, and health systems that collect, transmit, and analyze patient data in real time.



Applications of IoMT in Healthcare

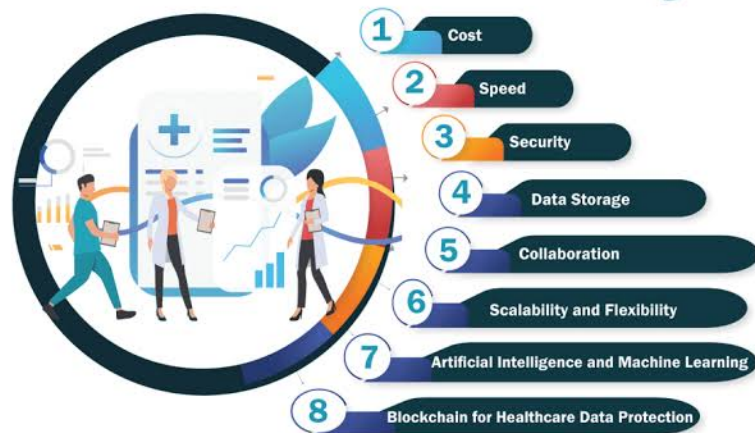
- **IoMT** – IoT for medical and health purposes, data collection and analysis for research, and monitoring.
- **IoMT - Smart Healthcare** - creating a digitized healthcare system, connecting available medical resources and healthcare services.
- IoT devices can be used to enable **remote health** monitoring and emergency notification systems.
- **IoMT in healthcare** plays a fundamental role in managing chronic diseases and in disease prevention and control.



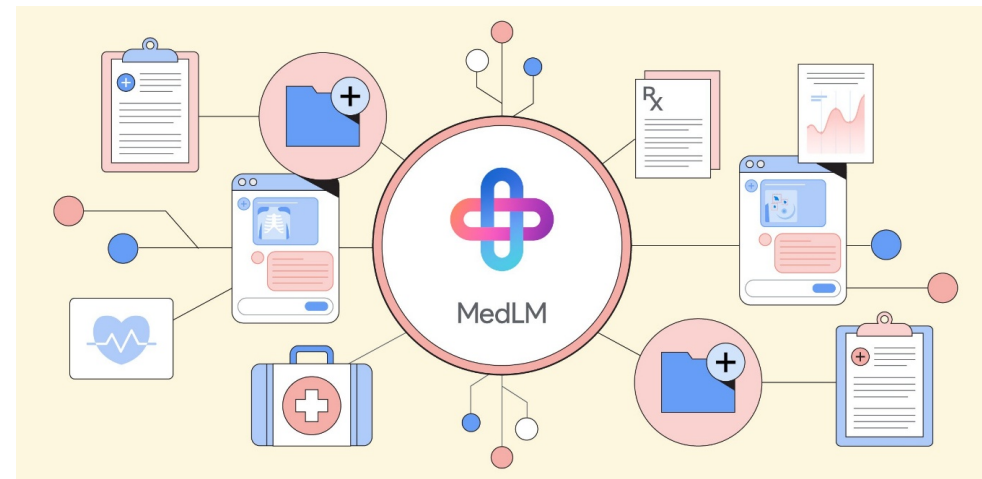
Cloud Computing in Healthcare

- Cloud computing refers to delivery of computing services over the internet, rather than through on-premises physical infrastructure.
- Cloud healthcare uses online computer networks to store, manage, and process medical data safely instead of using physical local servers.

Benefits of Cloud Computing in Healthcare Industry



Medical generative AI model - Google MedLM





Robotics in Healthcare

Robot - A programmable machine that automatically executes complex actions using a sense-compute-act feedback loop with sensors, a computer brain, and physical actuators

- Medical Robots
 - Surgical Robots • Rehabilitation Robots • Non-invasive Radiosurgery Robots..**
- Surgical Robots
 - Laparoscopy Surgical Robots • Orthopaedic Surgical Robots • Neurosurgical Robots..**
- Rehabilitation Robots
 - Therapeutic Robots • Assistive Robots • Prosthetics/Orthotics/Exoskeletons Robots....**
- Hospital and Pharmacy Robots:
 - Pharmacy Robots • Telemedicine Robots..**



Revolutionizing Healthcare: Impact of Robots



- Robots in Diagnostic
- Robotic Assisted Surgery (BrainLab/Stryker/CMR Surgical)
- Enhanced Rehabilitation (ReWalk Robotics/Cyberdyne)
- Robotics in Patient Care
- Pharmaceutical Advancements (NiCoLA-B)
- Logistic and Supply Chain Management





Our Research in Healthcare

- **ECG • Biometric • Cardiac Arrhythmia Classification**
- **AI in Ophthalmology • Glaucoma Screening**

