Generative and Agentic AI in Practice

DS 246 (1:2)

Generative and Agentic AI in Practice: DS 246 (1:2)

Prof. Sashikumaar Ganesan

Course Schedule*

Phase 1: Foundations (Weeks 1-8, leading to Midterm)

- Week 1 (Aug 6): Practical Generative AI Foundations
  - Lecture: How to make your organization AI-first
- **Assignment**
  - Industry analysis - identify 3 GenAI use cases in your chosen domain with implementation feasibility assessment

Link to join MS-Teams

*The complete course schedule is available in MS Teams

Generative and Agentic AI in Practice: DS 246 (1:2)

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Tools & Technologies Covered Throughout Course

- PyTorch, Hugging Face, Weights and Biases, LangChain, LangGraph, MCP, A2A, ADK, Agents SDK, TensorFlow, Keras, Large Multi Modal Models, FastMCP, FastAPI, ClearML, OpenAI LLM Evals, RAGAS
- Assessment Structure
  - Weekly Assignments: 40%
  - Midterm Exam: 20%
  - Group Capstone Project: 40%

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The Plan

AI, ML & DS Overview

Introduction To GenAI

Not Only AI

Career Paths

AI, ML, Data Science

What, Why, Where and How?

Disclaimer:

- Only working definitions
- No clear agreeable-to-all definitions and subject classification
- No one right answer, and there are no 100% wrong answers
- Everything depends on the context

Machine Learning (ML)

Machine Learning

Ability of a system to make predictions without being explicitly programmed.

- Developing and implementing algorithms to receive data and process it to
  - analyze and learn patterns, insights, relations, etc
  - make prediction sand/or recommendations

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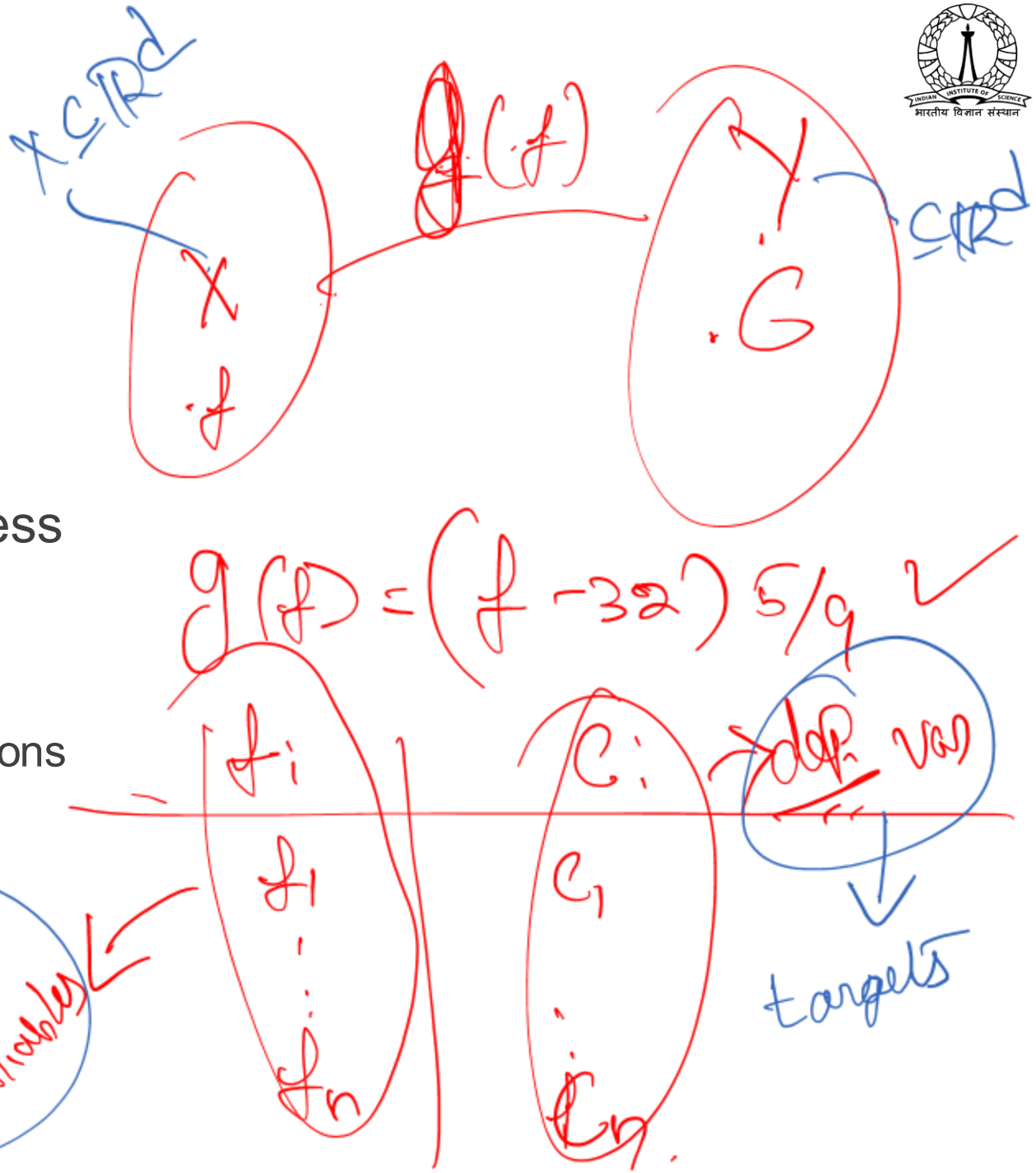
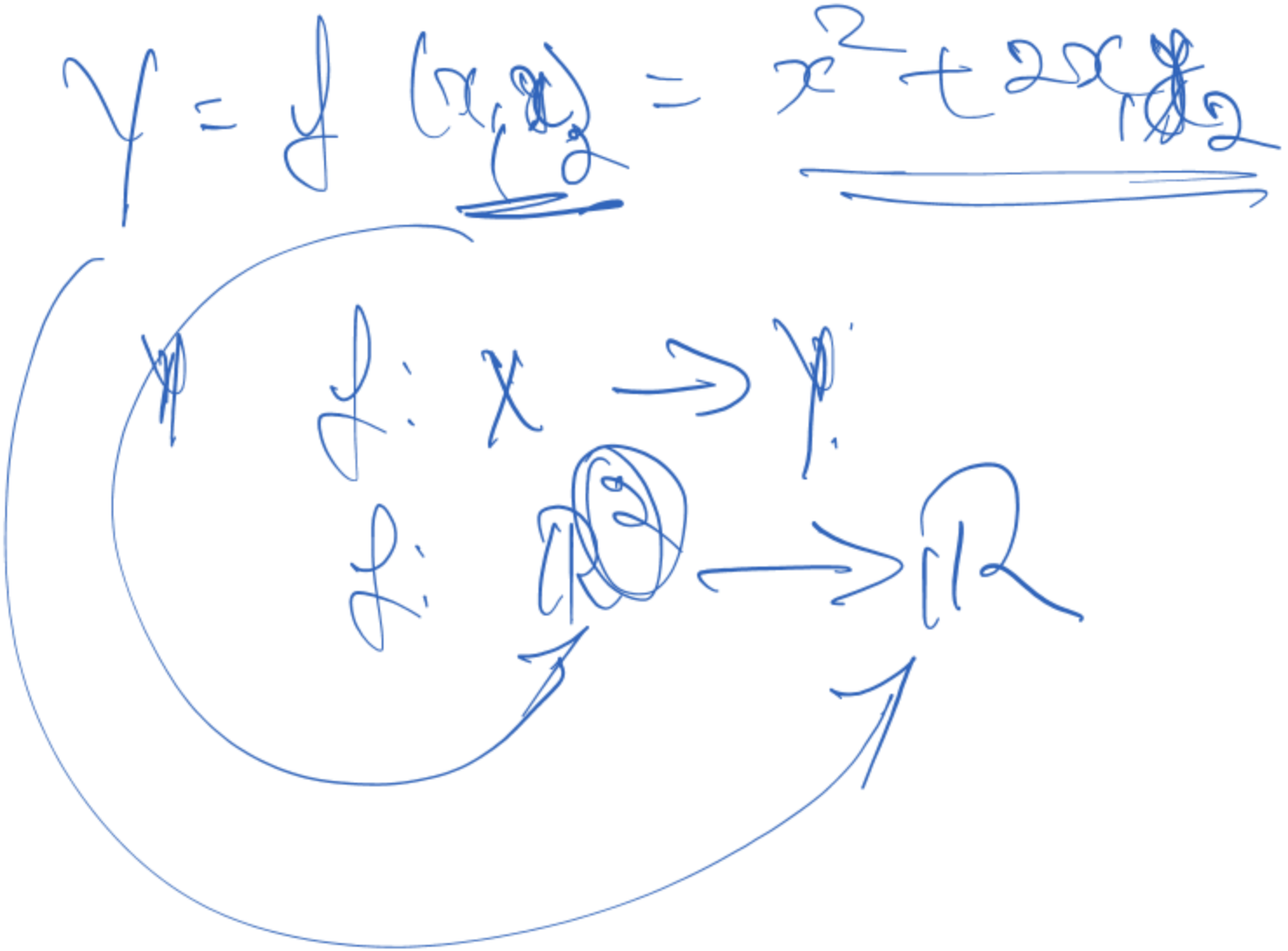
How to find this relation?

