## I'm not a robot



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on June 24 at 11amET.Register NowHow can financial brands set themselves apart through visual storytelling? Our experts explainhow.Learn MoreThe Motorsport Images Collections captures events from 1895 to todays most recentcoverage. Discover The Collection What is AI? Artificial Intelligence (AI) refers to the development of computer systems
of performing tasks that require human intelligence. AI aids, in processing amounts of data identifying patterns and making decisions based on the collected information. This can be achieved through techniques like Machine Learning, Natural Language Processing, Computer Vision and Robotics. AI encompasses a range of abilities including
learning, reasoning, perception, problem solving, data analysis and language comprehension. The ultimate goal of AI is to create machines that can emulate capabilities and carry out diverse tasks, with enhanced efficiency and precision. The field of AI holds potential to revolutionize aspects of our daily lives. In this article, we will know about What is
Artificial Intelligence?, its evolution, various types of AI, training models, benefits. What is Artificial Intelligence (AI) has become increasingly integrated into various aspects of our lives, revolutionizing industries and impacting daily routines. Here are some examples illustrating the diverse applications of
AI:Virtual Personal Assistants: Popular examples like Siri, Google Assistant, and Amazon Alexa utilize AI to understand and respond to user commands. These assistants employ natural language processing (NLP) and machine learning algorithms to improve their accuracy and provide more personalized responses over time. Autonomous Vehicles: AI
powers the development of self-driving cars, trucks, and drones. Companies like Tesla, Waymo, and Uber are at the forefront of this technology, using AI algorithms to analyze sensory data from cameras, radar, and lidar to make real-time driving decisions. Healthcare Diagnosis and Treatment: AI algorithms are used to analyze medical data, including
patient records, imaging scans, and genetic information, to assist healthcare professionals in diagnosing diseases and planning treatments. IBM's Watson for Health and Google's DeepMind are examples of AI platforms employed in healthcare. Recommendation Systems: Online platforms like Netflix, Amazon, and Spotify utilize AI to analyze user
behaviour and preferences, providing personalized recommendations for movies, products, and music. These systems employ collaborative filtering and content-based filtering techniques to enhance user experience and increase engagement. Fraud Detection: AI algorithms are employed by financial institutions to detect fraudulent activities in real-
time. These systems analyze. AI has the potential to revolutionize many industries and fields, such as healthcare, finance, transportation, and education. However, it also raises important ethical and societal questions, such as the impact on employment and privacy, and the responsible development and use of AI technology. Importance of AIToday, the
amount of data in the world is so humongous that human fall short of absorbing, interpreting, and making decision-making requires higher cognitive skills than human beings. This is why were trying to build machines better than us, in these task. Another major characteristic that AI machines possess but we
dont is repetitive learning. Let consider an example of how Artificial Intelligence is important to us. Data that is fed into the machines could be real-life incidents. How people interact, behave and react? etc. So, in other words, machines learn to think like humans, by observing and learning from humans. Thats precisely what is called Machine
Learning which is a subfield of AI. Humans are observed to find repetitive tasks highly boring. Accuracy is another factor in which we humans lack. Machines can also take risks instead of human beings. AI is used in various fields like: Health CareRetailManufacturingBanking
etc. Types of AIAI can be broadly classified into two major categories: Based on Capabilities: 1. Narrow AI: N
understanding of human intelligence. Narrow AI is the most common form of AI currently in use and has found widespread application across various industries and focused on performing a specific function or solving a particular
problem.Limited scope: These systems are not capable of generalizing their knowledge or skills to other domains outside of their designated tasks. Lack of consciousness: Narrow AI lacks self-awareness and consciousness. It operates based on predefined algorithms and data inputs without understanding the context or implications of its
actions. Examples: Virtual personal assistants like Siri and Alexa, recommendation systems, image recognition software, chatbots, and autonomous vehicles are all examples of Narrow AI.2. General AI: Also referred to as "General AI". Here is where there is no difference between a machine and a human being. This is the kind of AI we see in the
movies, the robots. A close example (not the perfect example) would be the worlds first citizen robot, Sophia talks like she has emotions. General AI, also known as Strong AI or Artificial General Intelligence (AGI), refers to artificial intelligence systems that replicate human-like cognitive
abilities and understanding across a wide range of tasks and domains. Unlike Narrow AI, which is task-specific, General AI aims to simulate human intelligence comprehensively, including reasoning, problem-solving, learning, and adaptation to new situations. Characteristics of General AI include: Human-like cognitive abilities: General AI systems can
understand, learn, and apply knowledge across various tasks and domains, similar to human intelligence. Adaptability: These systems have the ability to general AI is theorized to possess self-awareness, consciousness, and subjective experiences, although
achieving this level of intelligence remains a theoretical challenge. Examples: General AI remains largely theoretical and speculative, as researchers have not yet achieved human-level artificial intelligence. Development in this area continues to be a subject of ongoing research and exploration. 3. Super Intelligent AI: Super intelligence are not intelligence are not intelligence and exploration.
artificial intelligence systems that surpass human intelligence (ASI), represents the highest level of AI capabilities and poses significant implications for society and the future of humanity. Characteristics of Super intelligence (ASI), represents the highest level of AI capabilities and poses significant implications for society and the future of humanity. Characteristics of Super intelligence (ASI), represents the highest level of AI capabilities and poses significant implications for society and the future of humanity.
intelligent AI outperforms humans in terms of cognitive abilities, including problem-solving, creativity, and strategic planning. Rapid learning and adaptation: These systems can acquire and process information at an unprecedented speed and scale, leading to rapid advancements in various fields. Ethical and existential risks: The development of Super
intelligent AI raises concerns about its potential impact on society, including risks related to control, alignment with human values, and existential threats to humanity. Examples: Super intelligent AI remains theoretical, and no concrete examples exist as of now. However, researchers are actively exploring the implications and challenges associated
with its development. Based on Functionalities: 1. Reactive machines: These are the most basic type of AI and are purely reactive as the name suggests. They neither can form memories nor can use past experiences to form decisions. An example would be IBMs Deep Blue chess-playing supercomputer which is mentioned above. Deep Blue beat the
international grandmaster Garry Kasparov in 1997. It can choose the most optimal of the chess moves and beat the opponent. Apart from a rarely used chess-specific rule against repeating the same move three times, Deep Blue ignores everything before the present moment, thus not storing any memories. This type of AI just perceives the world, the
chess game in the case of Deep Blue, and acts on it.2. Limited memory: These machines can look into the past. Not the ability to predict what happened in the past, but the usage of memories to form decisions. A common example could include self-driving cars. For example, they observe other cars speed and directions and act accordingly. This
requires monitoring of how a car is driven for a specific amount of time. Just like how humans observe and learn the specifics. These pieces of information are not stored in the library of experiences and can learn from it, but limited memory
machines cant.3. Theory of mind: These are types of machines that can understand that people have beliefs, emotions, expectations, etc., and have some of their own. A "theory of mind" machine can think emotionally and can respond with emotions. Even though there are close examples of this kind of AI like Sophia, the research is not complete yet
In other words, these machines have a notion of not just the world, but also the existing entities of the world, like human beings, animals, etc. These machines will be capable of answering simple "what if" questions. They machines will be capable of answering simple "what if" questions. They machines will be capable of answering simple "what if" questions.
machines exist and the invention of them would be a milestone in the field of AI. These basically will have a sense of consciousness of who they are. The sense of sense of unit to play is different from the feeling of I know I want to play. In the
latter, if you notice, there is a sense of consciousness and is a characteristic of a self-aware machine, while the former feeling is a characteristic of a theory-of-mind machine. Self-aware machine machine, while the former feeling is a characteristic of a theory-of-mind machine. Self-aware machine machine, while the former feeling is a characteristic of a theory-of-mind machine.
techniques and approaches that enable machines to simulate human-like intelligence and perform tasks that traditionally require human assistance. AI systems work through a combination of algorithms, data, and computational power. Here's an overview of how AI works:Data Collection: AI systems rely on vast amounts of data to learn and make
decisions. Data can be collected from various sources, including sensors, digital devices, databases, the internet, and user interactions. The quality and quantity of data are crucial for training accurate and reliable AI models. Data Pre-processing: Once data is collected, it needs to be pre-processed to ensure it's clean, structured, and suitable for
analysis. This pre-processing stage may involve tasks such as cleaning noisy data, handling missing values, standardizing formats, and encoding categorical variables. Algorithms are suited for different types of tasks, such as
classification, regression, clustering, and pattern recognition. Common AI algorithms include neural networks, decision trees, support vector machines, and k-nearest neighbours. Model Training: In the training phase, AI models are fed with labelled data (supervised learning) or unlabelled data (unsupervised learning) to learn patterns and
relationships. During training, the model adjusts its parameters iteratively to minimize errors and improve its performance on the given task. This process involves optimization techniques like gradient descent and backpropagation in neural networks. Model Evaluation: After training, the AI model is evaluated using separate validation data to assess involves optimization techniques like gradient descent and backpropagation in neural networks. Model Evaluation:
its performance and generalization ability. Performance metrics such as accuracy, precision, recall, F1-score, and area under the curve (AUC) are used to quantify the model's effectiveness in making predictions or decisions. Model Deployment: Once the AI model meets the desired performance criteria, it can be deployed into production environments
to perform real-world tasks. Deployment involves integrating the model into existing systems, such as mobile apps, web services, or embedded devices, to provide AI-driven functionalities. Continuous Learning and Improvement: AI systems can adapt and improve over time through continuous learning. They can be updated with new data and
retrained periodically to stay relevant and accurate in dynamic environments. Techniques like online learning, and reinforcement learning enable AI model applies its learned knowledge to make predictions or
decisions on new, unseen data. Inference involves feeding input data into the model and obtaining output predictions or classifications based on the model's learned patterns and representations. Overall, AI systems work by leveraging data, algorithms, and computational power to learn from experience, make decisions, and perform tasks
autonomously. The specific workings of an AI system depend on its architecture, algorithms, and the nature of the tasks it's designed to accomplish. Applications of AIArtificial Intelligence (AI) has a wide range of applications and has been adopted in many industries to improve efficiency, accuracy, and productivity. Some of the most common uses of
AI are: Healthcare: AI is used in healthcare for various purposes such as diagnosing diseases, predicting patient outcomes, drug discovery, and personalized treatment plans. Finance industry for tasks such as credit scoring, fraud detection, portfolio management, and financial forecasting. Retail: AI is used in the retail industry for tasks such as credit scoring, fraud detection, portfolio management, and financial forecasting. Retail: AI is used in the retail industry for tasks such as credit scoring.