Bioelectrical Signals: Electrocardiogram

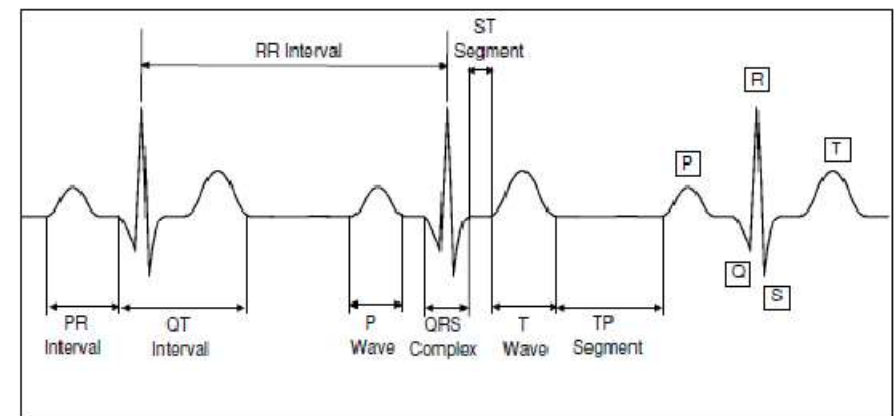
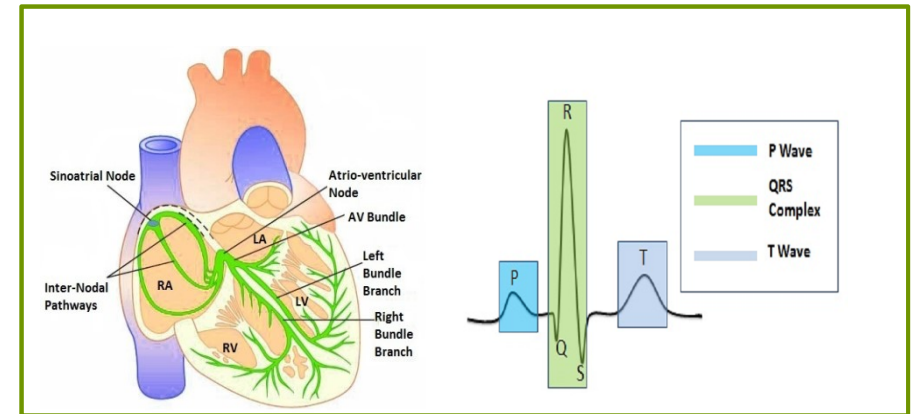


BIOELECTRICAL SIGNALS (ECG) AS BIOMETRICS

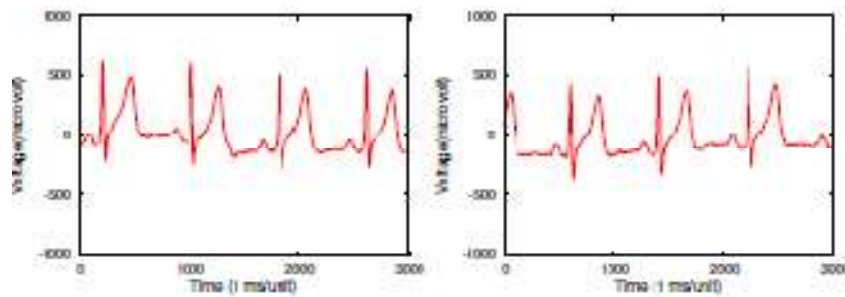
- Generated from complex self regulatory system.
- Unique to an individual
- Confidential and secret
- Difficult to mimic and hard to be copied
- Requires low computational effort

WHY ECG

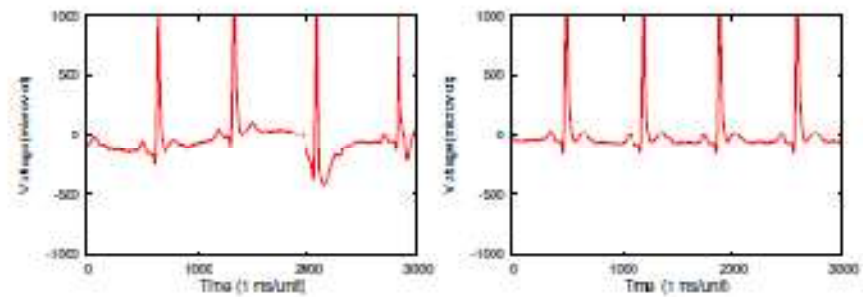
- Universality
- Secrecy - Highly confidential and secured
- Vitalityness - Robustness against falsification
- Uniqueness due to -
 - Chest geometry, position, size and physical condition
 - Geometry of myocardial cells, properties of cardiac tissues, hearts electrical rhythm.



