Cognitive Computing

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Course Assessment Components

a) Exams (65%)

1. Mid Term-1 (20%)
2. Mid Term-2 (20%)
3. End Term (25%)

b) Assignments/Presentations (20%)

c) Quizzes (15%)

Cognitive Science Society

- The **Cognitive Science Society** is a professional society for the interdisciplinary field of cognitive science.
- It brings together researchers from many fields who hold the common goal of understanding the nature of the human mind.
- The society promotes scientific interchange among researchers in disciplines comprising the field of cognitive science, including artificial intelligence, linguistics, anthropology, psychology, neuroscience, philosophy, and education.

Understanding Cognition

- The word *cognition*, from the Latin root gnosis, meaning to know and learn, dates back to the 15th century.
- Understanding how the human brain works and processes information provides a blueprint for the approach to cognitive computing.
- By understanding cognition we can build systems that have many of the characteristics required to continuously learn and adapt to new information.
- You will react differently for any particular situation.
- This isn't an innate reaction; it is learned as a response to a stimulus.

Cognition

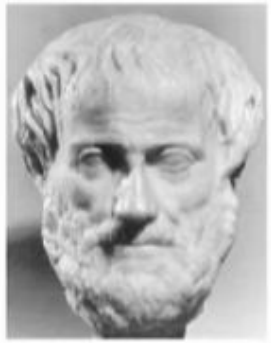
- Cognition is about **knowing**.
- The collection of mental processes and activities used in perceiving, learning, remembering, thinking, and understanding.
- Knowing has a relationship.
- A relationship between Knower and known.
  - It **is not** about knower and world

Rationalism and Empiricism

- Cognition is concerned with knowing.
- There is a centuries old discussion about the roles of
  - the senses and experience
  - direct observation

  - reason, logic, and certainty
  - abstraction from particulars

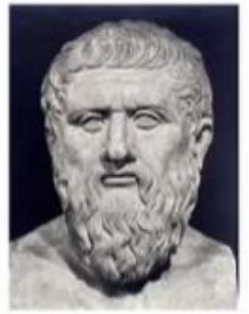
Empiricism



Aristotle

John Locke
"Blank slate"

Rationalism



Plato

Descartes

Rationalism and Empiricism

- **Empiricism**
- Knowledge arises from direct experience and observation
- Experimental science is empirical at heart
- Knowledge obtained through the senses or by experiment is never 100% certain, and may be revised in light of new experience

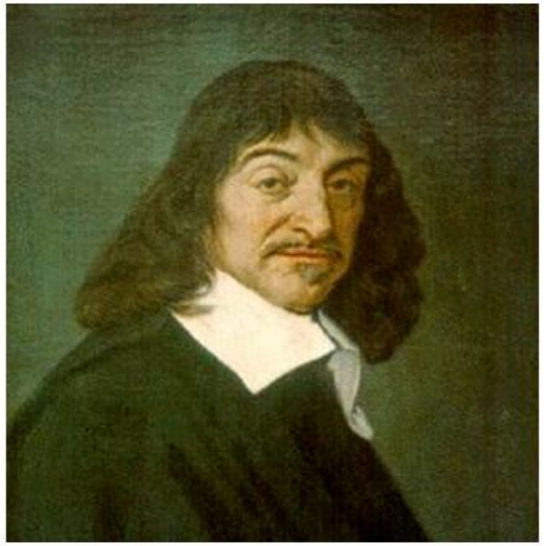
Rationalism and Empiricism

- **Rationalism**
- Knowledge is arrived at through the application of reason or logic
- Mathematical truth illustrates optimally certain knowledge
- Ideally, knowledge should be completely certain
- Sense experience does not produce certainty and is a poor basis for reasoning
- Insists that “true” knowledge is justified

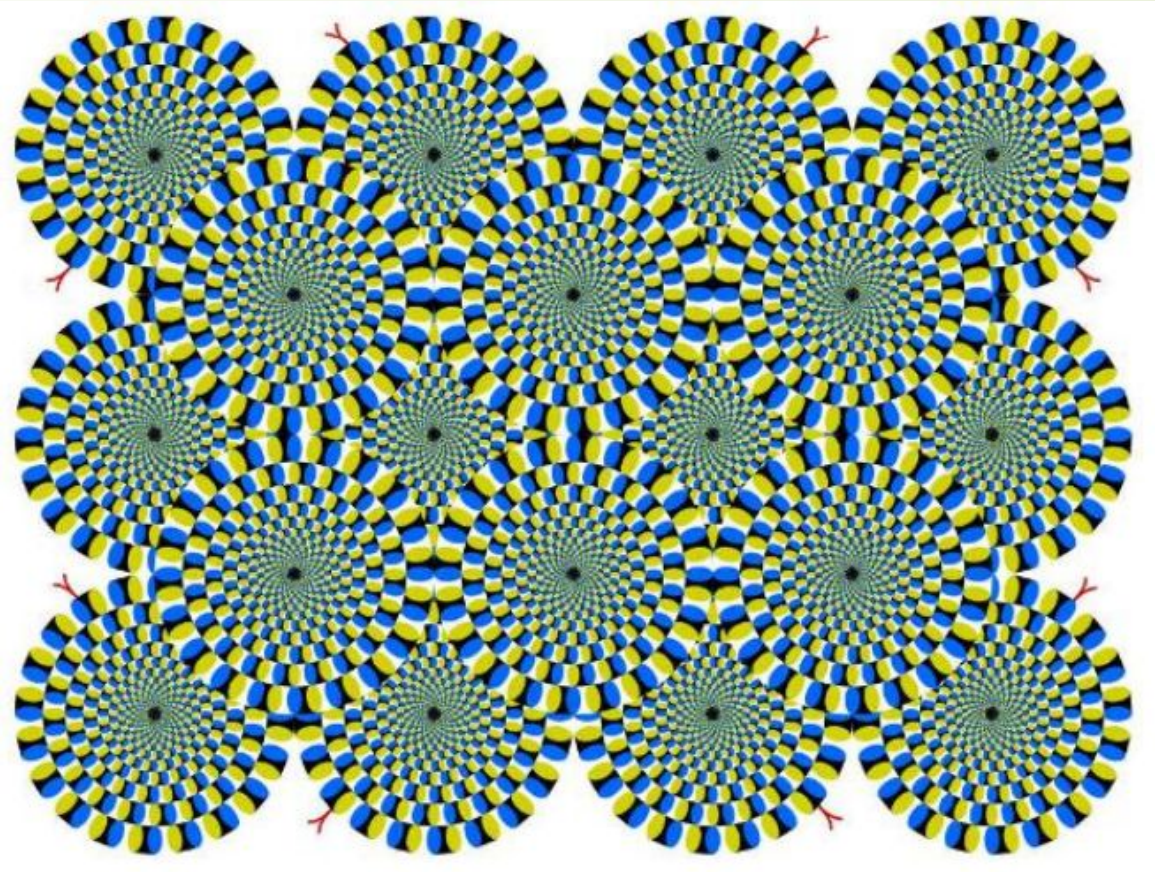
Descartes View

René Descartes (1596-1650)

As a rationalist, he wanted to find a basis for certain knowledge.



Descartes View



Misleading:
Descartes knew about hallucinations and illusions

He always tried to find justification behind knowledge

Want to find better reason

He knew senses can be fooled

Descartes View

[Suppose for the sake of argument that] I have convinced myself that there is absolutely nothing in the world, no sky, no earth, no minds, no bodies. Does it now follow that I too do not exist?

No: if I convinced myself of something then I certainly existed. But there is a deceiver of supreme power and cunning who is deliberately and constantly deceiving me.

In that case I too undoubtedly exist, if he is deceiving me; and let him deceive me as much as he can, he will never bring it about that I am nothing so long as I think that I am something. So after considering everything very thoroughly, I must finally conclude that this proposition, I am, I exist, is necessarily true whenever it is put forward by me or conceived in my mind. (Med. 2, AT 7:25)

Here is Descartes' skepticism at work: Hence: I think, therefore I am.

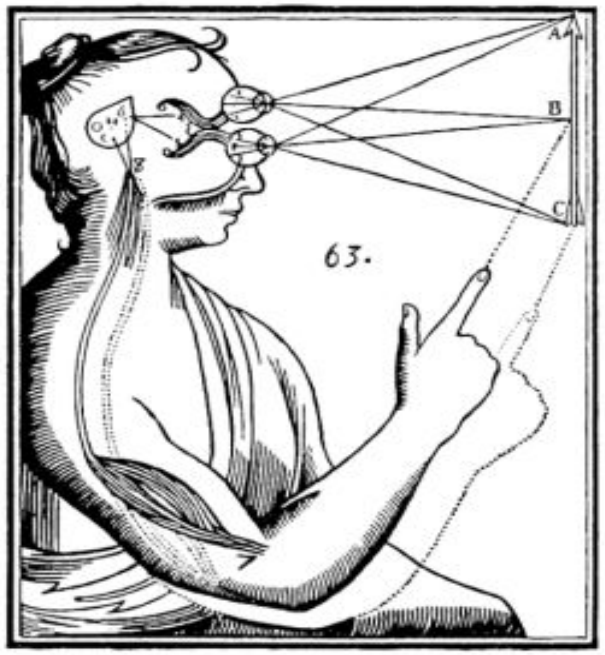
Descartes View

- **Descartes said**
- **Animals are machine and**
- **Humans are separate part of the nature**
- We have soul (mind).
- Choose to act and take responsibility

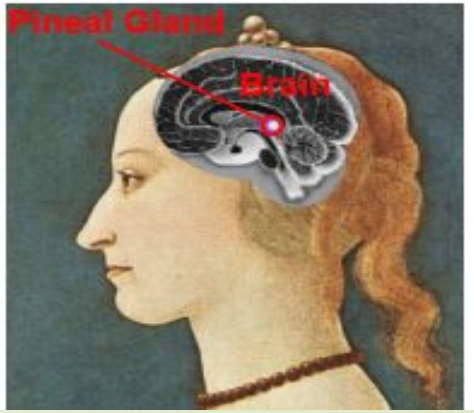
Descartes View

This project led Descartes to conclude that the mind was a completely distinct substance from matter....It is invisible, without dimensions, immaterial, unchanging, indivisible and without limit