for applications such as customer service, demand forecasting, and personalized marketing. Manufacturing for tasks such as quality control, predictive maintenance, and supply chain optimization. Transportation: AI is used in transportation for optimizing routes, improving traffic flow, and reducing fuel
consumption. Education: AI is used in education for personalizing learning experiences, improving student engagement, and providing educational resources. Marketing: AI is used in marketing for developing
intelligent game characters and providing personalized gaming experiences. Security: AI is used in NLP for tasks such as speech recognition, and cyber threat analysis. These are some of the
most common uses of AI, but the Applications of AI are constantly expanding, evolving, and it is likely to involve continued advancements in machine learning, natural language processing, and computer vision, which will enable AI systems to become increasingly capable and
integrated into a wide range of applications and industries. Some potential areas of growth for AI include healthcare, finance, transportation, and customer service. Additionally, there may be increasing use of AI in more sensitive areas such as decision making in criminal justice, hiring and education, which will raise ethical and societal implications
that need to be addressed. It is also expected that there will be more research and development in areas such as explainable AI, trustworthy AI and AI safety to ensure that AI systems are transparent, reliable and safe to use. Intelligence of machines "AI" redirects here. For other uses, see AI (disambiguation) and Artificial intelligence
(disambiguation). Part of a series on Artificial intelligence (AI) Major goals Artificial general intelligence epresentation Natural language processing Robotics AI safety Approaches Machine learning Symbolic Deep learning Bayesian networks Evolutionary
algorithms Hybrid intelligent systems Systems integration Applications Bioinformatics Deepfake Earth sciences Finance Generative AIArt Audio Music Government Health Industry Translation Military Physics Projects Philosophy Artificial consciousness Chinese room Friendly AIControl problem Takeover Ethics Existential risk Turing
testUncanny valleyHistoryTimelineProgressAI winterAI boomGlossaryGlossaryvteArtificial intelligence (AI) is the capability of computational systems to perform tasks typically associated with human intelligence, such as learning, reasoning, problem-solving, perception, and decision-making. It is a field of research in computer science that develops
and studies methods and software that enable machines to perceive their environment and use learning and intelligence to take actions that maximize their chances of achieving defined goals.[1]High-profile applications of AI include advanced web search engines (e.g., Google Search); recommendation systems (used by YouTube, Amazon, and
Netflix); virtual assistants (e.g., Google Assistant, Siri, and Alexa); autonomous vehicles (e.g., Waymo); generative and Go). However, many AI applications are not perceived as AI: "A lot of cutting edge AI has filtered into general
applications, often without being called AI because once something becomes useful enough and common enough it's not labeled AI anymore."[2][3]Various subfields of AI research include learning, reasoning, knowledge representation, planning,
natural language processing, perception, and support for robotics.[a] To reach these goals, AI researchers have adapted and integrated a wide range of techniques, including search and mathematical optimization, formal logic, artificial neural networks, and methods based on statistics, operations research, and economics.[b] AI also draws upon
psychology, linquistics, philosophy, neuroscience, and other fields.[4] Some companies, such as OpenAI, Google DeepMind and Meta, aim to create artificial intelligence was founded as an academic discipline in 1956,[6] and the field went
through multiple cycles of optimism throughout its history,[7][8] followed by periods of disappointment and loss of funding, known as AI winters.[9][10] Funding and interest vastly increased after 2012 when graphics processing units started being used to accelerate neural networks, and deep learning outperformed previous AI techniques.[11] This
growth accelerated further after 2017 with the transformer architecture.[12] In the 2020s, the period of rapid progress marked by advanced generative AI became known as the AI boom. Generative AI and its ability to create and modify content exposed several unintended consequences and harms in the present and raised ethical concerns about AI's
long-term effects and potential existential risks, prompting discussions about regulatory policies to ensure the safety and benefits of the technology. The general problem of simulating (or creating) intelligent system to display.
The traits described below have received the most attention and cover the scope of AI research.[a] Early researchers developed for dealing with uncertain or incomplete
 information, employing concepts from probability and economics.[14]Many of these algorithms are insufficient for solving large reasoning problems grow.[15] Even humans rarely use the step-by-step deduction that early AI research could model
intelligently and make deductions about real-world facts. Formal knowledge representations are used in content-based indexing and actionable inferences from large databases),[21] and other areas.[22]A knowledge base is a body of
knowledge represented in a form that can be used by a program. An ontology is the set of objects, relations, concepts, and properties used by a particular domain of knowledge bases need to represent things such as objects, properties, categories, and relations between objects; [24] situations, events, states, and time; [25] causes and
effects;[26] knowledge about knowledge (what we know about what other people know);[27] default reasoning (things that humans assume are true until they are told differently and will remain true even when other facts are changing);[28] and many other aspects and domains of knowledge. Among the most difficult problems in knowledge
representation are the breadth of commonsense knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally).[16] There is also the difficulty of knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally).[16] There is also the difficulty of knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally).[16] There is also the difficulty of knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally).[16] There is also the difficulty of knowledge (much of what people know is not represented as "facts" or "statements" that they could express verbally).[16] There is also the difficulty of knowledge (much of what people know is not represented as "facts" or "statements" o
acquisition, the problem of obtaining knowledge for AI applications.[c]An "agent" is anything that perceives and takes actions in the world. A rational agent has a specific goal.[33] In automated decision-making, the agent has preferencesthere
are some situations it would prefer to be in, and some situations it is trying to avoid. The decision-making agent assigns a number to each situation (called the "utility") that measures how much the agent prefers it. For each possible action, it can calculate the "expected utility": the utility": the utility of all possible outcomes of the action, weighted by the
probability that the outcome will occur. It can then choose the action with the maximum expected utility. [34] In classical planning, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be. [35] In most real-world problems, however, the agent knows exactly what the effect of any action will be action will be action with the effect of any action will be action wi
for certain what will happen after each possible action (it is not "deterministic"). It must choose an action by making a probabilistic guess and then reassess the situation to see if the action worked.[36]In some problems, the agent's preferences may be uncertain, especially if there are other agents or humans involved. These can be learned (e.g., with
inverse reinforcement learning), or the agent can seek information to improve its preferences.[37] Information value theory can be used to weigh the value of exploratory or experimental actions. [38] The space of possible future actions and situations while being
uncertain of what the outcome will be. A Markov decision process has a transition model that describes the probability that a particular way and a reward function that supplies the utility of each state and the cost of each action. A policy associates a decision with each possible state. The policy could be
calculated (e.g., by iteration), be heuristic, or it can be learned. [39] Game theory describes the rational behavior of multiple interacting agents and is used in AI programs that make decisions that involve other agents. [40] Machine learning is the study of programs that can improve their performance on a given task automatically. [41] It has been a part
of AI from the beginning.[e]There are several kinds of machine learning analyzes a stream of data and finds patterns and makes predictions without any other guidance.[44] Supervised learning the training data with the expected answers, and comes in two main varieties: classification (where the program
must learn to predict what category the input belongs in) and regression (where the program must deduce a numeric function based on numeric input).[45] In reinforcement learning, the agent is rewarded for good responses that are classified as "good".[46] Transfer learning is when
the knowledge gained from one problem is applied to a new problem. [47] Deep learning is a type of machine learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through biologically inspired artificial neural networks for all of these types of learning that runs inputs through the runs input t
required), or by other notions of optimization. [49] Natural language processing (NLP)[50] allows programs to read, write and communicate in human languages such as English. Specific problems include speech recognition, speech synthesis, machine translation, information extraction, information retrieval and question answering. [51] Early work,
based on Noam Chomsky's generative grammar and semantic networks, had difficulty with word-sense disambiguation[f] unless restricted to small domains called "micro-worlds" (due to the common sense knowledge problem[29]). Margaret Masterman believed that it was meaning and not grammar that was the key to understanding languages, and
that thesauri and not dictionaries should be the basis of computational language structure. Modern deep learning techniques for NLP include word embedding (representing words, typically as vectors encoding their meaning), [52] transformers (a deep learning architecture using an attention mechanism), [53] and others. [54] In 2019, generative pre-
trained transformer (or "GPT") language models began to generate coherent text,[55][56] and by 2023, these models were able to get human-level scores on the bar exam, SAT test, GRE test, and many other real-world applications.[57]Machine perception is the ability to use input from sensors (such as cameras, microphones, wireless signals, active
lidar, sonar, radar, and tactile sensors) to deduce aspects of the world. Computer vision is the ability to analyze visual input.[58]The field includes speech recognition,[61] and robotic perception.[63]Kismet, a robot head which was made in the 1990s; it is a machine
dynamics of human interaction, or to otherwise facilitate humancomputer interaction. However, this tends to give nave users an unrealistic conception of the intelligence of existing computer agents. [66] Moderate successes related to affective computing include textual sentiment analysis and, more recently, multimodal sentiment analysis, wherein AI
classifies the effects displayed by a videotaped subject. [67] A machine with artificial general intelligence should be able to solve a wide variety of techniques to accomplish the goals above. [b] AI can solve many problems by intelligently searching
through many possible solutions.[69] There are two very different kinds of search used in AI: state space search and local search through trees of goals and subgoals, attempting to find a path to a target goal, a process
called means-ends analysis.[71]Simple exhaustive searches[72] are rarely sufficient for most real-world problems: the search space (the number of places to slow or never completes.[15] "Heuristics" or "rules of thumb" can help prioritize choices that are more likely to
reach a goal.[73]Adversarial search is used for game-playing programs, such as chess or Go. It searches through a tree of possible moves and countermoves, looking for a winning position.[74]Illustration of gradient descent for 3 different starting points; two parameters (represented by the plan coordinates) are adjusted in order to minimize the loss
function (the height) Local search uses mathematical optimization to find a solution to a problem. It begins with some form of guess and refines it incrementally adjusting them to minimize a loss function. Variants of gradient descent are
commonly used to train neural networks,[76] through the backpropagation algorithm. Another type of local search is evolutionary computation, which aims to iteratively improve a set of candidate solutions by "mutating" and "recombining" them, selecting only the fittest to survive each generation. [77] Distributed search processes can coordinate via
swarm intelligence algorithms. Two popular swarm algorithms used in search are particle swarm optimization (inspired by bird flocking) and trails).[78]Formal logic comes in two main forms: propositional logic (which operates on statements
that are true or false and uses logical connectives such as "and", "or", "not" and "implies")[80] and predicate logic (which also operates on objects, predicates and relations and uses quantifiers such as "Every X is a Y" and "There are some Xs that are Ys").[81]Deductive reasoning in logic is the process of proving a new statement (conclusion) from
other statements that are given and assumed to be true (the premises). [82] Proofs can be structured as proof trees, in which nodes are labelled by sentences, and children nodes are connected to parent nodes by inference rules. Given a proof tree whose root node is labelled by
a solution of the problem and whose leaf nodes are labelled by premises or axioms. In the case of Horn clauses, problem-solving search can be performed by reasoning forwards from the premises or backwards from the premises of 
which a problem is solved by proving a contradiction from premises that include the negation of the problem to be solved.[84]Inference in both Horn clauses, which underpins computation in the logic programming language Prolog, is
Turing complete. Moreover, its efficiency is competitive with computation in other symbolic programming languages.[85]Fuzzy logic assigns a "degree of truth" between 0 and 1. It can therefore handle propositions that are vague and partially true.[86]Non-monotonic logics, including logic programming with negation as failure, are designed to handle
default reasoning.[28] Other specialized versions of logic have been developed to describe many complex domains. A simple Bayesian network, with the associated conditional probability tablesMany problems in AI (including reasoning, planning, learning, perception, and robotics) require the agent to operate with incomplete or uncertain information
AI researchers have devised a number of tools to solve these problems using methods from probability theory and economics.[87] Precise mathematical tools have been developed that analyse how an agent can make choices and plan, using decision theory, decision analysis, [88] and information value theory. [89] These tools include models such as
Markov decision processes,[90] dynamic decision networks,[91] game theory and mechanism design.[92]Bayesian networks[93] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[9][95] learning (using the synchronic decision networks)[98] and perception (using the synchronic decision networks)[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] and perception (using the synchronic decision networks)[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm),[98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inference algorithm), [98] are a tool that can be used for reasoning (using the Bayesian inf
dynamic Bayesian networks).[91]Probabilistic algorithms can also be used for filtering, prediction, smoothing, and finding explanations for streams of data, thus helping perception systems analyze processes that occur over time (e.g., hidden Markov models or Kalman filters).[91]Expectationmaximization clustering of Old Faithful eruption data starts
from a random guess but then successfully converges on an accurate clustering of the two physically distinct modes of eruption. The simplest AI applications can be divided into two types: classifiers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if diamond then pick up"), on the other hand. Classifiers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if diamond then pick up"), on the other hand. Classifiers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one hand, and controllers (e.g., "if shiny then diamond"), on one 
pattern matching to determine the closest match. They can be fine-tuned based on chosen examples using supervised learning. Each pattern (also called an "observation") is labeled with a certain predefined class. All the observation is received, that observation is
 classified based on previous experience.[45]There are many kinds of classifiers in use.[100] The decision tree is the simplest and most widely used analogical AI until the mid-1990s, and Kernel methods such as the support vector machine (SVM)
displaced k-nearest neighbor in the 1990s.[102]The naive Bayes classifier is reportedly the "most widely used learner"[103] at Google, due in part to its scalability.[104]Neural network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain. An artificial neural network is an interconnected group of nodes, akin to the vast network is an interconnected group of nodes.
