BOOZ ALLEN HAMILTON INTERNAL

DEMYSTIFYING AI

What is Data Science, Machine Learning, and Artificial Intelligence?

JULY 2020

LET'S START WITH DATA SCIENCE

> Data science is a "concept to unify statistics, data analysis, machine learning and their related methods" in order to "understand and analyze actual phenomena" with data.

> Data science is a multidisciplinary blend of data inference, algorithm development, and technology in order to solve analytically complex problems.

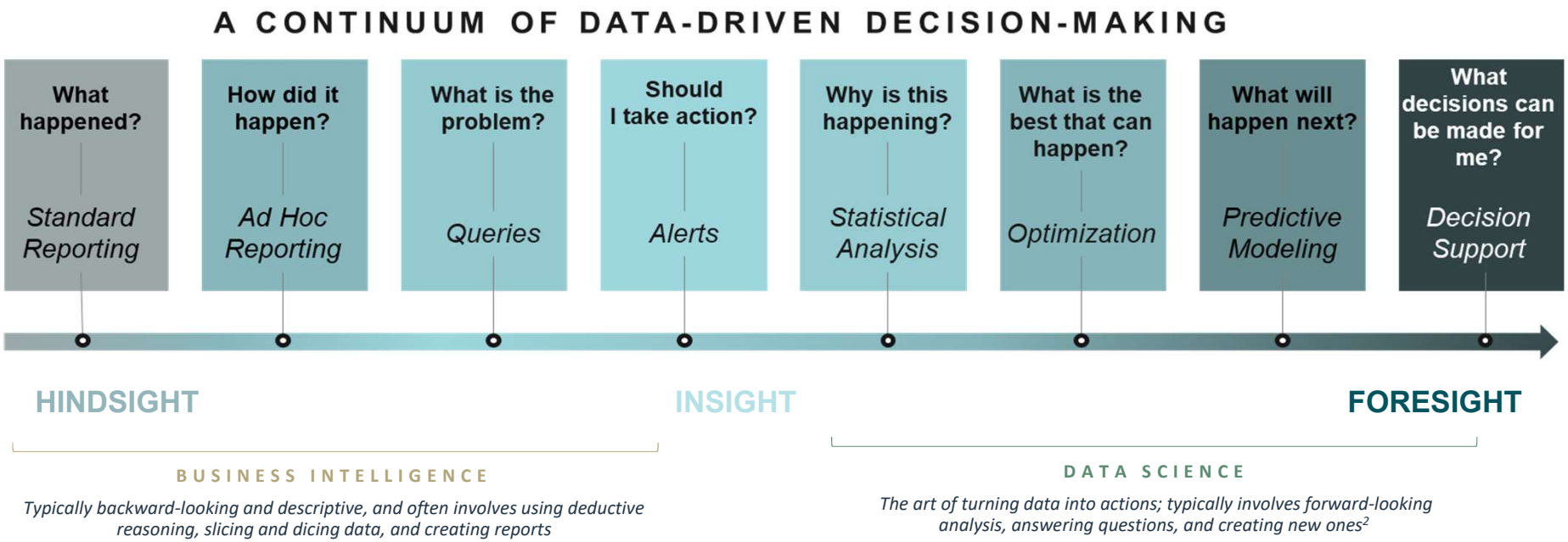
> Data science is the field of study that combines domain expertise, programming skills, and knowledge of math and statistics to extract meaningful insights from data.

*Data science is the **multi-disciplinary field of inquiry** in which **quantitative** and **analytical** approaches, processes, and systems are developed and used to **extract knowledge and insights** from **increasingly large** and/or complex sets of data.*

- NIH Strategic Plan for Data Science

ANALYTICS: A CONTINUUM OF QUESTIONS

Data becomes memorable when we ask deliberate questions



DATA SCIENCE FURTHER DEFINED

Data science is the art of turning data into actions.

DATA SCIENCE IS…

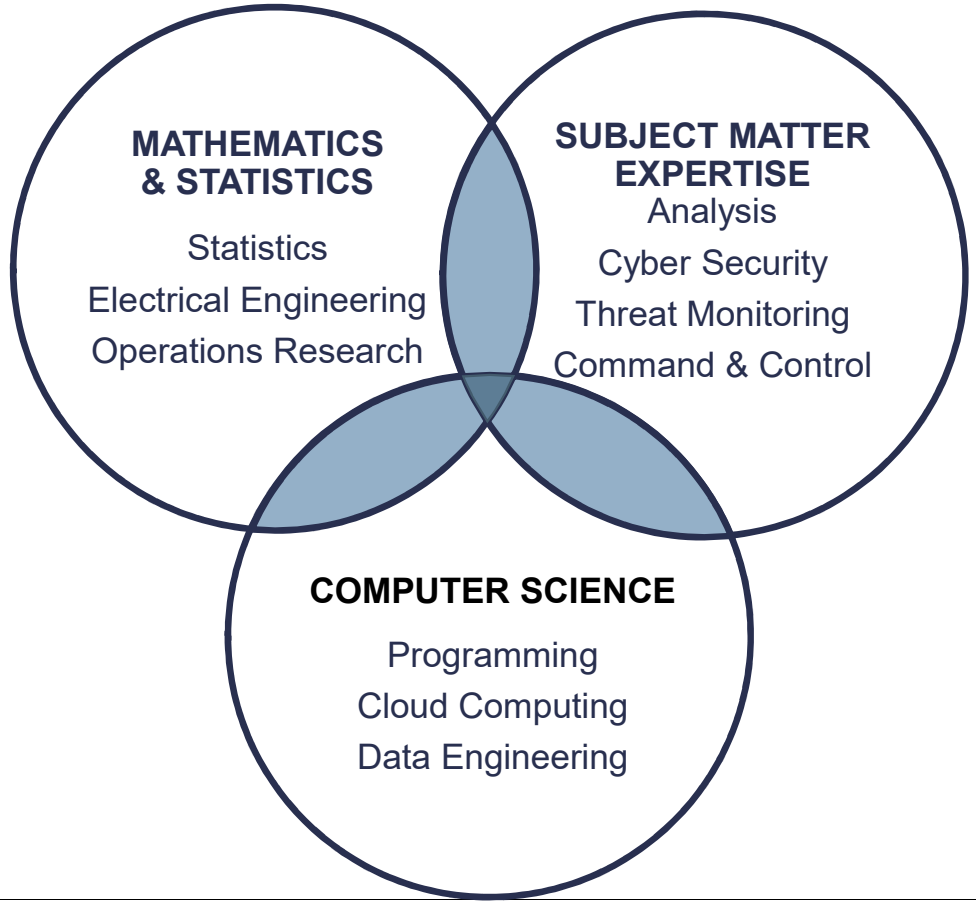
- **Standardizing** units, addressing **missing values**, and validating **completeness** of data
- The practice of **obtaining, exploring, modeling, and interpreting** data
- Identifying **hidden patterns** and relationships for **future prediction**
- A way of **problem solving** and **thinking** that can be used in **everyday life**

