MACHINE LEARNING AND AI FOR HEALTHCARE

By Arjun Panesar

WHAT IS THIS BOOK ABOUT?

#1

can AI and machine learning be applied in an everyday healthcare setting?

This book is intended for those who seek to understand what AI and machine learning are and how intelligent systems can be

- *developed,*
- *evaluated, and*
- *Deployed*

within their health ecosystem

By the end of the book…

- Explaining key aspects of AI and machine learning to stakeholders.
- Describe …
  - *the machine learning approach and limitations,*
  - *fundamental algorithms,*
  - *the usefulness and requirements of data,*
  - *the ethics and governance of learning, and*
  - *how to evaluate the success of such systems.*

WHAT IS ARTIFICIAL INTELLIGENCE?

#2

“Knowledge on its own is nothing, but the application of useful knowledge? That's powerful.” -- Osho

Approach of the book

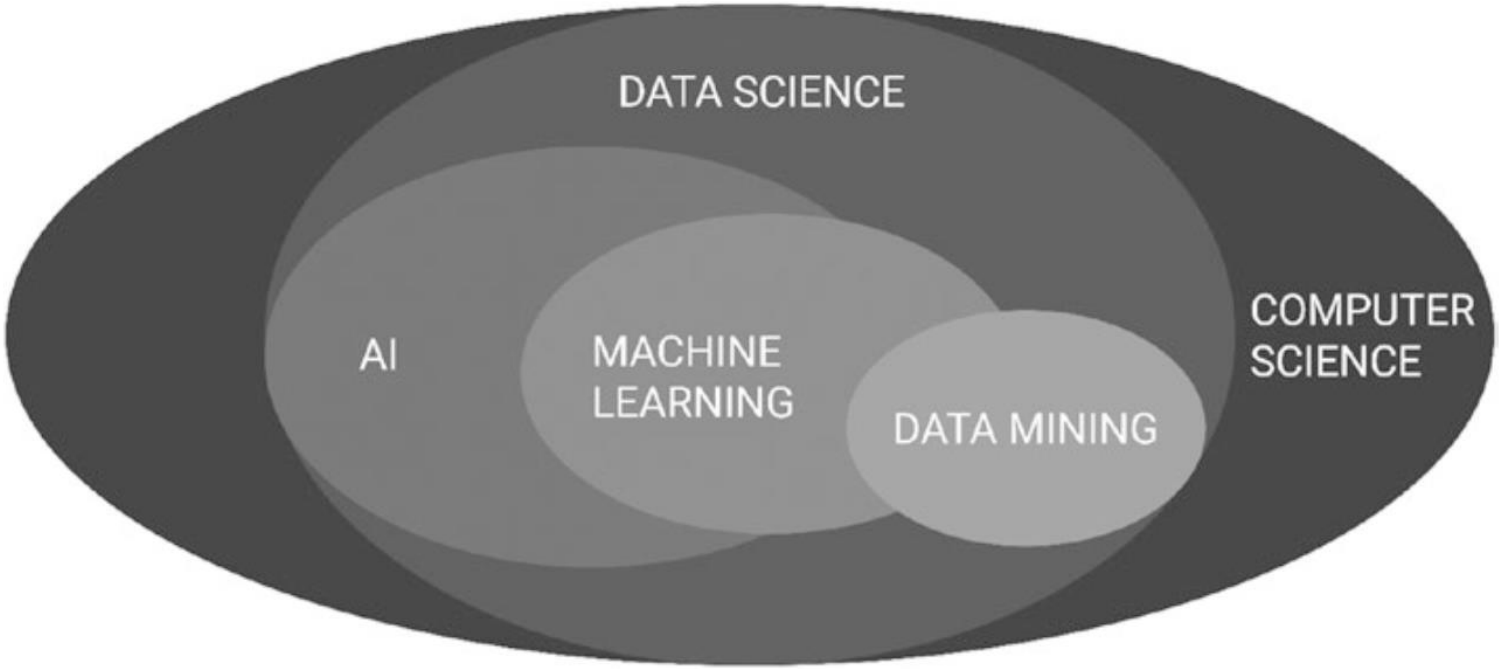
- Rather than focus on overwhelming statistics and algebra, theory
- practical applications of AI and machine learning in healthcare are explored
- —with methods and tips on how to evaluate the efficacy, suitability, and success of AI and machine learning applications.