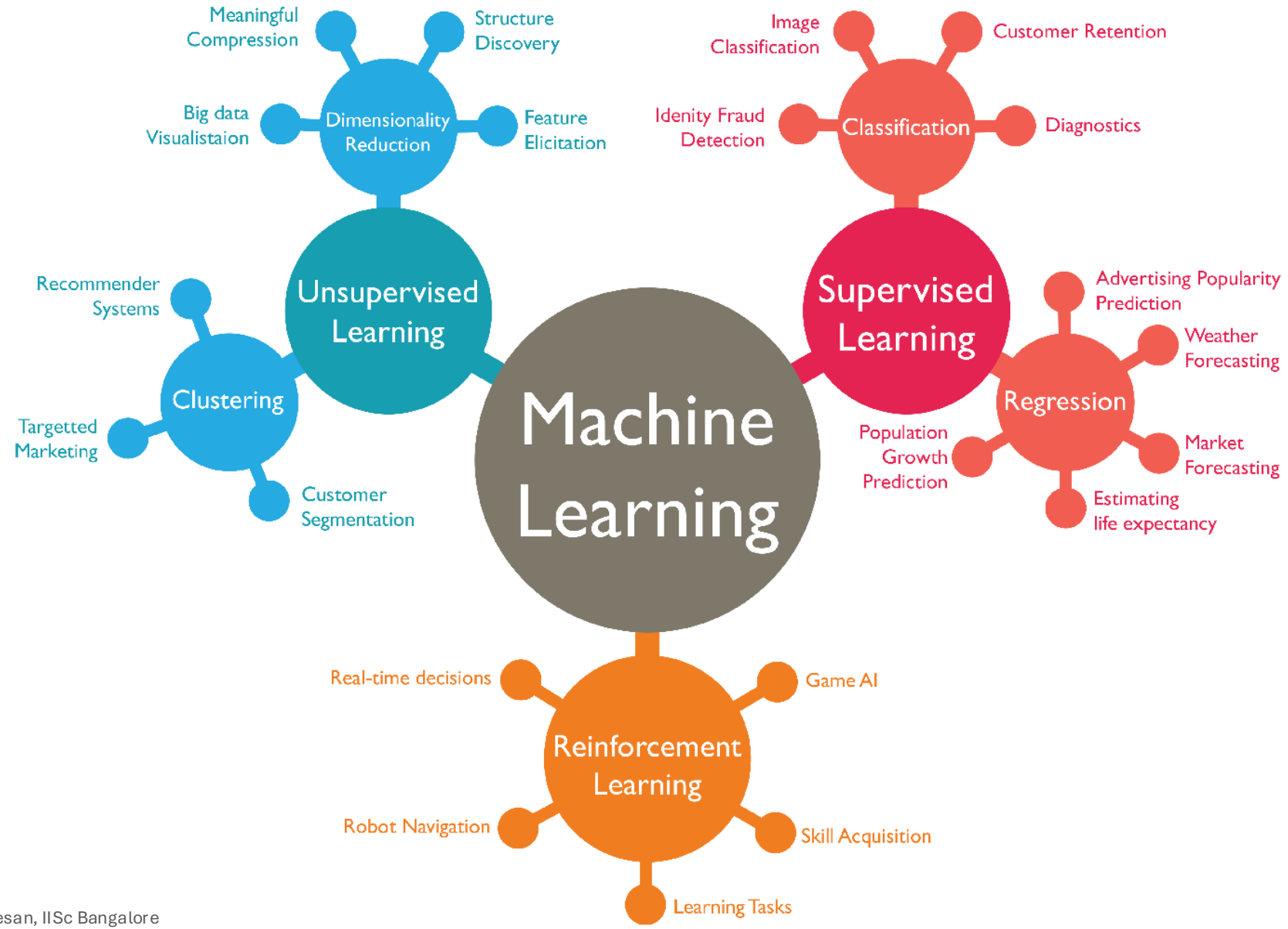
=> ML Training



Machine Learning



Machine Learning



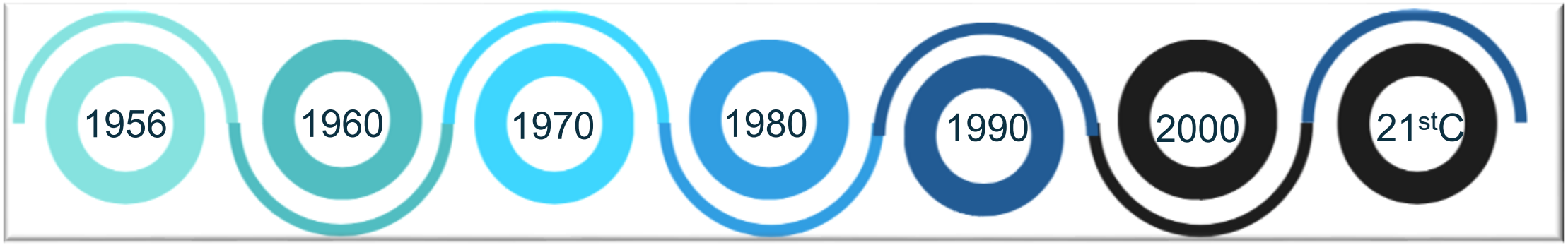
Artificial Intelligence (AI)

AI: Historical Overview

1956: In 20yrs, AI can do whatever a human can do

Revived by expert systems

More mathematical models, verifiable results



Field of AI was born

AI-winter

LISP system collapse. Longer AI-winter

DS revived AI:
Advances in ML, supercomputers, improved algorithmic, data access, open-source tools, cloud computing, etc

Modern backpropagation [edit]

Modern backpropagation was first published by Seppo Linnainmaa as "reverse mode of automatic differentiation" (1970)[27] for discrete connected networks of nested differentiable functions.[28][29][30]

In 1982, Paul Werbos applied backpropagation to MLPs in the way that has become standard.[31][32] Werbos described how he developed backpropagation in an interview. In 1971, during his PhD work, he developed backpropagation to mathematicize Freud's "flow of psychic energy". He faced repeated difficulty in publishing the work, only managing in 1981.[33] He also claimed that "the first practical application of back-propagation was for estimating a dynamic model to predict nationalism and social communications in 1974" by him.[34]

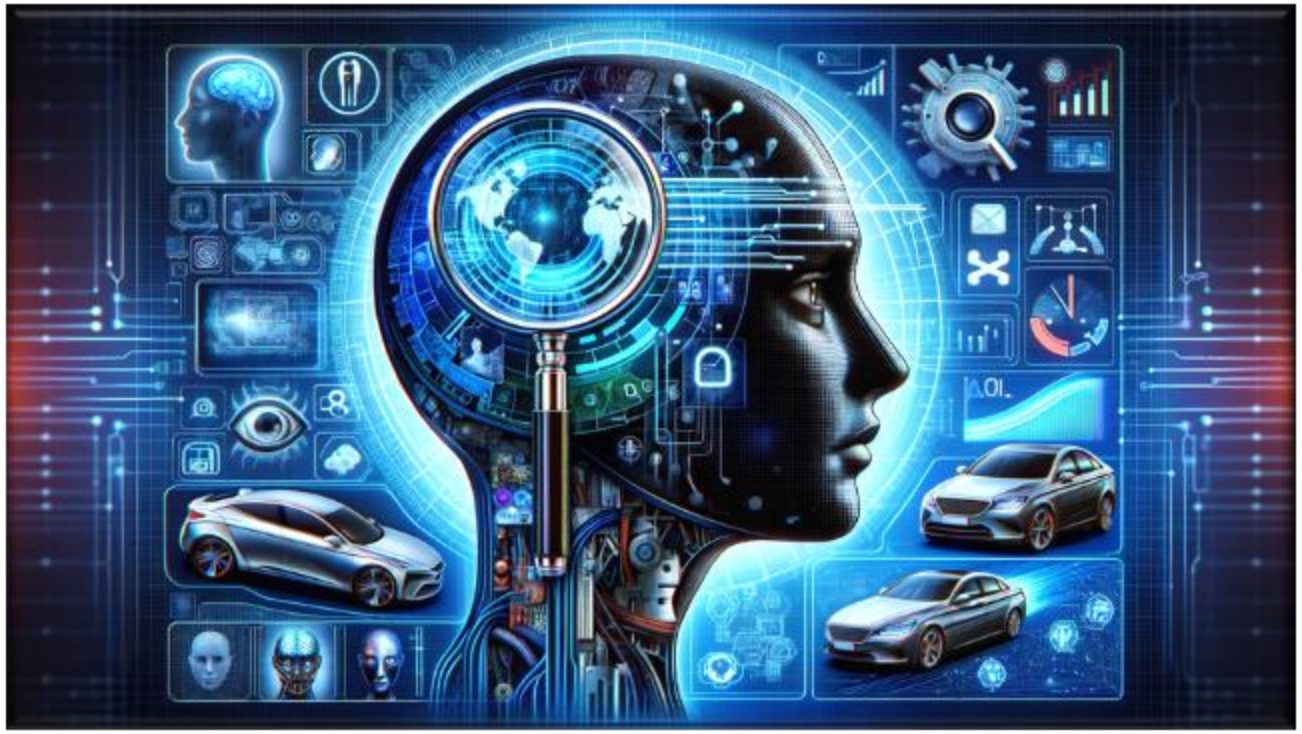
Around 1982,[33]:376 David E. Rumelhart independently developed[35]:252 backpropagation and taught the algorithm to others in his research circle. He did not cite previous work as he was unaware of them. He published the algorithm first in a 1985 paper, then in a 1986 Nature paper an experimental analysis of the technique.[36] These papers became highly cited, contributed to the popularization of backpropagation, and coincided with the resurging research interest in neural networks during the 1980s.[35][37][38]

