Revolutionizing Agriculture: A Case Study of IBM's AI Innovations

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ABSTRACT

Background / Purpose: *The development of computer systems that can carry out tasks that traditionally require human intelligence is referred to as artificial intelligence (AI). It entails the development of intelligent machines that can reason, learn, solve issues, and make judgements. A fast-developing topic, AI has enormous ramifications for many different businesses and facets of society. By leveraging advanced algorithms and data analysis techniques, AI systems can process and interpret large amounts of information in real-time, enabling them to extract valuable insights and patterns that may be difficult for humans to perceive.AI technologies have a wide range of applications across multiple domains, including healthcare, finance, transportation, manufacturing, education, entertainment, including agriculture. When referring to AI in the context of agriculture, we mean the use of advanced analytics and computational algorithms to analyse massive volumes of agricultural data, anticipate the future, and give farmers and stakeholders useful information. The main goal of using AI to agriculture is to increase efficiency, sustainability, and productivity across a range of farming operations, also to create smart and efficient systems that can monitor, analyze, and control water resources in real-time, leading to improved water management and sustainable agricultural practices, thereby addressing the challenges faced by the agricultural sector.AI offers significant potential to optimize water usage, enhance crop productivity, and mitigate environmental impact. In this paper, IBM, a significant provider of services in the sector of agriculture in recent years, is examined.*
Objective: *In this case study, artificial intelligence is the main topic with particular emphasis on IBM's agricultural technology.*
Design/Methodology/Approach: *Academic works published in a variety of peer-reviewed journals, conferences, and business websites provided the necessary information and specifics for this case study on IBM.*
Findings/Result: *This study is primarily concerned with the usefulness and significance of AI in the modern world. The demand for and necessity of the numerous resources provided by IBM, discussion topics include the company's business plan, varied results, top clientele, and numerous service types.*
Originality/Value: *The analysis gives a concise description of IBM, the types of data collected and managed, information on artificial intelligence (AI), and the numerous AI services offered by IBM.*
Paper Type: *Case study on the importance of storage and computing requirements for AI services offered by different service providers, with a focus on IBM.*
Keywords: Artificial Intelligence, Internet of Things, Machine Learning, Expert Systems, Agriculture, Irrigation, IBM.

1. INTRODUCTION :

The foundation of AI can be traced back to the work of mathematician and logician Alan Turing, who proposed the concept of a "universal machine" capable of mimicking any other machine.
In 1950, Turing published the influential paper "Computing Machinery and Intelligence," which introduced the idea of the Turing Test to determine a machine's ability to exhibit intelligent behaviour. The Dartmouth Conference, held in the summer of 1956, is considered the birth of AI as a formal discipline. It brought together researchers from various fields to discuss the possibility of creating artificial intelligence (Haenlein, M. et.al. (2019). [1]).
Early AI researchers focused on symbolic or "good old-fashioned AI" (GOFAI) approaches, aiming to develop systems that could reason and manipulate symbolic representations of knowledge. In 1956, John McCarthy coined the term "artificial intelligence" and proposed the development of a program called the Logic Theorist, which aimed to prove mathematical theorems. In the 1960s, researchers like Allen Newell and Herbert Simon developed the General Problem Solver (GPS), a program that could solve a wide range of problems using heuristics. The 1970s saw the rise of expert systems, which used knowledge and rules to solve complex problems in specific domains.
In 1974, the MYCIN system, developed at Stanford University, demonstrated the potential of expert systems in diagnosing bacterial infections. During this period, AI research faced significant setbacks and funding cuts due to unfulfilled promises and unrealistic expectations. In the 1980s, research shifted towards knowledge-based systems that represented and manipulated explicit knowledge about the world.
Machine learning techniques gained prominence, allowing systems to learn from data and improve their performance over time. Expert systems (Liao, S. H. (2005). [2]) were commercialized and applied in various industries, such as finance and healthcare.
In 1986, Geoffrey Hinton and colleagues developed the back propagation algorithm, a key advancement in training neural networks. The late 1980s and early 1990s witnessed an "AI winter" characterized by waning interest and funding in AI research.
However, AI experienced a resurgence in the late 1990s, driven by advancements in computing power, availability of large datasets, and breakthroughs in machine learning techniques. In 1997, IBM's Deep Blue defeated world chess champion Garry Kasparov, showcasing the potential of AI in complex tasks. The mid-2000s marked a significant shift towards deep learning, a subfield of machine learning that employs neural networks with multiple layers.
Deep learning models, such as convolution neural networks (CNNs) (Nielsen, M. A. (2015). [3]) and recurrent neural networks (RNNs), achieved groundbreaking results in areas like image recognition and natural language processing.AI applications have become increasingly prevalent in various domains, including autonomous vehicles, virtual assistants, healthcare, finance, and more. Recent advancements in AI have also raised ethical concerns regarding bias, privacy, and the impact of automation on jobs.
Artificial Intelligence (AI) has emerged as a powerful tool in agriculture (Eli-Chukwu, N. C. (2019). [4]), revolutionizing various aspects of the industry. It offers numerous benefits and has the potential to address key challenges faced by farmers, increase productivity, and promote sustainable practices. Agriculture has always been a data-intensive industry, relying on various factors such as weather patterns, soil conditions, crop diseases, and market demands. Traditionally, farmers have relied on their experience and intuition to make decisions. However, with the advent of AI technologies (Allen, G. (2020). [5]), farmers can now leverage large volumes of data to make informed and optimized decisions.
Precision farming techniques, which use sensors, drones, and satellite photography to gather information about the health of crops, moisture in the soil levels, and nutrient content, are made possible by AI. This data is then analyzed using AI algorithms to provide farmers with precise recommendations on irrigation, fertilization, and pesticide usage, leading to optimized resource allocation and increased yields.

