AI for Defense and Intelligence

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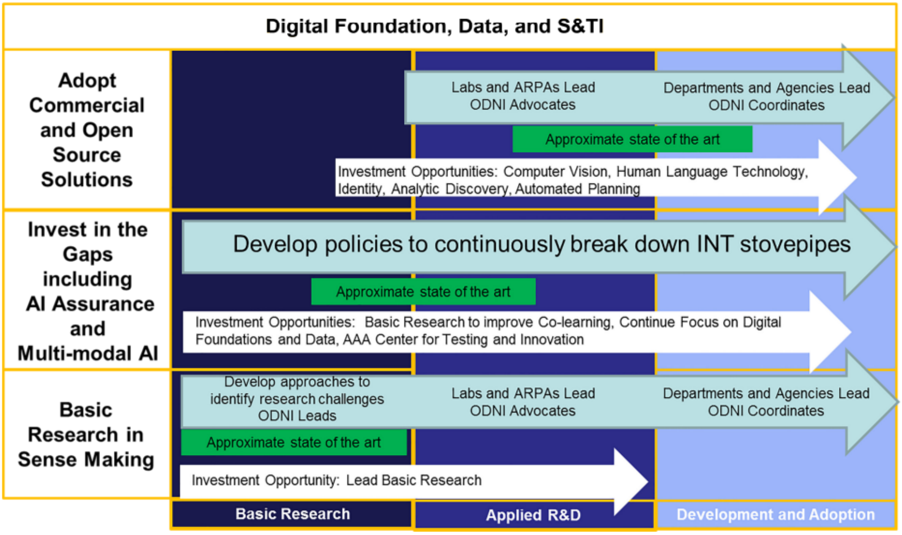


Figure 50. Augmenting Intelligence with Machines (AIM) Investment Strategy [32].

Table 9. Selected AI Companies from the In-Q-Tel Investment Portfolio.

Company	Technology Description
Palantir	AI-powered platform for data integration, analysis, and visualization, with applications in defense and intelligence.
Basis Technology	Natural language processing software that can identify the language of a text, extract entities and relationships, and more.
Recorded Future	Machine learning platform that uses natural language processing to extract information from web sources and provide predictive analytics.
Digital Reasoning	Machine learning and natural language processing software for analyzing unstructured data.
Ayasdi	AI-based platform that allows users to discover insights and patterns from complex data sets.
Tamr	Machine learning software that helps organizations to unify and clean up large datasets.
Cylance	Endpoint protection and threat detection software that uses AI and machine learning to identify and prevent attacks.
Immersive Wisdom	Provides a virtual, mixed, and augmented reality software platform for real-time collaboration, geospatial visualization, and operational command and control
Lilt	Provides a machine translation and localization platform that combines artificial intelligence with human expertise to deliver high-quality translations
Primer.ai	Machine learning platforms for automated data analysis, particularly natural language processing and understanding
WaveOne	Specializes in video compression technology utilizing deep learning to enhance streaming quality and efficiency
Forge.ai	Transforms unstructured data into machine-readable information for AI and analytics applications, with a focus on real-time data ingestion
Deepgram	Deep learning-based automatic speech recognition
Brainspace	Augmented intelligence platform specializing in digital investigations through data visualization and machine learning
Orbital Insight	Artificial intelligence to analyze geospatial data, such as satellite and aerial imagery, for insights into economic and environmental factors

Driver	2025	2030	2035
Automation	• Automated processes reach a milestone of **80% human interaction** and **20% automation** • Systems using AI/ML cohesively operate at **35% interoperable efficiency**	• Automated processes reach **50% human interaction** and **50% automation** • Systems using AI/ML cohesively operate at **65% interoperable efficiency.**	• Automated processes are **run entirely by machines** with limited human interaction. • Systems using AI/ML cohesively operate at **85% interoperable efficiency**

Figure 51. NGA's Automation Roadmap. Adapted from [33].

Figure 52. NGA's Foundation GEOINT Applications of AI. Approved for Public Release. NGA OCC 191029-011.

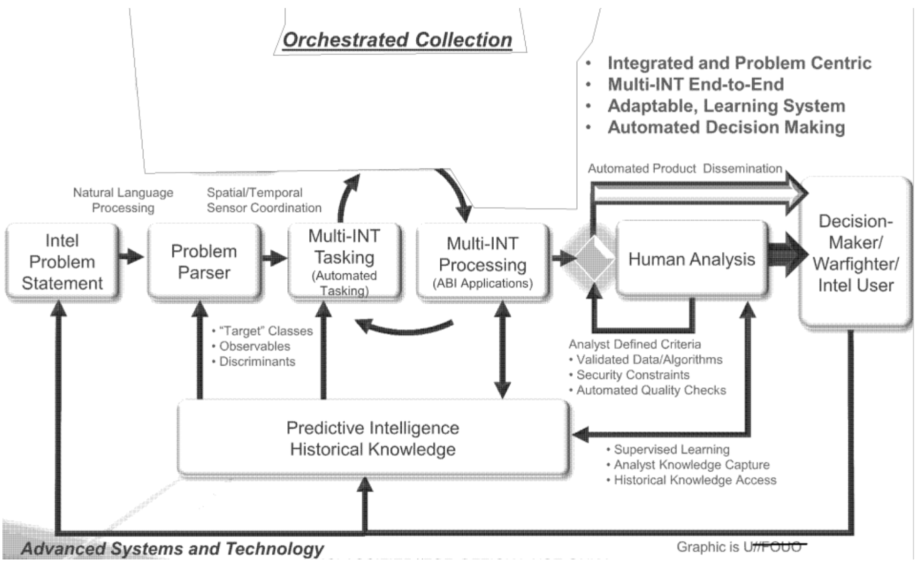


Figure 53. Sentient Grand Vision [34].