network is based on a collection of nodes also known as artificial neurons, which loosely model the neurons in a biological brain. It is trained to recognise patterns; once trained, it can recognise a function and once the weight crosses its an input, at least one hidden layer of nodes and an output. Each node applies a function and once the weight crosses its an input, at least one hidden layer of nodes and an output.
specified threshold, the data is transmitted to the next layer. A network is typically called a deep neural network if it has at least 2 hidden layers. [105] Learning algorithms for neural network is typically called a deep neural network if it has at least 2 hidden layers.
algorithm.[106] Neural networks learn to model complex relationships between inputs and outputs and find patterns in data. In theory, a neural networks feed the output signal back into the input, which allows short
term memories of previous input events. Long short term memory is the most successful architecture for recurrent neural networks strengthen the connection between neurons that are "close" to each otherthis is
especially important in image processing, where a local set of neurons must identify an object.[112]Deep learning[111] uses several layers of neurons between the network's inputs and outputs. The multiple layers can progressively extract higher-level features from the raw input. For example, in image
processing, lower layers may identify edges, while higher layers may identify the concepts relevant to a human such as digits, letters, or faces.[113]Deep learning has profoundly improved the performance of programs in many important subfields of artificial intelligence, including computer vision, speech recognition, natural language processing
 image classification,[114] and others. The reason that deep learning performs so well in so many applications is not known as of 2021.[115] The sudden success of deep neural networks and backpropagation had been described by many people, as
far back as the 1950s)[i] but because of two factors: the incredible increase in computer power (including the hundred-fold increase in speed by switching to GPUs) and the availability of vast amounts of training data, especially the giant curated datasets used for benchmark testing, such as ImageNet.[j]Generative pre-trained transformers (GPT) are
large language models (LLMs) that generate text based on the semantic relationships between words in sentences. Text-based GPT models are pre-training consists of predicting the next token (a token being usually a word, subword, or punctuation). Throughout this pretraining
GPT models accumulate knowledge about the world and can then generate human-like text by repeatedly predicting the next token. Typically, a subsequent training phase makes the model more truthful, useful, and harmless, usually with a technique called reinforcement learning from human feedback (RLHF). Current GPT models are prone to
generating falsehoods called "hallucinations". These can be reduced with RLHF and quality data, but the problem has been getting worse for reasoning systems.[123] Such systems are used in chatbots, which allow people to ask a question or request a task in simple text.[124][125]Current models and services include Gemini (formerly Bard),
ChatGPT, Grok, Claude, Copilot, and LLaMA.[126] Multimodal GPT models can process different types of data (modalities) such as images, videos, sound, and text.[127]Main artificial intelligence and Hardware for artificial intelligence and Hardware for artificial intelligence and the late 2010s, graphics processing units (GPUs) that were increasingly
designed with AI-specific enhancements and used with specialized TensorFlow software had replaced previously used central processing unit (CPUs) as the dominant means for large-scale (commercial and academic) machine learning models' training.[128] Specialized programming languages such as Prolog were used in early AI research,[129] but
general-purpose programming languages like Python have become predominant.[130]The transistor density in integrated circuits has been observed to roughly double every 18 months trend known as Moore's law, named after the Intel co-founder Gordon Moore, who first identified it. Improvements in GPUs have been even faster,[131] a trend
sometimes called Huang's law,[132] named after Nvidia co-founder and CEO Jensen Huang. Main article: Applications of the essential applications of the essen
(offered by Netflix, YouTube or Amazon), driving internet traffic, targeted advertising (AdSense, Facebook), virtual assistants (such as Siri or Alexa), autonomous vehicles (including drones, ADAS and self-driving cars), autonomous vehicles (including drones, ADAS and self-driving drones, ADAS and self-driving cars), autonomous vehicles (including drones, ADAS and self-driving drones, ADAS and self-driving cars), autonomous vehicles (including drones, ADAS and self-driving drones, ADAS and self-driving cars), autonomous vehicles (including drones, ADAS and self-driving drones, ADAS and self-driving cars), autonomous vehicles (including drones, ADAS and self-driving drones
and Google's FaceNet) and image labeling (used by Facebook, Apple's Photos and TikTok). The deployment of AI may be overseen by a Chief automation officer (CAO). Main article: Artificial intelligence in healthcare The application of AI may be overseen by a Chief automation officer (CAO). Main article: Artificial intelligence in healthcare The application of AI in medicine and medical research has the potential to increase patient care and quality of life. [133] Through the
lens of the Hippocratic Oath, medical professionals are ethically compelled to use AI, if applications can more accurately diagnose and treat patients. [134] [135] For medical professionals are ethically compelled to use AI, if applications can more accurately diagnose and treat patients.
imaging as a key technique in fabrication.[136] It has been suggested that AI can overcome discrepancies in funding allocated to different fields of research.[136] New AI tools can deepen the understanding of biomedically relevant pathways. For example, AlphaFold 2 (2021) demonstrated the ability to approximate, in hours rather than months
the 3D structure of a protein.[138] In 2023, it was reported that AI-guided drug discovery helped find a class of antibiotics capable of killing two different types of drug-resistant bacteria.[139] In 2024, researchers used machine learning to accelerate the search for Parkinson's disease drug treatments. Their aim was to identify compounds that block
the clumping, or aggregation, of alpha-synuclein (the protein that characterises Parkinson's disease). They were able to speed up the initial screening process ten-fold and reduce the cost by a thousand-fold.[140][141]Main article: Game artificial intelligenceGame playing programs have been used since the 1950s to demonstrate and test AI's most
advanced techniques.[142] Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov, on 11 May 1997.[143] In 2011, in a Jeopardy! quiz show exhibition match, IBM's question answering system, Watson, defeated the two greatest Jeopardy! champions, Brad Rutter and Ken Jennings, by a
significant margin.[144] In March 2016, AlphaGo won 4 out of 5 games of Go in a match with Go champion Lee Sedol, becoming the first computer Go-playing system to beat a professional Go player without handicaps. Then, in 2017, it defeated Ke Jie, who was the best Go player in the world.[145] Other programs handle imperfect-information games
such as the poker-playing program Pluribus. [146] DeepMind developed increasingly generalistic reinforcement learning models, such as with MuZero, which could be trained to play chess, Go, or Atari games. [147] In 2019, DeepMind's AlphaStar achieved grandmaster level in StarCraft II, a particularly challenging real-time strategy game that
involves incomplete knowledge of what happens on the map.[148] In 2021, an AI agent competed in a PlayStation Gran Turismo drivers using deep reinforcement learning.[149] In 2024, Google DeepMind introduced SIMA, a type of AI capable of autonomously playing nine previously
unseen open-world video games by observing screen output, as well as executing short, specific tasks in response to natural language instructions. [150] Large language models, such as GPT-4, Gemini, Claude, Llama or Mistral, are increasingly used in mathematics. These probabilistic models are versatile, but can also produce wrong answers in the
form of hallucinations. They sometimes need a large database of mathematical problems to learn from, but also methods such as supervised fine-tuning[151] or trained classifiers with human-annotated data to improve answers for new problems and learn from corrections.[152] A February 2024 study showed that the performance of some language
models for reasoning capabilities in solving math problems not included in their training data was low, even for problems with only minor deviations from training the models to produce correct reasoning steps, rather than just the correct result.[154] The Alibaba Group
developed a version of its Qwen models called Qwen2-Math, that achieved state-of-the-art performance on several mathematics problems.[155] In January 2025, Microsoft proposed the technique rStar-Math that leverages Monte Carlo tree search and step-by
step reasoning, enabling a relatively small language model like Qwen-7B to solve 53% of the AIME 2024 and 90% of the MATH benchmark problems.[156] Alternatively, dedicated models for mathematical problem solving with higher precision for the outcome including proof of theorems have been developed such as AlphaTensor, AlphaGeometry,
AlphaProof and AlphaEvolve[157] all from Google DeepMind,[158] Llemma from EleutherAI[159] or Julius.[160]When natural language is used to describe mathematical problems, converters can transform such prompts into a formal language is used to describe mathematical problems.