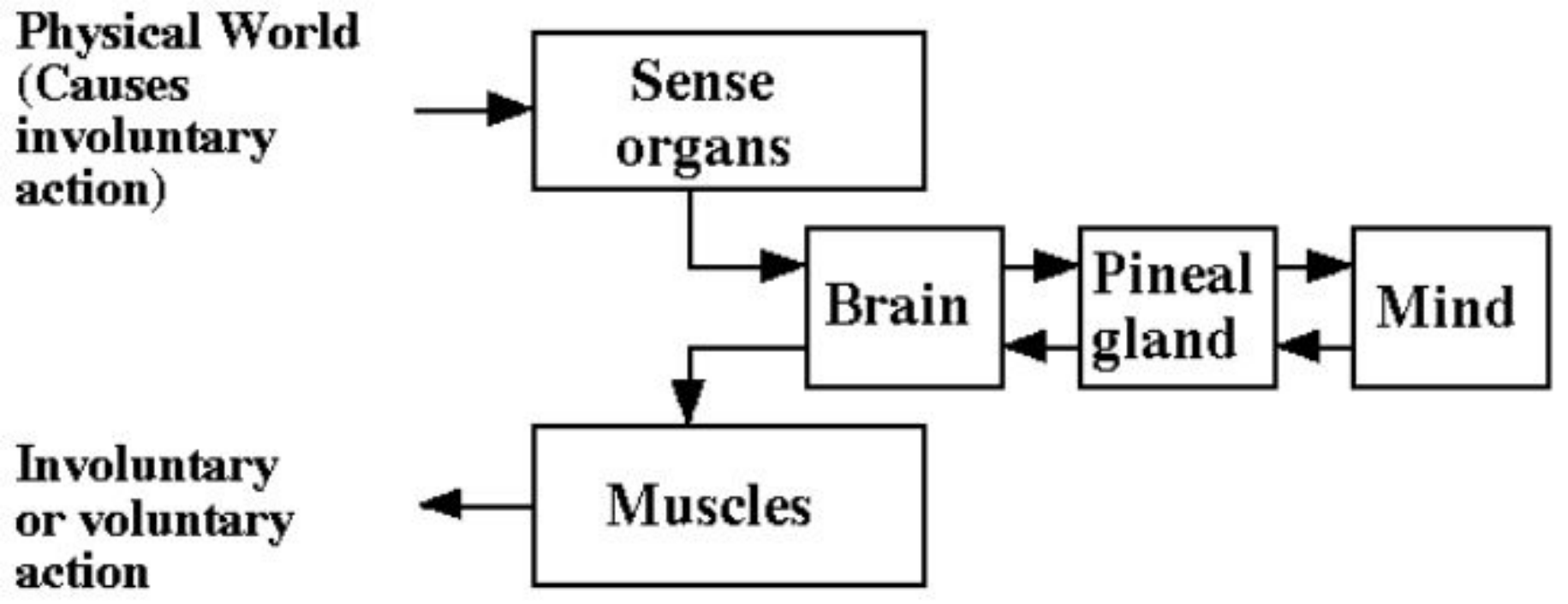
Descartes View



The **mental** and the **physical** are seen as different kinds of things. How they interact is one big problem for "***substance dualism***". Descartes suggested the pineal gland was where the two domains intersected



Descartes View



Cognitive Computing

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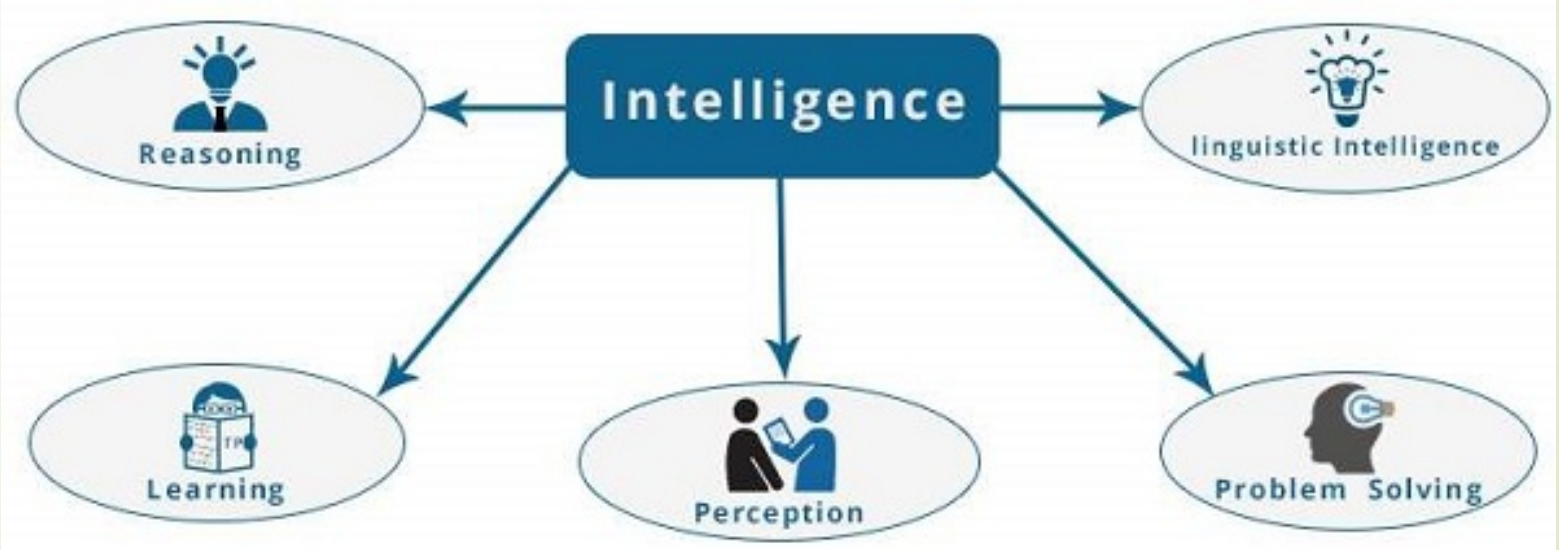
Intelligence

We call ourselves Homo sapiens

- Wise Man: Thinking

- **Intelligence:** Perceive, understand, predict, and manipulate a world



AI definitions

Thinking Humanly	**Thinking Rationally**
"The exciting new effort to make computers think . . . *machines with minds*, in the full and literal sense." (Haugeland, 1985) "[The automation of] activities that we associate with human thinking, activities such as decision-making, problem solving, learning . . ." (Bellman, 1978)	"The study of mental faculties through the use of computational models." (Charniak and McDermott, 1985) "The study of the computations that make it possible to perceive, reason, and act." (Winston, 1992)
Acting Humanly	**Acting Rationally**
"The art of creating machines that perform functions that require intelligence when performed by people." (Kurzweil, 1990) "The study of how to make computers do things at which, at the moment, people are better." (Rich and Knight, 1991)	"Computational Intelligence is the study of the design of intelligent agents." (Poole *et al.*, 1998) "AI . . . is concerned with intelligent behavior in artifacts." (Nilsson, 1998)

Acting humanly: The Turing Test approach

- The Turing test, originally called the **imitation game** by Alan Turing in 1950, is a test of a machine's ability to exhibit intelligent behaviour equivalent to, or indistinguishable from, that of a human.
- Turing proposed that a computer can be said to possess artificial intelligence if it can mimic human responses under specific conditions.
- To **Acting Humanly**, the computer would need to possess the following capabilities:
  - Natural language processing
  - Knowledge representation
  - Automated reasoning
  - Machine learning
- To pass the total Turing Test, the computer will need
  - COMPUTER VISION • computer vision to perceive objects, and
  - ROBOTICS • robotics to manipulate objects and move about.

Thinking humanly: The cognitive modeling approach

- If we are going to say that a given program thinks like a human, we must have some way of determining how humans think. We need to get inside the actual workings of human minds.
- There are three ways to do this: through introspection—**trying to catch our own thoughts as they go** by; through psychological experiments—**observing a person in action**; and through brain imaging—**observing the brain in action**.
- Once we have a sufficiently precise theory of the mind, it becomes possible to express the theory as a computer program.
- If the program's input–output behavior matches corresponding human behavior, that is evidence that some of the program's mechanisms could also be operating in humans.

Thinking rationally: The “laws of thought” approach

- The Greek philosopher Aristotle was one of the first to attempt to codify “right thinking,” that is, irrefutable reasoning processes.
- Patterns for argument structures that always yielded correct conclusions.
- For example, “Socrates is a man; all men are mortal; therefore, Socrates is mortal.”
- These laws of thought were supposed to govern the operation of the mind; their study initiated the field called **logic**.

Acting rationally: The rational agent approach

- An agent is just something that acts.
- Of course, all computer programs do something, but computer agents are expected to do more:
  - operate autonomously
  - perceive their environment
  - persist over a prolonged time period
  - adapt to change
  - create and pursue goals.
- **A rational agent is one that acts so as to achieve the best outcome or, when there is uncertainty, the best expected outcome.**

Intelligence by different branches

- We discuss disciplines that contributed ideas, viewpoints, and techniques to AI.
  - Philosophy
  - Mathematics
  - Neuroscience
  - Psychology
  - Computer engineering
  - Control theory
  - Linguistics

Philosophy

- Can formal rules be used to draw valid conclusions?
- How does the mind arise from a physical brain?
- Where does knowledge come from?
- How does knowledge lead to action?
- Aristotle (384–322 B.C.) was the first to formulate a precise set of laws governing the rational part of the mind. He developed an informal system of syllogisms for proper reasoning, which in principle allowed one to generate conclusions.
- Ren´e Descartes (1596–1650) gave the first clear discussion of the distinction between mind and matter and of the problems that arise.
- He held that there is a part of the human mind (or soul or spirit) that is outside of nature, exempt from physical laws.
- The final element in the philosophical picture of the mind is the connection between knowledge and action. This question is vital to AI because **intelligence requires action as well as reasoning.**

Mathematics

- What are the mathematical formal rules to draw valid conclusions?
- What can be computed?
- How do we reason with uncertain information?
- Philosophers staked out some of the fundamental ideas of AI, but the **leap to a formal science required a level of mathematical formalization** in three fundamental areas: logic, computation, and probability.