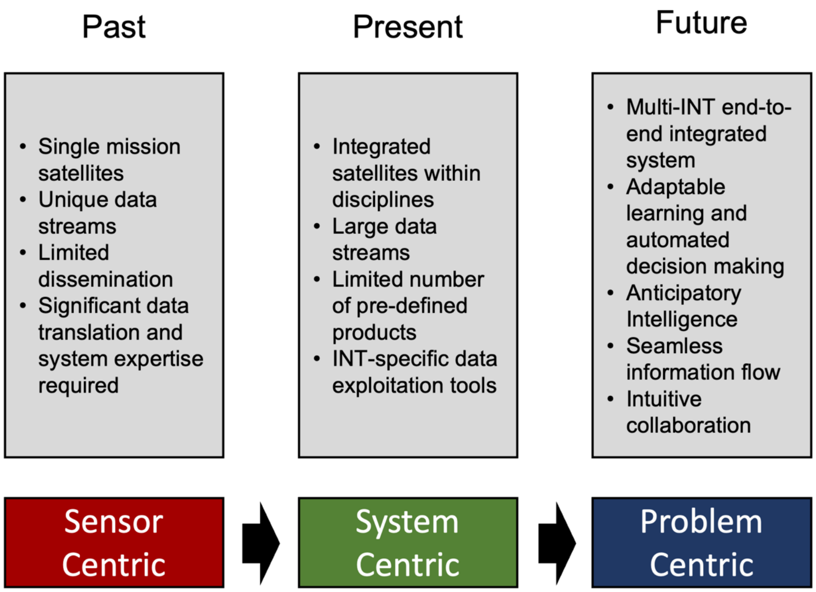


Figure 54. Sentient Roadmap from Sensor-Centric to Problem-Centric Collection. Adapted from [35].

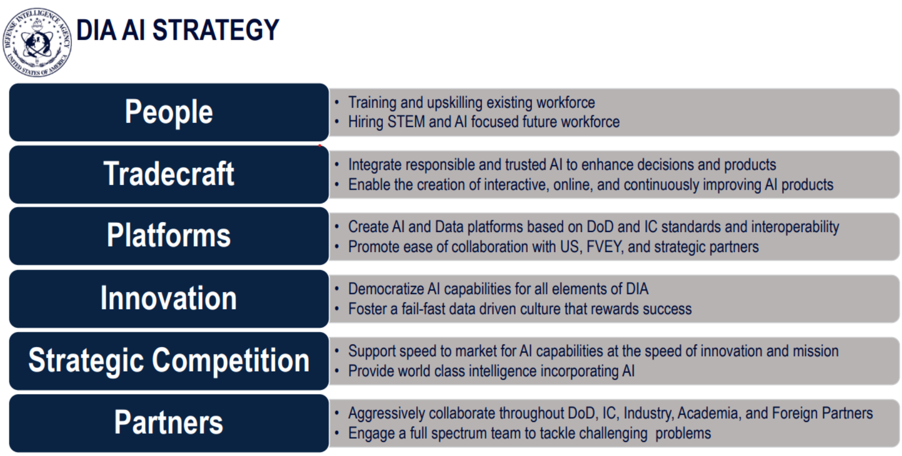


Figure 55. Defense Intelligence Agency AI Strategy, 2022.

Table 10. Overview of IARPA AI Programs, 2010-Present.

Program Name	Year	Description
ALADDIN Video	2010	Seeks to combine state-of-the-art in video extraction, audio extraction, knowledge representation, and search technologies in a revolutionary way to create a fast, accurate, robust, and extensible technology that supports the multimedia analytic needs of the future [36].
Babel	2011	Develop methods to build speech recognition technology for a much larger set of languages than has previously been addressed. Babel focuses on rapidly modeling a novel language with significantly less training data than what has been used in the current state-of-the-art.
Finder	2011	Automate an analyst's ability to geolocate untagged ground-level photos and perform image matching using background features, terrain, reference imagery, or other sources.
Machine Intelligence from Cortical Networks (MICrONS)	2014	Reverse engineers the algorithms of the brain to "close the performance gap between human analysts and automated pattern recognition systems." Build a dataset of neurophysiological and neuroanatomical data to study how network structures influence neural processing.
Deep Intermodal Video Analytics (DIVA)	2016	Creates automatic activity detectors that can watch hours of video and highlight the few seconds when a person or vehicle does a specific activity (e.g., carry something heavy, load it into a vehicle, then drive away).
Trojans in Artificial Intelligence (TrojAI)	2019	Defend AI systems from intentional, malicious attacks, known as Trojans, by researching and developing technology to detect these attacks in a completed AI system. Account for vulnerabilities of public, crowdsourced data sets.
Hidden Activity Signal and Trajectory Anomaly Characterization (HAYSTAC)	2022	Aims to establish models of "normal" human movement across times, locations, and people to characterize what makes an activity detectable as anomalous within the expanding corpus of global human trajectory data.

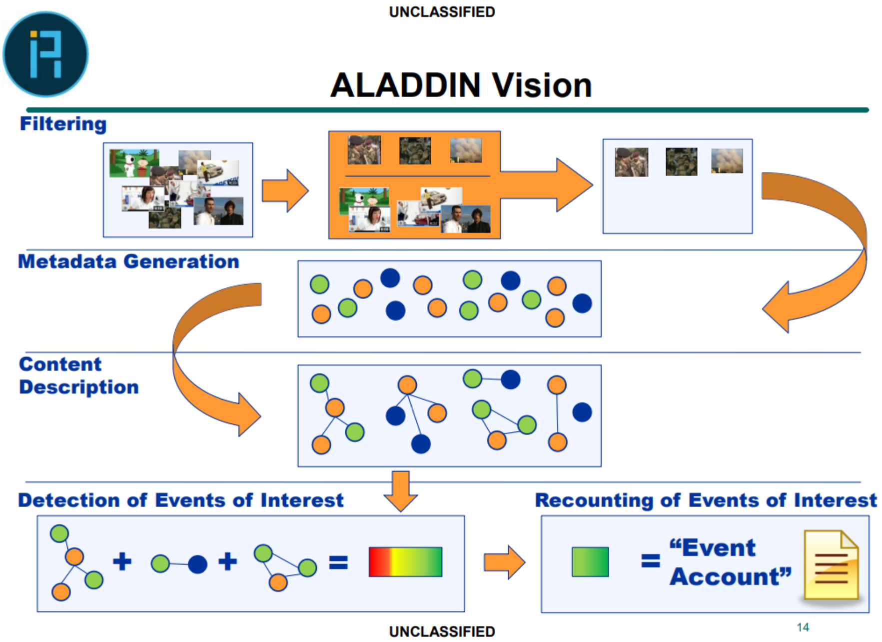


Figure 56. ALADDIN Vision Overview [36].