DATA SCIENCE IS NOT…

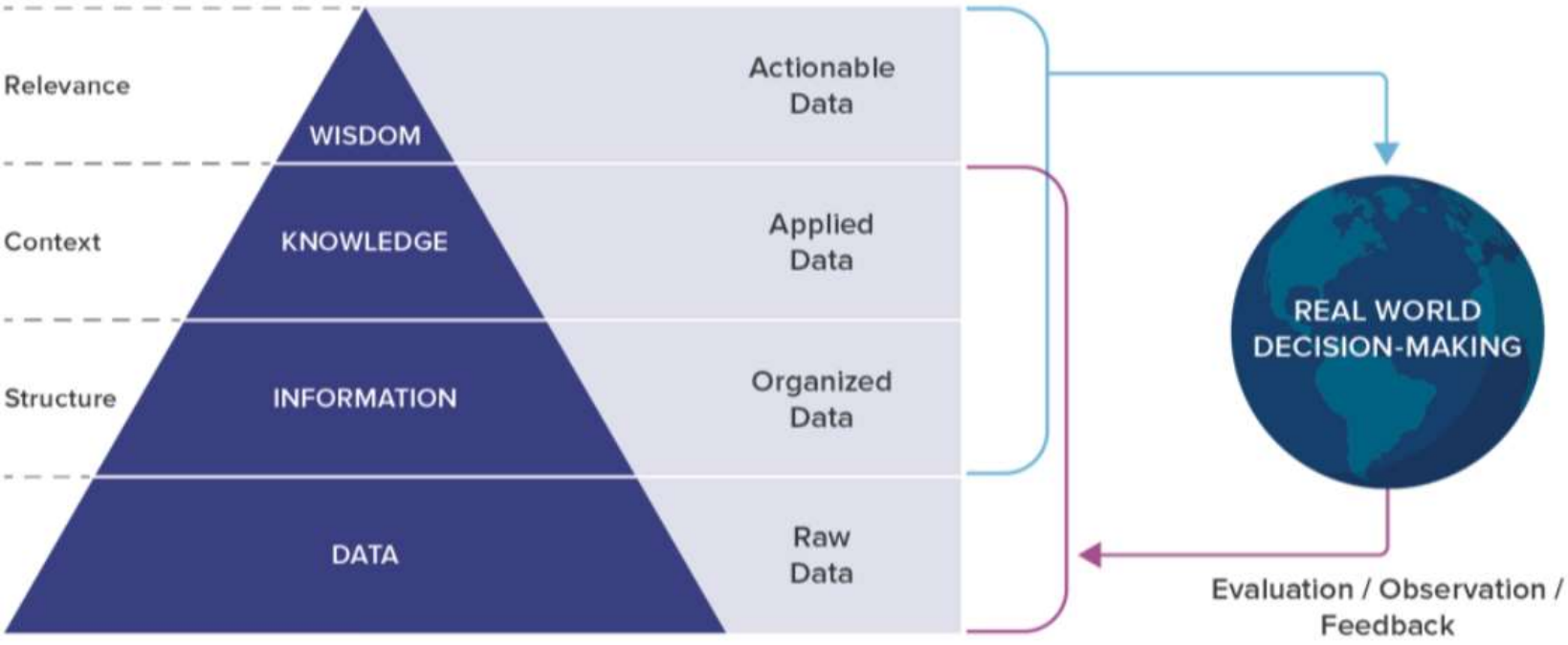
- **New**
- **Only** machine learning
- Methods dependent on **costly** and **complicated technology**
- An attempt to **replace human intelligence and intuition**