- Thomas Bayes (1702–1761) proposed a rule for updating probabilities in the light of new evidence. Bayes' rule underlies most modern approaches to uncertain reasoning in AI systems

- The idea of formal logic can be traced back to the philosophers of ancient Greece, but its mathematical development really began with the work of George Boole (1815–1864), who worked out the details of propositional, or Boolean, logic (Boole, 1847).

Neuroscience

- How do brains process information?
- Neuroscience is the study of the nervous system, particularly the brain.
- The measurement of intact brain activity began in 1929 with the invention by Hans Berger of the electroencephalograph (EEG).
- The recent development of functional magnetic resonance imaging (fMRI) (Ogawa et al., 1990; Cabeza and Nyberg, 2001) is giving neuroscientists unprecedentedly detailed images of brain activity, enabling measurements that correspond in interesting ways to ongoing cognitive processes.
- **Note:** Even with a computer of unlimited capacity, we still would not know how to achieve the brain's level of intelligence.

Computer engineering

- How can we build an efficient computer?
- For artificial intelligence to succeed, we need two things: **intelligence and an artifact.**
- The computer has been the artifact of choice. The first operational computer was the electromechanical Heath Robinson, built in 1940 by Alan Turing's team for a single purpose: **deciphering German messages.**
- Of course, there were calculating devices before the electronic computer.
- Charles Babbage (1792–1871) Analytical Engine was far more ambitious: it included addressable memory, stored programs, and conditional jumps.

Control theory

- How can artifacts operate under their own control?

- Ktesibios of Alexandria (c. 250 B.C.) built the first self-controlling machine: a water clock with a regulator that maintained a constant flow rate. This invention changed the definition of what an artifact could do.

- Other examples of self-regulating feedback control systems include the steam **engine governor, created by James Watt** (1736–1819), and the **thermostat,** invented by Cornelis Drebbel (1572–1633), who also invented the submarine.

- **Linguistics**
- How does language relate to thought?
- Understanding language requires an understanding of the subject matter and context, not just an understanding of the structure of sentences.

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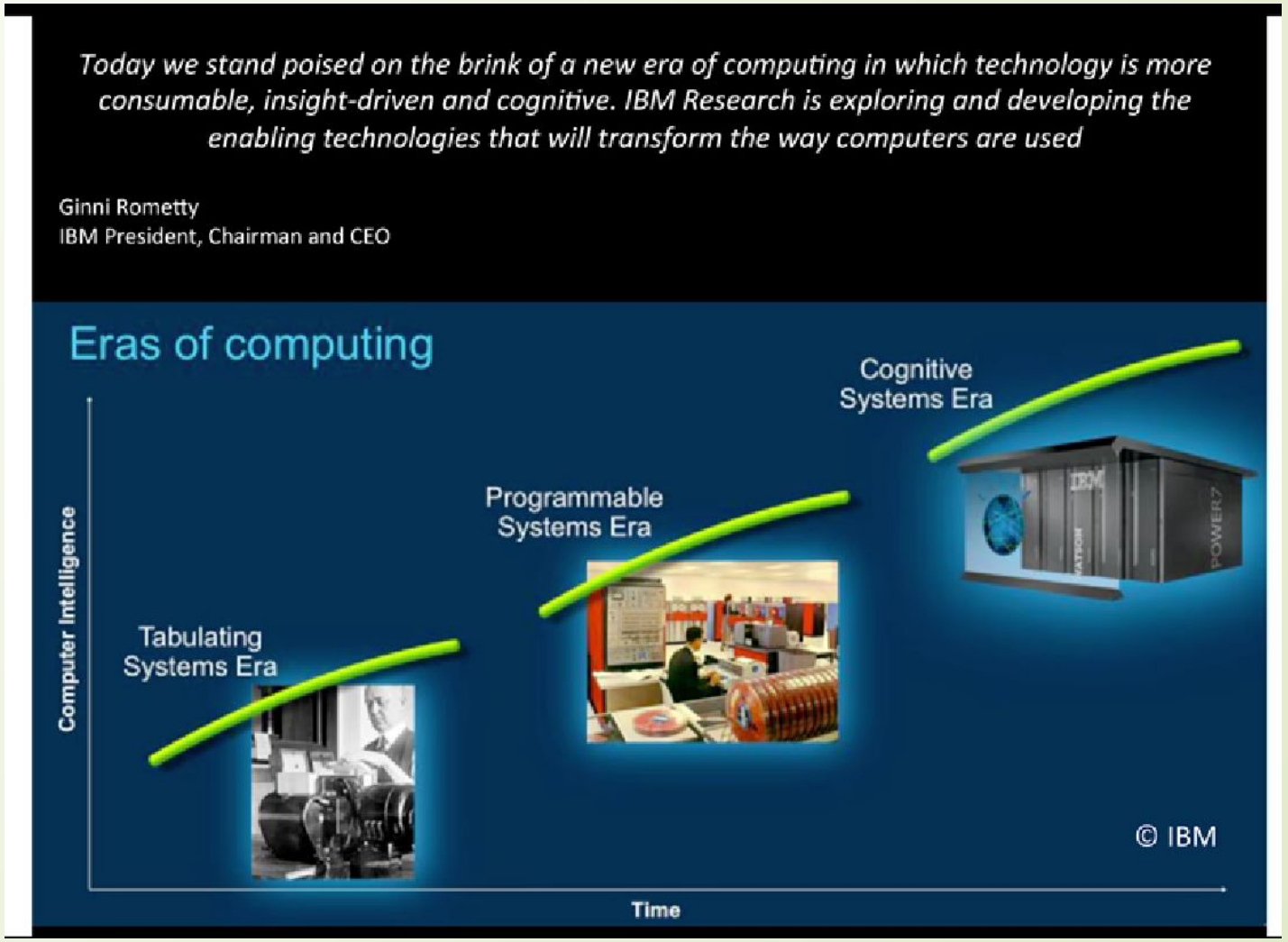
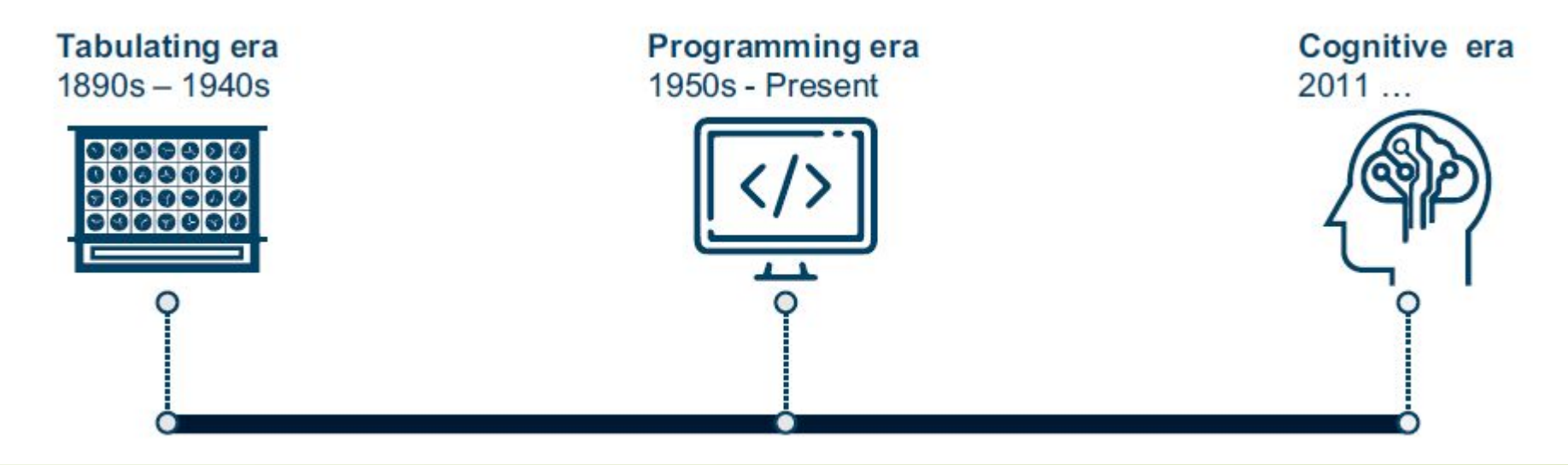
The eras of computing



The eras of computing

- Till now, two distinct eras of computing have occurred: the *tabulating era* and the *programming era*.

- We are entering the third and most transformational era in computing's evolution, the *cognitive computing era* (cognitive era).



The eras of computing

- Tabulating era (1890s - 1940s)
- The first era of computing consisted of single-purpose electromechanical systems that counted, using punched cards to input and store data, and to eventually instruct the machine what to do.
- These tabulation machines were essentially calculators designed to count and summarize information and they did it really well but were ultimately *limited to a single task*.

The eras of computing

- Programming era (1950s - present)
- This era started with the shift from mechanical tabulators to electronic systems
- The introduction of general purpose computing systems that are programmable
- They can be reprogrammed to perform different tasks and solve multiple problems in business and society.
- But ultimately, they must be programmed and are still somewhat constrained in the interaction with human beings.

The eras of computing

- Cognitive era (2011 - future)

- As **J.C.R Licklider** predicted (“Man-Computer Symbiosis”), cognitive computing is a necessary and natural evolution of programmable computing.
- Cognitive computing systems are meant to *extend the boundaries of human cognition*.

- Cognitive computing technologies are not about replacing or necessarily even replicating the way that the human brain works; they are about extending the capabilities of the human brain.

The eras of computing

- Humans excel at reasoning, deep thinking, and solving complex problems.
- But the human ability to read, analyze, and process huge volumes of data, both structured and unstructured, is quite poor.
- That, of course, is the strength of the computer system.
- The first role of a cognitive computing system is to combine strengths of human and machine into a collaborative situation.
- Another key element of cognitive systems is a more *natural interaction* between human and machine, combined with the capability to *learn and adapt over time*.