In 1985, the method was also described by David Parker.[39][40] Yann LeCun proposed an alternative form of backpropagation for neural networks in his PhD thesis in 1987.[41]

Key milestones include the Turing Test (1950), expert systems (1970s), and deep learning breakthroughs (2010s), Attention Is All You Need (2017)

Artificial Intelligence (AI)

AI is a field in interdisciplinary science that focuses on creating systems/agents capable of performing tasks that typically require human intelligence.



Artificial Intelligence (AI)

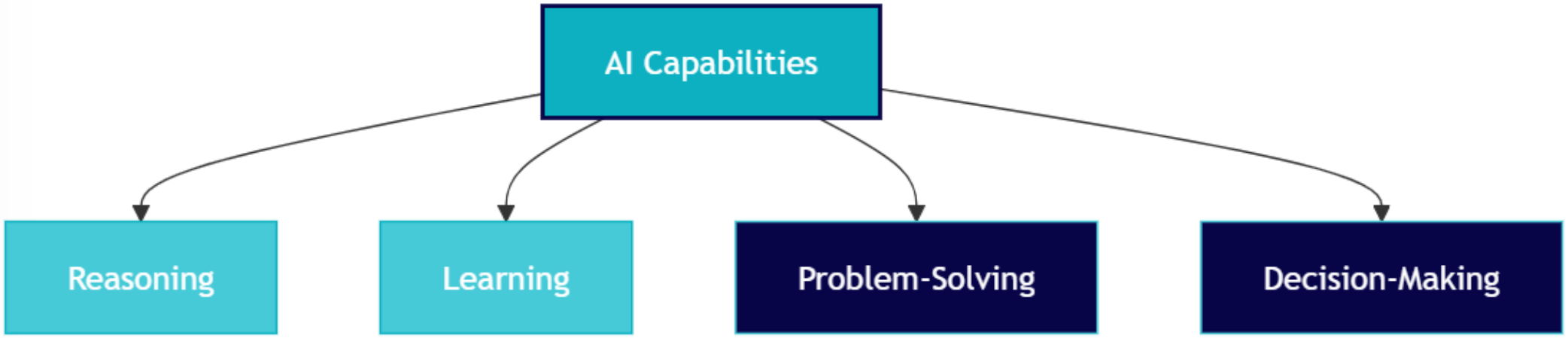
Classification

- Narrow AI
  - Designed to perform a narrow task (e.g., facial recognition, internet searches, or driving a car). Most current AI applications fall under this category
- General AI or AGI
  - Refers to systems that possess the ability to understand, learn, and apply intelligence in a wide range of contexts, much like a human being.
  - Still largely theoretical and remains a subject of ongoing research.
- Artificial Super Intelligence (ASI)
  - A type of AI that surpasses human intelligence and can perform any task better than a human.

Key Characteristics of AI Systems

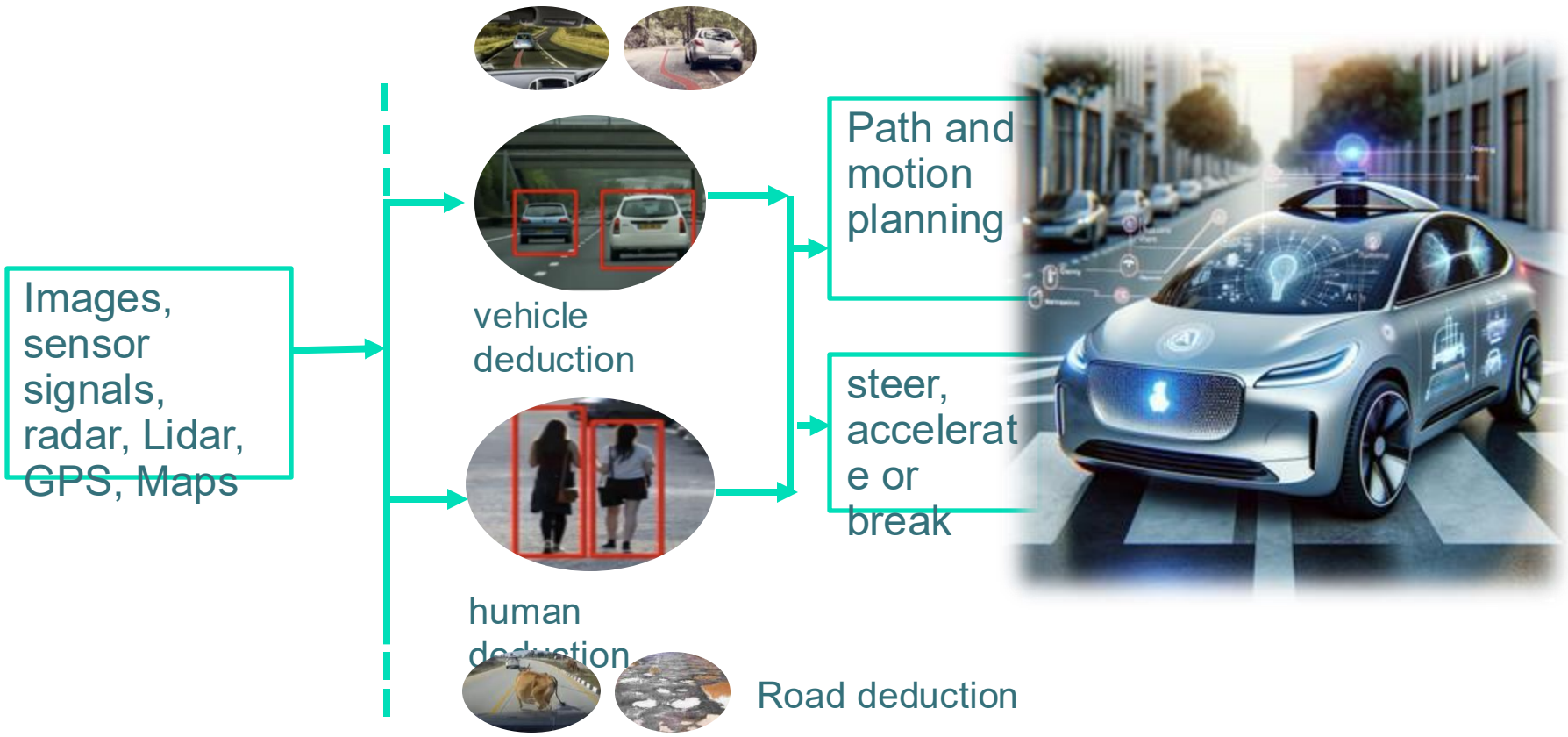
Capabilities

- Ability to learn from data, adapt to changes, and execute tasks autonomously.
- AI relies on vast datasets, efficient algorithms, and computational resources.
- A



Key Characteristics of AI Systems

Capabilities



Potential Impact of AI

Potential Impact

2025 AI Industry Impact Predictions

Industry	Prediction	Impact	Details
Healthcare	Widespread adoption of AI diagnostics in medical imaging	High	FDA approvals for diagnostic tools will leading to integration in 40%+ of US hospitals
Education	Personalized AI tutoring becomes mainstream	Medium	Integration in major learning platforms, but concerns about equity and access will limit adoption
Financial Services	AI-driven risk assessment and fraud detection	High	80% of major banks will implement advanced AI fraud detection systems
Manufacturing	Predictive maintenance and quality control	Medium	30% efficiency gains in early adopter facilities
Customer Service	Human-AI hybrid support becomes standard	High	60% of Fortune 500 companies will deploy advanced AI assistants
Software Development	AI pair programming becomes standard practice	Medium	40% productivity increase in code generation and testing
Creative Industries	AI-assisted content creation tools	Medium	Widespread adoption in marketing, but limited in premium creative work
Transportation	Enhanced autonomous vehicle testing	Low	Limited to controlled environments and specific routes