and reach good results in benchmark tests, others to serve as educational tools in mathematics.[161]Topological deep learning integrates various topological approaches. Finance is one of the fastest growing sectors where automated "robot
advisers" have been in use for some years.[162]According to Nicolas Firzli, director of the World Pensions & Investments Forum, it may be too early to see the emergence of highly innovative AI-informed financial products and services. He argues that "the deployment of AI tools will simply further automatise things: destroying tens of thousands of
jobs in banking, financial planning, and pension advice in the process, but I'm not sure it will unleash a new wave of [e.g., sophisticated] pension innovation."[163]Main article: Military applications of artificial intelligenceVarious countries are deploying AI military applications.[164] The main applications enhance command and control, so that I'm not sure it will unleash a new wave of [e.g., sophisticated] pension innovation."[163]Main article: Military applications of artificial intelligenceVarious countries are deploying AI military applications.
communications, sensors, integration and interoperability.[165] Research is targeting intelligence collection and analysis, logistics, cyber operations, information of sensors and effectors, threat detection and identification, marking of enemy
an excerpt from Generative artificial intelligence (Generative artificial intelligence (Generative artificial intelligence that uses generative models to produce text, images, videos, or other forms of data.[170][171][172] These models learn the underlying patterns and structures of their training data and use
them to produce new data[173][174] based on the input, which often comes in the form of natural language prompts.[175][176]Generative AI tools have become more common since an "AI boom" in the 2020s. This boom was made possible by improvements in transformer-based deep neural networks, particularly large language models (LLMs). Major
tools include chatbots such as ChatGPT, Copilot, Gemini, Grok, and DeepSeek; text-to-image models such as Stable Diffusion, Midjourney, and DALL-E; and text-to-video models such as Veo and Sora.[177][178][179][180] Technology companies developing generative AI include OpenAI, Anthropic, Meta AI, Microsoft, Google, DeepSeek, and Baidu
[175][181][182]Generative AI has raised many ethical questions. It can be used for cybercrime, or to deceive or manipulate people through fake news or deepfakes. [183] Even if used ethically, it may lead to mass replacement of human jobs. [184] The tools themselves have been criticized as violating intellectual property laws, since they are trained on
copyrighted works. [185] Main article: Agents are used in various applications, including virtual assistants, chatbots
autonomous vehicles, game-playing systems, and industrial robotics. Al agents operate within their defined scope and have finite memory and processing capabilities. In real-world applications
AI agents often face time constraints for decision-making and action execution. Many AI agents incorporate learning, AI agents can adapt to new situations and optimise their behaviour for their designated tasks. [186][187]
[188]Applications of AI in this domain include AI-enabled menstruation and fertility trackers that analyze user data to offer predictions, [189] AI-integrated sexual education content, [191] and AI agents that simulate sexual and romantic partners (e.g., Replika), [192] AI is also used for the production of
non-consensual deepfake pornography, raising significant ethical and legal concerns.[193]AI technologies have also been used to attempt to identify online gender-based violence and online sexual grooming of minors.[194][195]There are also thousands of successful AI applications used to solve specific problems for specific industries or institutions.
In a 2017 survey, one in five companies reported having incorporated "AI" in some offerings or processes. [196] A few examples are energy storage, medical diagnosis, military logistics, applications for evacuation and disaster management are
growing. AI has been used to investigate patterns in large-scale and small-scale evacuation conditions.[197][198][199]In agriculture, AI has helped farmers to increase yield and identify areas that need irrigation, fertilization
pesticide treatments. Agronomists use AI to conduct research and development. AI has been used to predict the ripening time for crops such as tomatoes, monitor soil moisture, operate agricultural robots, conduct predictive analytics, classify livestock pig call emotions, automate greenhouses, detect diseases and pests, and save water. Artificial
intelligence is used in astronomy to analyze increasing amounts of available data and applications, mainly for "classification, regression, clustering, forecasting solar activity, and distinguishing between signals and
instrumental effects in gravitational wave astronomy. Additionally, it could be used for activities in space exploration, including the analysis of data from space missions, real-time science decisions of spacecraft, space debris avoidance, and more autonomous operation. During the 2024 Indian elections, US$50 million was spent on
authorized AI-generated content, notably by creating deepfakes of allied (including sometimes deceased) politicians to better engage with voters, and by translating speeches to various local languages. [200] Main article: Ethics of artificial intelligence AI has potential benefits and potential risks. [201] AI may be able to advance science and find
solutions for serious problems: Demis Hassabis of DeepMind hopes to "solve intelligence, and then use that to solve everything else".[202] However, as the use of AI has become widespread, several unintended consequences and risks have been identified.[203] In-production systems can sometimes not factor ethics and bias into their AI training
processes, especially when the AI algorithms are inherently unexplainable in deep learning algorithms require large amounts of data. The techniques used to acquire this data have raised concerns about privacy, surveillance and copyright. AI-
powered devices and services, such as virtual assistants and IoT products, continuously collect personal information, raising concerns about intrusive data gathering and unauthorized access by third parties. The loss of privacy is further exacerbated by AI's ability to process and combine vast amounts of data, potentially leading to a surveillance
society where individual activities are constantly monitored and analyzed without adequate safeguards or transparency. Sensitive user data collected may include online activity records, geolocation data, video, or audio. [205] For example, in order to build speech recognition algorithms, Amazon has recorded millions of private conversations and
allowed temporary workers to listen to and transcribe some of them. [206] Opinions about this widespread surveillance range from those who see it as a necessary evil to those for whom it is clearly unethical and a violation of the right to privacy. [207] All developers argue that this is the only way to deliver valuable applications and have developed
several techniques that attempt to preserve privacy while still obtaining the data, such as Cynthia Dwork, have begun to view privacy in terms of fairness. Brian Christian wrote that experts have pivoted "from the question of 'what they know' to
the question of 'what they're doing with it'." [209] Generative AI is often trained on unlicensed copyrighted works, including in domains such as images or computer code; the output is then used under the rationale of "fair use". Experts disagree about how well and under what circumstances this rationale will hold up in courts of law; relevant factors
may include "the purpose and character of the use of the copyrighted work" and "the effect upon the potential market for the copyrighted work".[212] In 2023, leading authors (including John Grisham and Jonathan Franzen) sued AI companies
for using their work to train generative AI.[213][214] Another discussed approach is to envision a separate sui generis system of protection for creations generated by AI to ensure fair attribution and compensation for human authors.[215]The commercial AI scene is dominated by Big Tech companies such as Alphabet Inc., Amazon, Apple Inc., Meta
Platforms, and Microsoft.[216][217][218] Some of these players already own the vast majority of existing cloud infrastructure and computing power from data centers, allowing them to entrench further in the marketplace.[219][220]See also: Environmental impacts of artificial intelligence In January 2024, the International Energy Agency (IEA)
released Electricity 2024, Analysis and Forecast to 2026, forecasting electric power use. [221] This is the first IEA report to make projections for data centers and power consumption for artificial intelligence and cryptocurrency. The report states that power demand for these uses might double by 2026, with additional electric power usage equal to
electricity used by the whole Japanese nation. [222] Prodigious power consumption by AI is responsible for the growth of fossil fuel use, and might delay closings of obsolete, carbon-emitting coal energy facilities. There is a feverish rise in the construction of data centers throughout the US, making large technology firms (e.g., Microsoft, Meta, Google
Amazon) into voracious consumers of electric consumption is so immense that there is concern that it will be fulfilled no matter the source. A ChatGPT search involves the use of 10 times the electrical energy as a Google search. The large firms are in haste to find power sources from nuclear energy to geothermal to fusion.
The tech firms argue that in the long view AI will be eventually kinder to the environment, but they need the energy now. AI makes the power grid more efficient and "intelligent", will assist in the growth of nuclear power, and track overall carbon emissions, according to technology firms. [223] A 2024 Goldman Sachs Research Paper, AI Data Centers
and the Coming US Power Demand Surge, found "US power demand (is) likely to experience growth not seen in a generation...." and forecasts that, by 2030, US data centers will consume 8% of US power, as opposed to 3% in 2022, presaging growth for the electrical power generation industry by a variety of means. [224] Data centers' need for more
and more electrical power is such that they might max out the electrical grid. The Big Tech companies counter that AI can be used to maximize the utilization of the grid by all.[225]In 2024, the Wall Street Journal reported that big AI companies have begun negotiations with the US nuclear power providers to provide electricity to the data centers. In
March 2024 Amazon purchased a Pennsylvania nuclear-powered data center for US$650 million.[226] Nvidia CEO Jensen Huang said nuclear power is a good option for the data centers.[227]In September 2024, Microsoft announced an agreement with Constellation Energy to re-open the Three Mile Island nuclear power plant to provide Microsoft
with 100% of all electric power produced by the plant for 20 years. Reopening the plant, which suffered a partial nuclear meltdown of its Unit 2 reactor in 1979, will require Constellation to get through strict regulatory processes which will include extensive safety scrutiny from the US Nuclear Regulatory Commission. If approved (this will be the first
ever US re-commissioning of a nuclear plant), over 835 megawatts of power enough for 800,000 homes of energy will be produced. The cost for re-opening and upgrading is estimated at $1.6 billion (US) and is dependent on tax breaks for nuclear power contained in the 2022 US Inflation Reduction Act.[228] The US government and the state of
Michigan are investing almost $2 billion (US) to reopen the Palisades Nuclear reactor on Lake Michigan. Closed since 2022, the plant is planned to be reopened in October 2025. The Three Mile Island facility will be renamed the Crane Clean Energy Center after Chris Crane, a nuclear proponent and former CEO of Exelon who was responsible for
Exelon's spinoff of Constellation. [229] After the last approval in September 2023, Taiwan suspended the approval of data centers north of Taoyuan with a capacity of more than 5 MW in 2024, due to power supply shortages. [230] Taiwan aims to phase out nuclear power by 2025. [230] On the other hand, Singapore imposed a ban on the opening of data
centers in 2019 due to electric power, but in 2022, lifted this ban.[230]Although most nuclear plants in Japan have been shut down after the 2011 Fukushima nuclear eccident, according to an October 2024 Bloomberg article in Japan near nuclear
power plant for a new data center for generative AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient, cheap and stable power for AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient for a new data center for generative AI.[231] Ubitus CEO Wesley Kuo said nuclear power plants are the most efficient for a new data center for plants are the most efficient for a new data center for a new data cen
power station Susquehanna to Amazon's data center. [232] According to the Commission Chairman Willie L. Phillips, it is a burden on the electricity grid as well as a significant cost shifting concern to households and other business sectors.
from the energy consumption of AI at 180 million tons. By 2035, these emissions could rise to 300-500 million tonnes depending on what measures will be taken. This is below 1.5% of the energy sector emissions, but rebound effects (for example if people
switch from public transport to autonomous cars) can reduce it.[233]See also: YouTube Moderation and offensive contentYouTube, Facebook and others use recommender systems to guide users to more content. These AI programs were given the goal of maximizing user engagement (that is, the only goal was to keep people watching). The AI learned
that users tended to choose misinformation, conspiracy theories, and extreme partisan content, and, to keep them watching, the AI recommended more of it. Users also tended to watch more content on the same misinformation. [234] This convinced
many users that the misinformation was true, and ultimately undermined trust in institutions, the media and the government. [236] The AI program had correctly learned to maximize its goal, but the result was harmful to society. After the U.S. election in 2016, major technology companies took some steps to mitigate the problem. [236] In 2022,
generative AI began to create images, audio, video and text that are indistinguishable from real photographs, recordings, films, or human writing. [237] It is possible for bad actors to use this technology to create massive amounts of misinformation or propaganda. [238] One such potential malicious use is deepfakes for computational propaganda.