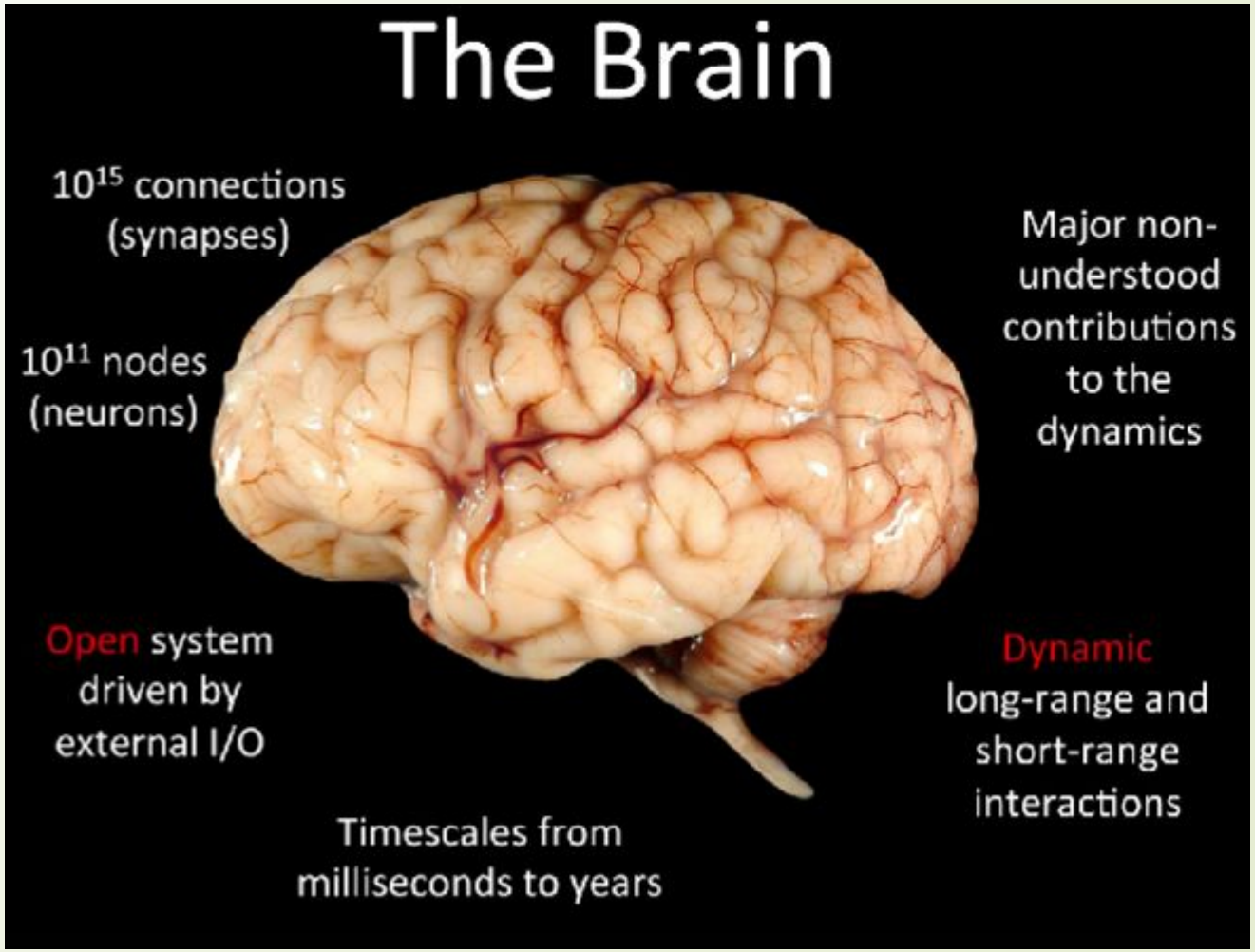
Cognition

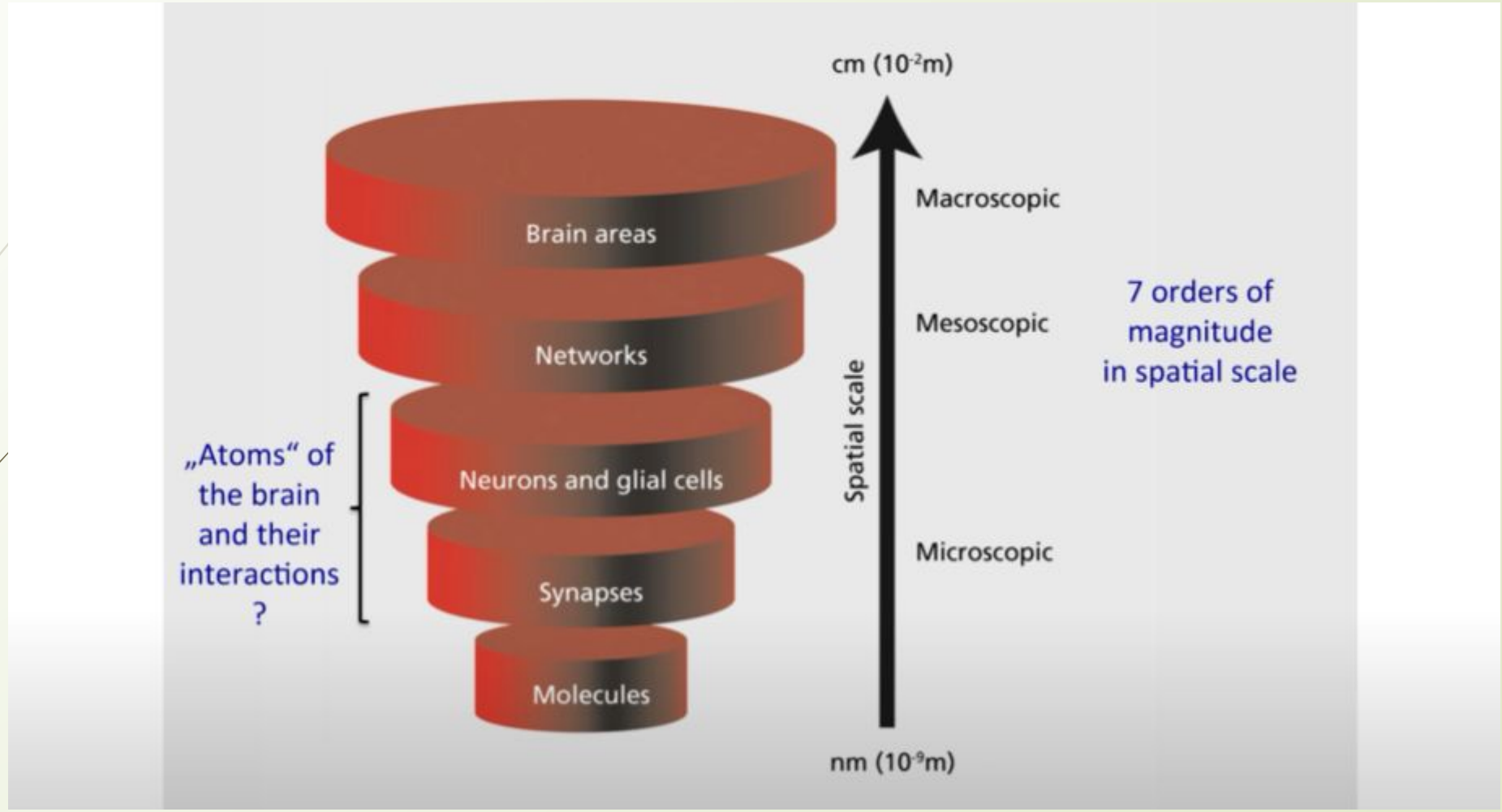
Mental action or process of acquiring knowledge and understanding through thought, experience, and the senses.

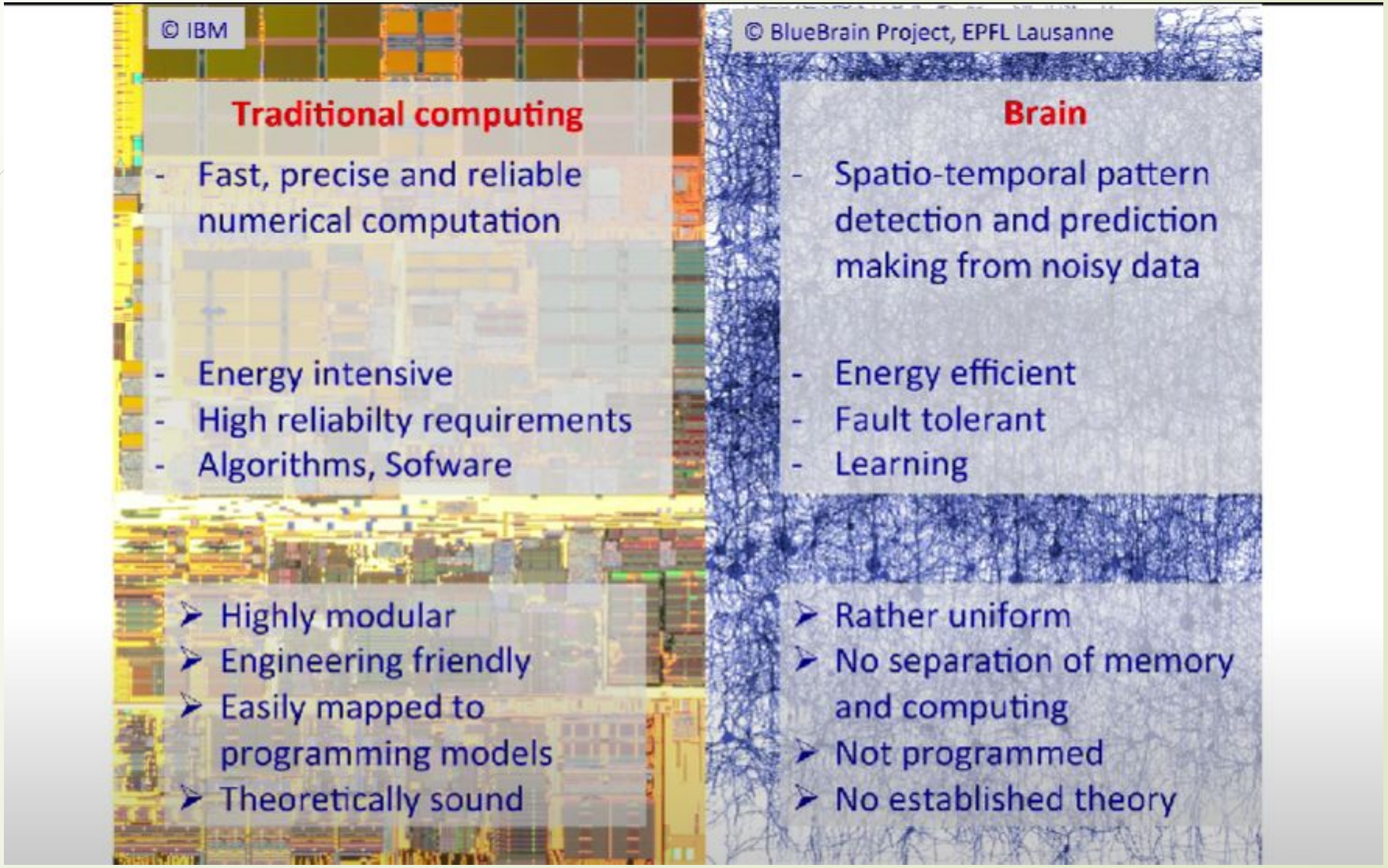
Critical for day-to-day life, governing our thoughts and actions. We need cognition to help us understand information about the world around us and interact safely with our environment, as the sensory information we receive is vast and complicated.