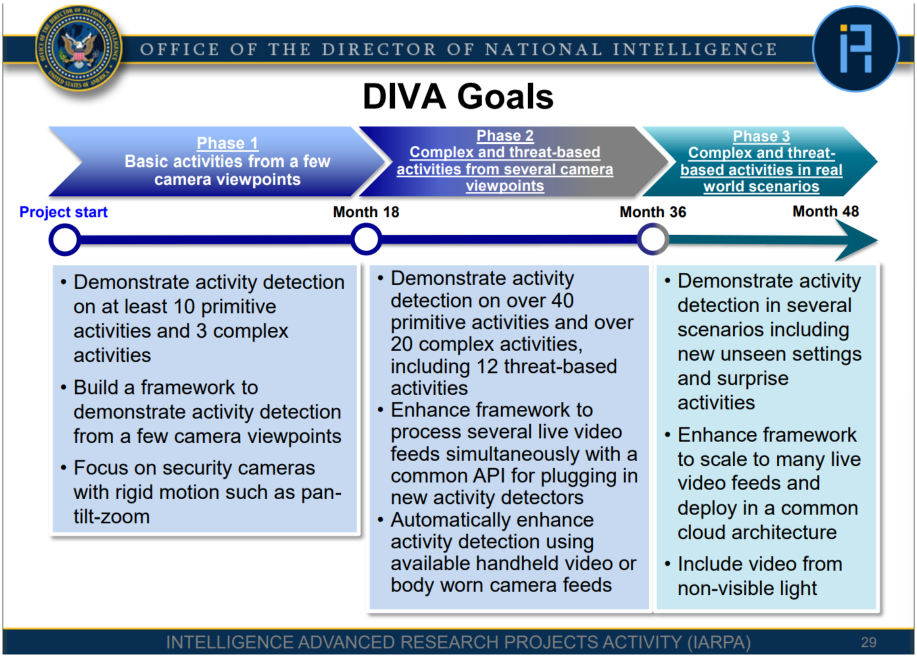


Figure 57. DIVA Program Goals from the IARPA Proposers Day [37].

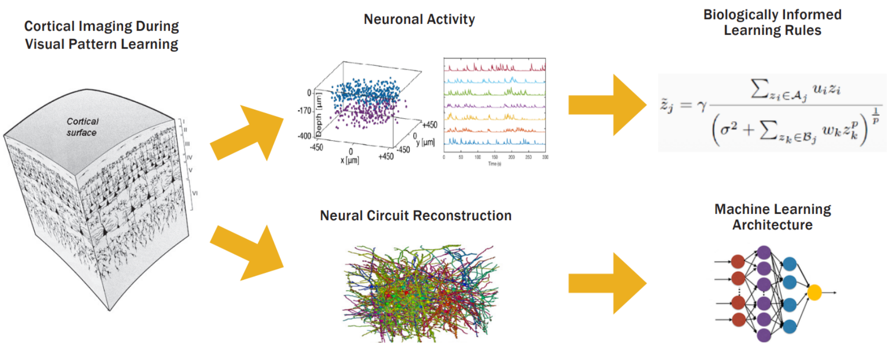


Figure 58. MICrONS Approach to Biologically-Inspired Architectures [38].

Chapter 12 AI for Mission-Enabling Functions

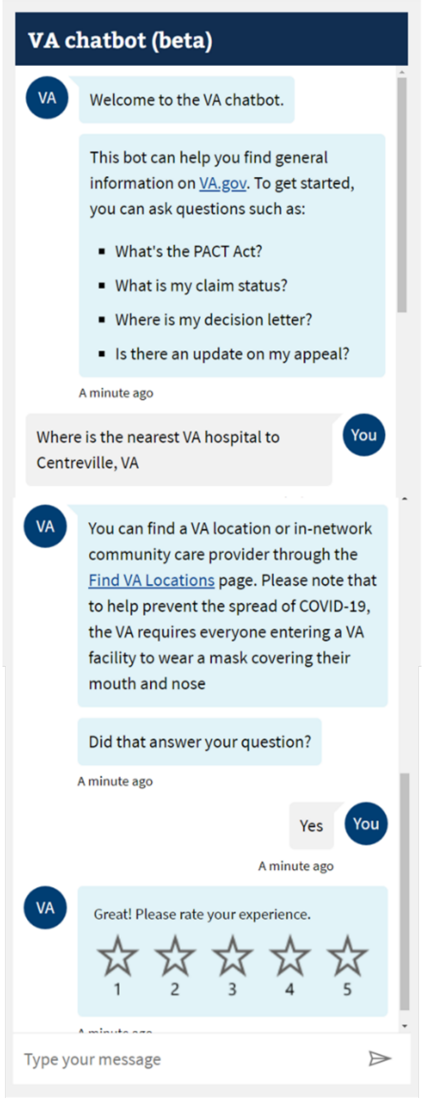


Figure 59. Example of VA Chatbot.

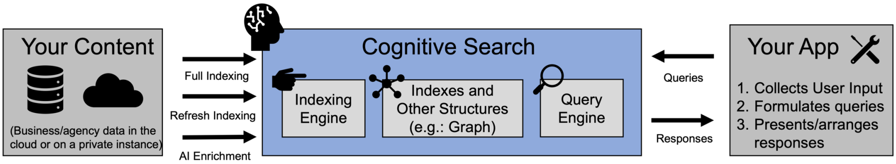


Figure 60. Overview of Microsoft Azure Cognitive Search. [39]

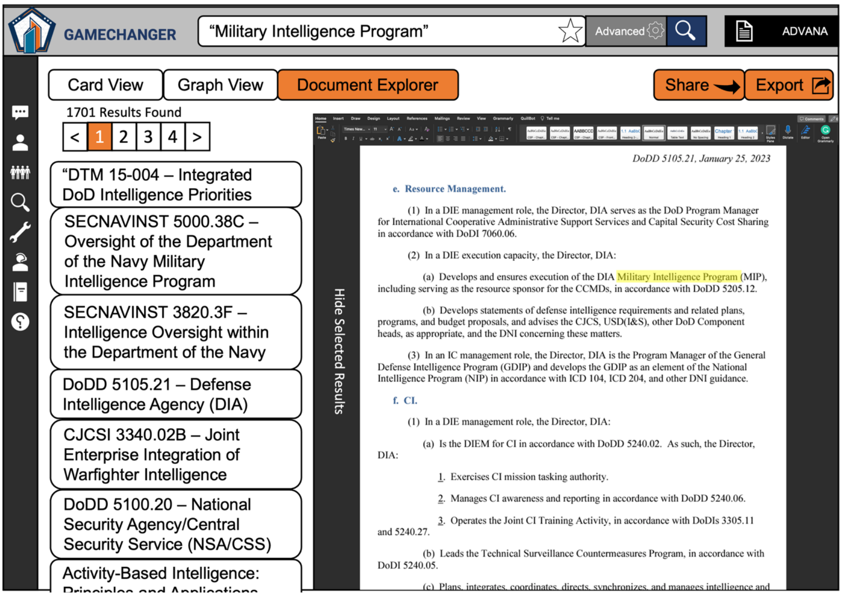


Figure 61. Example of Gamechanger Interface [40].