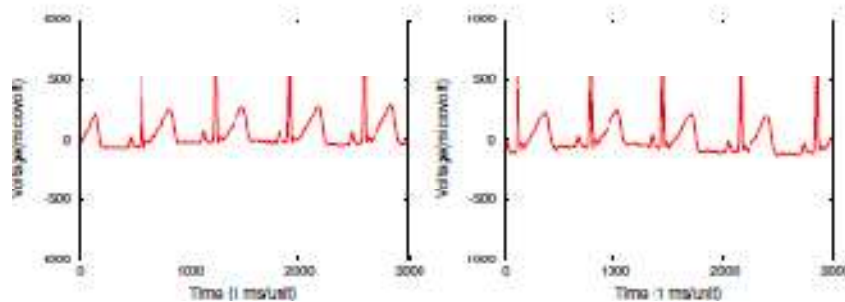
Heterogeneity of ECG



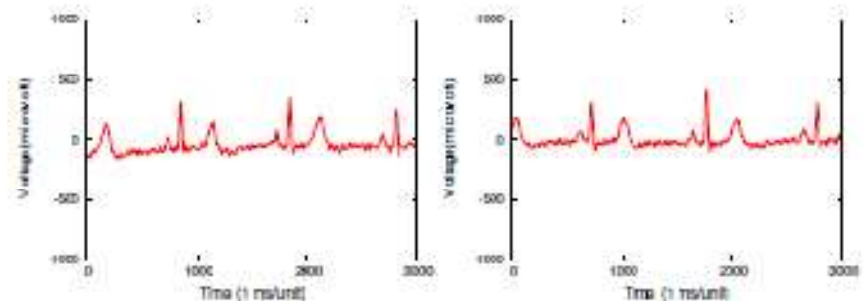
(a)



(c)



(b)



(d)

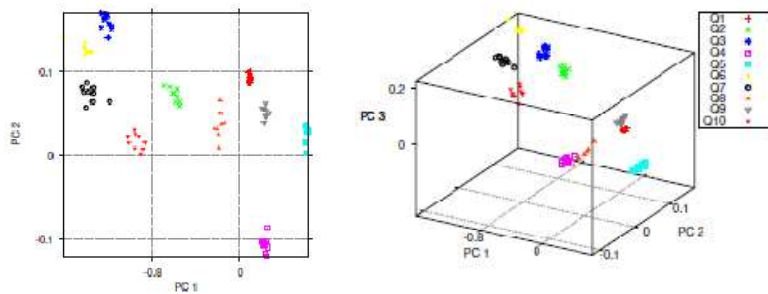
ECG as Biometrics

- ❑ **ECG as a Biometric Modality** – its' applications are,
- ❑ **Securing Medical Records**
- ❑ **Specialized Applications**
 - ❑ Road Safety management – By monitoring ill- health condition of drivers - stress level, fatigue, health stroke risk factor to avoid road accidents.
- ❑ **Boarder/Security/Military Applications**
 - ❑ Using wireless devices to acquire quality ECG signal may use to identify individual from a distance