Cognition is needed to distill all this information down to its essentials.

The Brain


10^{15} connections (synapses)
10^{11} nodes (neurons)
Major non-understood contributions to the dynamics
Open system driven by external I/O
Dynamic long-range and short-range interactions
Timescales from milliseconds to years


cm (10⁻²m)
Brain areas
Networks
Neurons and glial cells
Synapses
Molecules
„Atoms“ of the brain and their interactions ?
Spatial scale
Macroscopic
Mesoscopic
Microscopic
7 orders of magnitude in spatial scale
nm (10⁻⁹m)


© IBM
Traditional computing
- Fast, precise and reliable numerical computation
- Energy intensive
- High reliabilty requirements
- Algorithms, Sofware
➢ Highly modular
➢ Engineering friendly
➢ Easily mapped to programming models
➢ Theoretically sound
© BlueBrain Project, EPFL Lausanne
Brain
- Spatio-temporal pattern detection and prediction making from noisy data
- Energy efficient
- Fault tolerant
- Learning
➢ Rather uniform
➢ No separation of memory and computing
➢ Not programmed
➢ No established theory

CC: The future computing

- *"Those of us engaged in serious information science and in its application in the real world of business and society understand the enormous potential of intelligent systems. The future of such technology — which we believe will be cognitive, not "artificial"— has very different characteristics from those generally attributed to AI, spawning different kinds of technological, scientific and societal challenges and opportunities, with different requirements for governance, policy and management."*

Computing, cognition and the future of knowing: How humans and machines are forging a new age of understanding, Dr. John E. Kelly

- *"Cognitive computing refers to systems that learn at scale, reason with purpose and interact with humans naturally. Rather than being explicitly programmed, they learn and reason from their interactions with us and from their experiences with their environment."*

Cognitive Processes

- Learning and Memory
- Thinking and Reasoning (Planning, Decision Making, Problem Solving ...)
- Language
- Vision-Perception
- Social Cognition
- Dreaming and Consciousness

Cognitive steps in human

- When we as humans seek to understand something and to make a decision, we go through four key steps:
- 1. *Observe* visible phenomena and bodies of evidence.
- 2. *Interpret* what we see by drawing on what we know in order to generate hypotheses about it means.
- 3. *Evaluate* which hypotheses are right or wrong.
- 4. *Decide* (choose) the option that seems best and act accordingly.

- Just as humans become experts by going through the process of observation, evaluation and decision-making, cognitive systems use similar processes to reason about the information they absorb.

Cognitive Science

- “The interdisciplinary study of mind and intelligence”

- “Study of cognitive processes involved in the acquisition, representation and use of human knowledge”

Impact of cognitive computing to our lives

- Whether you realize this or not, cognitive computing is already having an impact on our lives.
- Often when you talk to a call center, your interaction is likely with a computer.
- Articles that you read might have been written by a machine. In many cases, such as online shopping, cognitive computing understands your behavior and activities and makes recommendations based on that understanding.
- Chatbots that are powered by cognitive computing have been built to successfully support complaint-resolution services.

Some basic concepts

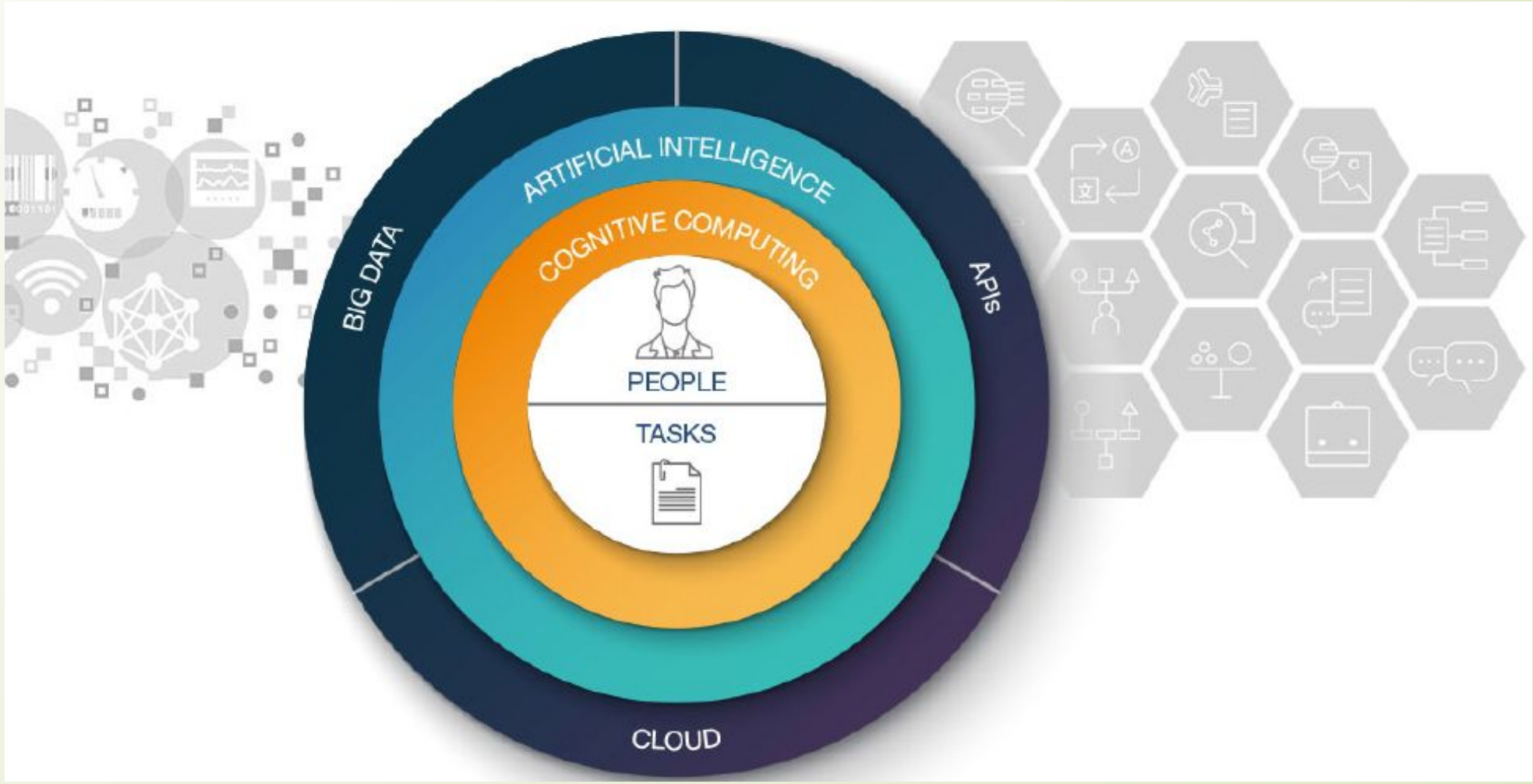
Basic concept (Cognition)

- Cognition, the “act of thinking,” is the mental process of acquiring understanding through thought and personal or shared experiences.
- Brain-based skills are part of every human action and are essential in carrying out any task, from the simplest to the most difficult.
- Tasks include human senses (hearing, touch, smell, sight, taste, and even extra-sensory perception), learning, remembering, motor skills, language, empathy, social skills, and problem solving capabilities.

Basic concept (Cognition)

- As stated, cognition is the process of acquiring knowledge through thoughts, experiences, and senses.
- Cognitive processing helps us understand and interact with the world around us from the basic to the complex.

Cognitive System: Integration of basic concepts



Basic concept (AI)

- The study and development of AI systems aim at building computer systems able to perform tasks that normally require human intelligence.
- AI-based machines are intended to perceive their environment and take actions that optimize their level of success.
- Today's AI can be considered weak, in that it is designed to perform narrow and specific tasks.
- The goal of many researchers is to create strong AI that learns like a human and can solve human-type problems.

- AI research uses techniques from many fields, such as computer science, philosophy, linguistics, economics, speech recognition, and psychology, which are manifested in applications, such as control systems, natural language processing, facial recognition, speech recognition, analytics, pattern matching, data mining, and logistics.

Basic concept (Cognition computing)

- Humans are inherently capable of a set of skills that help us learn, discover, and make decisions:
- Humans can apply common sense, morals, and reason through dilemmas.
- Humans can think of new ideas and make generalizations when essential clues and pieces of information are missing.
- But humans are restricted by the amount of time spent to learn, process, and absorb new information, and limited by the unconscious biases we all possess that influence the decisions we make.