DATA SCIENCE NEEDS EXPERTISE

Data Science is the **multi-disciplinary field** of inquiry…

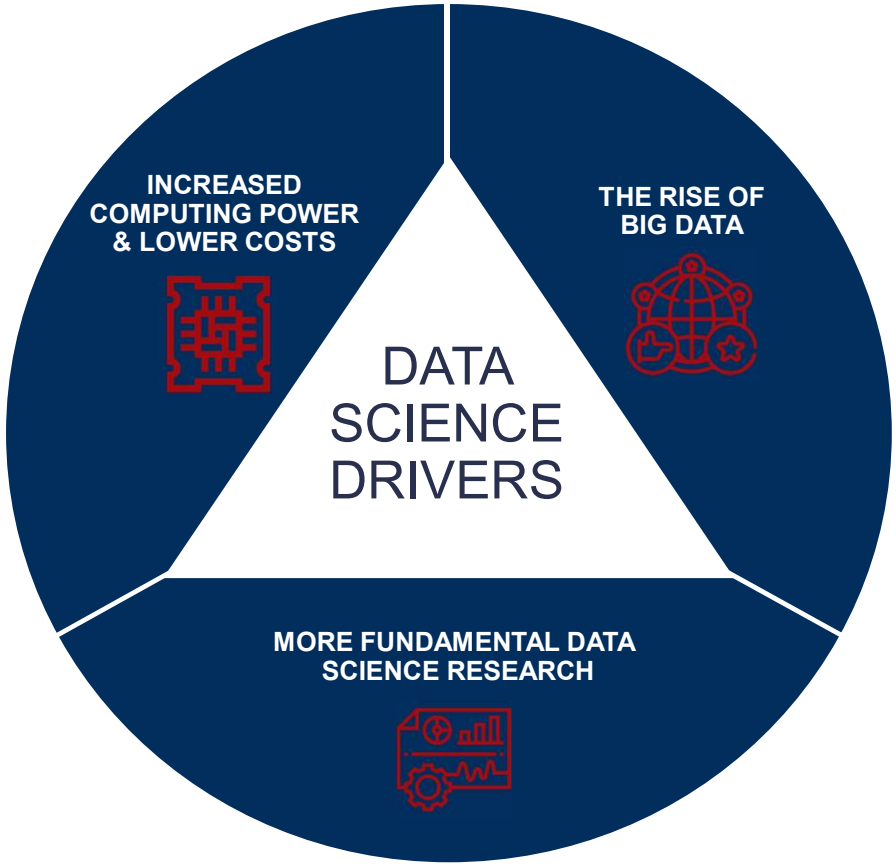


DATA TO WISDOM DIAGRAM- DATA SCIENCE IN ACTION



WHY NOW?

…**more sophisticated computer hardware** and software solutions became necessary



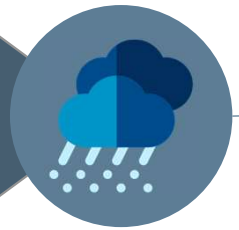
…**data is growing exponentially**

…and investments in **data science research** became a priority

DATA SCIENCE IS EVERYWHERE:

CHECK THE WEATHER

You check the weather on your iPhone's weather app. Weather forecasts are developed using predictive analytics on historical data as well as real-time data retrieved from satellites



The **National Oceanic and Atmospheric Administration (NOAA)** uses data collected since the 1800's to identify time series trends in global temperatures. These reports help inform climate change projections, and have impact on businesses such as airlines and shipping companies.

BUY A CUP OF COFFEE

You head to a café to buy a cup of coffee. Retail chains use analytics to determine which products consumers will buy, preemptively assign staff to support high-traffic time periods, and ship supplies.

Starbucks uses geospatial data showing population density, consumer demographics, traffic patterns, and public transportation hubs to determine the optimal locations for new stores.

UPDATE YOUR SOCIAL MEDIA

You upload photos from a vacation you took to your Facebook profile. Facebook and other social media platforms use image recognition to recognize patters in the faces of individuals featured in photos.

U.S. Customs and Border Protection (CBP) is piloting facial recognition software at airports. Under this program, photos of visa-holders taken before their flight are compared against their passport photo using facial geometry scan.

ANALYTICS: A CONTINUUM OF QUESTIONS

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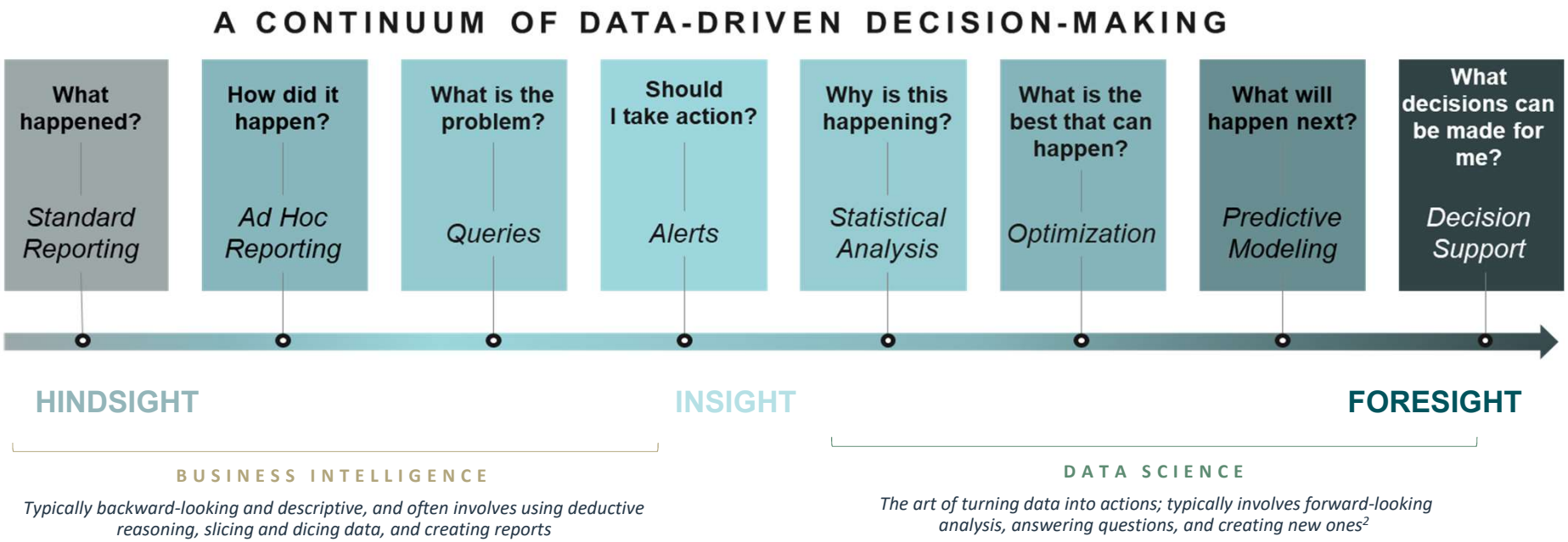