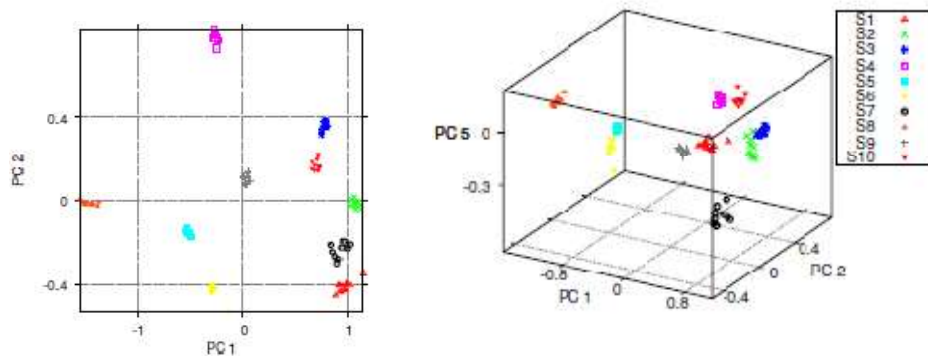


ECG Classification

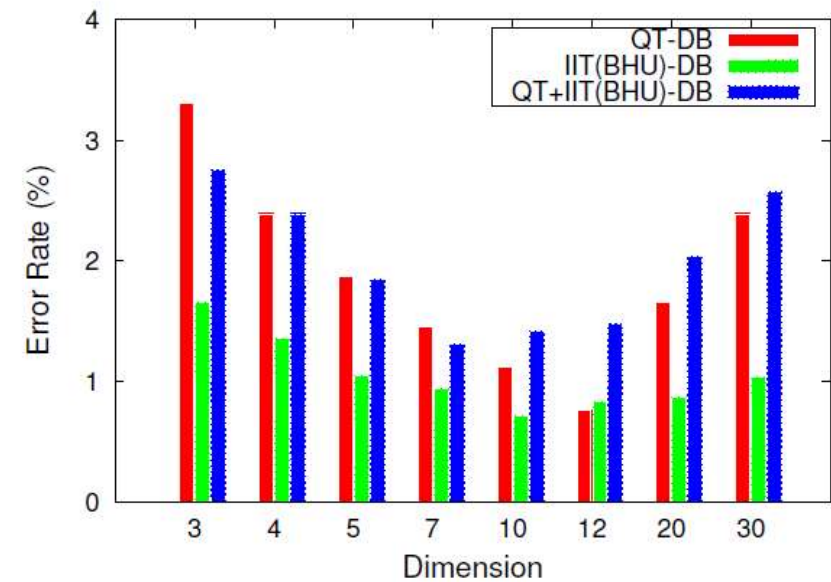
MIT-QT Database



BME-IIT(BHU) Database

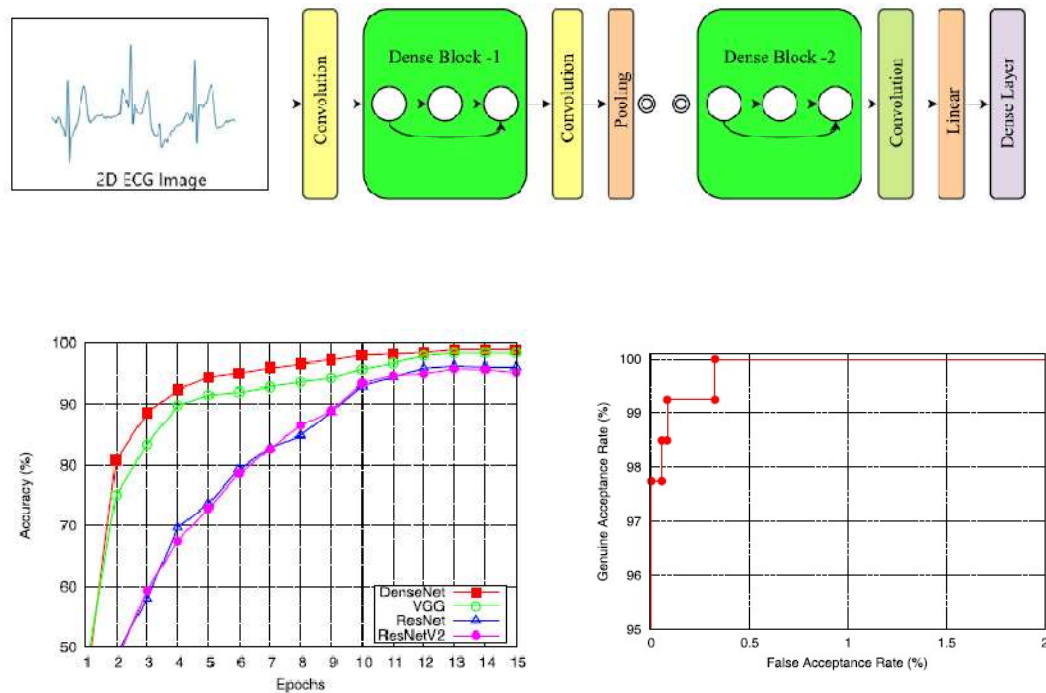


Performance Histogram

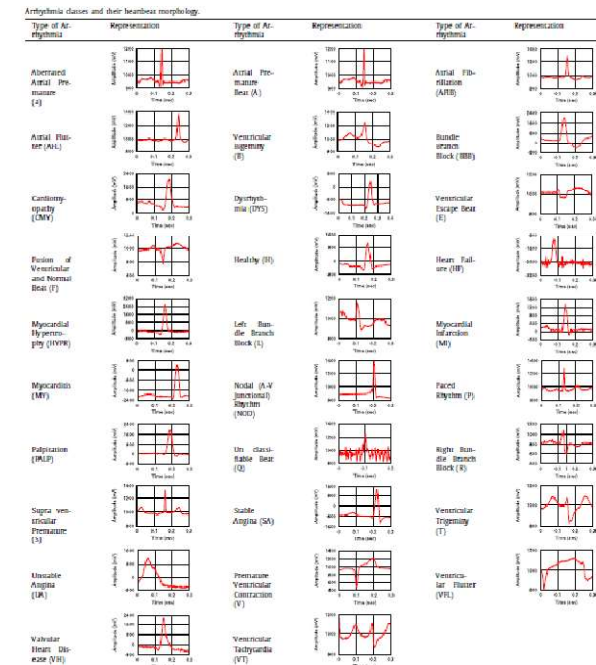
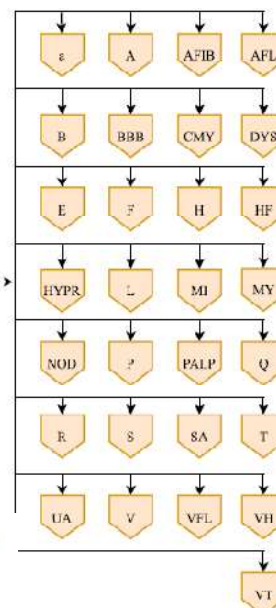