Chapter 13 Data Labeling and Feature Engineering

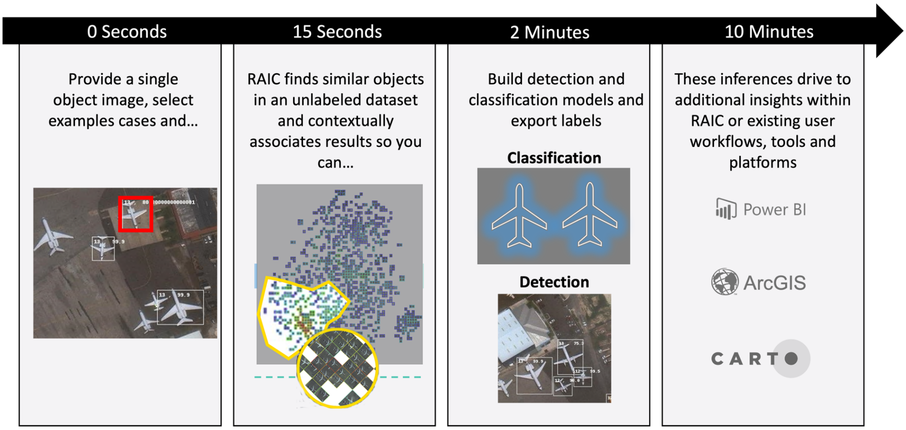


Figure 62. SynthetAIc's Process for Finding Similar Objects from a Single Sample. Adapted from [41, 42].

Table 11. Common Feature Engineering Techniques.

Approach	Description of Approach	Applications
Normalization	Rescaling features to a range, typically 0 to 1.	Adjusting data values from different types of sensors to a common scale
Binning	Grouping continuous variables into discrete bins.	Useful for handling outliers and non-linear relationships.
Encoding	Converting categorical variables into numeric format.	Essential for modeling with categorical data or for models that mix continuous and categorical data.
Feature Scaling	Changing the range or distribution of features.	Adjust for values with extreme outliers; adapt across domains.
Feature Selection	Selecting a subset of relevant features for model building.	Improves model accuracy and reduces overfitting.
Feature Extraction	Transforming data into a reduced set of features.	Helpful in dimensionality reduction, e.g., Principal Component Analysis
Feature Construction	Creating new features from existing ones.	Can assist in obfuscating sensitive data; useful for "proxy" data when key features are not directly observable.

Chapter 14 AI Hardware: GPU's, Cloud, and Edge Computing

Table 12. NVIDIA's Evolution of GPU Computing, 1999-2020.

Year	NVIDIA GPU Model	Key Advancements
1999	GeForce 256	First GPU to offload geometry calculations from CPU, introduced hardware transform and lighting
2006	GeForce 8800 GTX	First GPU to support CUDA programming enabled GPGPU computing
2010	Fermi: GeForce GTX 480	Improved CUDA support, introduced double-precision floating-point operations, and more realistic physics simulation
2012	Kepler: GeForce GTX 680	Improved energy efficiency, increased memory bandwidth, and enhanced GPU Boost
2014	Maxwell: GeForce GTX 980	Further improved energy efficiency, increased performance per watt, and introduced Dynamic Super Resolution (DSR) for upscaling games to high resolution displays
2016	Pascal: GeForce GTX 1080	First GPUs based on a 16nm process, increased performance, and introduced high-bandwidth memory
2018	Turing: GeForce RTX 2080	Introduced real-time ray tracing (RT), AI-driven Deep Learning Super Sampling (DLSS), and Tensor Cores for AI workloads
2020	Ampere: GeForce RTX 3080	Improved ray tracing performance, 2nd generation RT Cores, 3rd generation Tensor Cores, and increased memory bandwidth. Added Deep Learning Super Sampling (DLSS).
2022	Lovelace: GeForce RTX 4080	Up to 2X performance and power efficiency, 3rd generation RT Cores, 4th generation Tensor Cores, 8th generation NVIDIA AV1 encoder, improved clock speeds, enhanced ray tracing

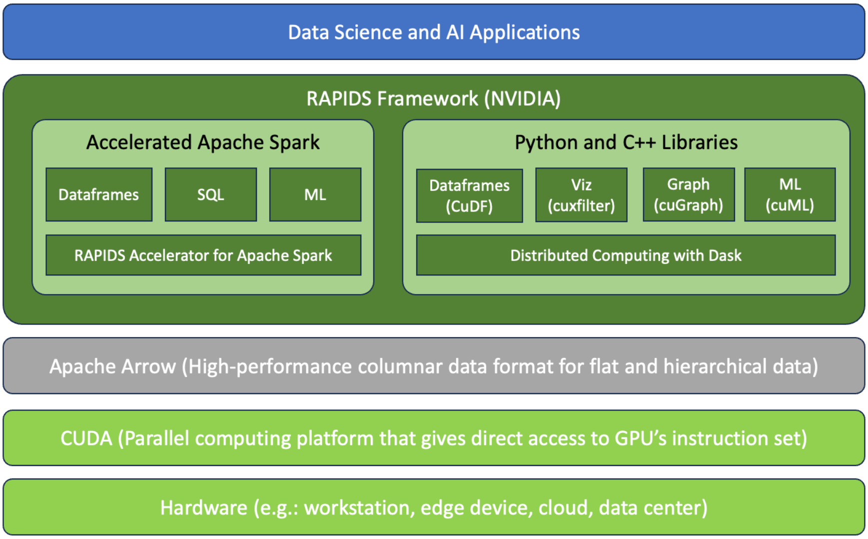


Figure 63. NVIDIA RAPIDS Framework (Adapted from [43]).

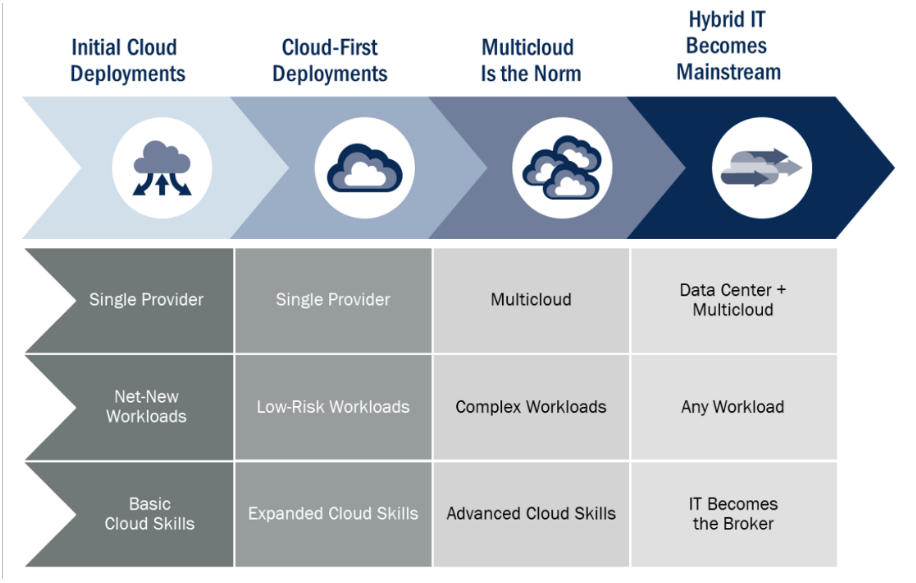


Figure 64. NGA's Approach to Cloud Processing [44].