AI is nothing new

- Virtual assistants can determine our music tastes with remarkable accuracy,
- cars are now able to drive themselves, and
- mobile apps can reverse diseases once considered to be chronic and progressive.

AI technologies have existed for decades. It is, in fact, going through a resurgence—and it is being driven by availability of data and cheaper computing.

AI is a subset of computer science



A bit of history

- Start of AI research -> 1930s
- 1950 -> Alan Turing published Computing Machinery and Intelligence
  - *can machines think?*
  - *The Turing Test proposed a test of a machine's ability to demonstrate "artificial" intelligence, evaluating whether the behavior of a machine is indistinguishable from that of a human.*
- "AI" was first coined in 1956 by Dartmouth College Professor John McCarthy.
  - *"every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it"*

The truth of AI

- The truth is that AI, at its core, is merely programming

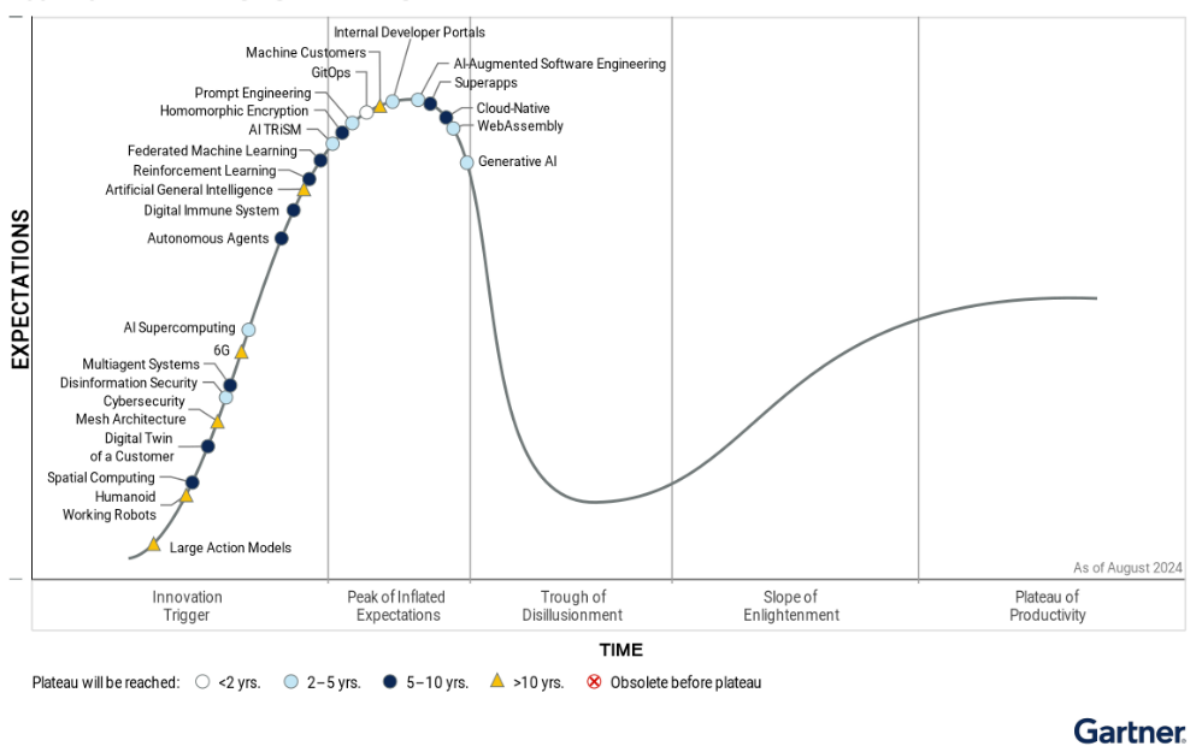
Why has AI become more popular and practical now?

- Explosion of data
  - *It was estimated by IBM in 2011 that 90% of global data had been created in the preceding 2 years.*
  - *It is estimated that there will be 150 billion networked measuring sensors in the next decade—which is 20 times the global population. (IOT)*
- Cheaper/more powerful computers

With data comes a plethora of learning opportunities

- the focus has now shifted to learning from available data and the development of intelligent systems.
- The more data a system is given, the more it is capable of learning, which allows it to become more accurate.