AI pioneer Geoffrey Hinton expressed concern about AI enabling "authoritarian leaders to manipulate their electorates" on a large scale, among other risks. [240] AI researchers at Microsoft, OpenAI, universities and other organisations have suggested using "personhood credentials" as a way to overcome online deception enabled by AI models.
[241]Main articles: Algorithmic bias and Fairness (machine learning)Machine learning applications will be biased[k] if they learn from biased data. [243] The developers may not be aware that the bias exists. [244] Bias can be introduced by the way training data is selected and by the way a model is deployed. [245] [243] If a biased algorithm is used to
make decisions that can seriously harm people (as it can in medicine, finance, recruitment, housing or policing) then the algorithm may cause discrimination. [246] The field of fairness studies how to prevent harms from algorithm may cause discrimination.
"gorillas" because they were black. The system was trained on a dataset that contained very few images of black people, [247] a problem called "sample size disparity". [248] Google Photos still could not identify a gorilla, and neither
could similar products from Apple, Facebook, Microsoft and Amazon. [249] COMPAS is a commercial program widely used by U.S. courts to assess the likelihood of a defendant becoming a recidivist. In 2016, Julia Angwin at ProPublica discovered that COMPAS exhibited racial bias, despite the fact that the program was not told the races of the
defendants. Although the error rate for both whites and blacks was calibrated equal at exactly 61%, the errors for each race were differentthe system consistently overestimated the chance that a black person would not re-offend [250] In 2017, several researchers[1] showed
that it was mathematically impossible for COMPAS to accommodate all possible measures of fairness when the base rates of re-offense were different for whites and blacks in the data. [252] A program can make biased decisions even if the data does not explicitly mention a problematic feature (such as "race" or "gender"). The feature will correlate
with other features (like "address", "shopping history" or "first name"), and the program will make the same decisions based on these features as it would on "race" or "gender".[253] Moritz Hardt said "the most robust fact in this research area is that fairness through blindness doesn't work."[254]Criticism of COMPAS highlighted that machine
learning models are designed to make "predictions" that are only valid if we assume that the future will resemble the past. If they are trained on data that includes the results of racist decisions will be made in the future. If an application then uses these predictions as
recommendations, some of these "recommendations" will likely be racist.[255] Thus, machine learning is not well suited to help make decisions in areas where then the future will be better than the past. It is descriptive rather than prescriptive.[m]Bias and unfairness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because the developers are overwhelmingly whiteness may go undetected because t
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and male: among AI engineers, about 4% are black and 20% are women. [248] There are various conflicting definitions and mathematical models of fairness. These notions depend on ethical assumptions, and are influenced by beliefs about society. One broad category is distributive fairness, which focuses on the outcomes, often identifying groups and seeking to compensate for statistical disparities. Representational fairness tries to ensure that AI systems do not reinforce negative stereotypes or render certain groups invisible. Procedural fairness may depend on the context, notably the type of AI

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application and the stakeholders. The subjectivity in the notions of bias and fairness makes it difficult for companies to operationalize them. Having access to sensitive attributes such as race or gender is also considered by many AI ethicists to be necessary in order to compensate for biases, but it may conflict with anti-discrimination laws. [242] At its
2022 Conference on Fairness, Accountability, and Transparency (ACM FAccT 2022), the Association for Computing Machinery, in Seoul, South Korea, presented and published findings that recommend that until AI and robotics systems are demonstrated to be free of bias mistakes, they are unsafe, and the use of self-learning neural networks trained
on vast, unregulated sources of flawed internet data should be curtailed.[dubious discuss][257]See also: Explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explain transparency and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explainable AI, Algorithmic transparency, and Right to explain the explain transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explainable AI, Algorithmic transparency and Right to explain the explain the explainable AI, Algorithmic transparency and Right transpa
linear relationships between inputs and outputs. But some popular explainability techniques exist. [259] It is impossible to be certain that a program is operating correctly if no one knows how exactly it works. There have been many cases where a machine learning program passed rigorous tests, but nevertheless learned something different than what
 the programmers intended. For example, a system that could identify skin diseases better than medical professionals was found to actually have a strong tendency to classify images with a ruler as "cancerous", because pictures of malignancies typically include a ruler to show the scale. [260] Another machine learning system designed to help
effectively allocate medical resources was found to classify patients with asthma as being at "low risk" of dying from pneumonia. Having asthma is actually a severe risk factor, but since the patients with asthma as being at "low risk" of dying from pneumonia. Having asthma would usually get much more medical care, they were relatively unlikely to die according to the training data. The correlation between
asthma and low risk of dying from pneumonia was real, but misleading.[261]People who have been harmed by an algorithm's decision have a right to an explanation.[262] Doctors, for example, are expected to clearly and completely explain to their colleagues the reasoning behind any decision they make. Early drafts of the European Union's General
Data Protection Regulation in 2016 included an explicit statement that this right exists.[n] Industry experts noted that this is an unsolved problem with no solution, the tools should not be used.[263]DARPA established the XAI ("Explainable Artificial
Intelligence") program in 2014 to try to solve these problems. [264] Several approaches aim to address the transparency problem. SHAP enables to visualise the contribution of each feature to the output. [265] LIME can locally approximate a model's outputs with a simpler, interpretable model. [266] Multitask learning provides a large number of
 outputs in addition to the target classification. These other outputs can help developers deduce what the network has learned learned learned, and produce output that can suggest what the network is
learning.[268] For generative pre-trained transformers, Anthropic developed a technique based on dictionary learning that associates patterns of neuron activations with human-understandable concepts.[269]Main articles: Lethal autonomous weapon, Artificial intelligence arms race, and AI safetyArtificial intelligence provides a number of tools that
are useful to bad actors, such as authoritarian governments, terrorists, criminals or rogue states. A lethal autonomous weapon is a machine that locates, selects and engages human targets without human supervision. [o] Widely available AI tools can be used by bad actors to develop inexpensive autonomous weapons and, if produced at scale, they are
 potentially weapons of mass destruction.[271] Even when used in conventional warfare, they currently cannot reliably choose targets and could potentially kill an innocent person.[271] In 2014, 30 nations (including China) supported a ban on autonomous weapons under the United Nations' Convention on Certain Conventional Weapons, however the
 United States and others disagreed.[272] By 2015, over fifty countries were reported to be researching battlefield robots.[273]AI tools make it easier for authoritarian governments to efficiently control their citizens in several ways. Face and voice recognition allow widespread surveillance. Machine learning, operating this data, can classify potential
enemies of the state and prevent them from hiding. Recommendation systems can precisely target propaganda and misinformation. Advanced AI can make authoritarian centralized decision-making more competitive than liberal and decentralized systems such as
 markets. It lowers the cost and difficulty of digital warfare and advanced spyware. [274] All these technologies have been available since 2020 or earlierAI facial recognition systems are already being used for mass surveillance in China. [275][276] There are many other ways in which AI is expected to help bad actors, some of which can not be foreseen.
For example, machine-learning AI is able to design tens of thousands of toxic molecules in a matter of hours. [277] Main articles: Workplace impact of artificial intelligence and Technological unemployment if there is no adequate social policyment.