2. RELATED WORKS :

The following table Table-1 lists literature reviews for the scholarly publications that are currently available.

Table 1: An analysis of literature on Artificial Intelligence and Machine Learning.

S. No.	Research Field	Focal Point	Result	Reference
1	Artificial intelligence and the legal profession	The methods businesses use to recruit using AI	Organisations can save money and time by having better access and accuracy throughout the whole hiring process.	Ben-Ari, D. et al. (2016). [6]
2	Machine learning methods and their use in the manufacturing industry.	Analyses uses where various machine learning techniques have been successfully used and rates them.	Obtain interpretable ensemble classifiers.	Pham, D. T. et al. (2005). [7]
3.	A review of the literature on artificial intelligence in agriculture.	Presents a comprehensive assessment of the literature on the application of artificial intelligence techniques in agriculture.	AI enables real-time, more automated, and more accurate systems.	Bannerjee, G. et al. (2018). [8]
4.	IoT, big data, and AI in the food and agricultural industries.	A description of the Internet of Things (IoT), big data, and artificial intelligence (AI), as well as how they are reshaping the way agri-food systems are created.	The benefits of blockchain technology with next-generation genome sequencing for food safety and traceability in the event of pathogen outbreaks	Misra, N. N. et al. (2020). [9]
5.	Model for recommending agriculture using AI and sensors to determine the suitability of the land.	Combines artificial intelligence and sensor networks to suggest an expert system. such as multi-layer perceptron (MLP) and neural networks for assessing the suitability of agricultural land	Using MLP with four hidden layers to manage the information obtained from numerous sensors has ensured greater efficiency.	Vincent, D. R. et al. (2019). [10]
6.	Agriculture and artificial intelligence: a new area of study.	It offers a glimpse of how artificial intelligence (AI) might support agriculture's many sectors.	The farmers are able to increase their average production per hectare and have better control over food grain prices, guaranteeing that they continue to make a profit.	Khandelwal, P. M. et.al. (2019). [11]

3. RESEARCH AGENDA :

(1) What is the importance of AI Concepts?
(2) How can artificial intelligence and machine learning be used to manage irrigation requirements in agriculture?
(3) What are the various algorithms employed in different irrigation techniques?

4. STUDY OBJECTIVES :

(1) To research and comprehend the idea of AI.
(2) To assess the value of the AI concept and the various AI methods applied in the agricultural sector.

(3) To evaluate the function and significance of AI services in managing client needs.
(4) To present an overview of IBM Enterprises (P) Limited.
(5) To conduct a SWOC analysis of IBM Enterprises (P) Limited.

5. METHODOLOGY :

The study's foundation is data that came from numerous sources. Common reference book on AI concepts, a wide range of articles and websites, and literature evaluations on AI and AI services are all included in the contents.