Cardiac Arrhythmias Classification

CardioNet: ECG Arrhythmia Classifier (2020)



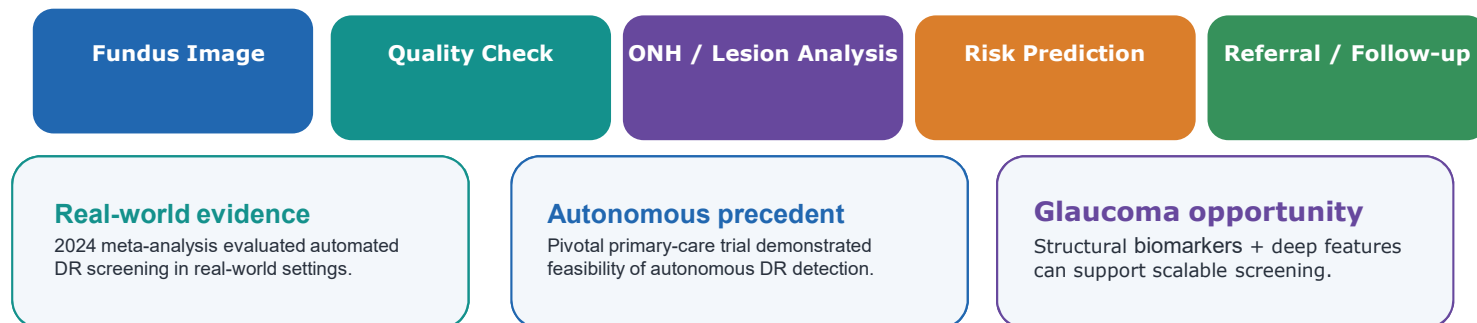
Heartbeat classes representing arrhythmia





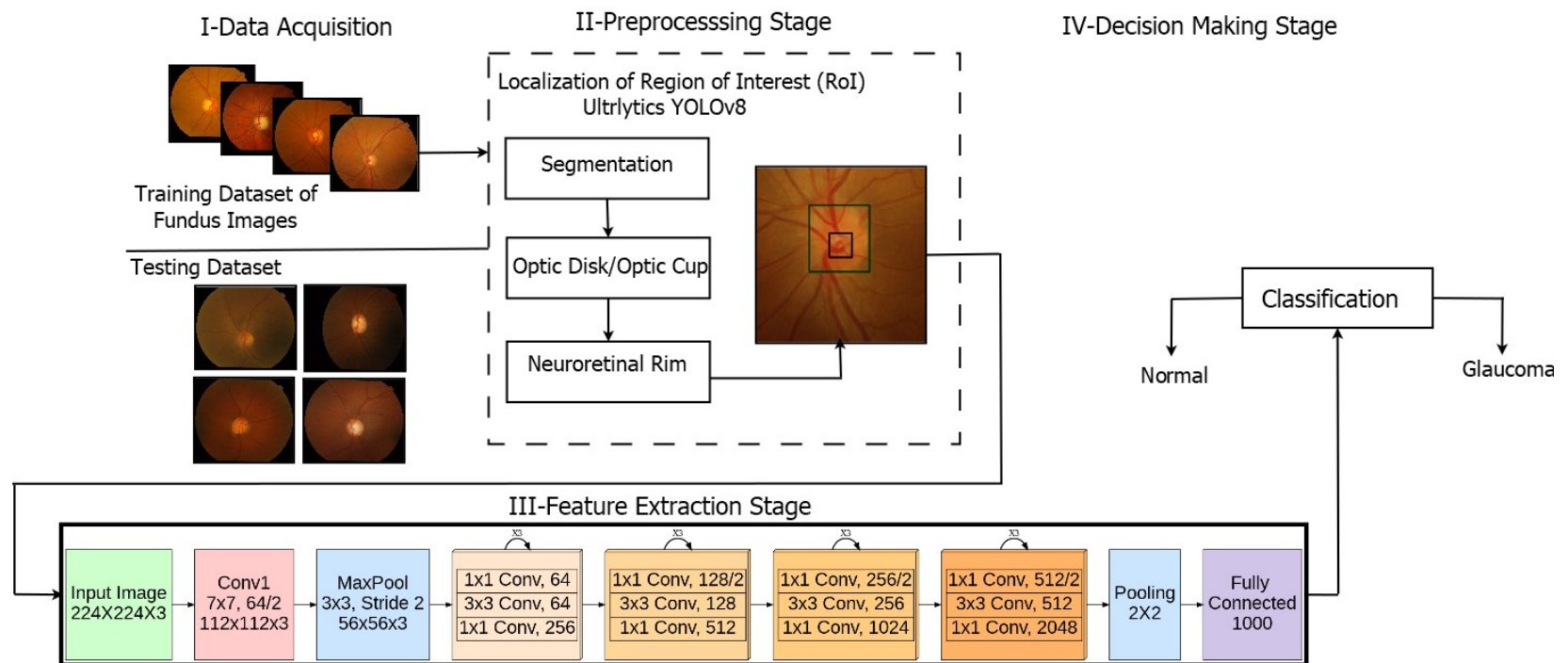
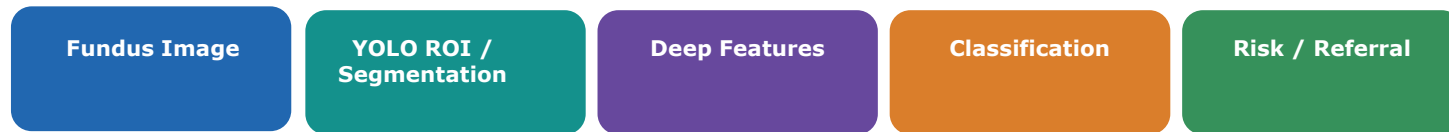
AI in Ophthalmology: Early Glaucoma Screening