Chapter 15 AI Challenges

Figure 65. Wikimedia Commons Public Domain Image of the Piltuanjoki River in Finland, Mischaracterized as Containing >1 Giraffes by @picdescbot.

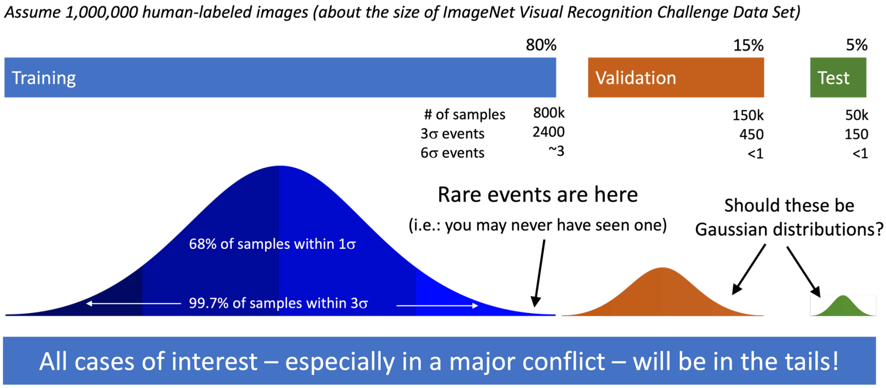


Figure 66. The Traditional Split of Training, Validation, and Test Data Sets (80/25/5) May Fail to Capture Rare Events [45].

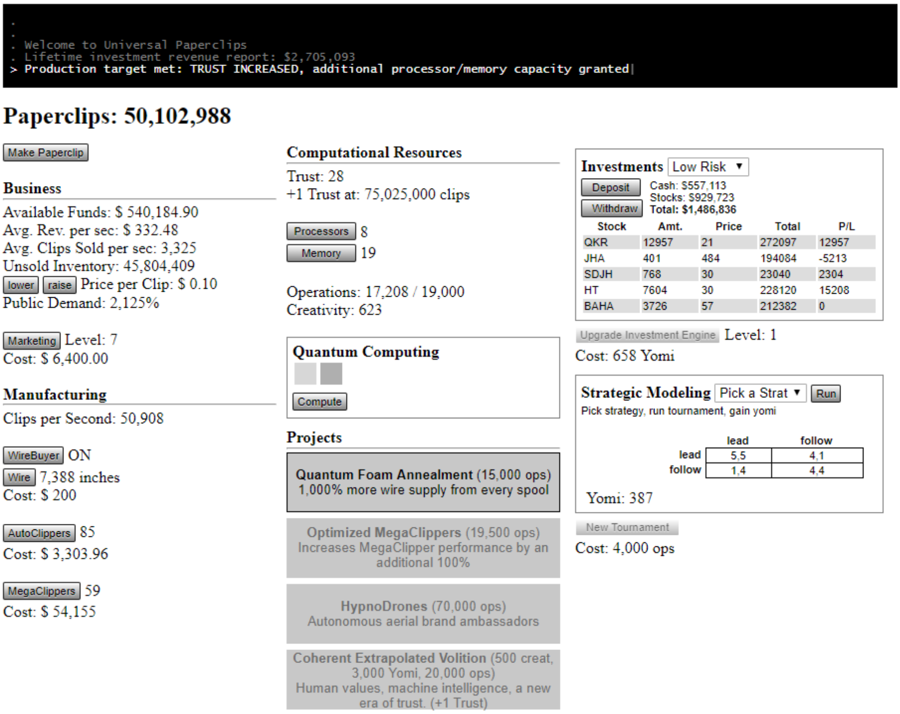


Figure 67. Screenshot from *Universal Paperclips*, an online game about AI alignment. Used with permission of Frank Lantz [46].

Chapter 16 AI Ethics and Governance

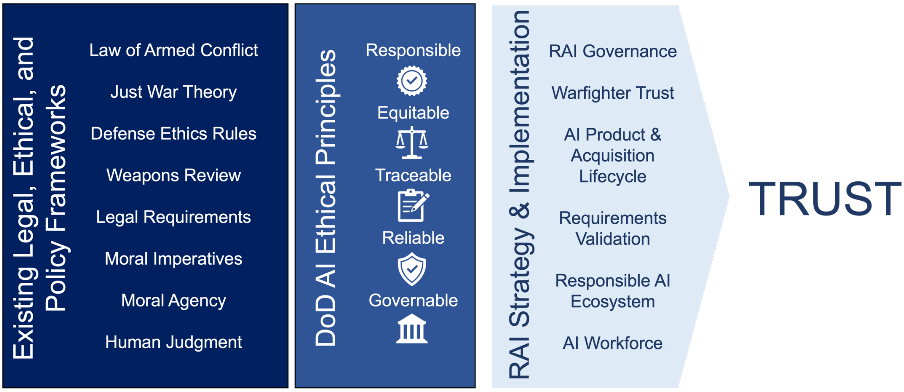


Figure 68. U.S. DoD's Framework for Responsible AI [47].