5.1 Database searches:

Google Scholar, IEEE Explore, and Research Gate are a few of the online and World Wide Web services that are archives of several conference publications and peer-reviewed journals that are widely utilised to obtain information.

6. AI CONCEPTS :

The study of artificial intelligence is concerned with developing computer programmes that can do mental tasks that previously could only be performed by people. In recent years, AI has developed swiftly, altering people's lifestyles. The advancement of AI has turned out to be a critical development strategy for countries all over the world in order to maintain security and increase national competitiveness. Preferential policies have been widely implemented, and critical deployment has been accelerated (Zhang, C. et al. (2021). [12]).
Based on the relatively mature development of technical conditions, such as data, algorithms, and processing capabilities, AI has begun to successfully solve problems and provide economic benefits. Financial services, healthcare, the automotive industry (Longo, L. et. al. (2020). [13]), and retail are a few examples of industries with a substantial data base and somewhat advanced AI application scenarios.
According to Luger and Stubblefield, artificial intelligence is "the branch of computer science that is concerned with the automation of intelligent behaviour" (Geetha, R. (2018). [14]). The intelligent agent method is believed to be involved. The concept of Artificial Intelligence Systems (Geetha, R. (2018). [14]) represented in Fig.1. A system that perceives and takes action is an agent. In terms of resolving genuine issues, it actually matters. As a result, behaviour is prioritised, and behaviour may be tested scientifically more than thought. More generally, try employing an intelligent machine to tackle difficult problems rather than trying to use the human brain to do it.

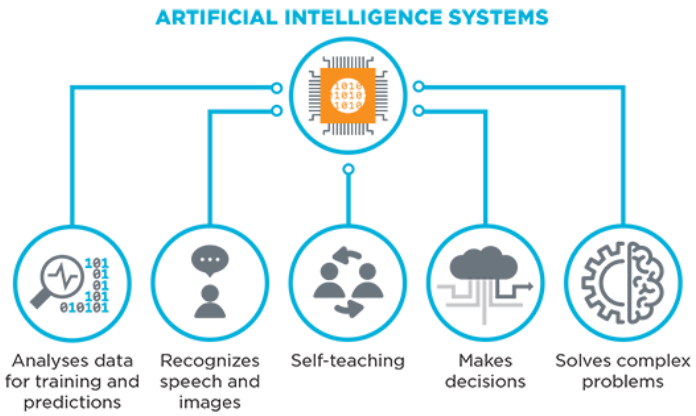

Fig.1: Artificial Intelligence System [14]

Artificial intelligence (AI) has two subfields: machine learning and deep learning (Janiesch, C. et.al. (2021). [15]), which teach computers to learn from data and make deft predictions or judgements.
The creation of algorithms and models that can recognise patterns and correlations in data without explicit programming is the focus of the AI subfield of machine learning. It makes use of statistical approaches to provide computers the ability to autonomously learn from experience. Deep learning is a branch of machine learning that focuses on deep neural networks, which are neural networks with

several layers. By creating intricate computational models known as artificial neural networks (ANNs), deep learning algorithms seek to replicate the composition and operation of the human brain. Each neuron in these networks consists of interconnected nodes (neurons) that are arranged in layers and performs a straightforward computation.

A model is created using machine learning, an area of artificial intelligence that focuses on prediction based on known attributes obtained from training data, to learn the trends. A technology that focuses on understanding the representations and features of the data is deep learning (Salehi, H. et.al. (2018). [16]), a subset of machine learning. The many intelligent strategies mentioned above are schematically shown in Fig 2.