- Glaucoma is a progressive optic neuropathy causes irreversible damage to optic nerve head (ONH).
- Early/precise diagnosis is important because vision loss caused by glaucoma is irreversible.
- Conventional assessment relies on retinal structures such as the optic disc (OD), optic cup (OC), neuroretinal rim and cup-to-disc ratio (CDR).
- Manual assessment can be affected by image quality, inter-subject variability and subjective grading.
- AI supported automated pipeline that localizes relevant retinal regions and classifies eyes as glaucomatous or normal.



AI in Ophthalmology

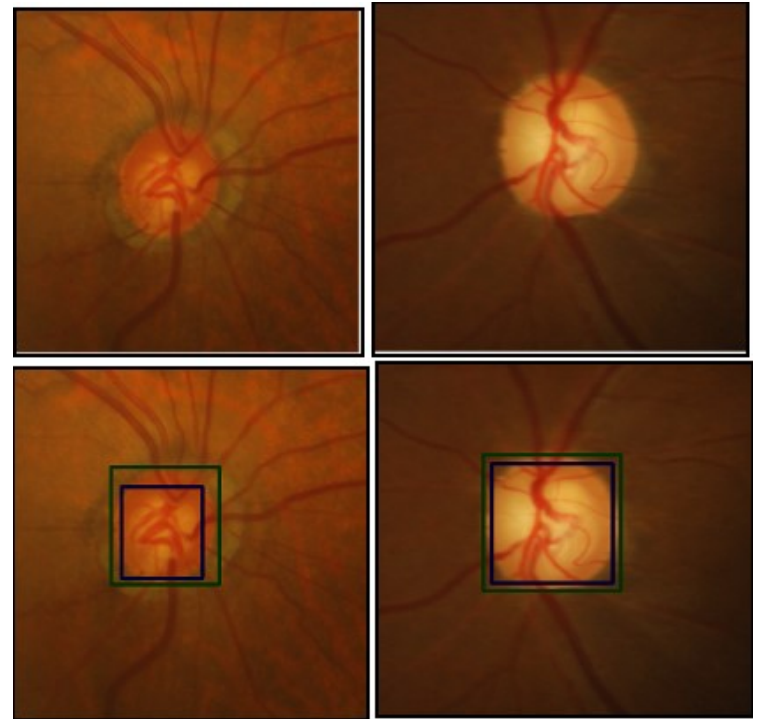
Early Glaucoma Screening



AI in Ophthalmology:

ROI Localization & Segmentation using YOLOv8

- YOLOv8 is used to localize the optic disc (OD) and optic cup (OC) as regions of interest.
- Each detected region is represented by a bounding box with position, size, class label and confidence score.
- Segmentation is then applied inside the detected regions to obtain precise OD and OC pixel regions.
- The segmented regions also allow calculation of the clinically relevant cup-to-disc ratio (CDR).