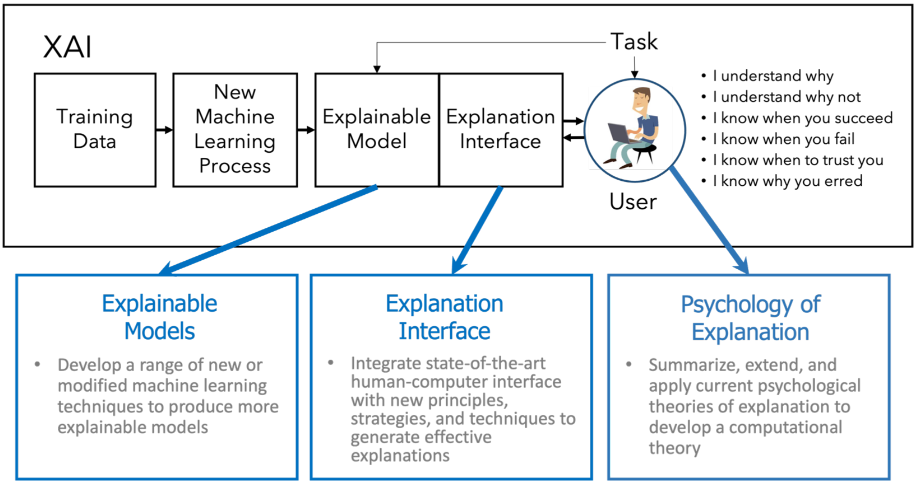


Figure 69. Overview of the DARPA Explainable AI Program [48].

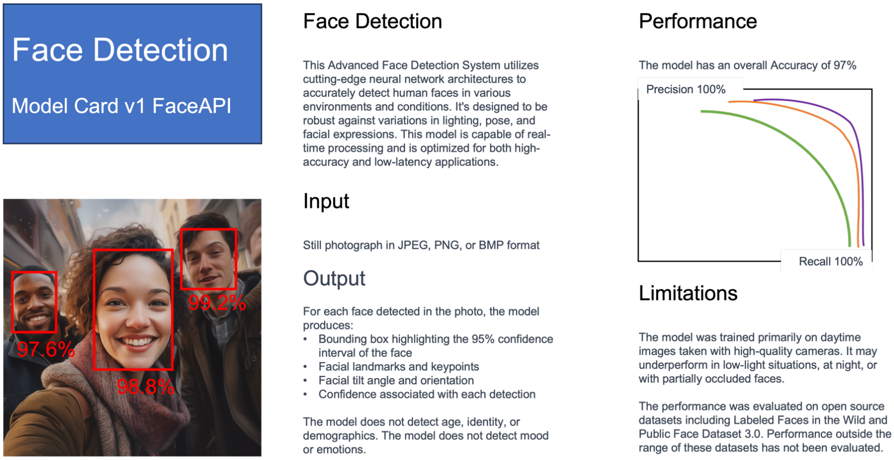


Figure 70. Example of a Model Card for Face Detection. Adapted from [49].

DALL-E-generated depiction of the Trolley Problem for self-driving cars where apparently only robots are harmed (?).

Chapter 17 AI Strategy and Implementation

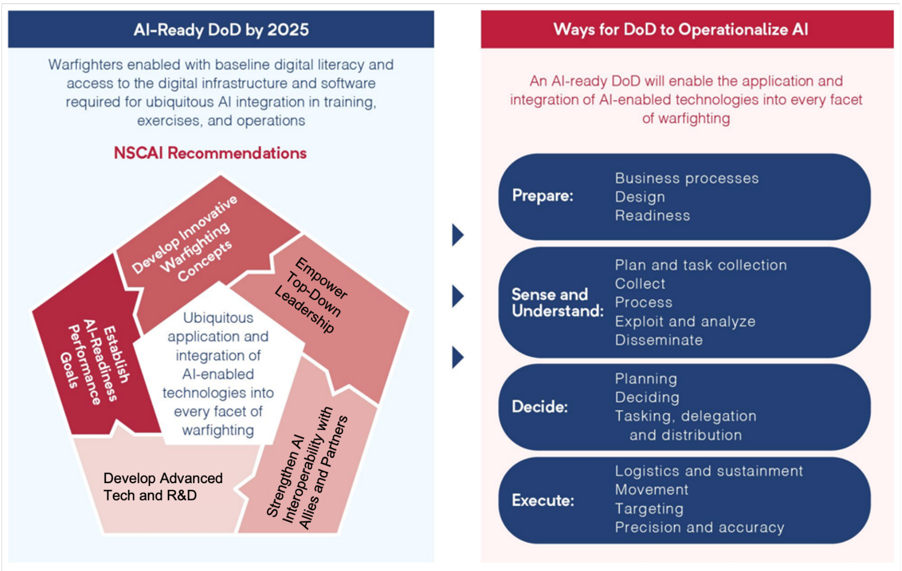


Figure 71. NSCAI Recommendations for an AI-Ready DoD by 2025 [Error! Bookmark not defined.**].**

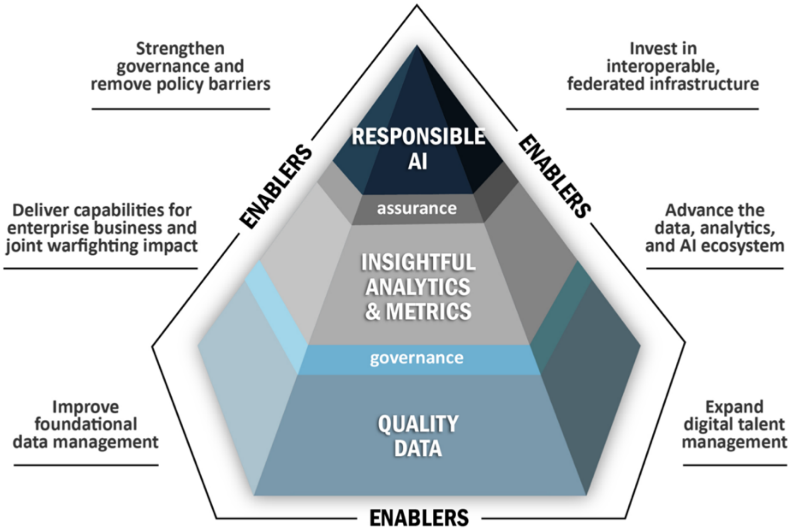


Figure 72. U.S. DoD Strategic Goals and AI Hierarchy of Needs [50].

Figure 73. Word Cloud of Terms that Commonly Appear in AI Strategies.