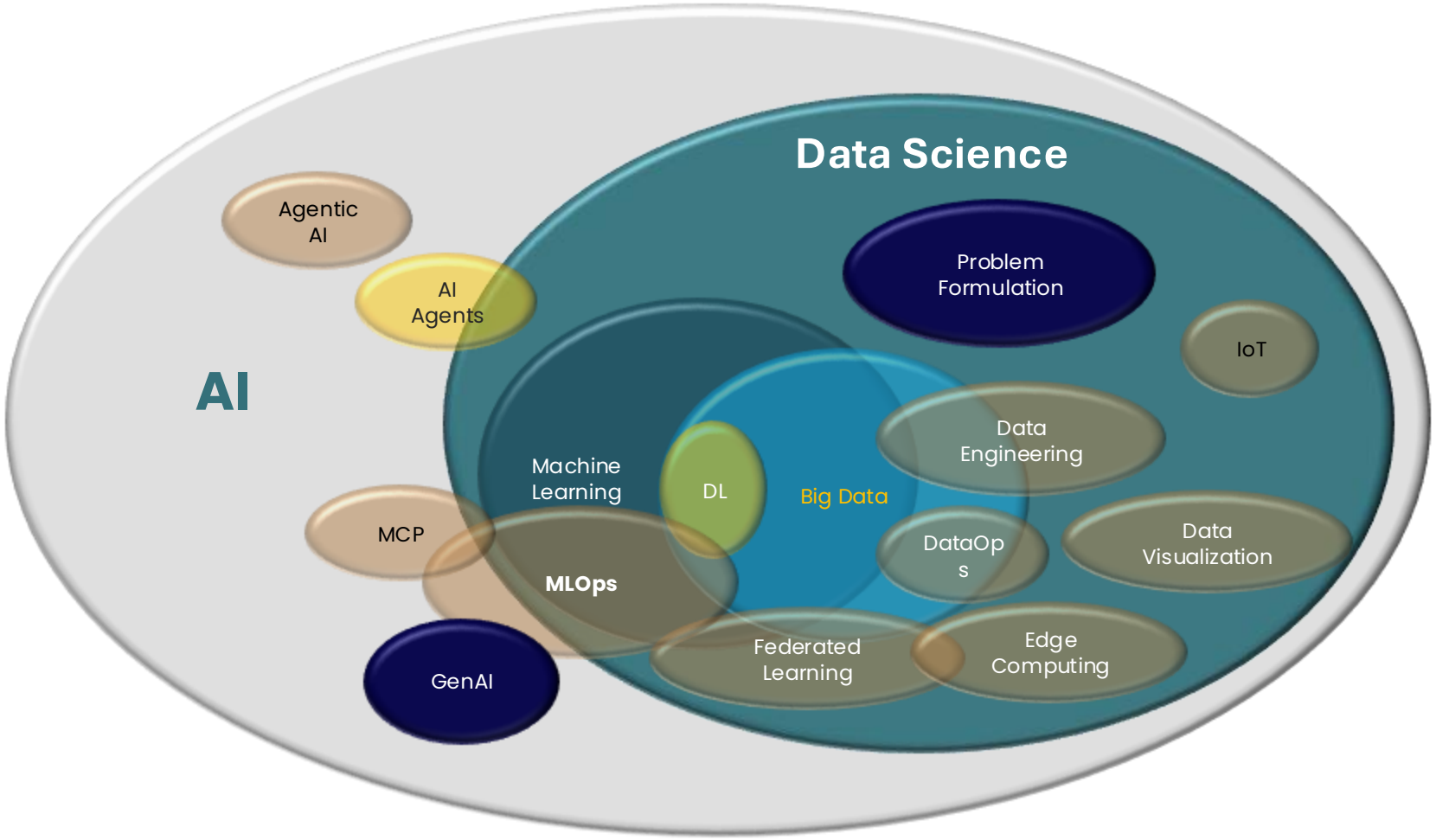
Claude content

2025 Predictions: What Will Actually Happen?

Prediction	Likelihood	Impact	Description
Agent-Led Economy	✅ High	🔥 Major	Jobs like "AI Developer" shift to "Agent Trainer" or "Agent Marketplace Owner."
Autopoietic AI	✅ Medium	⚠️ High	Systems that "self-create" new agents will disrupt workflows in every industry.
End of Human-Led Turing Test	✅ High	🚀 Transformational	Agents will evaluate human rationality, not the other way around.
Agent IDEs Go Mainstream	✅ High	🔥 Major	Developers will use IDEs to "drag-and-drop" agents like LEGO blocks.
Agent Synergy with Humans	✅ Medium	🤝 Transformational	New roles emerge where human-agent collaborations become the norm.
Fractal-Based Agent Tracking	✅ High	🔍 Essential	Fractal-based anomaly detection becomes a crucial cybersecurity tool.
Universal Agentic Platform	✅ High	🔥 Major	Platforms like "PhD Corner" will host community-driven AGI development.
AGI as Distributed Agents	✅ High	🚀 Revolutionary	AGI emerges not as one brain, but as a collective of specialized agents.
Epigenetic Imprints on Behavior	✅ Medium	🔮 Inevitable	Children born in an AI-augmented world will inherit new "norms" of social behavior.

Data Science

AI, ML and Data Science



Generative AI

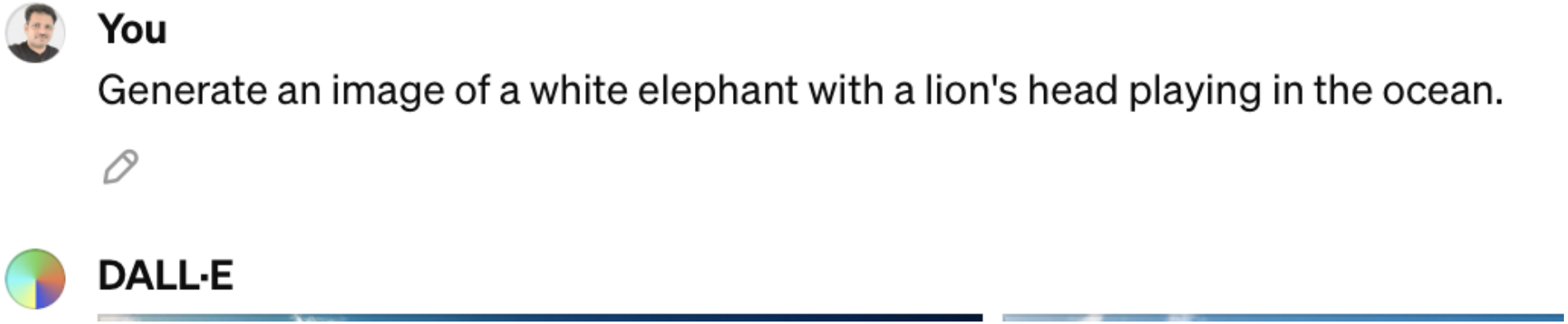
Beyond Prediction to Creation

What is Generative AI?

Generative AI refers to artificial intelligence systems that create new content, such as text, images, or audio, based on learned patterns from existing data.

- Core Characteristics
  - Content Creation: Produces new data instances.
  - Pattern Learning: Captures underlying data structures.
  - Diverse Outputs: Generates varied outputs that resemble training data.
  - Unsupervised Learning: Operates without explicit labels.
  - Creativity: Capable of producing unexpected and innovative results.

What is Generative AI?



What is Generative AI?

Image of a mythical creature with the body of a white elephant and the head of a lion playing joyously in the ocean

2023 DALL-E

2024 DALL-E

2025 DALL-E

2025 SORA

How to use AI to solve problem?