for full employment.[278]In the past, technology has tended to increase rather than reduce total employment, but economists showed disagreement about whether the increasing use of robots and AI will cause a substantial increase in long-term unemployment, but
 they generally agree that it could be a net benefit if productivity gains are redistributed. [280] Risk estimates vary; for example, in the 2010s, Michael Osborne and Carl Benedikt Frey estimated 47% of U.S. jobs as "high risk". [p][282] The methodology of
speculating about future employment levels has been criticised as lacking evidential foundation, and for implying that technology, rather than social policy, creates unemployment, as opposed to redundancies. [278] In April 2023, it was reported that 70% of the jobs for Chinese video game illustrators had been eliminated by generative artificial
 intelligence.[283][284]Unlike previous waves of automation, many middle-class jobs may be eliminated by artificial intelligence; The Economist stated in 2015 that "the worry that AI could do to white-collar jobs what steam power did to blue-collar ones during the Industrial Revolution" is "worth taking seriously".[285] Jobs at extreme risk range from
 paralegals to fast food cooks, while job demand is likely to increase for care-related professions ranging from personal healthcare to the clergy. [286] From the early days of the development of artificial intelligence, there have been arguments, for example, those put forward by Joseph Weizenbaum, about whether tasks that can be done by computers
actually should be done by them, given the difference between quantitative, value-based judgement. [287] Main article: Existential risk from artificial intelligence It has been argued AI will become so powerful that humanity may irreversibly lose control of it. This could, as physicist
Stephen Hawking stated, "spell the end of the human race".[288] This scenario has been common in science fiction, when a computer or robot suddenly develops a human-like "self-awareness" (or "sentience" or "consciousness") and becomes a malevolent character.[q] These sci-fi scenarios are misleading in several ways. First, AI does not require
 human-like sentience to be an existential risk. Modern AI programs are given specific goals and use learning and intelligence to achieve them. Philosopher Nick Bostrom argued that if one gives almost any goal to a sufficiently powerful AI, it may choose to destroy humanity to achieve it (he used the example of a paperclip maximizer).[290] Stuart
 Russell gives the example of household robot that tries to find a way to kill its owner to prevent it from being unplugged, reasoning that "you can't fetch the coffee if you're dead." [291] In order to be safe for humanity, a superintelligence would have to be genuinely aligned with humanity more to prevent it from being unplugged, reasoning that "you can't fetch the coffee if you're dead." [291] In order to be safe for humanity, a superintelligence would have to be genuinely aligned with humanity and values so that it is "fundamentally on our side"
[292]Second, Yuval Noah Harari argues that AI does not require a robot body or physical control to pose an existential risk. The essential parts of civilization are built on language; they exist because there are stories that billions of people believe. The current
 prevalence of misinformation suggests that an AI could use language to convince people to believe anything, even to take actions that are destructive. [293] The opinions amongst experts and industry insiders are mixed, with sizable fractions both concerned by risk from eventual superintelligent AI. [294] Personalities such as Stephen
 Hawking, Bill Gates, and Elon Musk,[295] as well as AI pioneers such as Yoshua Bengio, Stuart Russell, Demis Hassabis, and Sam Altman, have expressed concerns about existential risk from AI.In May 2023, Geoffrey Hinton announced his resignation from Google in order to be able to "freely speak out about the risks of AI" without "considering how
 this impacts Google".[296] He notably mentioned risks of an AI takeover,[297] and stressed that in order to avoid the worst outcomes, establishing safety guidelines will require cooperation among those competing in use of AI.[298]In 2023, many leading AI experts endorsed the joint statement that "Mitigating the risk of extinction from AI should be a
 global priority alongside other societal-scale risks such as pandemics and nuclear war".[299]Some other researchers were more optimistic. AI pioneer Jrgen Schmidhuber did not sign the joint statement, emphasising that in 95% of all cases, AI research is about making "human lives longer and healthier and easier."[300] While the tools that are now
 being used to improve lives can also be used by bad actors, "they can also be used against the bad actors."[301][302] Andrew Ng also argued that "it's a mistake to fall for the doomsday hype on Aland that regulators who do will only benefit vested interests."[303] Yann LeCun "scoffs at his peers' dystopian scenarios of supercharged misinformation
and even, eventually, human extinction."[304] In the early 2010s, experts argued that the risks are too distant in the future to warrant research or that humans will be valuable from the perspective of a superintelligent machine.
[306]Main articles: Machine ethics, AI safety, Friendly artificial intelligence, Artificial moral agents, and Human CompatibleFriendly AI are machines that benefit humans. Eliezer Yudkowsky, who coined the term, argues that developing friendly AI should be a higher
research priority: it may require a large investment and it must be completed before AI becomes an existential risk.[307]Machines with intelligence to make ethical decisions. The field of machine ethics provides machines with ethical principles and procedures for resolving ethical dilemmas.[308]The field of
machine ethics is also called computational morality,[308] and Stuart J. Russell's three principles for developing provably beneficial machines.[311] and Stuart J. Russell's three principles for developing provably beneficial machines.
Face,[312] Google,[313] EleutherAI and Meta.[314] Various AI models, such as Llama 2, Mistral or Stable Diffusion, have been made open-weight, [315][316] meaning that their architecture and trained parameters (the "weights") are publicly available. Open-weight models can be freely fine-tuned, which allows companies to specialize them with their
own data and for their own use-case.[317] Open-weight models are useful for research and innovation but can also be misused. Since they can be fine-tuned, any built-in security measure, such as objecting to harmful requests, can be trained away until it becomes ineffective. Some researchers warn that future AI models may develop dangerous
capabilities (such as the potential to drastically facilitate bioterrorism) and that once released on the Internet, they cannot be deleted everywhere if needed. They recommend pre-release audits and cost-benefit analyses.[318]Artificial intelligence projects can be guided by ethical considerations during the design, development, and implementation of
an AI system. An AI framework such as the Care and Act Framework, developed by the Alan Turing Institute and based on the SUM values, outlines four main ethical dimensions, defined as follows:[319][320]Respect the dignity of individual peopleConnect with other people sincerely, openly, and inclusivelyCare for the wellbeing of everyoneProtect
social values, justice, and the public interestOther developments in ethical frameworks include those decided upon during the Asilomar Conference, the Montreal Declaration for Responsible AI, and the IEEE's Ethics of Autonomous Systems initiative, among others;[321] however, these principles are not without criticism, especially regarding the
people chosen to contribute to these frameworks. [322] Promotion of the wellbeing of the people and communities that these technologies affect requires consideration, and collaboration between job roles such as data scientists, product managers
 data engineers, domain experts, and delivery managers.[323]The UK AI Safety Institute released in 2024 a testing toolset called 'Inspect' for AI safety evaluations available under an MIT open-source licence which is freely available on GitHub and can be improved with third-party packages. It can be used to evaluate AI models in a range of areas
including core knowledge, ability to reason, and autonomous capabilities. [324] Main articles: Regulation of artificial intelligence, Regulation of artificial intelligence is
the development of public sector policies and laws for promoting and regulating AI; it is therefore related to the broader regulation of algorithms. [325] The regulatory and policy landscape for AI is an emerging issue in jurisdictions globally. [326] According to AI Index at Stanford, the annual number of AI-related laws passed in the 127 survey
countries jumped from one passed in 2016 to 37 passed in 2016 to 37 passed in 2022 alone. [327] [328] Between 2016 and 2020, more than 30 countries adopted dedicated strategies for AI. [329] Most EU member states had released national AI strategies, as had Canada, China, India, Japan, Mauritius, the Russian Federation, Saudi Arabia, United Arab Emirates, U.S., and
 Vietnam. Others were in the process of elaborating their own AI strategy, including Bangladesh, Malaysia and Tunisia.[329] The Global Partnership on Artificial Intelligence was launched in June 2020, stating a need for AI to be developed in accordance with human rights and democratic values, to ensure public confidence and trust in the technology
[329] Henry Kissinger, Eric Schmidt, and Daniel Huttenlocher published a joint statement in November 2021 calling for a government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published a joint statement in November 2021 calling for a government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to regulate AI.[330] In 2023, OpenAI leaders published recommendations for the government commission to recommendations for the government commission to recommendation and the government commission to recommendation and the government commission to recommendation and the government commission and the government commission and the government commission and the go
also launched an advisory body to provide recommendations on AI governance; the body comprises technology company executives, government officials and academics.[332] In 2024, the Council of Europe created the first international legally binding treaty on AI, called the "Framework Convention on Artificial Intelligence and Human Rights,
 Democracy and the Rule of Law". It was adopted by the European Union, the United States, the United Kingdom, and other signatories. [333] In a 2022 Ipsos survey, attitudes towards AI varied greatly by country; 78% of Chinese citizens, but only 35% of Americans, agreed that "products and services using AI have more benefits than drawbacks". [327]
A 2023 Reuters/Ipsos poll found that 61% of Americans agree, and 22% disagree, that AI poses risks to humanity.[334] In a 2023 Fox News poll, 35% of Americans thought it "somewhat important", for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding "not very important" and 8% for the federal government to regulate AI, versus 13% responding to responding to respo
responding "not at all important".[335][336]In November 2023, the first global AI Safety Summit was held in Bletchley Park in the UK to discuss the near and far term risks of AI and the European Union issued a declaration at
the start of the summit, calling for international co-operation to manage the challenges and risks of artificial intelligence. [338] In May 2024 at the AI Seoul Summit, 16 global AI tech companies agreed to safety commitments on the development of AI.[340][341]Main article: History of artificial intelligence. [338][339] In May 2024 at the AI Seoul Summit, 16 global AI tech companies agreed to safety commitments on the development of AI.[340][341]Main article: History of artificial intelligence.
of artificial intelligence. In 2024, AI patents in China and the US numbered more than three-fourths of AI patents worldwide. [342] Though China had more AI patents in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians in antiquity of mechanical or "formal" reasoning began with philosophers and mathematicians and mathematicians are proportional or "formal" reasoning began with philosophers and mathematicians are proportional or "formal" reasoning began with philosophers and mathematicians are proportional or "formal" reasoning began with philosophers and mathematicians are proportional or "formal" reasoning began with philosophers and mathematicians are proportional or "formal" reasoning began with philosophers are proportional or "formal" reasoning began with philosophers are proportional or "formal"
The study of logic led directly to Alan Turing's theory of computation, which suggested that a machine, by shuffling symbols as simple as "0" and "1", could simulate any conceivable form of mathematical reasoning.[343][344] This, along with concurrent discoveries in cybernetics, information theory and neurobiology, led researchers to consider the
possibility of building an "electronic brain".[r] They developed several areas of research that would become part of AI,[346] such as McCulloch and Pitts design for "artificial neurons" in 1943,[116] and Turing's influential 1950 paper 'Computing Machinery and Intelligence', which introduced the Turing test and showed that "machine intelligence" was
plausible.[347][344]The field of AI research was founded at a workshop at Dartmouth College in 1956.[s][6] The attendees became the leaders of AI research in the 1960s.[t] They and their students produced programs that the press described as "astonishing":[u] computers were learning checkers strategies, solving word problems in algebra, proving
 logical theorems and speaking English.[v][7] Artificial intelligence laboratories were set up at a number of British and U.S. universities in the latter 1950s and early 1960s.[344]Researchers in the 1960s and the 1970s were convinced this the
goal of their field.[351] In 1965 Herbert Simon predicted, "machines will be capable, within twenty years, of doing any work a man can do".[352] In 1967 Marvin Minsky agreed, writing that "within a generation... the problem of creating 'artificial intelligence' will substantially be solved".[353] They had, however, underestimated the difficulty of the
 problem.[w] In 1974, both the U.S. and British governments cut off exploratory research in response to the criticism of Sir James Lighthill[355] and ongoing pressure from the U.S. Congress to fund more productive projects.[356] Minsky and Papert's book Perceptrons was understood as proving that artificial neural networks would never be useful for
 solving real-world tasks, thus discrediting the approach altogether.[357] The "AI winter", a period when obtaining funding for AI projects was difficult, followed.[9]In the early 1980s, AI research was revived by the commercial success of expert systems, [358] a form of AI projects was difficult, followed.[9]In the early 1980s, AI research was revived by the commercial success of expert systems, [358] a form of AI projects was difficult.