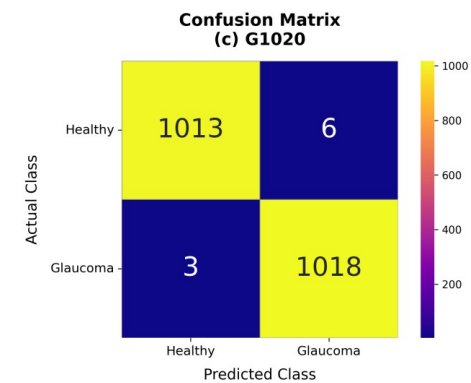
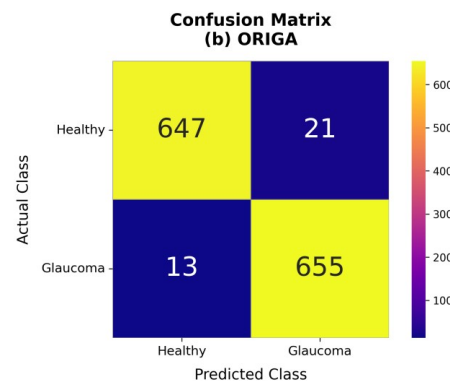
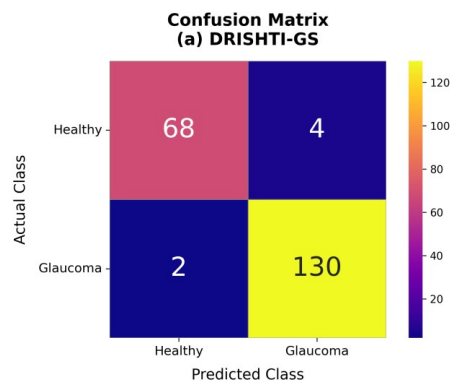


AI in Ophthalmology:

ROI Localization & Segmentation using YOLOv8

Dataset	Images	Glaucoma / Normal	Purpose
DRISHTI-GS	101	31 / 70	OD/OC segmentation and glaucoma evaluation
ORIGA	650	168 / 482	Fundus-based glaucoma analysis
G1020	1020	278 / 742	Benchmark large dataset

Dataset	Accuracy	Sensitivity	Specificity	F1-score
DRISHTI-GS	97.06%	97.14%	97.01%	95.77%
ORIGA	97.46%	98.03%	96.89%	97.44%
G1020	99.56%	99.70%	99.41%	99.56%



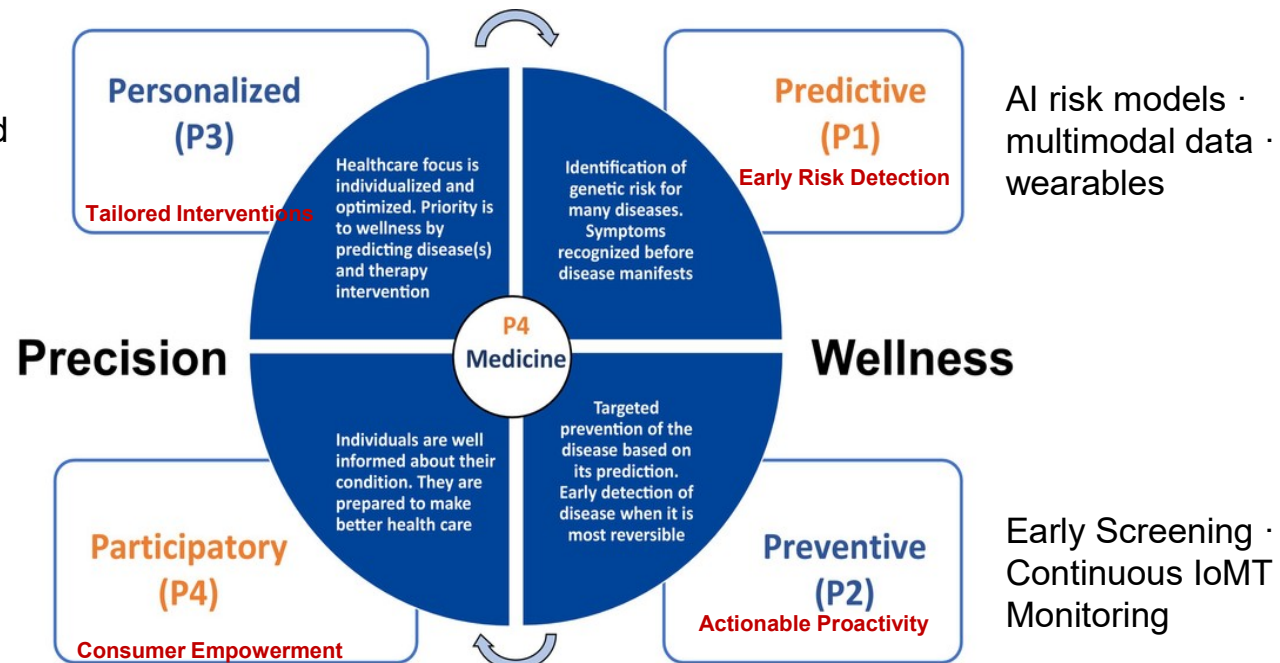
Future of Healthcare – 4P Model

Evolution of the concept:

- 18th Century – Clinical Medicine describing symptoms and syndromes..
- 20th Century - Molecular biology - Curative Medicine with Curative Treatments (antibiotics, and chemotherapy)/ Preventive Treatments – Vaccines..
- 21th Century – Targeted Therapy..4P in Medicine and beyond..