Predictive AI vs. Generative AI

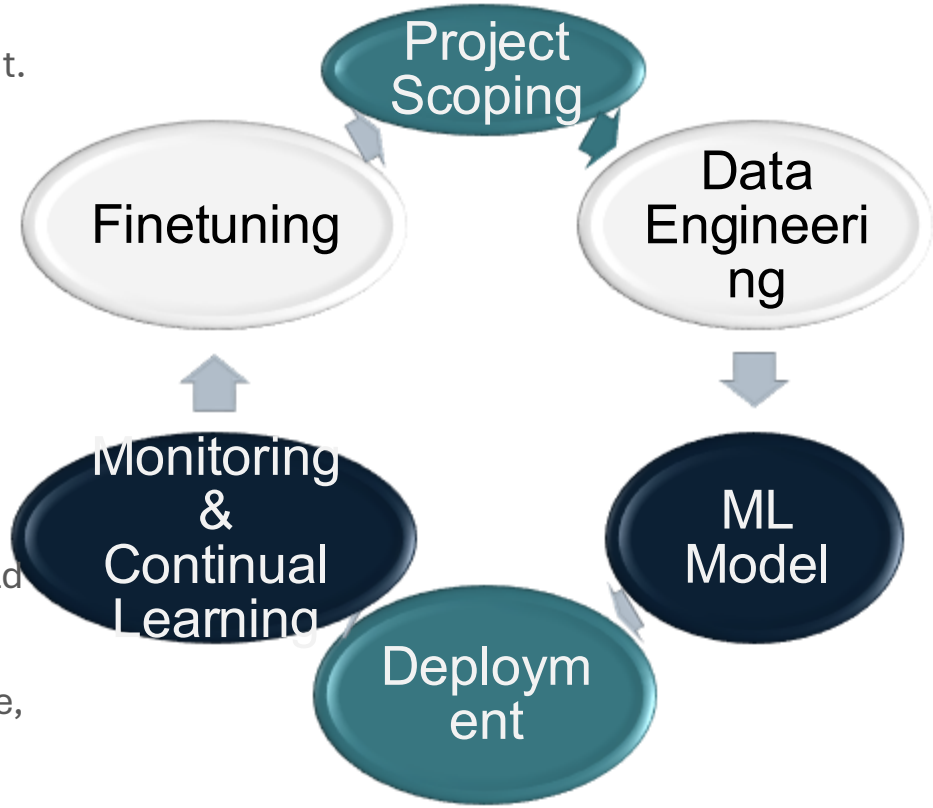
- Predictive AI:
  - Focuses on forecasting based on past data.
  - Outputs are probabilistic predictions (e.g., customer behavior forecasting).
- Generative AI:
  - Creates new, original content based on learned data.
  - Example: Generating new molecular structures in drug discovery.

AI Model: Development

- AI model development is an **iterative and cyclical process**, not a one-time event.
- It begins with **Project Scoping** to define the problem and objectives.

- **Data Engineering** is a crucial foundational step, involving data collection, cleaning, and preparation.
- **ML Model Development** is where the core ML algorithms are trained.

- **Deployment** integrates the AI model into a production environment for real-world use.
- **Monitoring & Continual Learning** is vital for tracking AI model performance, identifying issues, and enabling ongoing improvements.
- **Finetuning** based on real-world feedback, leading back to potentially re-scoping or further data engineering



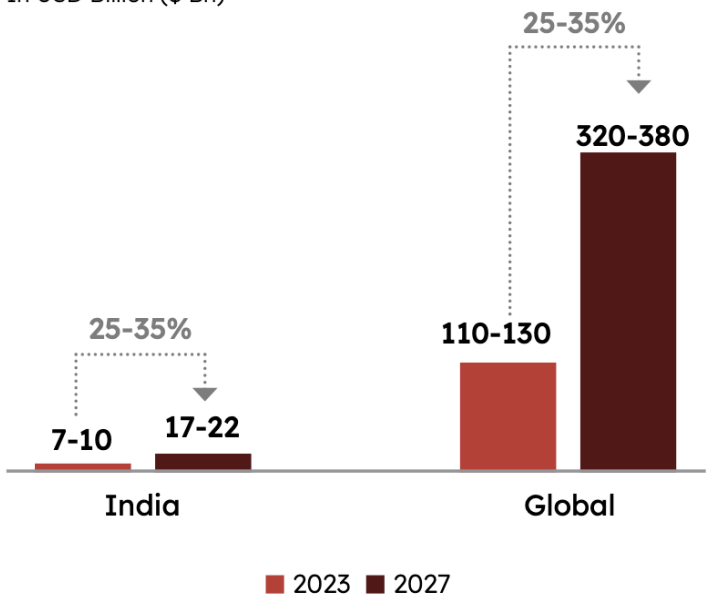
Challenges in AI

Market Growth

Global and India AI markets are set to grow at 25% - 35% CAGR through 2027, with lion's share from AI software and services, and Generative AI.

Expected Global and India AI Market Growth, 2023-2027

In USD Billion ($ Bn)



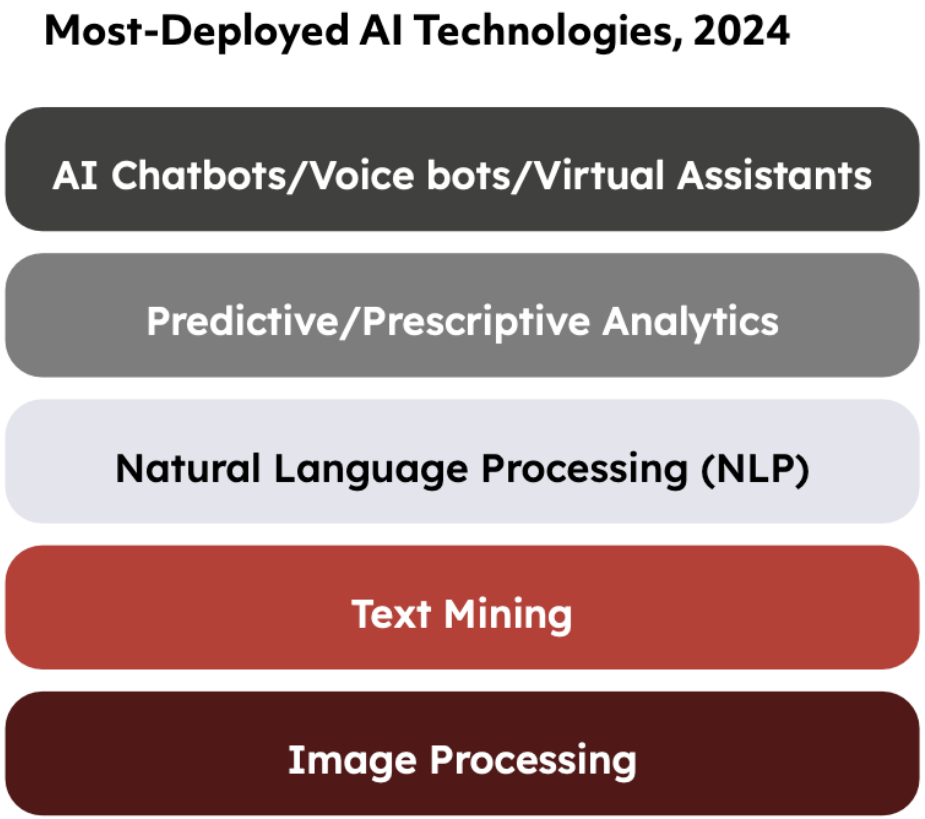
66%

Share of **AI services and software** in the global AI market by 2027, up from 58% in 2023

33%

Share of **Generative AI** in the global AI market by 2027, up from 13% in 2023

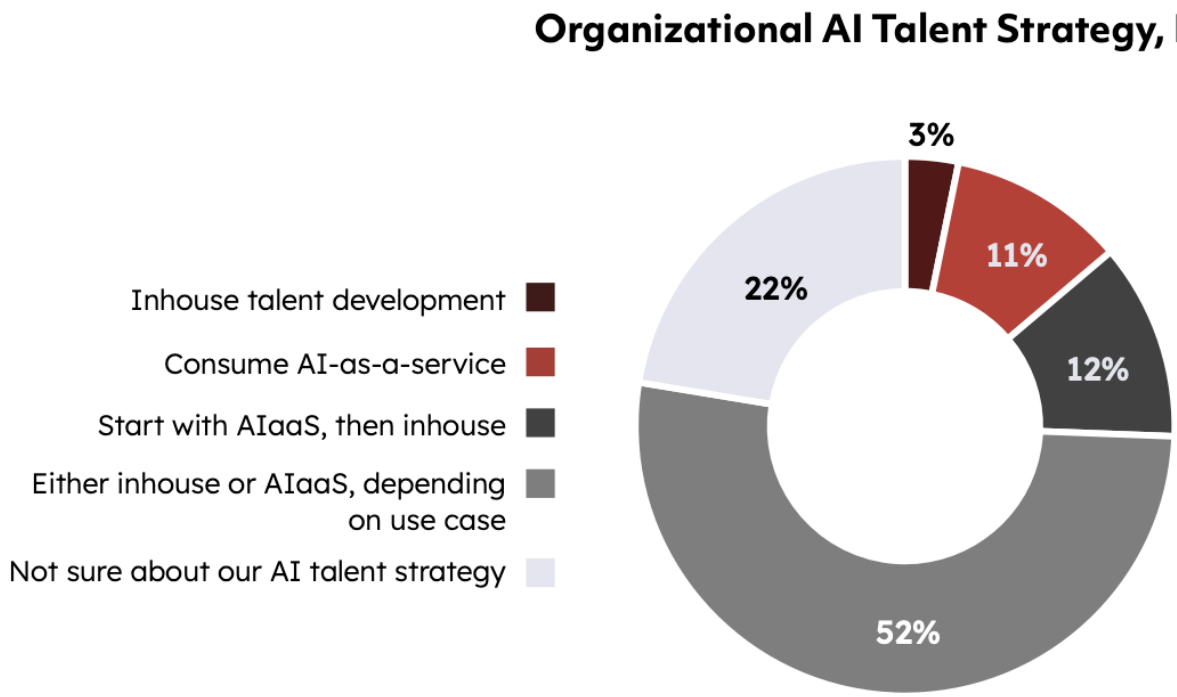
Market Growth



- **50%+** enterprises have production-grade chatbots and virtual assistants, and at least one production-level predictive analytics use case
- **~20%** have piloted or implemented speech recognition and video processing
- **BFSI, Manufacturing, and Transport & Logistics** sectors demonstrate superior penetration of advanced AI tech