AI AS AN OUTCOME

the ability of machines to perform tasks that typically require human-level intelligence

	perception	notification	suggestion	automation	prediction	prevention	situational awareness
	Describe and understand surroundings	*Provide alerts, reminders, etc.*	*Build on past preferences and modify over time*	*Follow routine steps to accomplish an objective*	*Forecast the likelihood of future events based on past events*	*Apply cognitive reckoning to identify potential threats*	*Summarize the current, and likely future, environment*
Key Questions Answered	What's happening now?	What do I need to know?	What do you recommend?	What should I do?	What can I expect to happen?	What can/should I avoid?	What do I need to do now?

THE CURRENT ROLE OF AI:	NOT THE ROLE OF AI:
Curator — Recommender — Orchestrator	Critical Thinker — Decision Maker

Source: Constellation Research

HISTORY OF AI

Artificial Intelligence *has long captured our imagination, but it has also existed as an area of serious academic research for more than 60 years*

AI Events

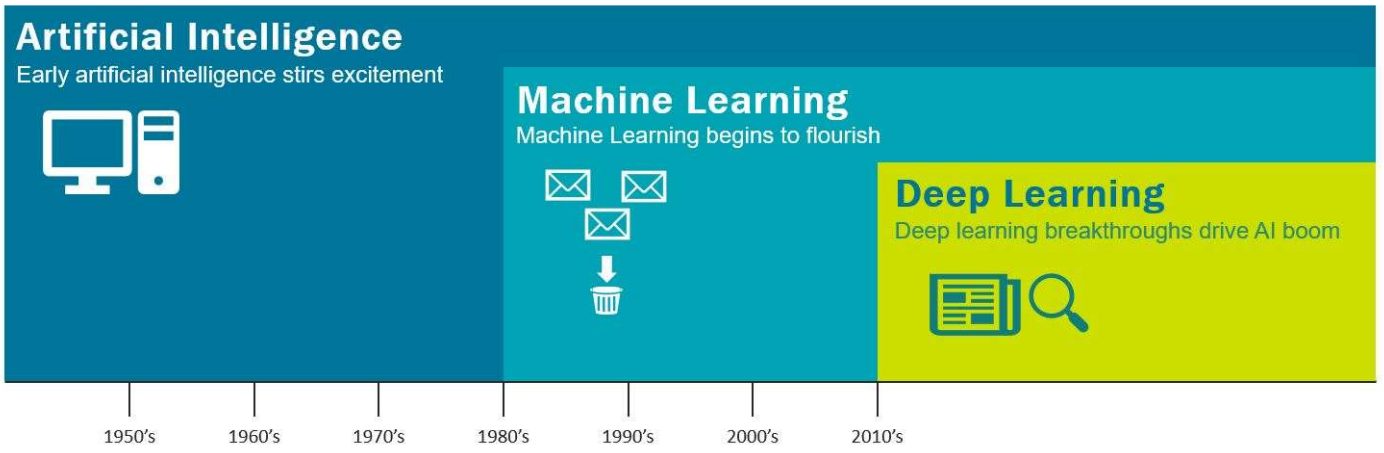
1950's
AI coined by American Computer Scientist at Dartmouth College in 1956.

1970's: AI Winter
Reduced funding and interest in AI, fueled by pessimism from slow advances.

1980's – 1990's
Machine Learning shifts from a knowledge-driven approach to a data-driven approach largely thanks to the internet revolution.

2010's
Deep Learning becomes possible thanks to recent advances in Deep Learning Research, the explosion of available data, and the increased computing power from new hardware like GPU chips.

Machine Learning/ AI Timeline



What is a GPU?
A graphics processing unit or (GPU) is designed to handle lots of parallel computations and have large memory bandwidth, which leads to higher efficiency.