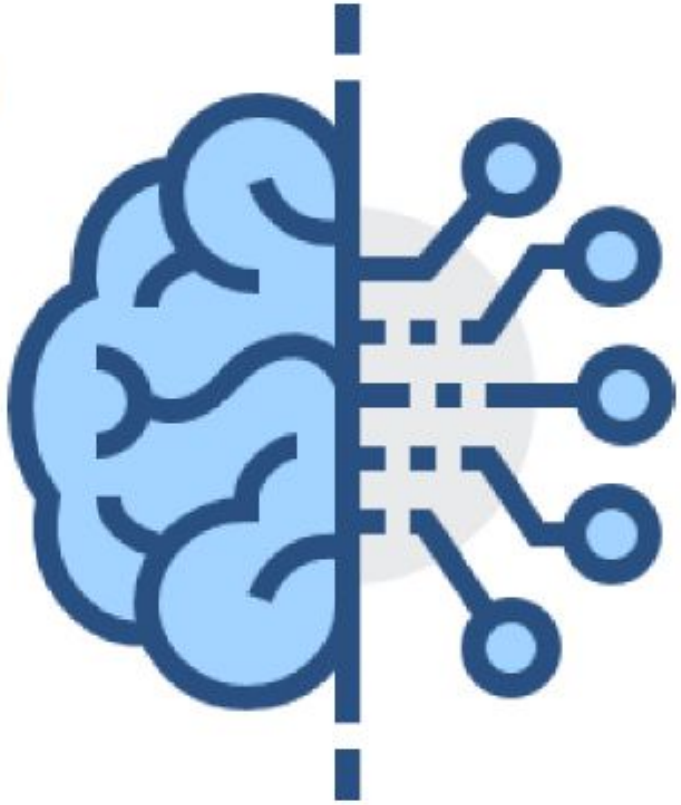
Basic concept (Cognition computing)

- Cognitive computing is among the subdisciplines that shape AI.
- It is about putting together a system that combines the best of human and machine capabilities.
- Consider capabilities that humans naturally have, such as imagination and emotions, combined with capabilities that computers excel at, such as number crunching, identifying patterns, and processing huge amounts of information.
- Cognitive computing uses machine strengths to “simulate” the human thought processes in a computerized model.

Basic concept (CC)

Humans Excel at:

Common sense
Morals
Imagination
Compassion
Abstraction
Dilemmas
Dreaming
Generalization



Cognitive Systems Excel at:

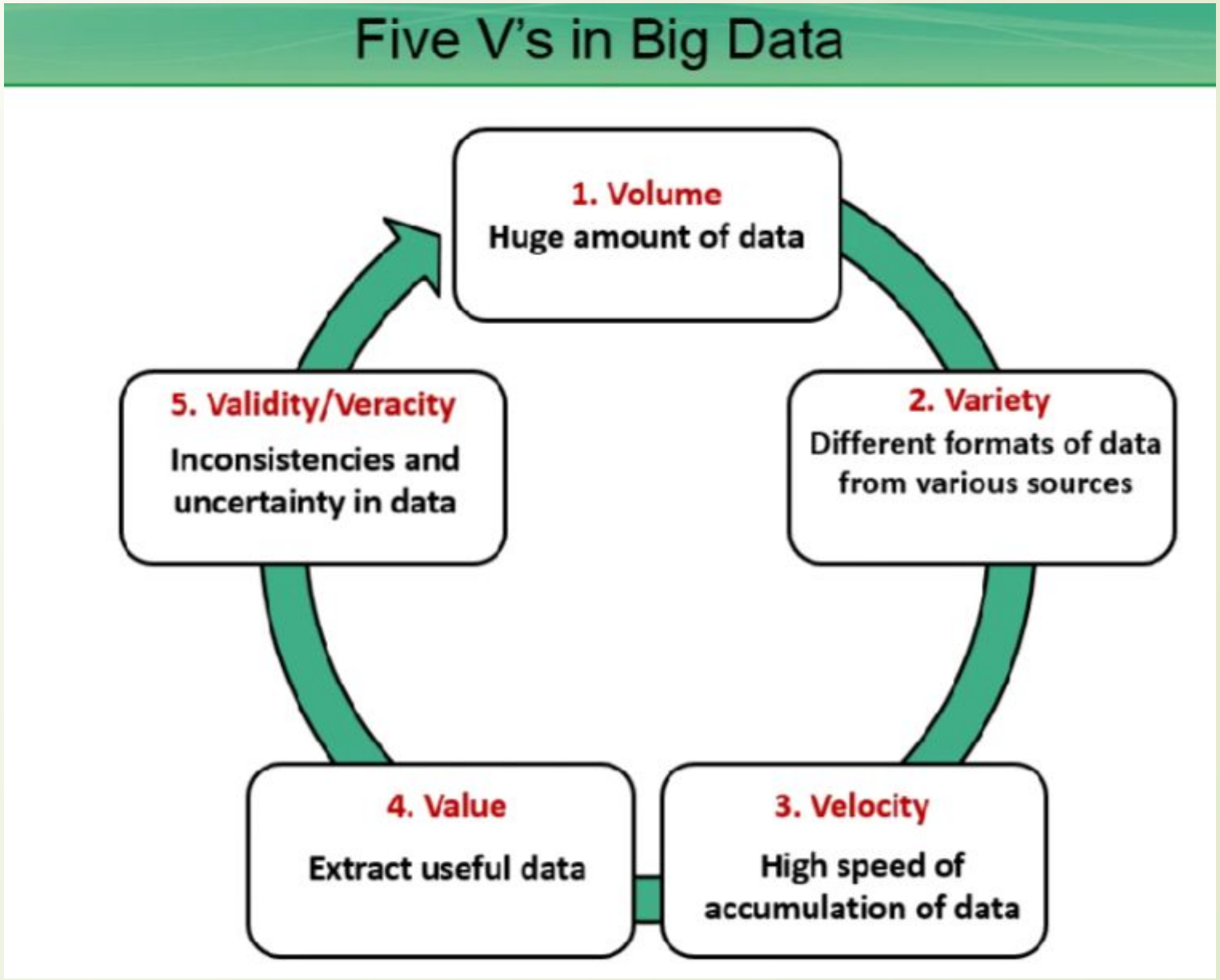
Locating Knowledge
Pattern Identification
Natural Language
Machine Learning
Eliminate Bias
Endless Capacity

Basic concept (Big data)

- Often big data characteristics are defined by the five V's: variety, volume, velocity, veracity, and value.
- Big data requires innovative forms of information processing to draw insights, automate processes, and assist in decision making.
- Big data can be structured data that corresponds to a formal pattern, such as traditional data sets and databases.

- Also big data includes semi-structured and unstructured formats, such as word processing documents, videos, images, audio, presentations, social media interactions, streams, web pages, and many other kinds of content.
- Unstructured data is not contained in a regular database and is growing exponentially, making up the majority of all the data in the world.

Five V's in Big Data



Basic concept (QA technology)

- Cognitive systems can ingest millions of pages of text and apply question-answering technology to respond to questions posed by humans in natural language.
- This approach allows people to “ask” and get almost instantaneous answers to complex questions.
- Combined with other application programming interfaces (APIs) and advanced analytics, QA technology distinguishes itself from the conventional search (that is triggered by keywords) by providing a more conversational discussion.

Basic concept (ML)

- Machine learning is a type of AI that gives computers the ability to learn and act without being explicitly programmed.
- This means that the computer model gets better over time by learning from its mistakes and new experiences (being exposed to new data), increasing its intelligence.
- If a computer program can improve how it performs certain tasks that are based on past experiences, then it has learned.
- This differs from performing the task always the same way because it has been programmed to do so.

Basic concept (NLP)

- NLP is the ability of computer software to understand human speech.
- By using NLP capabilities, computers can analyze text that is written in human language and identify concepts, entities, keywords, relations, emotions, sentiment, and other characteristics, allowing users to draw insights from content.
- Any system that takes natural language as input and is capable of processing it is a natural language processing system (for example, spam-detection software).
- A spam classifier is a system that looks at the content of the email subject line to assess whether the received email is or is not spam.

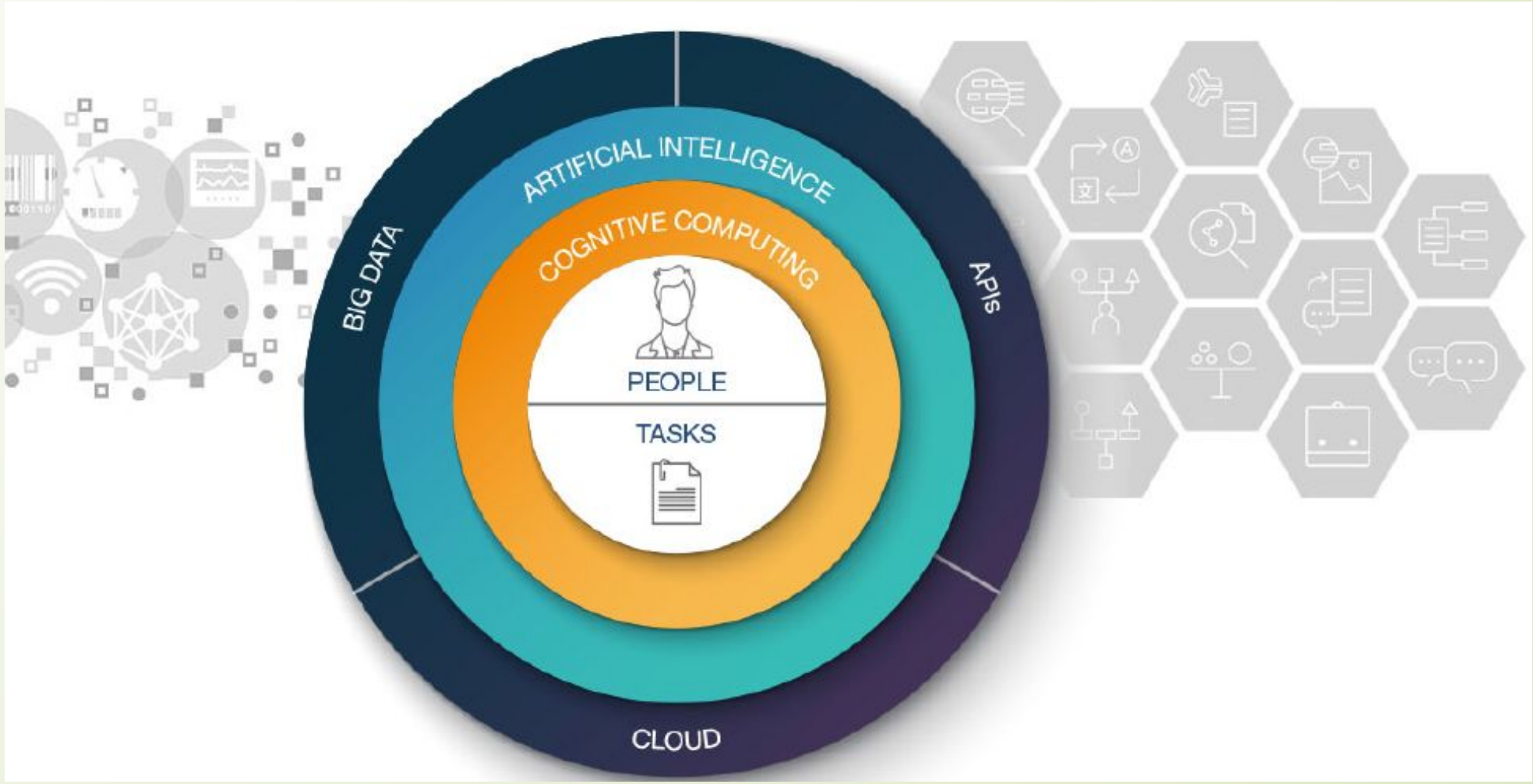
Basic concept (cloud computing)