Market Growth

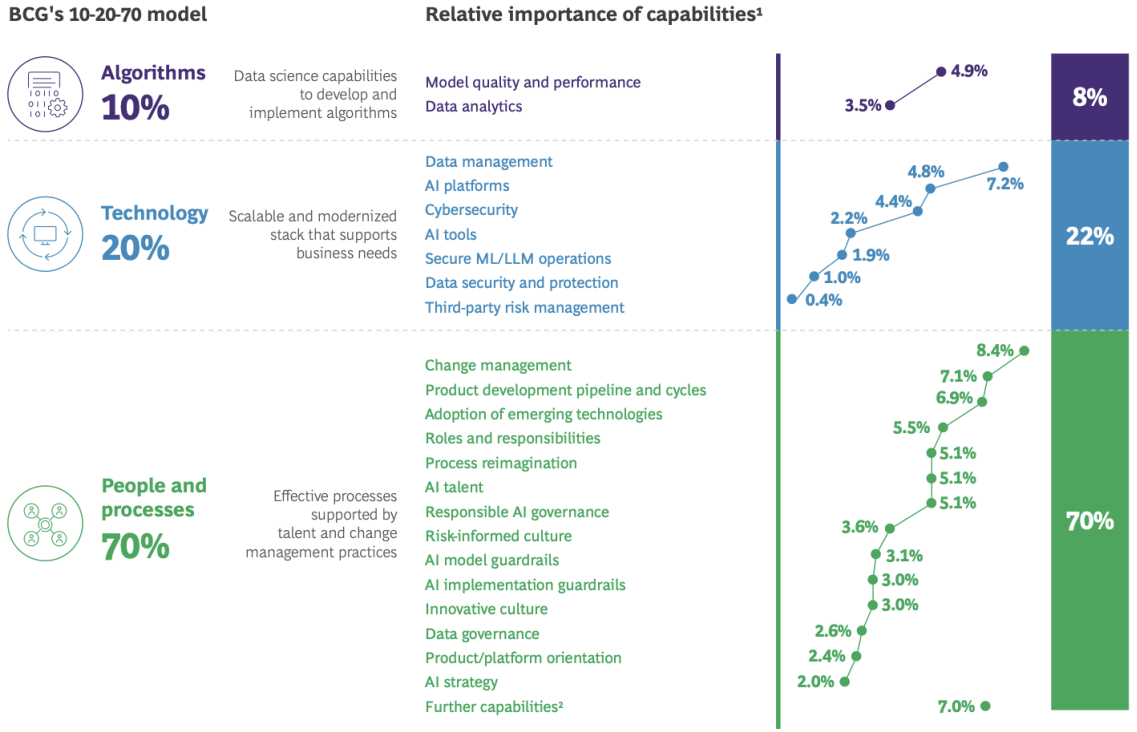
Due to limited availability of domain+tech skills in AI, enterprises increasingly rely on external service providers to kickstart their AI journey



- **75%** enterprises prefer starting AI foray as-a-service, particularly as inhouse talent building can be a challenging route.
- **Mature adopters** are not too distinct in that they follow a similar approach of starting with external access to AI talent.

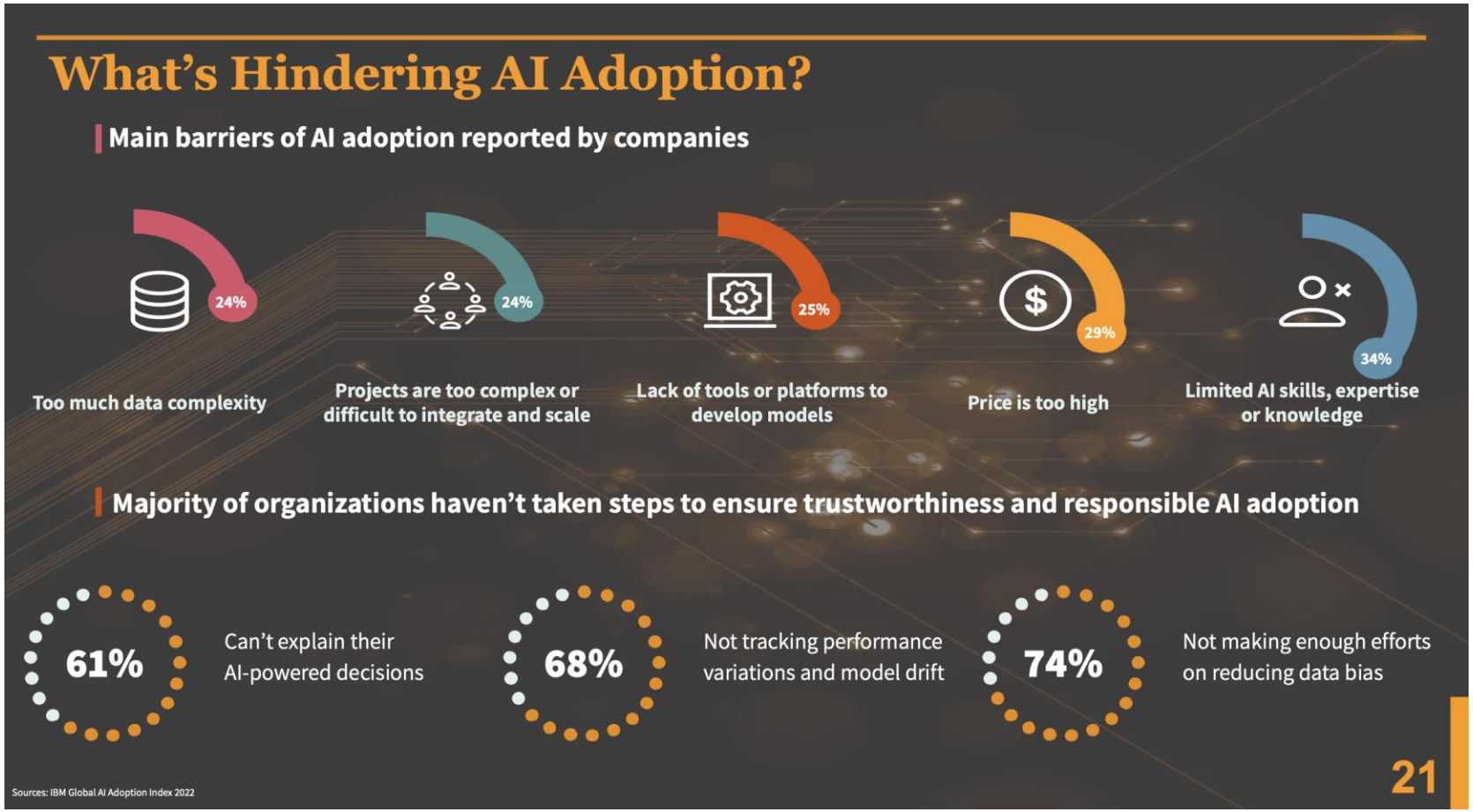
AI Adoption

Exhibit 6 - To Get an AI Transformation Right, 70% of the Focus Should Be on People and Processes



Source: BCG 2024 Global Study on AI and Digital maturity; n = 1,000.

AI Adoption



Why AI Fails

- **Fragmented AI efforts lead to slow development, security risks, and competitive disadvantage**
- **Corporate AI Projects Are Failing to Scale**
  - Up to 80% of AI projects fail*, which is roughly double the failure rate of traditional IT initiatives
  - **Key Reasons for Failure**

Misaligned Objectives

Often misunderstand AI's capabilities or miscommunicate — what problem needs to be solved using AI.

Data Challenges

The most frequent technical cause is poor data quality, inadequate data governance, or lack of "AI-ready" data.

Pilot Paralysis

POCs get stuck, unable to scale pilots to production due to infrastructure, integration, or organizational bottlenecks.

Lack of Integration

Treated as an isolated IT experiment, not integrated into core business.

Insufficient Skills and Resources

Shortages in AI expertise, resource allocation, and a lack of robust data platforms

Overhyped Expectations

Media and vendor hype fuel unrealistic AI expectations, leading to overpromising and pressure for impossible results.