The Gartner “Hype Cycle for Emerging Technologies”



ML in health is fresh, exciting, and innovative

- The Gartner “Hype Cycle for Emerging Technologies” in 2017 placed machine learning in the peak of inflated expectations, with 5 to 10 years before plateau.
- As a result, the applications of machine learning within the healthcare setting are fresh, exciting, and innovative.

Again, Data opportunity

- With more mobile devices than people today, the future of health is wrought with data from the patient, environment, and physician.

Pros of AI in healthcare

- All about the money !
  - *healthcare costs are increasing globally, and governmental and private bill payers are placing increasing pressures on services to become more cost-effective.*
  - *Costs must typically be managed without negatively impacting patient access, patient care, and health outcomes.*

EXAMINING ARTIFICIAL INTELLIGENCE

#3

Definition

- AI can be defined as the simulation of intelligent behavior in agents (computers) in a manner that we, as humans, would consider to be smart or human-like.
- The core concepts of AI include agents developing traits including
  - *knowledge,*
  - *reasoning, problem-solving,*
  - *perception,*
  - *learning,*
  - *planning, and*
  - *the ability to manipulate and move.*

Is this AI?

- 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).

Is this AI?

- 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.

Limitations of the past

- limited datasets,
- inability to store and subsequently index data
- Inability to analyze considerable volumes of data.
- Today,
  - *data comes in real time, from variety of sources*
  - *fuelled by exponential growth in mobile phone usage, digital devices, increasingly digitized systems, wearables, and the Internet of Things (IoT).*

CATEGORIES OF AI

#4

There are four distinctive categories of AI

- Reactive Machines
- Limited Memory
- Theory of Mind
- Self-Aware AI

1) Reactive Machines

- **Most basic AI**
- Reactive systems respond in a current scenario,
  - *relying on taught or recalled data to make decisions in their current state.*
- Reactive machines perform the tasks they are designed for well, but they can do nothing else.
- T hese systems are not able to use past experiences to affect future decisions.
- Example: Deep Blue, beat Garry Kasparov in 1996. (Kasparov won three of the remaining five games and defeated Deep Blue by four games to two.)

2) Limited Memory

- Systems That Think and Act Rationally
- This AI uses both pre- programmed knowledge and subsequent observations carried out over time.
- 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

3) Theory of Mind

- Systems That Think Like Humans
- AI systems that interpret their worlds and the actors, or people, in them.
- 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.
- Theory of mind AI can attempt to understand people’s intentions and predict how they may behave

4) Self-Aware AI

- Systems That Are Humans
- machines that have consciousness and recognize the world beyond humans.
- This AI does not exist yet
- In 2015, researchers at the Rensselaer Polytechnic Institute gave an updated version of the wise men puzzle, an induction self-awareness test, to three robots—and one passed. The test requires AI to listen and understand unstructured text as well as being able to recognize its own voice and its distinction from other robots.

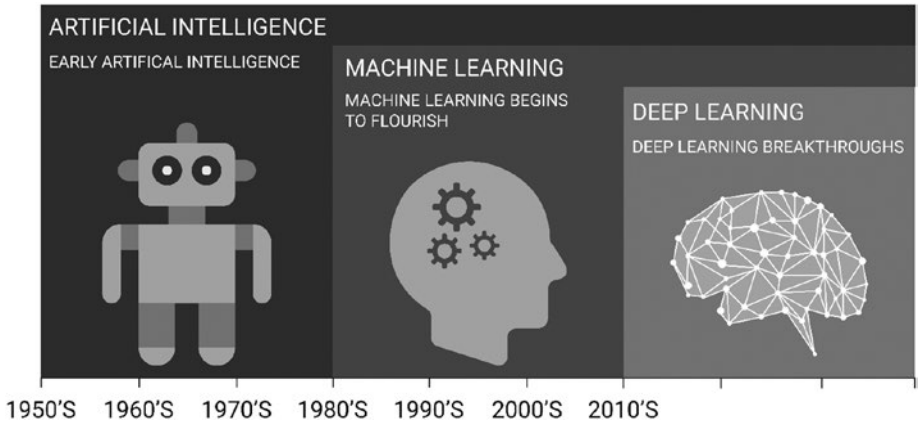
AI is only as good as the data

- Technology is now agile enough to access huge datasets in real time, and learn on the go.
- Ultimately, AI is only as good as the data that's used to create it—and with robust, high-volume data, we can be more confident about our decisions.