 1985, the market for AI had reached over a billion dollars. At the same time, Japan's fifth generation computer project inspired the U.S. and British governments to restore funding for academic research.[8] However, beginning with the collapse of the Lisp Machine market in 1987, AI once again fell into disrepute, and a second, longer-lasting winter
 began.[10]Up to this point, most of AI's funding had gone to projects that used high-level symbols to represent mental objects like plans, goals, beliefs, and known facts. In the 1980s, some researchers began to doubt that this approach would be able to imitate all the processes of human cognition, especially perception, robotics, learning and pattern
recognition,[359] and began to look into "sub-symbolic" approaches.[360] Rodney Brooks rejected "representation" in general and focussed directly on engineering machines that move and survive.[x] Judea Pearl, Lotfi Zadeh, and others developed methods that handled incomplete and uncertain information by making reasonable guesses rather than
precise logic.[87][365] But the most important development was the revival of "connectionism", including neural networks can recognize handwritten digits, the first of many successful applications of neural networks.[367]AI
 gradually restored its reputation in the late 1990s and early 21st century by exploiting formal mathematics and by finding specific solutions to specific problems. This "narrow" and "formal mathematics" is lowed researchers to produce verifiable results and collaborate with other fields (such as statistics, economics and mathematics). [368] By 2000
 solutions developed by AI researchers were being widely used, although in the 1990s they were rarely described as "artificial intelligence" (a tendency known as the AI effect).[369]However, several academic researchers became concerned that AI was no longer pursuing its original goal of creating versatile, fully intelligent machines. Beginning
around 2002, they founded the subfield of artificial general intelligence (or "AGI"), which had several well-funded institutions by the 2010s.[68]Deep learning began to dominate industry benchmarks in 2012 and was adopted throughout the field.[11]For many specific tasks, other methods were abandoned.[y]Deep learning's success was based on both
hardware improvements (faster computers,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of data[373] (including curated datasets,[371] graphics processing units, cloud computing[372]) and access to large amounts of datasets.
publications) increased by 50% in the years 20152019.[329] The number of Google searches for the term "AI" accelerated in 2022. In 2016, issues of fairness and the misuse of technology were catapulted into center stage at machine learning conferences, publications vastly increased, funding became available, and many researchers re-focussed their accelerated in 2022. In 2016, issues of fairness and the misuse of technology were catapulted into center stage at machine learning conferences, publications vastly increased, funding became available, and many researchers re-focussed their accelerated in 2022. In 2016, issues of fairness and the misuse of technology were catapulted into center stage at machine learning conferences, publications vastly increased, funding became available, and many researchers re-focussed their accelerated in 2022. In 2016, issues of fairness and the misuse of technology were catapulted into center stage at machine learning conferences, publications vastly increased in 2022. In 2016, issues of fairness and the misuse of technology were catapulted into center stage at machine learning conferences, publications are staged at machine learning conferences.
 careers on these issues. The alignment problem became a serious field of academic study.[306]In the late 2010s and early 2020s, AGI companies began to deliver programs that created enormous interest. In 2015, AlphaGo, developed by DeepMind, beat the world champion Go player. The program taught only the game's rules and developed a
strategy by itself. GPT-3 is a large language model that was released in 2020 by OpenAI and is capable of generating high-quality human-like text.[374] ChatGPT, launched on November 30, 2022, became the fastest-growing consumer software application in history, gaining over 100 million users in two months.[375] It marked what is widely regarded
 as AI's breakout year, bringing it into the public consciousness. [376] These programs, and others, inspired an aggressive AI boom, where large companies began invested in "AI" around 2022 in the U.S. alone and about 20% of the new U.S. Computer
Science PhD graduates have specialized in "AI".[377] About 800,000 "AI"-related U.S. job openings existed in 2022.[378] According to PitchBook research, 22% of newly funded startups in 2024 claimed to be AI companies.
 intelligence and how to make intelligent machines.[380] Another major focus has been whether machines can be conscious, and the associated ethical implications.[381] Many other topics in philosophy are relevant to AI, such as epistemology and free will.[382] Rapid advancements have intensified public discussions on the philosophy and ethics of
AI.[381]See also: Turing test, Intelligent agent, Dartmouth workshop, and Synthetic intelligent behaviour".[383] He advised changing the question from whether a machine "thinks", to "whether or not it is possible for machinery to show intelligent behaviour".[383] He devised
the Turing test, which measures the ability of a machine to simulate human conversation. [347] Since we can only observe the behavior of the machine, it does not matter if it is "actually" thinking or literally has a "mind". Turing notes that we can not determine these things about other people but "it is usual to have a polite convention that everyone
thinks."[384]The Turing test can provide some evidence of intelligence must be defined in terms of external behavior, not internal structure.[1] However, they are critical that the test requires the machine to imitate humans. "Aeronautical
engineering texts", they wrote, "do not define the goal of their field as making 'machines that fly so exactly like pigeons that they can fool other pigeons.'"[386] AI founder John McCarthy defines intelligence as "the computational part of
the ability to achieve goals in the world".[388] Another AI founder, Marvin Minsky, similarly describes it as "the ability to solve hard problems".[389] The leading AI textbook defined goals.[1] These definitions view intelligence in
 terms of well-defined problems with well-defined solutions, where both the difficulty of the program are direct measures of the "intelligence" of the program are direct measures of the program are direct measures of the program are direct measures of the machine and the performance of the program are direct measures of the "intelligence" of the machine and the performance of the program are direct measures of the program are direct measures of the machine and the performance of the program are direct measures of the machine and the performance of the program are direct measures of the program are direct measures of the machine and the performance of the machine and the performance of the program are direct measures of the machine and the performance of the machine and the performance of the machine and the performance of the program are direct measures of the machine and the performance of the performance of the machine and the performance of the machine and the performance of the 
 AI,[391] with many companies during the early 2020s AI boom using the term as a marketing buzzword, often even if they did "not actually use AI in a material way".[392]No established unifying theory or paradigm has guided AI research for most of its history.[aa] The unprecedented success of statistical machine learning in the 2010s eclipsed all
 other approaches (so much so that some sources, especially in the business world, use the term "artificial intelligence" to mean "machine learning with neural networks"). This approach is mostly sub-symbolic, soft and narrow. Critics argue that these questions may have to be revisited by future generations of AI researchers. Symbolic AI (or "GOFAI")
sufficient means of general intelligent action."[395]However, the symbolic approach failed on many tasks that humans solve easily, such as learning, recognizing an object or commonsense reasoning. Moravec's paradox is the discovery that high-level "intelligent" tasks were easy for AI, but low level "instinctive" tasks were extremely difficult.[396]
 Philosopher Hubert Dreyfus had argued since the 1960s that human expertise depends on unconscious instinct rather than conscious symbolic knowledge. [397] Although his arguments had been ridiculed and ignored when they were first presented, eventually, AI
 research came to agree with him.[ab][16]The issue is not resolved: sub-symbolic reasoning can make many of the same inscrutable mistakes that human intuition does, such as algorithmic bias. Critics such as Noam Chomsky argue continuing research into symbolic AI will still be necessary to attain general intelligence,[399][400] in part because subsequences.
symbolic AI is a move away from explainable AI: it can be difficult or impossible to understand why a modern statistical AI program made a particular decision. The emerging field of neuro-symbolic artificial intelligence attempts to bridge the two approaches. Main article: Neats and scruffies "Neats" hope that intelligent behavior is described using
 simple, elegant principles (such as logic, optimization, or neural networks). "Scruffies" expect that it necessarily requires solving a large number of unrelated problems. Neats defend their programs with theoretical rigor, scruffies rely mainly on incremental testing to see if they work. This issue was actively discussed in the 1970s and 1980s,[401] but
eventually was seen as irrelevant. Modern AI has elements of both. Main article: Soft computing is a set of techniques, including genetic algorithms, fuzzy logic and neural networks, that are tolerant of imprecision, uncertainty, partial truths a set of techniques, including genetic algorithms, fuzzy logic and neural networks, that are tolerant of imprecision, uncertainty, partial truths are tolerant of imprecision and imprecision are tolerant of imprecision are tolerant of imprecision and imprecision are tolerant of imprecision are toleran
and approximation. Soft computing was introduced in the late 1980s and most successful AI programs in the 21st century are examples of soft computing with neural intelligence and Artificial general intelligence and Artificial general intelligence and approximation.
superintelligence directly or to solve as many specific problems as possible (narrow AI) in hopes these solutions will lead indirectly to the field's long-term goals.[402][403] General intelligence is difficult to measure, and modern AI has had more verifiable successes by focusing on specific problems with specific solutions. The
sub-field of artificial general intelligence and Artificial general intelligence and Artificial consciousness and mental states in the same sense that human beings do. This issue considers the internal
experiences of the machine, rather than its external behavior. Mainstream AI research considers this issue irrelevant because it does not affect the goals of the field: to build machine a machine conscious in exactly the way humans are is not
 one that we are equipped to take on."[404] However, the question has become central to the philosophy of mind. It is also typically the central question at issue in artificial intelligence in fiction. Main articles: Hard problem of consciousness and Theory of mindDavid Chalmers identified two problems in understanding the mind, which he named the
 "hard" and "easy" problems of consciousness.[405] The easy problem is understanding how the brain processes signals, makes plans and controls behavior. The hard problem is explaining how this feels or why it should feel like anything at all, assuming we are right in thinking that it truly does feel like something (Dennett's consciousness illusionism
says this is an illusion). While human information processing is easy to explain, human subjective experience is difficult to explain. For example, it is easy to imagine a color-blind person who has learned to identify which objects in their field of view are red, but it is not clear what would be required for the person to know what red looks like.[406]Maintenance is difficult to explain.