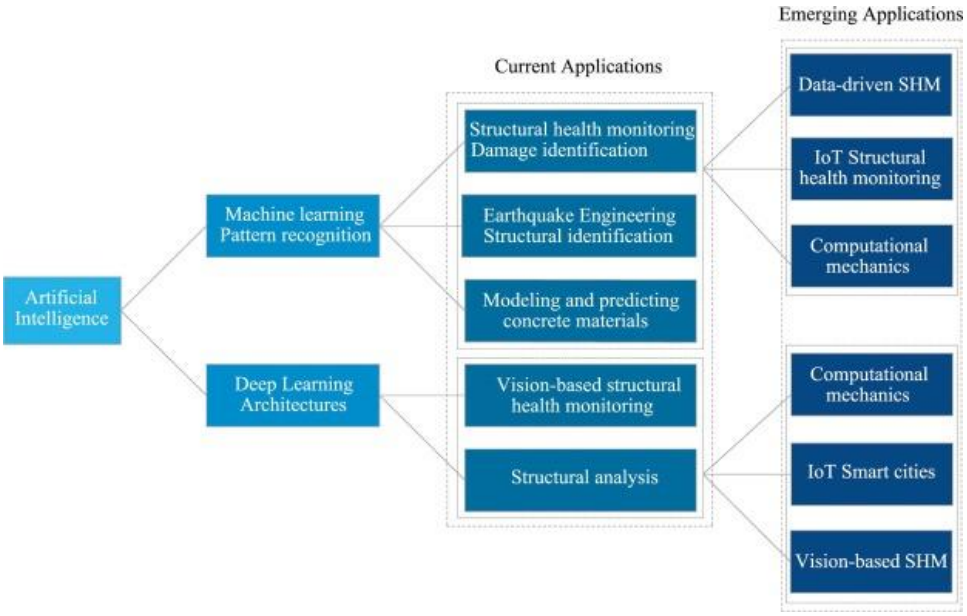

Fig. 2: Branches of Artificial Intelligence [17]

By enabling computers to learn from data and make wise decisions, machine learning and deep learning are potent techniques that have revolutionised numerous professions. They are widely used and keep becoming better as academics create new algorithms, designs, and methods to address ever-more complicated issues.

7. AI IN AGRICULTURE :

Agriculture is the foundation of any sustainable economy (Eli-Chukwu, N. C. (2019). [18]). According to it makes a major contribution to structural transformation and long-term economic growth (Ryan, M. et al. (2023), [19]). Growing crops and producing food were the only concerns of agriculture in the past. But during the last 20 years, it has evolved to encompass the processing, production, marketing, and distribution of agricultural and livestock goods. Given the exponential increase in world population, it is critical that agricultural practises be examined in order to offer creative ways for preserving and enhancing agricultural activity.

Applying AI to agriculture will be made possible by other technological developments, including big data analytics, robotics (Garcia, E. et al. (2007). [20]), the internet of things, the availability of inexpensive sensors and cameras, drone technology, and even widespread internet connectivity on geographically separated fields. AI systems will be able to forecast which crop to plant in a certain year and when the best dates to sow and harvest are in a particular location by looking at soil management data sources such as temperature, weather, soil analysis, moisture, and previous crop performance. Crop yields will increase as a result, and less water, fertiliser, and pesticide will be used.

8. AI IN IRRIGATION :

Artificial intelligence (AI) in irrigation refers to the use of artificial intelligence methods and tools for enhancing and automating irrigation systems. It entails utilising sensors, data analysis, and machine learning algorithms to enhance agricultural water management procedures. The techniques of

Artificial intelligence is utilised in irrigation to enhance water management in agriculture. In the field, sensors are set up to track vital metrics like soil moisture, temperature, humidity, and meteorological conditions. Continuous data is gathered by these sensors and sent for analysis to a centralised system.

Irrigation is the farming method that requires the most labour (Dharmaraj, V. et al. (2018). [21]). Automation of irrigation can increase productivity. This is made possible by AI-trained equipment that are educated about historical weather patterns, the state of the soil, and the kind of crops that should be grown. Around 70% of the fresh water supply in the world is used for irrigation; automation can assist farmers manage their water issues while also saving water.

Information about soil moisture levels, plant water content, atmospheric humidity, temperature, etc. must be gathered in order to perform smart irrigation (Krishnan, S. R. et al. (2022). [22]).
AI in irrigation entails the fusion of numerous technologies to improve agricultural water management. Field sensors (Tumanski, S. (2013). [23]) are used to keep tabs on important variables like soil moisture, temperature, humidity, and meteorological conditions. These sensors continuously gather data, which is subsequently sent to a centralised system for evaluation.
In order to find patterns, correlations, and trends, the AI system uses machine learning algorithms to analyse the obtained data. The AI system may make predictions (El Bilali, A. et al. (2020). [24]) and produce useful insights by comprehending the correlations between various variables. For instance, based on the crop type, development stage, soil conditions, and weather forecasts, it can determine the best timing and amount of water needed for irrigation.
Sensors for measuring humidity, temperature, and soil moisture can all be used to collect this data. These sensors are linked to inexpensive Arduino-based devices (Ga, S. et al. (2021). [25]) to store the collected data and run analysis algorithms to forecast the crop's water needs at a specific moment.
In order to find patterns, correlations, and trends, the AI system analyses the gathered data using machine learning techniques. The AI system can forecast outcomes and produce actionable insights by comprehending the connections between various variables. For instance, it can calculate the ideal irrigation schedule and volume based on the crop type, growth stage, soil characteristics, and weather predictions (Hamill, T. M. et al. (2006). [26]).