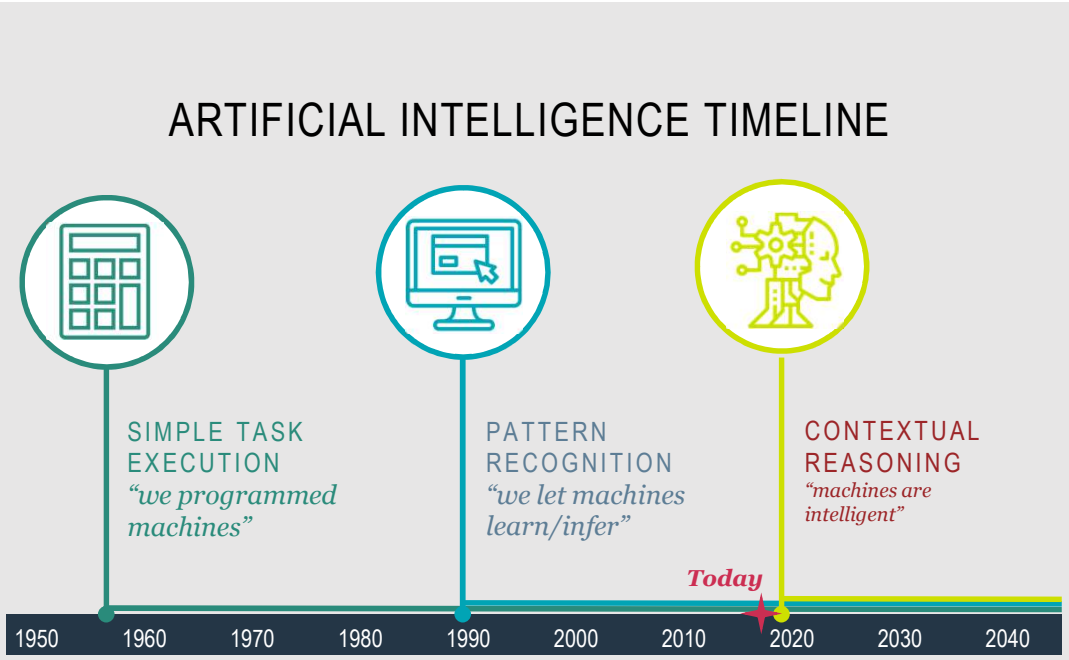
Source: NVIDIA

AN OVERVIEW OF ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) *is the ability of machines to perform tasks that typically require human-level intelligence; AI has existed since the* ***1950s****, but progress has recently accelerated*

AI DEVELOPMENT ACCELERANTS
(2010 - Present)

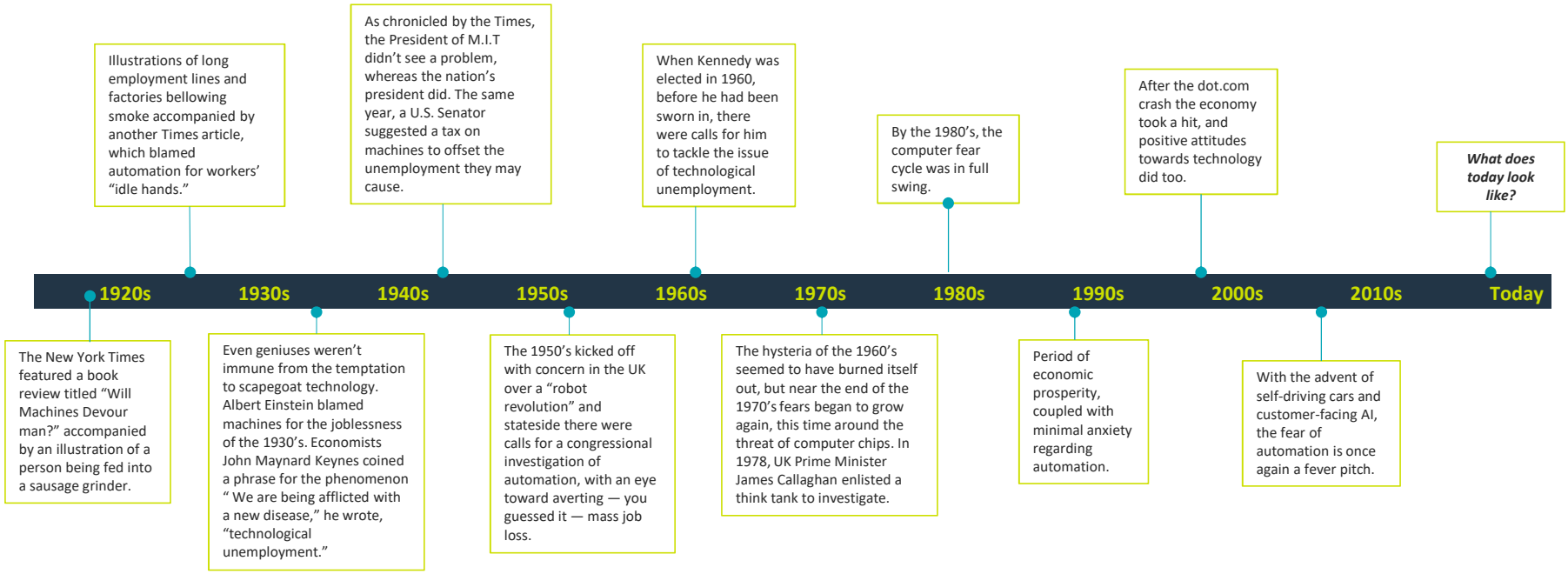
- **Vast amounts of available data**
- **Growth in Computing Power**
- **Advances in Deep Learning Research**