Tech Over Solutions

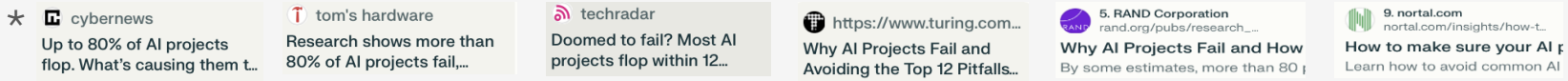
Focuses more on using the latest and greatest technology than on solving real problems.

Overly Ambitious AI

In some cases, AI projects fail because the technology is applied to problems that are too difficult for AI to solve.

Project Lead's Blindspot

Project team's lack of understanding of the project's purpose and domain context, often exacerbated by the absence of a laser-focused team lead who grasps the end-to-end solution.



As a Student What Should I Learn?

AI Team

Domain Expert

AI Team

Data Engineer

Data Capture

transforms data into a useful format for analysis

Collection, cleaning

Software solutions

advanced programming and system creation

creating software solutions around big data

Big Data

creating software solutions around big data

create data pipelines

understand the right tool

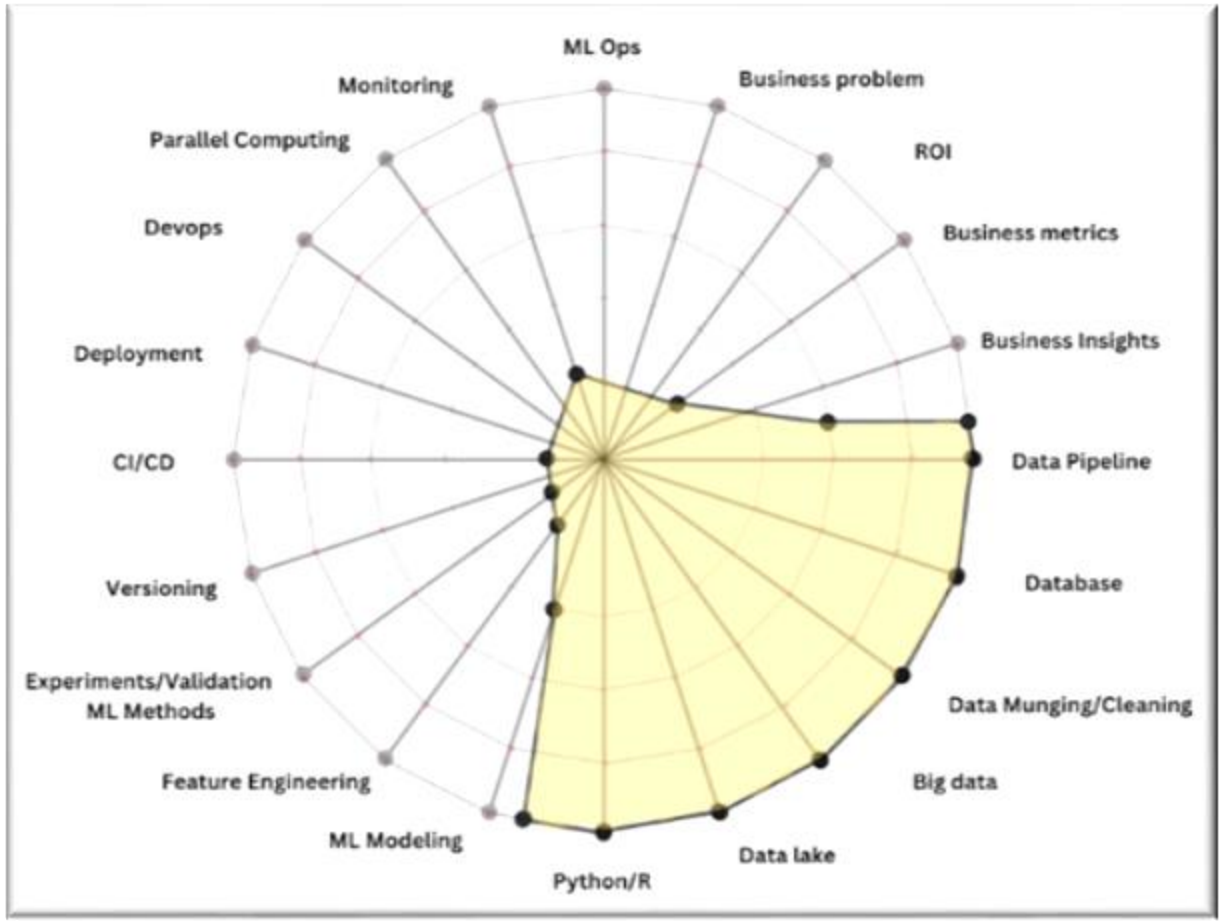
Skills

MySQL, MongoDB, Scala, Dask, Apache Spark, Hadoop

Hadoop, MapReduce, Hive, Pig, Data streaming, NoSQL, SQL,

AI Team

Data Engineer



AI Team

Data Scientist

ML Expert

Data analyst who applies ML/AI

picked up programming out of necessity

Domain Expert

Interact with business side

understand the domain enough to make insights

Data Story

Verbally and visually communicate complex results in a way that the business can understand and act on them

Skills

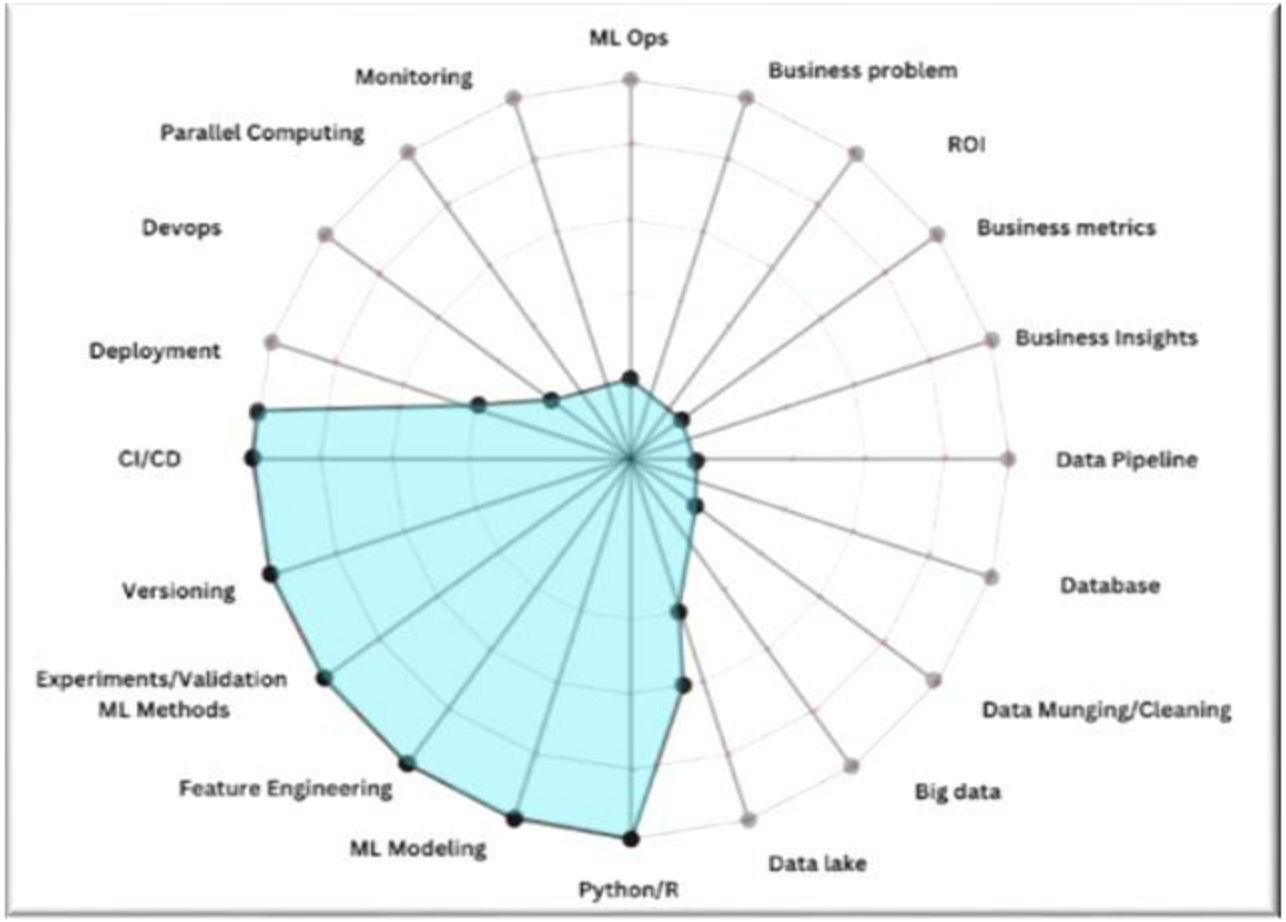
Math, statistics and basic programming to analyse data