MACHINE LEARNING

#5

What Is Machine Learning?



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.**

Machine learning

- 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.*

Knowledge in systems

- Hardcoded: system will typically experience difficulties in new environments.
- Acquired: difficulties can be overcome by a system that can acquire its own knowledge. This capability is known as machine learning.
- This requires
  - *knowledge acquisition,*
  - *inference,*
  - *updating and refining the knowledge base,*
  - *acquisition of heuristics,*
  - *and so forth.*

Machine learning is covered in greater depth in Chapter 3.

WHAT IS DATA SCIENCE?

What Is Data Science?

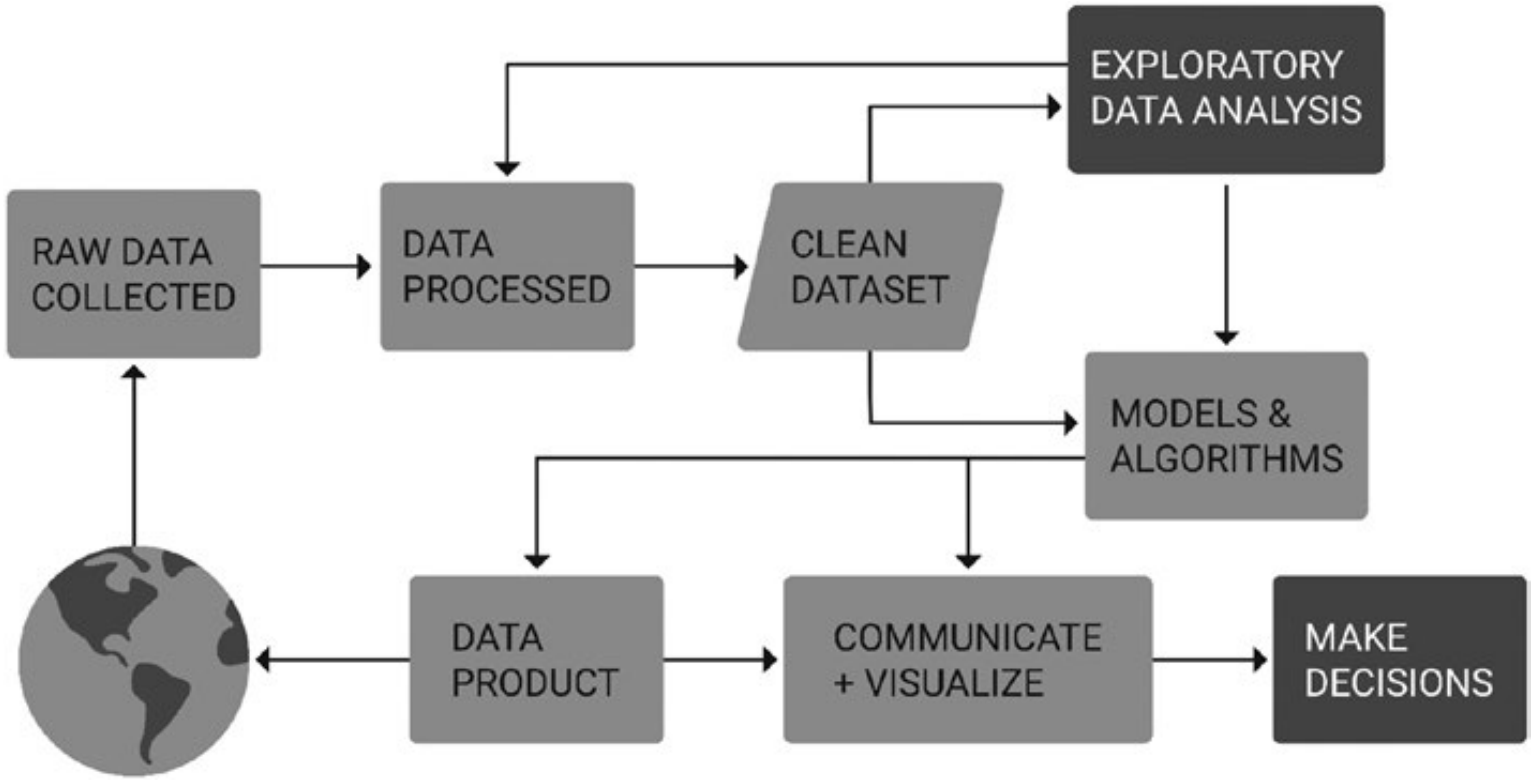
- All AI tasks will use some form of data.
- Data science is a growing discipline that encompasses anything related to data cleansing, extraction, preparation, and analysis.
- Data science is a general term for the range of techniques used when trying to extract insights (i.e., trying to understand)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

Why data science is important?