Source: Booz Allen analysis, Michael Copeland for NVIDIA

HISTORICAL LOOK AT TECHNOLOGY ADOPTION

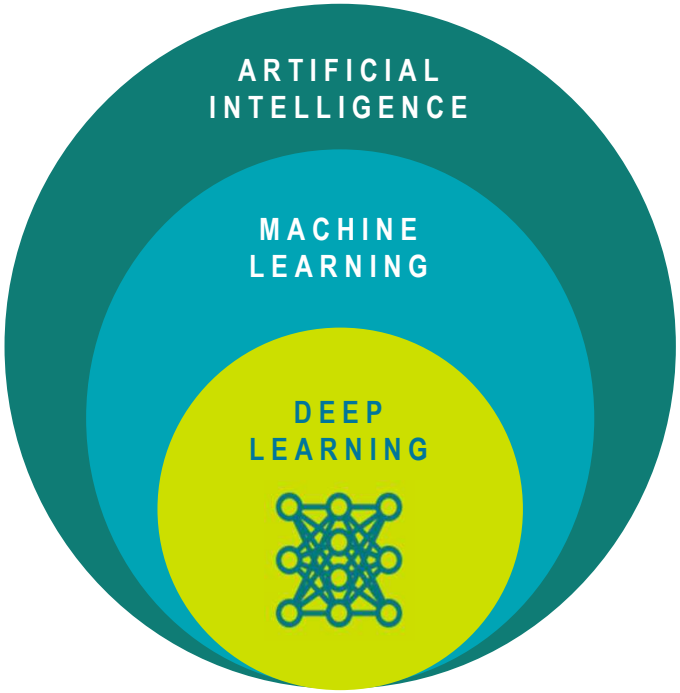
*Historically, technology advancements have always generated a spectrum of emotions. We need to **dispel fears**, in order to adopt **AI and realize its benefits***



Source: Louis Anslow, Timeline.com

AI, MACHINE LEARNING, AND DEEP LEARNING

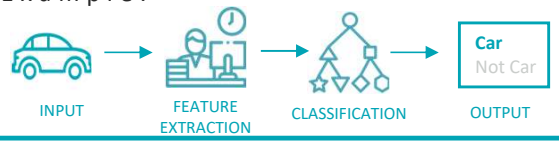
***AI** is often conflated with machine learning and deep learning; **deep learning** is a sub-field of **machine learning,** both of which are techniques for achieving AI*



ARTIFICIAL INTELLIGENCE: any technique which enables computers to mimic human behavior

MACHINE LEARNING: an approach to achieve AI that uses statistical methods to enable machines to improve with experiences/learning

Example:



DEEP LEARNING: subset of ML techniques for implementing scalable ML and enabling computation of multi-layer neural networks

Example:

Source: NVIDIA

HOW DO PEOPLE LEARN?

Learning from sources of knowledge happens in two main ways:

DIRECT	INDIRECT
Facts and specific details that you retain in various methods... • Washington DC is the capital of the US • More than half of the coastline of the entire United States is in Alaska	*Experiences you must have on your own to retain...* • Balancing on a bicycle • Pronunciation of a foreign language

Moving between deductive and inductive reasoning during the learning cycle is a learning technique used by humans and machines

UMD Cognitive Neurosciences, Booz Allen analysis
There are other forms of learning, this is a summary for context setting

HOW DO MACHINES LEARN?

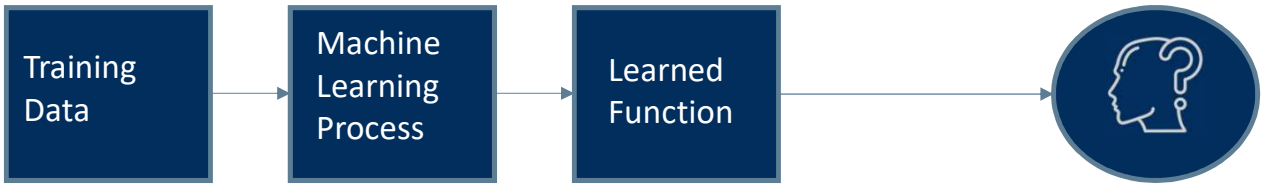
Five approaches to structuring machine learning algorithms

	"TRIBE"	ORIGINS	MOTIVATION	TECHNICAL APPROACH
1. Fill in gaps in existing knowledge	SYMBOLISTS	Logic, Philosophy	Automate the scientific method	Inverse Deduction
2. Emulate the human brain	CONNECTIONISTS	Neuroscience	Reverse engineer the human brain via math model of neurons	Backpropagation
3. Simulate evolution over generations	EVOLUTIONARIES	Evolutionary Biology	Replicate the evolution of the human brain over generations	Genetic Programming
4. Systematically reduce uncertainty	BAYESIANS	Statistics	Test hypotheses to determine the certainty of knowledge	Probabilistic Inference
5. Find similarities between old and new	ANALOGIZERS	Psychology	Use previous problems / solutions and extrapolate into new context	Kernel Machines

Pedro Domingos, Booz Allen analysis

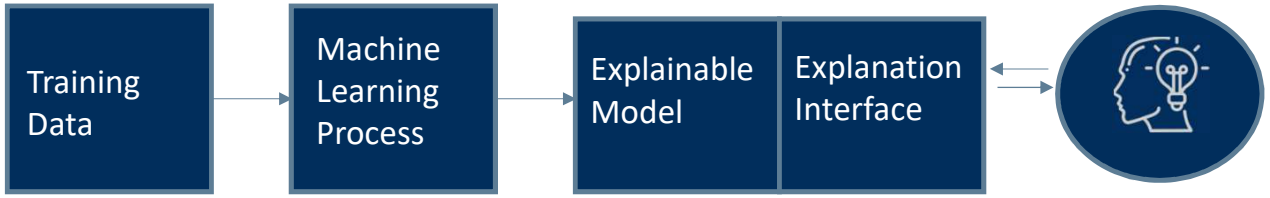
MAKING AI EXPLAINABLE

Unexplainable AI



- **Why did you do that?**
- **Why not something else**
- **When do you fail?**
- **When can I trust you?**
- **How do I correct an error?**