The ability of AI in irrigation to adapt to and learn from its surroundings is one of its main benefits. Based on input from the field, the AI system can improve its models and algorithms over time. This makes it possible to continuously improve irrigation plans and techniques to fit the unique requirements of the crops, save water, and increase yields. Aside from providing real-time monitoring (Syu, W. J. et al. (2020). [27]) and control capabilities, AI-based irrigation systems do so. Through mobile applications or web interfaces, farmers can remotely use the system to keep an eye on the irrigation process, get notifications, and make any adjustments. This makes it easier and more flexible to manage irrigation operations, even from a distance.

9. THE GROWTH OF AI :

Artificial intelligence (AI) has grown at an unparalleled rate in recent years, revolutionising (Makridakis, S. (2017). [28]) a number of industries and playing a significant role in our daily lives. This tremendous expansion has been facilitated by a number of important elements. First off, the development of AI has been greatly aided by improvements in computer capacity and the accessibility of vast amounts of data. The creation of robust technology, such as GPUs and dedicated AI chips, has boosted the processing capacity of AI systems, allowing them to execute complicated tasks with astounding quickness and effectiveness. The growth of the internet and linked gadgets has also generated a volume of data, giving AI algorithms the knowledge, they need to operate more accurately and efficiently.
Recent developments in AI research (Schank, R. C. (1987). [29]) and the emergence of deep learning have been crucial to the field's expansion. Deep learning algorithms, which are modelled after the structure of the human brain, have proven to have outstanding aptitudes for comprehending patterns, processing unstructured data, and carrying out challenging tasks like speech synthesis, image identification, and natural language processing. These developments have made AI systems more

practical and adaptable for a variety of applications, allowing them to achieve previously unheard-of levels of accuracy and dependability.

The rise of AI has been significantly influenced by the rising attention and funding from the public and private sectors. Companies from a variety of industries have made significant investments in AI research, development, and deployment because they understand how it can improve decision-making (Jarrahi, M. H. (2018). [30]), expedite operations, and improve consumer experiences. The strategic value of AI for boosting economic growth and competitiveness is also acknowledged by governments, which has resulted in favourable legislation, funding for research projects, and partnerships between academics and industry. The growth and use of AI technologies have been further accelerated by this collaborative effort, which has set off a positive innovation cycle.

Recent developments in high power computational capability processors and with the accessibility of enormous amounts of data, scientific advances in AI, the introduction of deep learning, and greater attention from the public and corporate sectors are all factors that have contributed to AI's astounding growth. These elements work together to catapult AI to new heights and promise even more revolutionary uses in the future in industries like healthcare, finance, transportation, and more. To fully realise AI's potential for the good of society, it is crucial to address ethical questions, privacy problems, and assure responsible development. Artificial intelligence (AI) startup funding worldwide from 2011 to 2023 (in billion U.S. dollars), by quarter explained with the help of chart in the Fig.3.