- Teams working on AI projects will undoubtedly be working with data, whether little or big in volume.
- In the case of big data, real-time data usually demands real-time analytics.
- 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.
- Although you cannot do big data without data science, you can perform data science without big data—all that is required is data.

Data scientist vs. Statistician

- Because data exploration requires statistical analysis, many academics see no distinction between data science and statistics. A data science team (even if it is a team of one) is fundamental to deploying a successful project.
- 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.*


EXPLORATORY
DATA ANALYSIS
RAW DATA
COLLECTED
DATA
PROCESSED
CLEAN
DATASET
MODELS &
ALGORITHMS
DATA
PRODUCT
COMMUNICATE
+ VISUALIZE
MAKE
DECISIONS

BIG DATA

#7

Learning from Real-Time, Big Data

- Volume
- Velocity
- Variety
- Veracity
- Value

AI Winters

- First Winter (mid-1970s to early 1980s)
  1. *Limiting computing power*
  2. *Failure of rule based systems*
  3. *Funding*
  4. *Overhyped promises*

- Second Winter (late 1980s to early 1990s)
  1. *Limitation of expert systems*
  2. *Computational bottlenecks*
  3. *Failed commercial*
  4. *Shift in academic focus*

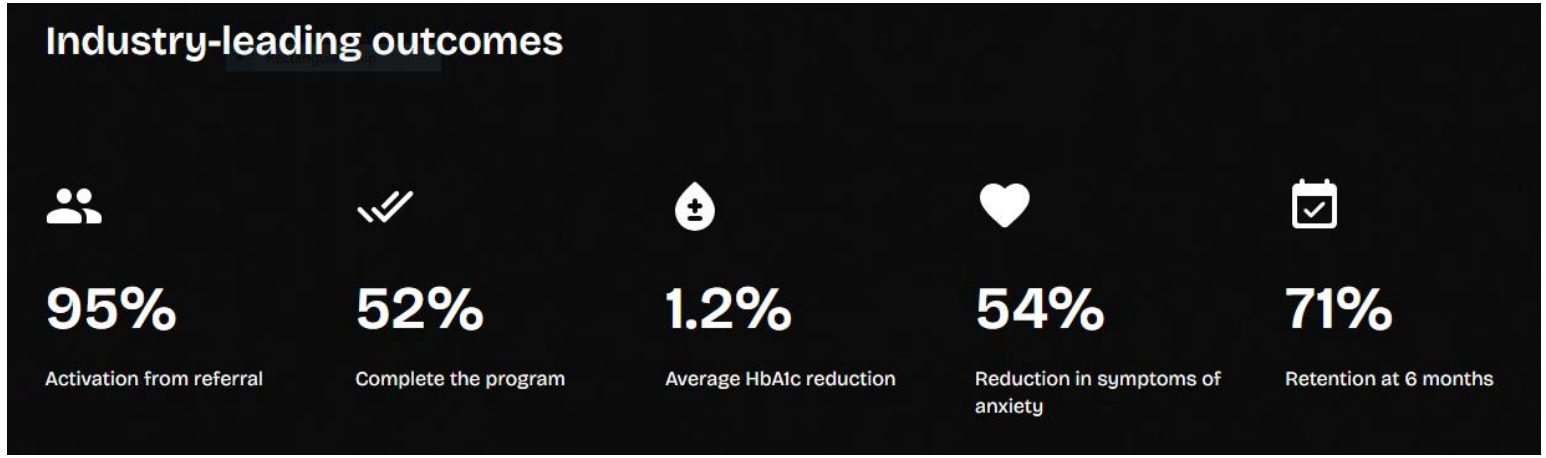
- The Apple iPhone 6 (2014) is over 32,000 times faster than the Apollo-era NASA computers that took man to the moon (1969)

AI in Healthcare

- Prediction
- Diagnosis
- Personalized Treatment and Behavior Modification
- Drug Discovery
- Follow-up Care

Diabetes Digital Media

- Low Carb Program
- Type 2 diabetes and prediabetes
- Saving over $1,015 per patient per year