R, create ML models

Jupyter, TensorFlow, PyTorch, RStudio. etc

AI Team

Data Scientist



Career Paths

Data Scientist

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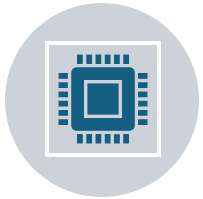
AI Team

ML Engineer

Need a systematic & efficient approach to be build ML Systems



Needs to apply DevOps' best-practices to the emerging ML technologies

Widespread adoption of ML systems globally necessitates a sudden rise in demand for ML Engineers

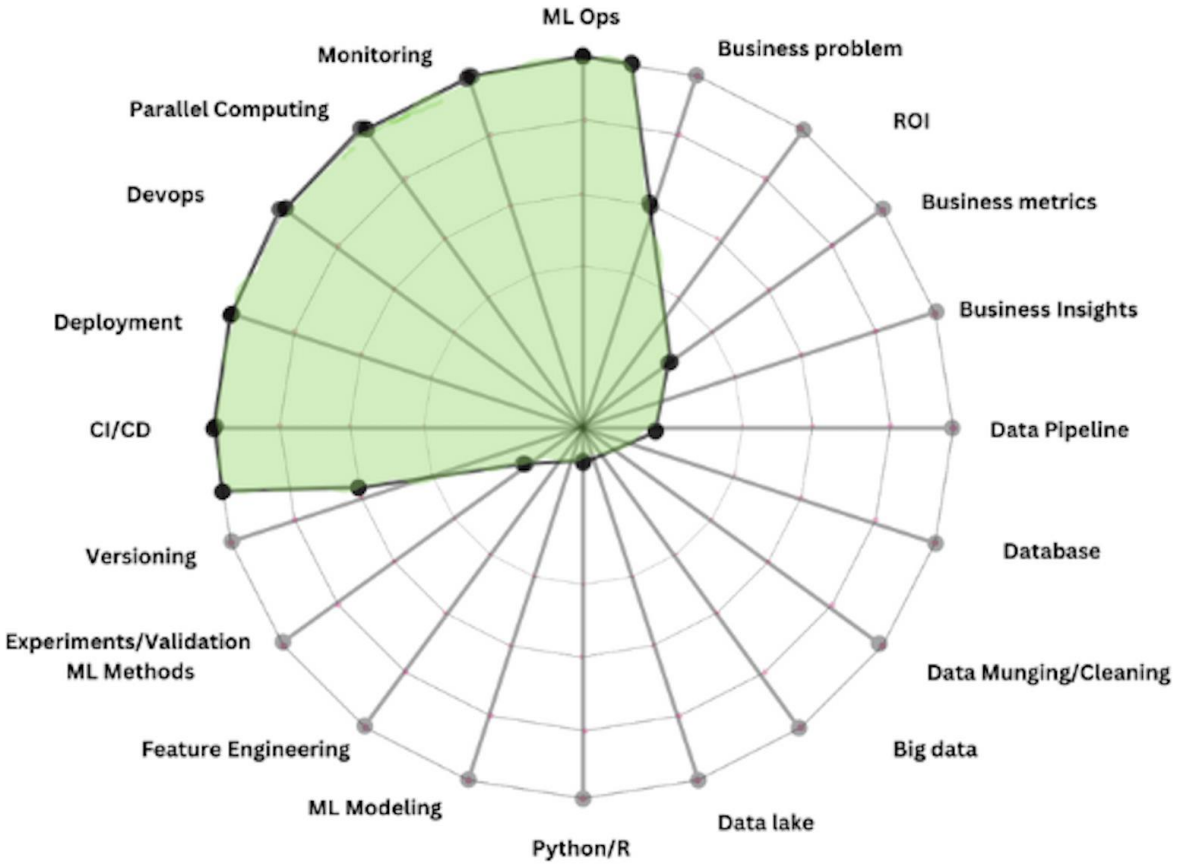
Cross-trained enough to become proficient at both data engineering and data science

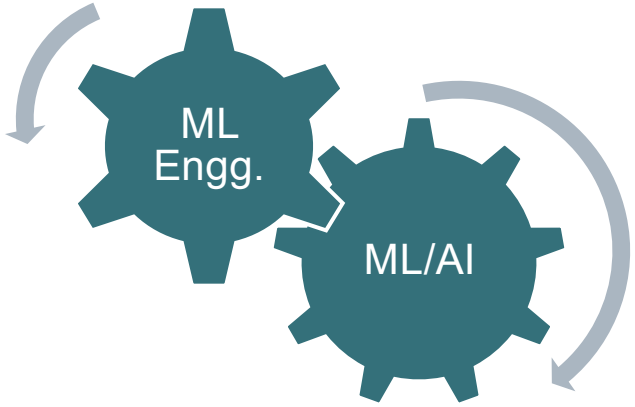
Primarily come from data & software engineering backgrounds

Sits at the crossroads of data science and data engineering, and has proficiency in both data engineering and data science

AI Team

ML Engineer



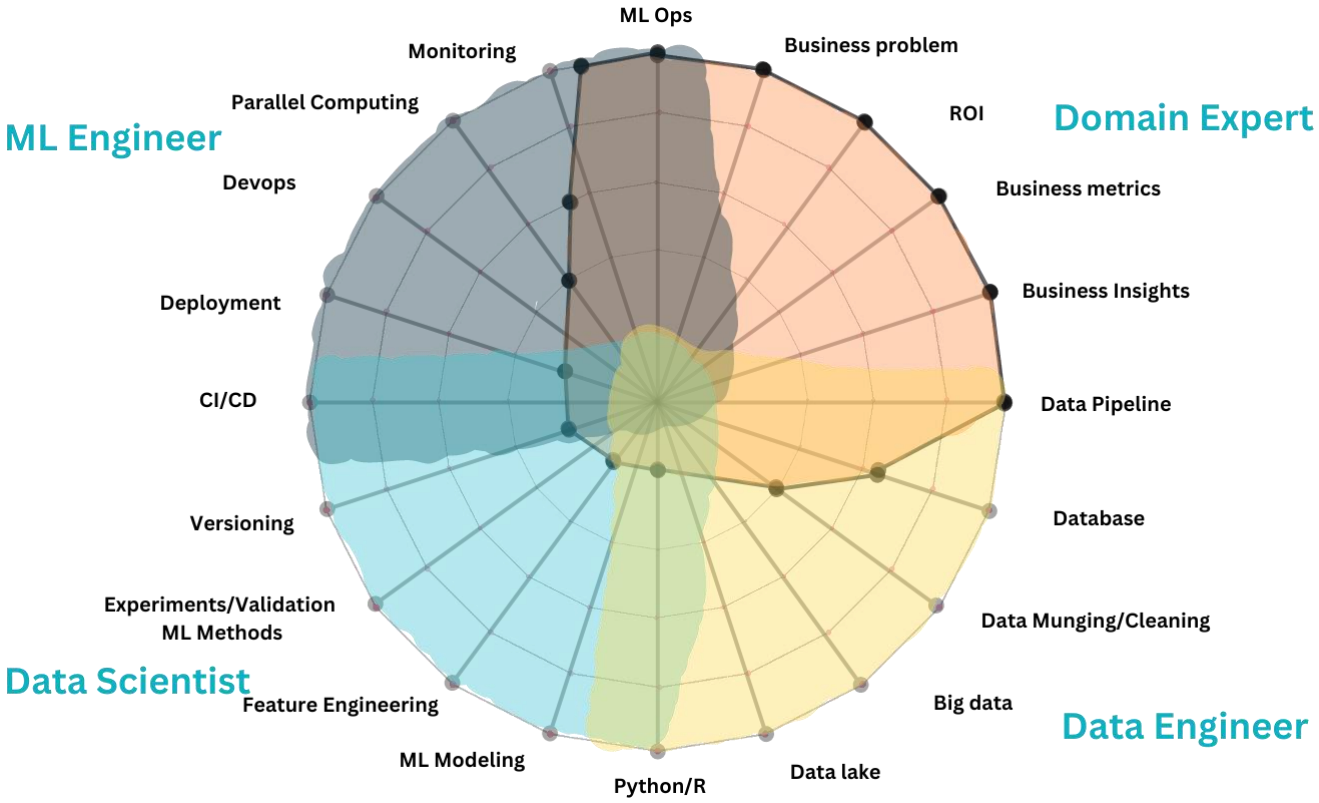


Career Paths

ML Engineer

- **Cloud Native ML Platform :** AWS SageMaker, Azure ML Studio, GCP AI Platform
- **Containerized Workflow:** Docker, Kubernetes, public and private containers
- **Serverless technology:** AWS Lambda, AWS Athena, Google Cloud Foundation, Azure Functions
- **Special hardware for ML:** GPUs, TPUs, A14, AWS Inferentia Elastic inference
- **Big data platforms:** Databriks, Hadoop/Spark, snowflake, Amazon EMR Google Big Query, Google big Query

AI Team



Welcome to DS 246

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