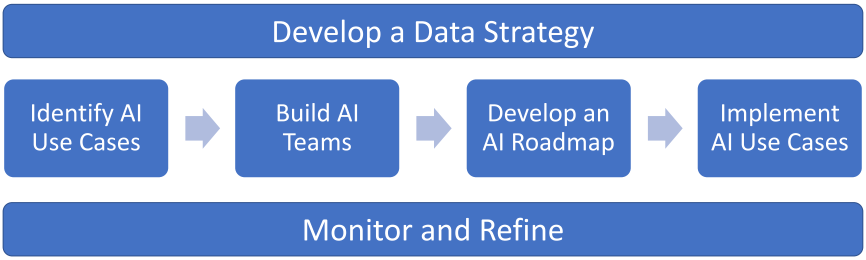


Figure 74. Process for Implementing an AI Strategy

Position Title	Occupational Series	Grade Levels
Information Technology Specialist	2210	GS-9 through GS-15
Computer Scientist (Artificial Intelligence)	1550	GS-9 through GS-15
Computer Engineer (Artificial Intelligence)	0854	GS-9 through GS-15
Management and Program Analyst	0343	GS-9 through GS-15

Chapter 18 Operationalizing AI

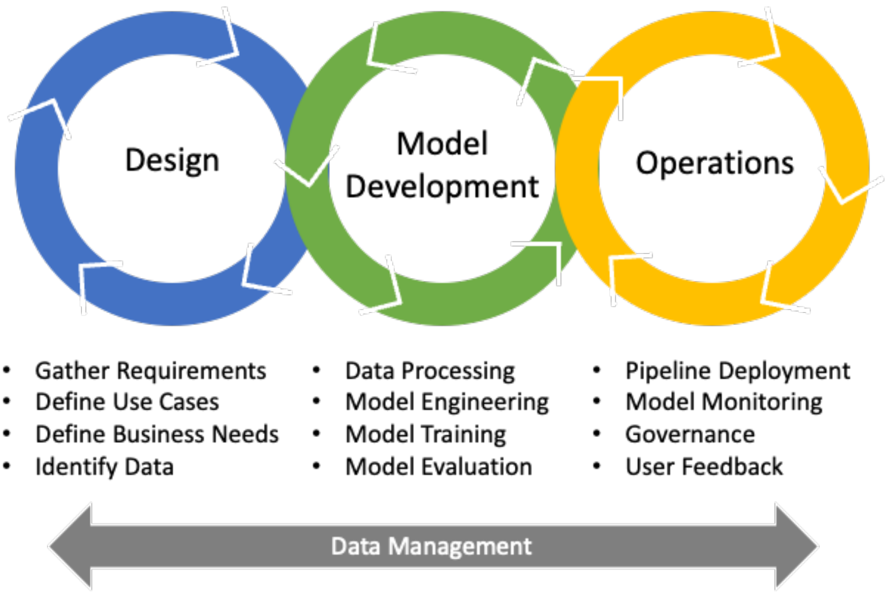


Figure 75. AIOps Life Cycle Process. Adapted from [51, 52, 53].

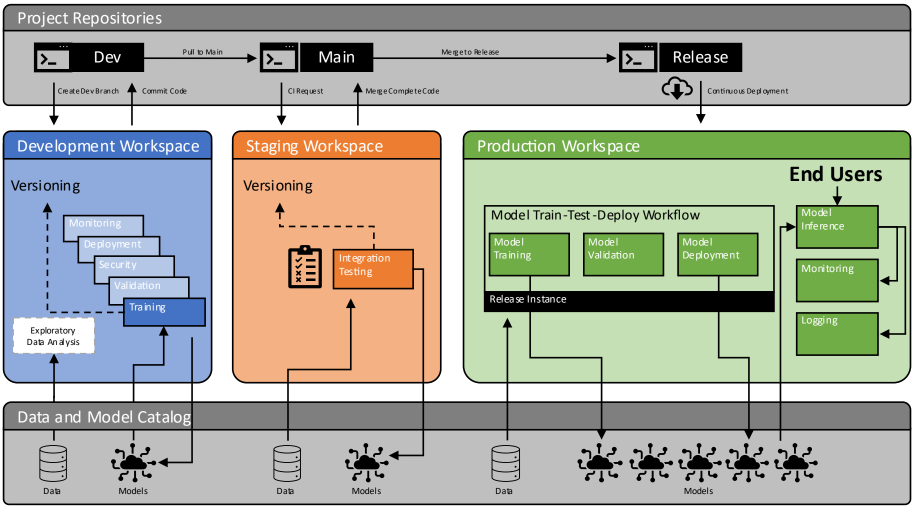


Figure 76. Reference Architecture for a Three-Stage AIOps Process. Adapted from [54].

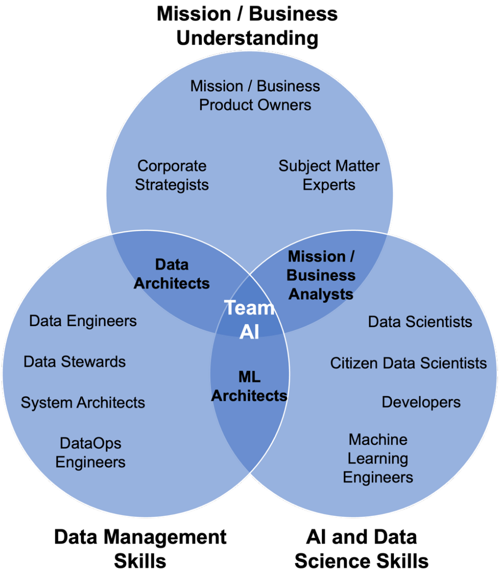


Figure 77. NGA's Approach to Integrating Mission Understanding with Data and AI Skill Sets [55].

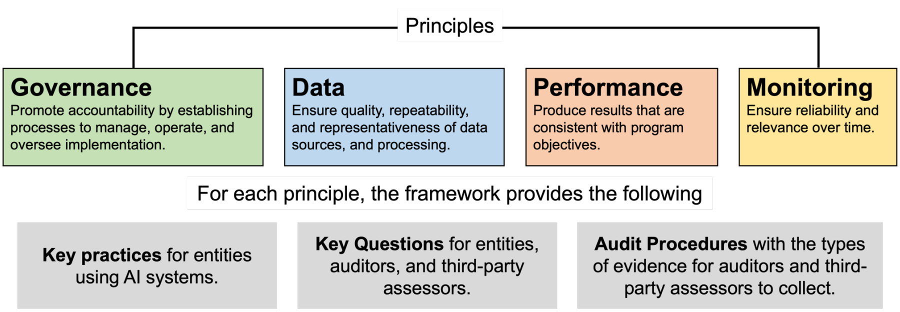


Figure 78. GAO's AI Governance Framework (GAO-21-519SP) [56].

Chapter 19 AI Business Models

Table 13. Summary of Common AI Business Models.