Explainable AI

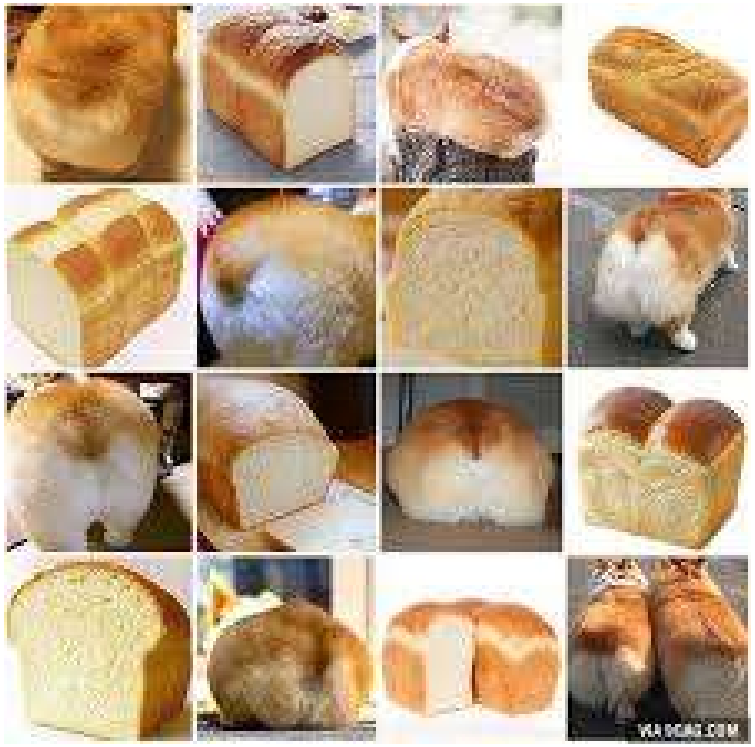


- **I understand why**
- **I understand why not**
- **I know when you succeed**
- **I know when you fail**
- **I know why you erred**

WHAT AI CANNOT DO

⊗ Tell the difference between fried chicken and a goldendoodle

⊗ Tell the difference between corgi butt and a loaf of bread



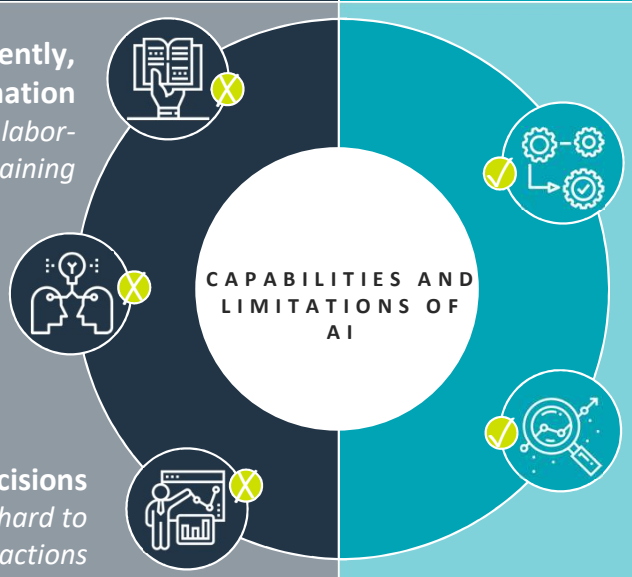
TODAY'S AI IS IMPRESSIVE, BUT FALLS FAR SHORT OF SCIENCE FICTION

WHAT AI CANNOT DO

Learn independently, with limited information
AI requires massive volumes of data and labor-intensive training

Apply knowledge to multiple domains
Algorithms operate in relative isolation and cannot generalize

Explain how it makes decisions
AI's complexity can make it hard to explain AI systems' actions



WHAT AI CAN DO

Perform simple, routine tasks which previously required human intelligence
AI can find objects in images, transcribe text, and perform other tasks humans used to do

Analyze and act on the analysis of massive volumes of digital data in real-time
AI can ingest and analyze huge amounts of information and respond in real-time

LIMITATIONS | *Organizations using AI cannot…*

- Relieve the workforce of tasks that require context, judgment, creativity, or responsiveness to change
- Replace an entire job/role with an AI system
- Create or update AI systems without lots of data

BENEFITS | *Organizations using AI can…*

- Relieve workers of rote, repetitive tasks
- Improve organizational accuracy at high-volume tasks
- Deliver more responsive, personalized, and dynamic products, tools, and services to customers and staff

Source: Booz Allen analysis

KEY RISKS WITH AI TODAY

*Previously, the **technological challenges impeded AI's adoption**, while many of today's challenges stem from **human concern around the impacts***

	KEY CHALLENGES	SOLUTION
ADOPTION RISKS	Lack of understanding of what AI can or can't do causing unnecessary fear in people	Initiate comprehensive educational campaigns to demystify AI
	Fear and lack of preparedness by all of the workforce to spend more time using critical thinking skills and less time on rote tasks	Widespread workforce reskilling programs that prepare all employees to operate in their modified roles
TECHNOLOGICAL RISKS	The rise in adversarial AI and "deepfakes"	Require robust, transparent, and explainable AI solutions with clear audit trails
	Mounting uncertainty over the future regulatory landscape	Ensure measured, monitored roll outs of AI solutions with clearly documented processes
ETHICAL RISKS	AI's ability to amplify bias in datasets in a way that inflicts harm among marginalized people	Prioritize ethics early in the design and development process
	Lack of clarity around how to ensure AI solutions are built and used in an ethical manner	Require involvement from leadership and key stakeholders throughout a solution's development (e.g., Board Members)

Source: Booz Allen analysis

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AI SPENDING AND NATIONAL STRATEGIES

We must continue to invest *to maintain our advantage as the international arena becomes more competitive*

UNITED STATES

Current leader in both spending and technical advancement, but increasingly narrow lead