Patient data analysis · Targeted therapies · Drug discoveries

Mobile Apps · Telemedicine · Shared Decisions





Responsible AI in Healthcare

T-E

Transparency and Explainability

AI models should not act as black boxes rather to know How/Why?

S-A

Safety and Accuracy

Uncertainty awareness and Accuracy alone is not enough for clinical use.

F-E

Fairness and Equity

Training datasets must represent diverse demographics; avoid demographic shortcuts.

P-D

Privacy and Data Protection

Patient medical data must be shielded from unauthorized breaches.

H-A

Human Accountability

AI tools are designed to augment clinical judgment, keeping doctors legally and ethically responsible.

G

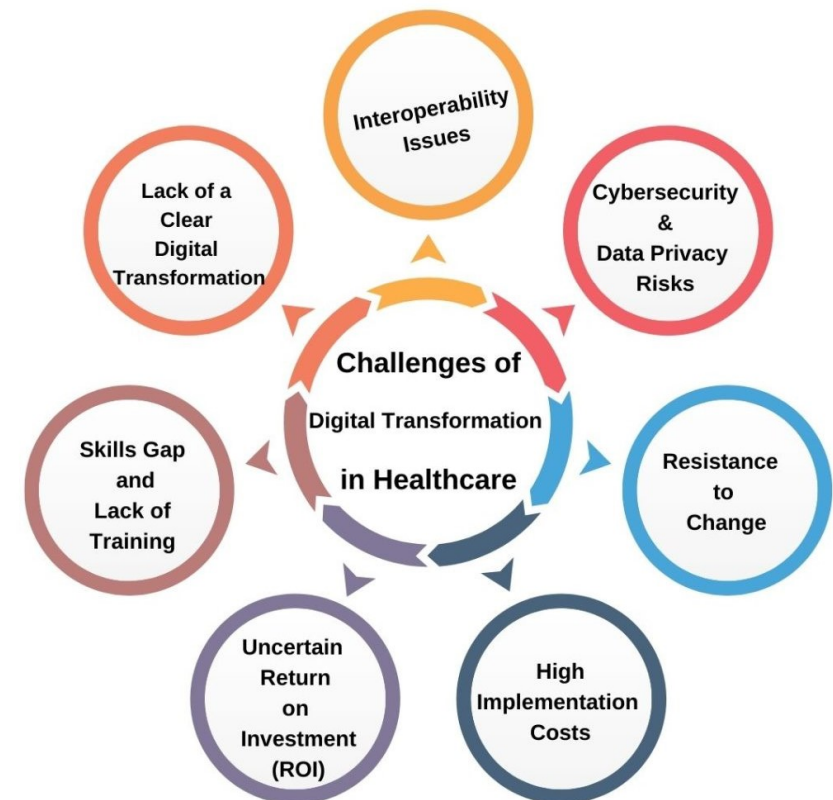
Generalization

Validate across settings, sites and populations.

Fairness must be treated as a deployment property — not merely a training-time metric.

Practical Challenges: Vision for Future Healthcare

Healthcare Quality Control and Improvement	Current Quality Control Measures	Challenges in Quality Control	Technological Advancements and AI Integration	Case Studies and Future trends
Importance of quality and patient-centered care	Assessments for treatment, patient outcomes and experiences	Variability in clinical practices	AI and machine learning for diagnostics	Case studies depicting successful quality improvements
Complexity of healthcare systems	Framework to reduce risks	Resource and workforce limitations		
Prevention of medical errors and risks	Infection control measures	Patient engagement issues	Big data and electronic health records for predictive analysis	Future trends: focusing on smart healthcare systems, AI, patient-centered approaches and remote monitoring
	Financial reimbursement linked to quality	Information-sharing challenges		
	Efforts to reduce repeated hospital admissions	Technological barriers		





Conclusion

Data to Decisions



AI, ML, IoMT, cloud, big data and robotics turn medical data into timely clinical decisions.

Responsible by design



Fairness, explainability, local validation and human oversight must accompany accuracy.

Real Goal: 4P care



Predictive, preventive, personalized and participatory healthcare for everyone.

A high-impact testbed



India's scale and diversity make it ideal for validated, equitable smart healthcare.



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Thank you for Attending!



Dr Y N Singh @ Google Sites

Thanks to Institution of Engineers, UP State Centre Lucknow