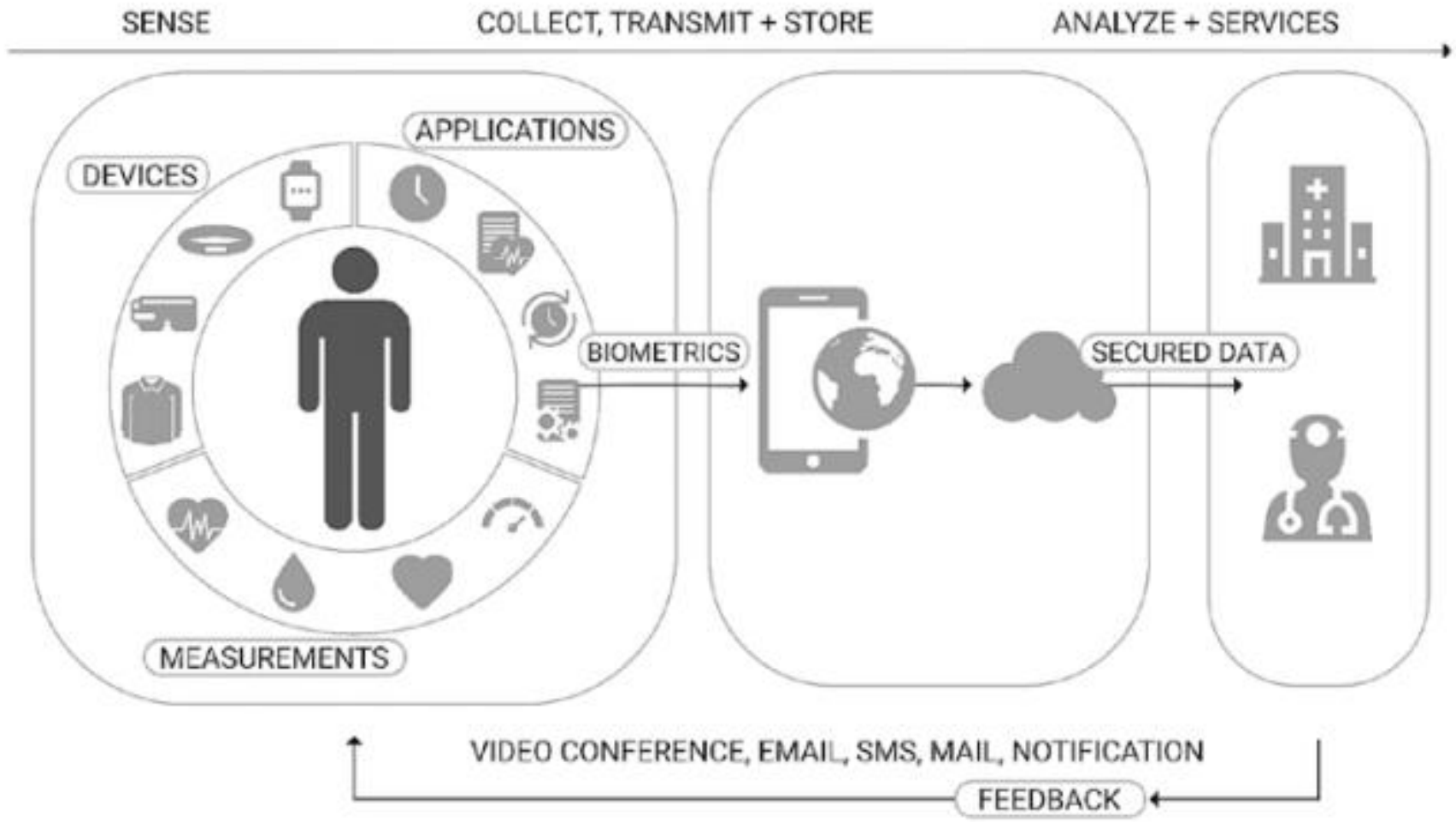


Figure 1-4. *A data-driven, patient–healthcare professional relationship*

CHALLENGES

#8

Challenges

- Understanding Gap
- Fragmented Data
- Appropriate Security
- Data Governance
- Bias
- Software and Technology

WannaCry ransomware attack

- 2017
- National Health Service in United Kingdom
- Encrypting or scrambling the data
- 150 Countries

AIHRC

THANK YOU