articles: Computational theory of mind and Functionalism (philosophy of mind) Computationalism is the position in the philosophy of mind that the human mind is an information processing system and that thinking is a form of computationalism argues that the relationship between mind and body is similar or identical to the relationship
 between software and hardware and thus may be a solution to the mindbody problem. This philosophical position was inspired by the work of AI researchers and thus may be a solution to the mindbody problem. This philosophers Jerry Fodor and Hilary Putnam. [407] Philosopher John Searle characterized this position as "strong AI": "The
 appropriately programmed computer with the right inputs and outputs would thereby have a mind in exactly the same sense human beings have minds."[ac] Searle challenges this claim with his Chinese room argument, which attempts to show that even a computer capable of perfectly simulating human behavior would not have a mind.[411]It is
 difficult or impossible to reliably evaluate whether an advanced AI is sentient (has the ability to feel), and if so, to what degree.[412] But if there is a significant chance that a given machine can feel and suffer, then it may be entitled to certain rights or welfare protection measures, similarly to animals.[413][414] Sapience (a set of capacities related to
high intelligence, such as discernment or self-awareness) may provide another moral basis for AI rights.[413] Robot rights are also sometimes proposed as a practical way to integrate autonomous agents into society.[415]In 2017, the European Union considered granting "electronic personhood" to some of the most capable AI systems. Similarly to the
 legal status of companies, it would have conferred rights but also responsibilities.[416] Critics argued in 2018 that granting rights to AI systems would downplay the importance of human rights, and that legislation should focus on user needs rather than speculative futuristic scenarios. They also noted that robots lacked the autonomy to take part in
 society on their own.[417][418]Progress in AI increased interest in the topic. Proponents of AI welfare and rights often argue that AI sentience, if it emerges, would be particularly easy to deny. They warn that this may be a moral blind spot analogous to slavery or factory farming, which could lead to large-scale suffering if sentient AI is created and
 carelessly exploited.[414][413]A superintelligence is a hypothetical agent that would possess intelligence far surpassing that of the brightest and most gifted human mind.[403] If research into artificial general intelligence produced sufficiently intelligent software, it might be able to reprogram and improve itself. The improved software would be even
 better at improving itself, leading to what I. J. Good called an "intelligence explosion" and Vernor Vinge called a "singularity".[419]However, technologies cannot improve exponentially indefinitely, and typically follow an S-shaped curve, slowing when they reach the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an S-shaped curve, slowing when they reach the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an S-shaped curve, slowing when they reach the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an S-shaped curve, slowing when they reach the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an S-shaped curve, slowing when they reach the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an II will be a support of the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an II will be a support of the physical limits of what I. J. Good called an "intelligence explosion" and typically follow an II will be a support of the physical limits of what I. J. Good called an "intelligence explosion" and typically follow and typically
designer Hans Moravec, cyberneticist Kevin Warwick and inventor Ray Kurzweil have predicted that humans and machines may merge in the future into cyborgs that are more capable and powerful than either. This idea, called transhumanism, has roots in the writings of Aldous Huxley and Robert Ettinger.[421]Edward Fredkin argues that "artificial
 intelligence is the next step in evolution", an idea first proposed by Samuel Butler's "Darwin among the Machines" as far back as 1863, and expanded upon by George Dyson in his 1998 book Darwin Among the Machines as far back as 1863, and expanded upon by George Dyson in his 1998 book Darwin Among the Machines. The Evolution of Global Intelligence. [422] Main article: Artificial intelligence in fiction The word "robot" itself was coined by Karel
apek in his 1921 play R.U.R., the title standing for "Rossum's Universal Robots". Thought-capable artificial beings have appeared as storytelling devices since antiquity, [423] and have been a persistent theme in science fiction. [424] A common trope in these works began with Mary Shelley's Frankenstein, where a human creation becomes a threat to its appeared as storytelling devices since antiquity, [423] and have been a persistent theme in science fiction.
 masters. This includes such works as Arthur C. Clarke's and Stanley Kubrick's 2001: A Space Odyssey (both 1968), with HAL 9000, the murderous computer in charge of the Discovery One spaceship, as well as The Terminator (1984) and The Matrix (1999). In contrast, the rare loyal robots such as Gort from The Day the Earth Stood Still (1951) and
 Bishop from Aliens (1986) are less prominent in popular culture. [425] while almost all artificial intelligence researchers are familiar with
 Asimov's laws through popular culture, they generally consider the laws useless for many reasons, one of which is their ambiguity. [427] Several works use AI to force us to confront the fundamental question of what makes us human, showing us artificial beings that have the ability to feel, and thus to suffer. This appears in Karel apek's R.U.R., the
 films A.I. Artificial Intelligence and Ex Machina, as well as the novel Do Androids Dream of Electric Sheep?, by Philip K. Dick considers the idea that our understanding of human subjectivity is altered by technology created with artificial intelligence. [428] Artificial consciousness Field in cognitive science Artificial intelligence and elections Usea (128) Artificial intelligence.
and impact of AI on political electionsArtificial intelligence content detection Software to detect AI-generated contentBehavior selection algorithm Algorit
past problemsComputational intelligence Ability of a computer to learn a specific task from data or experimental observationDigital immortality Hypothetical concept of Storing a personality in digital formEmergent algorithm Al
displaying short descriptions of redirect targetsGlossary of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence amplification Use of information technology to augment human intelligence amplification Use of information technology to augment human intelligence amplification Use of information technology to augment human intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions of terms and concepts commonly used in the study of artificial intelligence List of definitions are study of artificial intelligence List of the study of artificial intelligence Li
 process that combines robotic process automation and artificial intelligence Use of brain organoids for intelligence Use of brain organoids for intelligence Use of brain organoids for intelligence fiction
 novelWetware computer Computer composed of organic materialDARWIN EU - A European Union initiative coordinated by the European Medicines across the EU. a b This list of intelligent traits is based on the topics covered by
 the major AI textbooks, including: Russell & Norvig (2021), Luger & Stubblefield (2004), Poole, Mackworth & Goebel (1998) and Nilsson (1998)^ It is
 among the reasons that expert systems proved to be inefficient for capturing knowledge.[30][31]^ "Rational agent" is general term used in economics, philosophy and theoretical artificial intelligence. It can refer to anything that directs its behavior to accomplish goals, such as a person, an animal, a corporation, a nation, or in the case of AI, a
computer program. Alan Turing discussed the centrality of learning as early as 1950, in his classic paper "Computing Machinery and Intelligence".[42] In 1956, at the original Dartmouth AI summer conference, Ray Solomonoff wrote a report on unsupervised probabilistic machine learning: "An Inductive Inference Machine".[43] See AI winter
Machine translation and the ALPAC report of 1966^ Compared with symbolic logic, formal Bayesian inference is computationally expensive. For inference to be tractable, most observations must be conditionally independent of one another. AdSense uses a Bayesian network with over 300million edges to learn which ads to serve.[94]^
 Expectationmaximization, one of the most popular algorithms in machine learning, allows clustering in the presence of unknown latent variables. [96] Some form of deep neural networks (without a specific learning algorithm) were described by: Warren S. McCulloch and Walter Pitts (1943) [116] Alan Turing (1948); [117] Karl Steinbuch and Roger
David Joseph (1961).[118]Deep or recurrent networks that learned (or used gradient descent) were developed by:Frank Rosenblatt(1957);[117]Oliver Selfridge (1959);[118]Alexey Ivakhnenko and Valentin Lapa (1965);[119]Kaoru Nakano (1971);[120]Shun-Ichi Amari (1972);[120]John Joseph Hopfield (1982).[120]Precursors to backpropagation were
developed by:Henry J. Kelley (1960);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson and Yu-Chi Ho (1969);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson and Yu-Chi Ho (1969);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson and Yu-Chi Ho (1969);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson and Yu-Chi Ho (1969);[117] Arthur E. Bryson (1962);[117] Arthur E. Bryson (1962);[117
 thousands of times too small. [And] our computers were millions of times too slow."[122]^ In statistics, a bias is a systematic error or deviation from the correct value. But in the context of fairness, it refers to a tendency in favor or against a certain group or individual characteristic, usually in a way that is considered unfair or harmful. A statistically
unbiased AI system that produces disparate outcomes for different demographic groups may thus be viewed as biased in the ethical sense.[242]^ Including Jon Kleinberg (Cornell University), Sendhil Mullainathan (University), Sen
Max Planck Institute for Intelligent Systems) argues that machine learning "is fundamentally the wrong tool for a lot of domains, where you're trying to design interventions and mechanisms that change the world."[256]^ When the law was passed in 2018, it still contained a form of this provision. This is the United Nations' definition, and includes
 things like land mines as well.[270] See table 4; 9% is both the OECD average and the U.S. average.[281] Sometimes called a "robopocalypse"[289] "Electronic brain" was the term used by the press around this time.[343][345] Daniel Crevier wrote, "the conference is generally recognized as the official birthdate of the new science."[348]
 Russell and Norvig called the conference "the inception of artificial intelligence."[116]^ Russell and Norvig wrote, "it was astonishing whenever a computer did anything kind of smartish".[350]^ The programs described are Arthur
 Samuel's checkers program for the IBM 701, Daniel Bobrow's STUDENT, Newell and Simon's Logic Theorist and Terry Winograd's SHRDLU. Russell and Norvig write: "in almost all cases, these early systems failed on more difficult problems" [354] Embodied approaches to AI[361] were championed by Hans Moravec[362] and Rodney Brooks[363]
and went by many names: Nouvelle AI.[363] Developmental robotics. [364]^ Matteo Wong wrote in The Atlantic: "Whereas for decades, computer vision, and robotics used extremely different methods, now they all use a programming method called "deep learning". As a result, their code
and approaches have become more similar, and their models are easier to integrate into one another."[370]^ Jack Clark wrote in Bloomberg: "After a half-decade of quiet breakthroughs in artificial intelligence, 2015 has been a landmark year. Computers are smarter and learning faster than ever", and noted that the number of software projects th
 use machine learning at Google increased from a "sporadic usage" in 2012 to more than 2,700 projects in 2015.[372]^ Nils Nilsson wrote in 1983: "Simply put, there is wide disagreement in the field about what AI is all about." [393]^ Daniel Crevier wrote that "time has proven the accuracy and perceptiveness of some of Dreyfus's comments. Had he
 formulated them less aggressively, constructive actions they suggested might have been taken much earlier."[398]^ Searle presented this definition of "Strong AI" in 1999.[408] Searle's original formulation was "The appropriately programmed computer really is a mind, in the sense that computers given the right programs can be literally said to
understand and have other cognitive states."[409] Strong AI is defined similarly by Russell and Norvig: "Stong AI the assertion that machines that do so are actually thinking)."[410] a b c Russell & Norvig (2021), pp.14. AI set to exceed human brain power Archived 2008-02-19 at the Wayback Machine CNN.com
(July 26, 2006)^ Kaplan, Andreas; Haenlein, Michael (2019). "Siri, Siri, in my hand: Who's the fairest in the land? On the interpretations, and implications of artificial intelligence". Business Horizons. 62: 1525. doi:10.1016/j.bushor.2018.08.004. ISSN0007-6813. S2CID158433736.^ Russell & Norvig (2021, 1.2).^ "Tech companies want to
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rich from AI are going to have the interests of the rest of us close at heart,' ... writes [Gary Marcus]. 'We can't count on governments driven by campaign finance contributions [from tech companies] to push back.'... Marcus details the demands that citizens should make of their governments and the tech companies. They include transparency on how
AI systems work; compensation for individuals if their data [are] used to train LLMs (large language model)s and the right to consent to this use; and passing stricter product liability laws... Marcus also suggests... that a new, AI-
specific federal agency, akin to the FDA, the FCC, or the FTC, might provide the most robust oversight.... [T]he Fordham law professor Chinmayi Sharma... suggests... establish[ing] a professional licensing regime for engineers that would function in a similar way to medical licenses, malpractice suits, and the Hippocratic oath in medicine. 'What if,
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