- $2 billion investment into DARPA's AI Next fund
- $2.2 billion into Artificial Intelligence Initiative Act to fund AI research and create a national AI strategy
- Executive Order issued by President Trump in February 2019 on "Maintaining American Leadership in Artificial Intelligence"

UNITED KINGDOM

One of the top research engines in the world, with organizations like DeepMind and Oxford's Future of Humanity Institute. Positioning to be the leader in ethics, policy, and global regulatory frameworks

- AI Investment deal worth £1 billion
- $30 million to build AI Tech Incubators
- 1,000 Government backed AI PhDs

RUSSIA

Russia declared AI to be a key geopolitical asset and is increasing investments accordingly. Focused primarily on AI in military applications

- Perceived to lag behind advances in the U.S and China, with primary interest in using AI to offset asymmetric military capabilities
- Strong focus on leveraging AI for upgrading existing weapons platforms

CHINA

Grand ambitions to leverage AI for geopolitical positioning; on par with the U.S. in some technical areas, with significant planned investments

- $30 billion dollar investment into a state owned VC firm to fund innovation
- Part of the Chinese investment includes $2 billion for an AI research park in Beijing
- Comprehensive national plan to become a world leader in AI and create an industry worth $150 billion

Source: Booz Allen analysis

PROBLEM 1ST VS. AI 2ND

IS AI EVER OVERKILL?

A GOOD IDEA?

It's a Good Idea, but Too Soon

Generalized intelligence that's indistinguishable from humans

Humanoid robotics

Intelligent language generation

It's an Excellent Choice!

Identifying people and objects in images or video

Translating speech or text from one language to another

Detecting fraud and other anomalous behavior

Autonomous vehicles

GOLDILOCKS ZONE FOR AI

It's *Probably* Excessive

Searching across multiple databases

Creating monthly financial dashboards

Automating that Excel spreadsheet Jennifer made before she left on TDY

WHAT AI CAN DO…

AI Can…. ☑ **Automate simple, rules-based tasks** ☑ **Find and act on patterns in data**

Examples of AI's Capabilities

Everyday human stuff

- Recognize objects in images
- Navigate a map of the London Underground
- Transcribe speech better than professional transcribers
- Translate between languages
- Speak
- Find the text in a paragraph that answers your question
- Recognize emotions in images of faces
- Recognize emotions in speech

Security & Justice

- Spot burglars in your home
- Write its own encryption language
- Predict social unrest 5 days before it happens
- Unscramble pixelated images
- Detect malware
- Verify your identity
- Anticipate fraudulent payment attacks before they happen

Science & Medicine

- Discover new uses for existing drugs
- Spot cancer in tissue slides better than human epidemiologists
- Predict hypoglycemic events in diabetics 3 hrs. in advance
- Identify diabetic retinopathy from photos
- Analyze the genetic code of DNA to detect genomic conditions
- Detect a range of conditions from images
- Solve the quantum state of many particles at once

Travel

- Drive on a highway
- Fly a drone
- Predict parking difficulty by area

Agriculture

- Detect crop disease
- Spray pesticide with pinpoint accuracy
- Predict crop yields
- Sort cucumbers

COMMON APPLICATIONS: AI

INPUTS	BUSINESS QUESTION	AI TASK	HEALTHCARE	GOV SERVICES	GEOSPATIAL
Text Data, Images, Video, Audio	**What <u>type</u> of thing is "it"?**	**CLASSIFICATION**	Image Classification	Cyber Security	Full Motion Video analysis
	To what <u>extent</u> is "it" present?	**SEGMENTATION**	Tumor Size/Shape Analysis	Route Planning	Building + Road Detection
	What is the likely outcome?	**PREDICTION**	Survivability Prediction	Preventative Maintenance	Disaster Relief
	What will satisfy the objective?	**RECOMMENDATIONS**	Therapy Recommendation	Recommendation Engine	Infrastructure Planning
	What is the speaker saying?	**NATURAL LANGUAGE PROCESSING**	Expert diagnosis	Real time Language Translation	Verbal Scene Description

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AI OPPORTUNITIES

AI CAPABILITY		TECHNIQUE	USE CASES	EXAMPLE APPLICATIONS
Automation *Mature/deployed*		**Robotic Process Automation (RPA)**	• Routine task automation • Business process re-engineering/improvement	*A software "bot" transposes data from patient records into an online database*
Pattern recognition & Response *Maturing/Pilots and some scaled deployment*		**Machine Learning Software and Platforms**	• Complex task automation • Real-time data analysis and response	*Software scans patient data to identify new indicators of disease*
		Computer Vision	• Image/video tagging • Real-time video analysis • Sentiment analysis • Facial recognition • Scene analysis • Biometrics	*A x-ray machine automatically identifies anomalies in patient scans*
		Natural Language Processing and Generation	• Virtual assistants • Chatbots • Machine translation • Speech recognition • Language detection • Sentiment analysis • Text analysis • Report generation • Insight summarization	*Virtual assistants engage with patients to ask about symptoms and route them to the correct care provider*
		Autonomous Systems and Robotics	• Co-bots • Smart manufacturing • Smart logistics • Companion robots • Partially autonomous vehicles/unmanned systems	*A robotic surgeon performs surgery, automatically responding to changes in a patient's condition in real time*
Contextual Reasoning *In the lab*		**Semantic or "Cognitive" computing**	• Execution of tasks requiring context, judgment • Fully autonomous vehicles	*A vehicle drives down a crowded city road, responding to bad weather, unexpected pedestrian behavior, and obstacles in traffic*

QUESTIONS?