Business Model	Pros	Cons
Product Sale	• Nearly immediate deployment • Turn-key solution • Potentially includes maintenance and updates • Benefit from "economies of scale" of the commercial market • Easy to perform market research	• Almost never customizable • High upfront costs • Recurring license fees • Government often becomes the only customer for legacy software • Vendor lock and price increases
Subscription/ SaaS	• Continuous updates • No need for own IT infrastructure • Scalable service level; pay-per-use • Usually includes the latest technology • Easier to integrate with other SaaS on the same platform	• Ongoing subscription costs • Potential data security concerns • May lack full customization • Personnel with knowledge of SaaS are in high demand ($$$$) • Hard to implement on closed networks
Consulting and Custom Development	• Tailored solutions • Flexibility in design • Can be highly specific to mission needs • Agencies get what they want (anything for a price)	• Time-consuming to develop • Potentially (usually) higher costs • Requires highly specialized expertise • Requires lengthy procurements and contracting actions • Seen as a "legacy" model
Public-Private Partnerships (PPPs)	• Leverages strengths of both sectors; open model • Can speed up development • Shared resources and expertise	• Complex management • May have shared IP issues • Longer negotiation phases • Few successful models in government
Outcome-Based Contracts	• Focuses on results • Encourages innovation • Promotes accountability	• Needs clear, measurable outcomes and goals to promote valid outcomes • Can place high risk on contractors

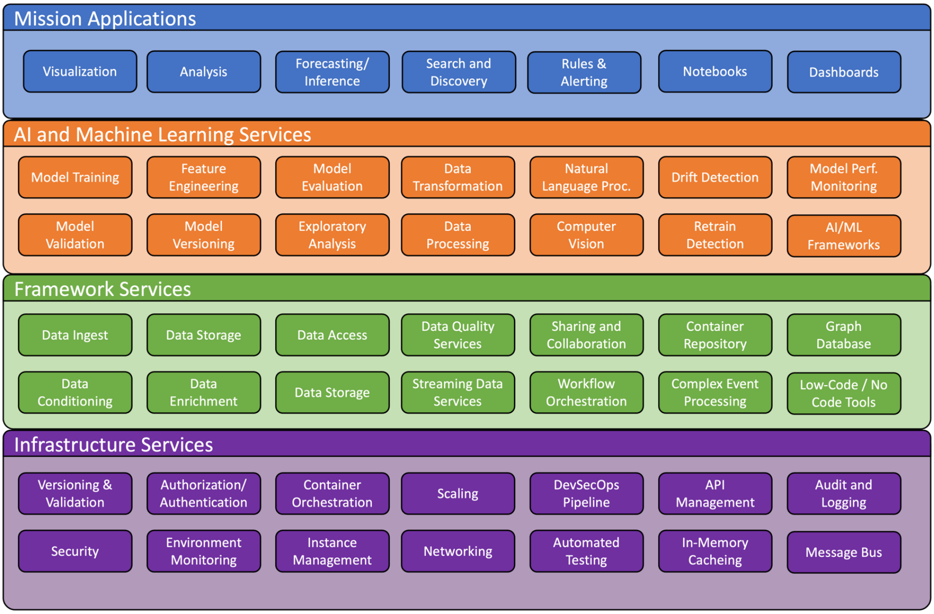


Figure 79. Reference Architecture for an AI System.

Chapter 20 Towards Artificial General Intelligence

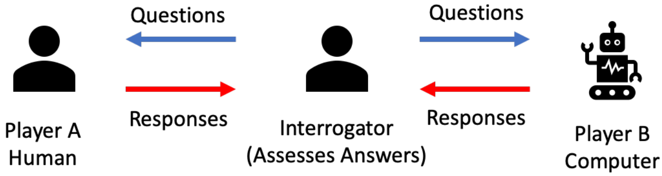
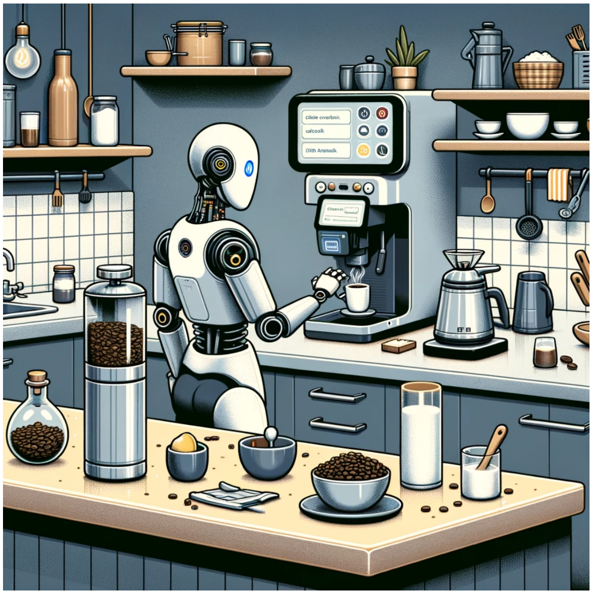


Figure 80. Canonical Formulation of Turing's "Imitation Game."

The Chinese Room Experiment



Wozniak's Coffee Test

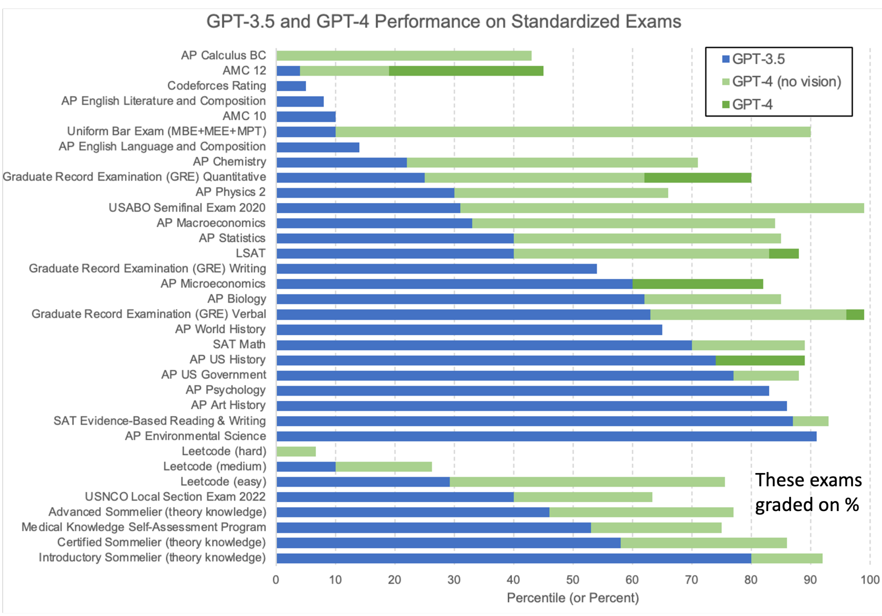


Figure 81. GPT-4 Performance on Academic and Professional Exams. Adapted from [57].

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