- Cloud computing is a general term that describes delivery of on-demand services, usually through the Internet, on a pay-per-use basis.
- Companies worldwide offer their services to customers.
- Services might be data analysis, social media, video storage, e-commerce, and cognitive computing in a way that is available through the Internet and supported by cloud computing.

Basic concept (APIs)

- In general, APIs expose capabilities and services.
- APIs enable software components to communicate with each other easily.
- Making the task easier to connect and interface with other applications or services.
- APIs abstract the underlying workings of a service, application, or tool, and expose only what a developer needs, so programming becomes easier and faster.

Cognitive System: Integration of basic concepts



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Characteristics of CC

Characteristics of CC

- An important concept to understand is that the first key element of cognitive systems is to *expand the boundaries of human cognition* rather than replace or replicate the way the human brain works.
- Humans excel at thinking deeply and solving complex problems, however our ability to read, analyze, and process huge volumes of data is poor.
- Reading, analyzing, and leveraging huge volumes of data is the strength of computer systems.
- A key element of a cognitive system is to *combine those two strengths (human and computer) into a collaborative solution*.

- The cognitive system must combine different pieces of information together, and possibly do some reasoning to make connections and relationships.

Characteristics of CC

- The second key element is to have *a more natural interaction between computers and humans*.
- Until recently, to interact with computers, humans had to adapt the way they work to the computer interface, which was often rigid and inflexible.
- Cognitive systems provide a much more natural engagement between the computer and the human.
- Speech recognition, for example, enables the human to interact with the computer by using voice commands.

Characteristics of CC

- A third key element of cognitive systems is the *use of learning, specifically machine learning*.
- Machine learning has been pursued for a long time and cognitive systems must go beyond the core foundations of machine learning.

- The intent is to broaden the potential for learning and the ability of a to *adapt over time with use*, which is a fourth key element of cognitive systems.
- A feedback mechanism captures the results of that interaction and the system must learn from the resulting interaction and evolve automatically over time, improving its performance.

Characteristics of CC

- Understand: Cognitive systems understand imagery, language, and other unstructured data like humans. Cognitive system operationalize virtually all data (structured and unstructured) like humans do.
- Reason: Cognitive systems can reason, grasp underlying concepts, form hypotheses, and infer and extract ideas.
- Learn: With each data point, interaction, and outcome, the cognitive systems develop and increase expertise, and continue to learn, adapt, and improve their expertise.
- Interact: With abilities to see, talk, and hear, cognitive systems interact with humans in a natural way.

Modelling of Cognition

Cognitive computing : Introduction

- The explosion of data, mainly unstructured data, over the past few years led to the development of a new type of computer system known as a *cognitive system*.
- Unlike the programmable computers that preceded it, the focus of cognitive systems is not about doing fast calculations on large amounts of data through traditional computer programs.
- Cognitive systems are about exploring the data, finding new correlations, and new context in that data to provide new solutions.
- Cognitive systems aim at expanding the boundaries of human cognition rather than replacing or replicating the way the human brain works.

Cognitive computing : Introduction

- Huge advancements in technology in the last 30 years, the ability to gain insights and actions from data hasn't changed much.
- In general, applications are still designed to perform predetermined functions or automate business processes, so their designers must plan for every usage scenario and code the logic accordingly.
- They don't adapt to changes in the data or learn from their experiences.
- **Computers are faster and cheaper, but not much smarter.**
- A new generation of an information system is emerging that departs from the old model of computing as process automation to provide a collaborative platform for discovery.

Cognitive computing : Introduction

- Acting as partners or collaborators for their human users, these systems may derive meaning from volumes of natural language text and generate and evaluate hypotheses in seconds based on analysis of more data than a person could absorb in a lifetime.

- Cognitive computing is a technology approach that enables humans to collaborate with machines.

- A cognitive system is designed to build a dialog between human and machine so that best practices are learned by the system as opposed to being programmed as a set of rules.

Fundamental principles

- If you look at cognitive computing as an analog to the human brain, you need to analyze *in context* all types of data, from structured data in databases to unstructured data in text, images, voice, sensors, and video.

- A cognitive system has three fundamental principles as described below:
  - **Learn**
  - **Model**
  - **Generate hypotheses**

- We are entering a new era in computing that will transform the way humans collaborate with machines to gain actionable insights.

Need of CC

- Organizations standardized business processes and managed business data more efficiently and accurately than with manual methods.
- However, as the volume and diversity of data has increased exponentially, many organizations cannot turn that data into actionable knowledge.
- The next generation of solutions combines some traditional technology techniques with innovations so that organizations can solve tedious problems.
- Cognitive computing is in its early stages of maturation.

What makes a system cognitive?

- Contextual insight from the model.
- Hypothesis generation (a proposed explanation of a phenomenon).
- Continuous learning from data across time.
- When diverse types of data is acquired, curated, and analyzed, the cognitive system must identify and remember patterns and associations in the data.
- This iterative process enables the system to learn and deepen its scope so that understanding of the data improves over time.

What makes a system cognitive?

- One of the most important practical characteristics of a cognitive system is the capability to provide the knowledge seeker with a series of alternative answers along with an explanation of the rationale or evidence supporting each answer.

- A cognitive computing system consists of tools and techniques, including Big Data and analytics, machine learning, Internet of Things (IoT), Natural Language Processing (NLP), causal induction, probabilistic reasoning, and data visualization.

What makes a system cognitive?

- Learn from experience with data/evidence and improve its own knowledge and performance without reprogramming.
- Generate and/or evaluate conflicting hypotheses based on the current state of its knowledge.
- Report on findings in a way that justifies conclusions based on confidence in the evidence.
- Discover patterns in data, with or without explicit guidance from a user regarding the nature of the pattern.

What makes a system cognitive?

- Emulate processes or structures found in natural learning systems (that is, memory management, knowledge organization processes, or modeling the neurosynaptic brain structures and processes).
- Use NLP to extract meaning from textual data and use deep learning tools to extract features from images, video, voice, and sensors.
- Use a variety of predictive analytics algorithms and statistical techniques.

Where we can use CC?

- Cognitive computing systems are often used in domains in which a single query or set of data may result in a hypothesis that yields more than one possible answer.
- **CC is Probabilistic rather than deterministic.**
- The cognitive solution is best suited to help when the domain is complex and conclusions depend on who is asking the question and the complexity of the data.
- For example, in the medical diagnostic example, the cognitive system may ask the physician to perform additional tests to rule out or to choose certain diagnoses.

Two disciplines in CC

- With cognitive computing, we are bringing together two disciplines:
  - **Cognitive science**—The science of the mind.
  - **Computer science**—The scientific and practical approach to computation and its applications. It is the systematic technique for translating this theory into practice.

Cognition System

- Traditional architectures rely on humans to interpret processes into code.
- AI assumes that computers can replace the thinking process of humans.
- With cognitive computing, the human leverages the unique ability of computers to process, manage, and associate information to expand what is possible.

Modelling of Cognition

- It is quite complicated to translate the complexity of human thought and actions into systems.
- In human systems, we are often influenced by emotion, instinct, habits, and subconscious assumptions about the world.
- *Cognition* is a foundational approach that leverages not just how we think, but also how we act and how we make decisions.

Modelling of Cognition

- Why does one doctor recommend one treatment whereas another doctor recommends a completely different approach to the same disease?
- Why do two people raised in the same household with a similar experience grow up to have diametrically opposed views of the world?
- What explains how we come to conclusions and what does this tell us about cognition and cognitive computing?

Two Systems of Judgment and Choice

- One of the most influential thinkers on the topic is Dr. Daniel Kahneman, an Israeli-American psychologist and winner of the 2002 Nobel Memorial Prize in Economic Sciences.

- He is well known for his research and writing in the field of the psychology of judgment and decision making.

- He published a book, *Thinking Fast and Slow*, which provides important insights for cognitive computing.

First System - Automatic Thinking: Intuition and Biases

- System 1 thinking is what happens automatically in our brains.
- It uses our intuition to draw conclusions.
- System 1 thinking begins almost from the moment we are born. We learn to see objects and understand their relationships to ourselves.
- As people learn over time, they begin to assimilate automatic thinking into their way of operating in the world.
- The chess master not only knows what his next move should be but also can anticipate what move his opponent will do next.

First System - Automatic Thinking: Intuition and Biases

- The benefit of System 1 thinking is that we can take in data from the world around us and discover the connections between events.
- It is easy to see that System 1 is important to cognitive computing because it allows us as humans to use sparse information we collect about events and observations and come to rapid conclusions.
- System 1 can generate predictions by matching these observations.

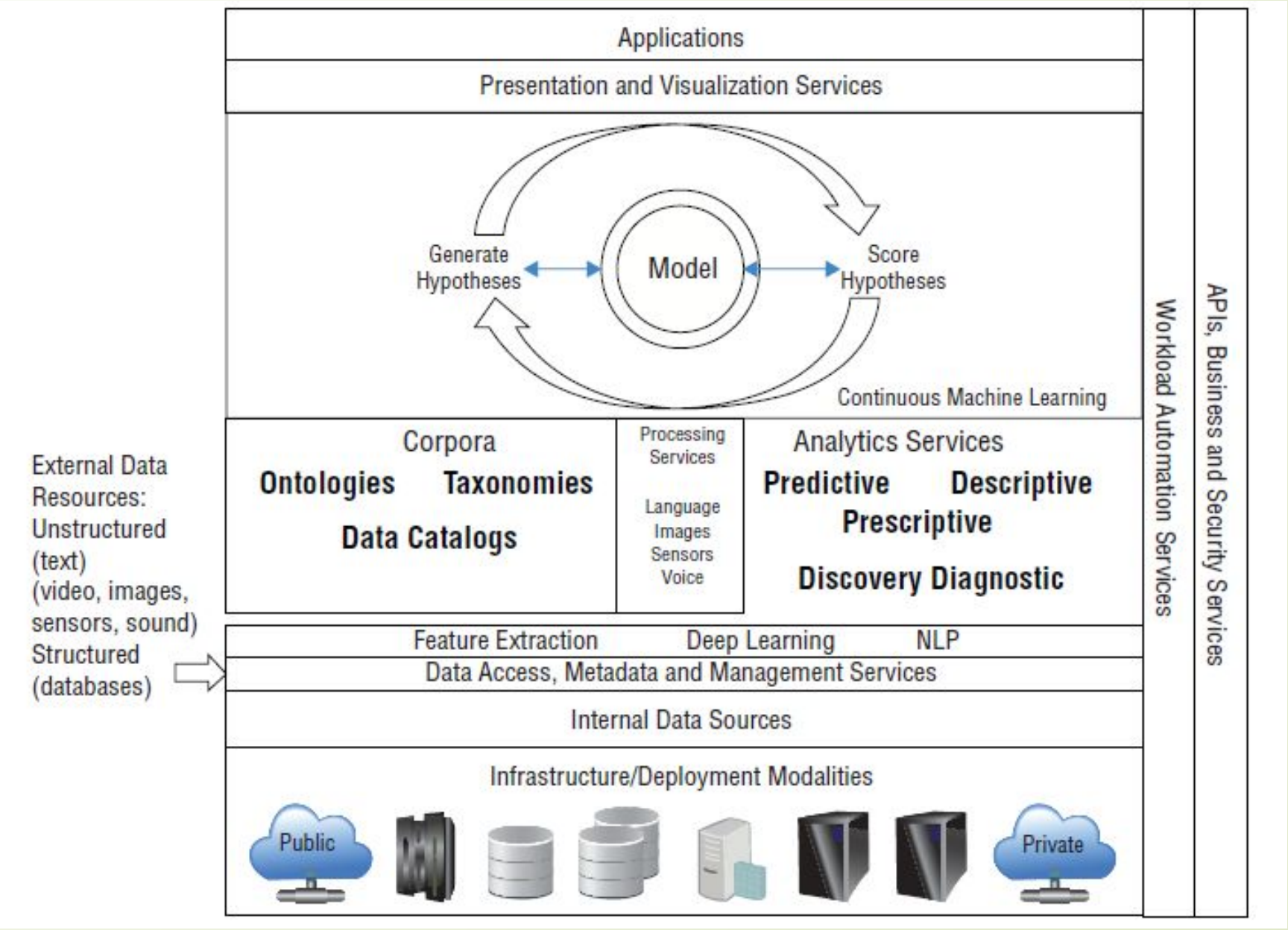
System 2—Controlled, Rule‐Centric, and Concentrated Effort

- Unlike System 1 thinking, System 2 thinking is a reasoning system based on a more deliberate process.
- thinking observes and tests assumptions and observations, instead of jumping to a conclusion based on what is assumed.
- This type of system requires that we collect a lot of data and build models that test System 1 intuition.
- thinking slows down the evaluation process and looks at the full context of the problem, collects more data and comes up with a solution.

Architecture for a cognitive system

- **Infrastructure and Deployment Modalities:** In a cognitive system it is critical to have a flexible and agile infrastructure to support applications that continue to grow over time.
- A highly parallelized and distributed environment, including compute and storage cloud services, must be supported.

- **Data Access, Metadata, and Management Services:**
- Because cognitive computing centers around data, it is not surprising that the sourcing, accessing, and management of data play a central role.
- Therefore, before adding and using that data, there has to be a range of underlying services.
- Data has to be vetted, cleansed, and monitored for accuracy.


Applications
Presentation and Visualization Services
Generate Hypotheses
Model
Score Hypotheses
Continuous Machine Learning
Corpora
Ontologies
Taxonomies
Data Catalogs
Processing Services
Language
Images
Sensors
Voice
Analytics Services
Predictive
Descriptive
Prescriptive
Discovery Diagnostic
External Data Resources:
Unstructured
(text)
(video, images, sensors, sound)
Structured
(databases)
Feature Extraction
Deep Learning
NLP
Data Access, Metadata and Management Services
Internal Data Sources
Infrastructure/Deployment Modalities
Public
Private
Workload Automation Services
APIs, Business and Security Services

Architecture for a cognitive system

- **The Corpus:** A *corpus* is the knowledge base of ingested data and is used to manage codified knowledge.
- The data required to establish the domain for the system is included in the corpus.
- In many cognitive systems, this data will primarily be text-based (documents, textbooks, patient notes, customer reports, and such).
- Other cognitive systems include many forms of unstructured and semi-structured data (such as videos, images, sensors, and sounds).

Architecture for a cognitive system

- **Data Analytics Services:**
- Data analytics services are the techniques used to gain an understanding of the data ingested and managed within the corpus.

- Use sophisticated algorithms to predict outcomes, discover patterns, or determine next best actions.

Architecture for a cognitive system

- **Continuous Machine Learning:**
- Machine learning is the technique that provides the capability for the data to learn without being explicitly programmed.
- Cognitive systems are not static.
- Rather, models are continuously updated based on new data, analysis, and
- interactions.
- A machine learning process has two key elements: hypothesis generation and hypothesis evaluation.

Architecture for a cognitive system

- **Presentation and Visualization Services:**
- Presentation services prepare results for output.
- Visualization services help to communicate results by providing a way to demonstrate the relationships between data.
- Patterns and relationships in data are easier to identify and understand when visualized with structure, color, and such.
- For example, a bar chart or pie chart is a visual representation of underlying data.
- Making data interactive through a visualization interface can help a cognitive system be more accessible and usable.

Cognitive computing system

- In a cognitive computing system, the *model* refers to the corpus and the set of assumptions and algorithms that generate and score hypotheses to answer questions, solve problems, or discover new insights.

- The initial model is developed by the designers of the system, but the cognitive system will update the model and use the model to answer questions or provide insights.

- The *corpus* is the body of knowledge that machine learning algorithms use to continuously update that model based on its experience, which may include user feedback.

Cognitive computing system

- Designing a cognitive system involves multiple steps.
  - It requires an understanding of the available data
  - The types of questions that need to be asked, and
  - The creation of a corpus comprehensive enough to support the generation of hypotheses about the domain based on observed facts.

- Therefore, a cognitive system is designed to create hypotheses from data, analyze alternative hypotheses, and determine the availability of supporting evidence to solve problems.

Cognitive computing system

- The design of a cognitive system needs to support the following differentiating characteristics:
- Access, manage, and analyze data in context.
- Generate and score multiple hypotheses based on the system's accumulated knowledge. A cognitive system may generate multiple possible solutions to every problem it solves and deliver answers and insights with associated confidence levels.
- The system continuously updates the model based on user interactions and new data. A cognitive system gets smarter over time in an automated way.

Building the Corpus

- A *corpus* is a machine-readable representation of the complete record of a particular domain or topic.
- In a cognitive computing application, the corpus or corpora represent the body of knowledge the system can use to answer questions, discover new patterns or relationships, and deliver new insights.
- Before the system is launched, however, a base corpus must be created and the data ingested.
- The contents of this base corpus constrain the types of problems that can be solved.
- The organization of data within the corpus has a significant impact on the efficiency of the system.

Building the Corpus

- Which internal and external data sources are needed for the specific domain areas and problems to be solved? Will external data sources be ingested in whole or in part?
- How can you optimize the organization of data for efficient search and analysis?
- How can you integrate data across multiple corpus?
- How can you ensure that the corpus is expanded to fill in knowledge gaps in your base corpus?
- How can you determine which data sources need to be updated and at what frequency?

Building the Corpus

- The choice of which sources to include in the initial corpus is critical.
- Sources ranging from medical journals to Wikipedia may now be efficiently imported in preparation for the launch of a cognitive system.
- In addition, it may be equally important to ingest information from videos, images, voice, and sensors.
- During the design phase of a cognitive system, a key consideration is whether to construct a taxonomy or ontology if none already exist for the domain.
- A data catalog, which includes metadata such as semantic information or pointers, may be used to manage the underlying data more efficiently.

Bringing Data into the Cognitive System

- Unlike many traditional systems, the data that is ingested into the corpus is not static.
- As you develop the model in the cognitive system, you refine the corpus.
- Therefore, you will continuously add to the data sources, transform those data sources, and refine and cleanse those sources based on the model development and continuous learning.

- The important thing to remember at the design stage is that with experience, a cognitive computing system should identify and request additional data from external sources when that data will enable it to make better decisions or recommendations.

Cognitive modelling

- A model is a simplified (usually formal) representation of reality
- **Cognitive modelling**
- Create formal (e.g. mathematical, algorithmic, symbolic) representations of cognitive processes
- Then, use these models to predict or explain behavior associated with those cognitive processes
- Computational modeling: the models usually implemented as computer programs with output corresponding to the predicted behavior
- Example of cognitive process: categorizing objects into groups.
- Modeling: use decision trees, or neural networks, or rules, etc.