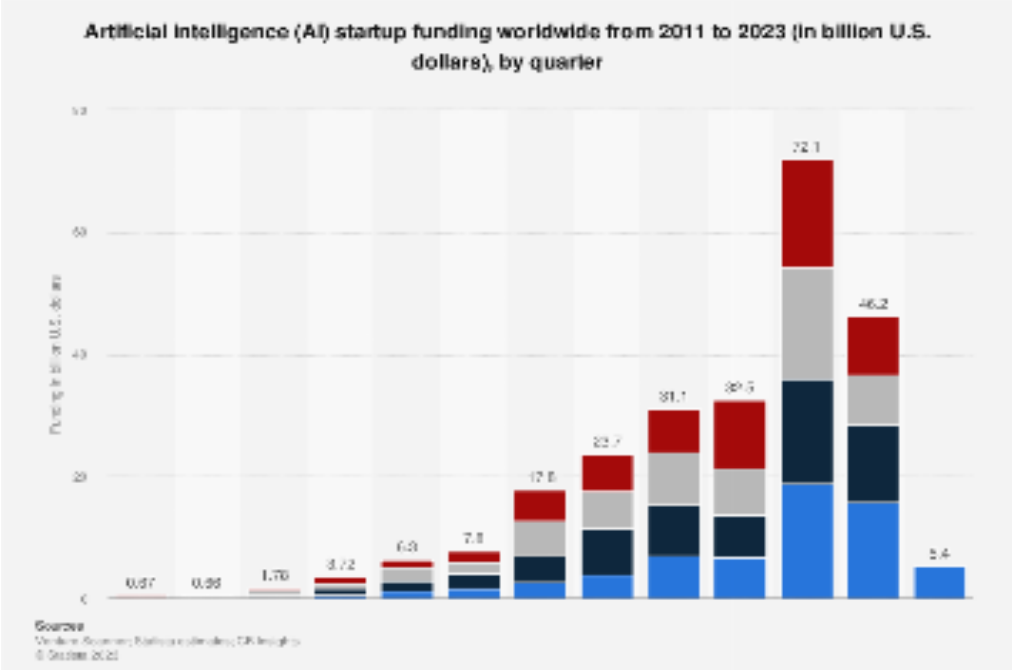

Fig. 3: AI funding worldwide 2011-2023, by quarter [31]

10. ALGORITHMS USED IN ARTIFICIAL INTELLIGENCE :

(1) Linear Regression: Linear regression (Poola, I. (2017). [32]) is a supervised learning approach used for predicting a continuous output variable based on one or more input features. It fits a linear relationship between the input and output variables to make predictions.

(2) Logistic Regression: Logistic regression (Poola, I. (2017). [32]) is a classification algorithm used for binary classification problems. It predicts the probability that an instance belongs to a certain class by fitting a logistic curve to the input data.

(3) Decision Trees: Decision trees (Hajjej, F. et al. (2022). [33]) are a non-linear, supervised learning algorithm used for both classification and regression tasks. They split the data into branches based on different features and create a tree-like model for making predictions.

(4) Random Forest: Multiple decision trees are combined in Random Forest, an ensemble learning technique, to increase accuracy and decrease overfitting. To reach a conclusion, it builds several trees and integrates their forecasts. (D. Rajkovi et al. (2023). [34]).

(5) Support Vector Machines (SVM): SVM is a potent supervised learning technique that is utilised for regression and classification tasks. In order to maximise the margin between the classes, it determines the optimal hyperplane for classifying the data (Mijwil, M. M. et al. (2021). [35]).
(6) k-Nearest Neighbours (KNN): According to (Mijwil, M. M. et al. (2021). [35]) KNN is a straightforward and understandable classification method that predicts the class of a data point based on the classes of its k nearest neighbours in the feature space.
(7) Naive Bayes: Based on Bayes' theorem, Naive Bayes is a probabilistic classification algorithm. It makes text classification and spam filtering computationally efficient and successful by assuming that the features are independent of one another (Ratha, A. K. et al. (2018). [36]).
(8) K-Means: Data is split into K clusters based on similarity using the unsupervised clustering algorithm K-Means. The cluster centroids are updated and data points are iteratively assigned to clusters up until convergence (Ratha, A. K. et al. (2018). [36]).
(9) Artificial Neural Networks (ANN): ANNs are modelled after how the human brain works and is organised. An input layer, one or more hidden layers, and an output layer are only a few of the layers made up of interconnected nodes (neurons) that make up these structures. Deep learning algorithms are built on ANNs, according to (Bobadilla, J. et al. (2020). [37]).
(10) Convolutional Neural Networks (CNN): CNN is a type of deep learning neural network primarily used for image recognition and computer vision tasks. It uses convolutional layers to automatically learn hierarchical patterns and features from the input data (Bobadilla, J. et al. (2020). [37]).
(11) Recurrent Neural Networks (RNN): RNN is a type of deep learning neural network well-suited for sequential data, such as time series or natural language. It uses feedback loops to pass information from previous time steps to the current one (Bobadilla, J. et al. (2020). [37]).
(12) Genetic Algorithms: A class of optimisation algorithms called genetic algorithms was developed as a result of the natural selection process. According to (J. Bobadilla. et al. (2020). [37]) they employ strategies like mutation, crossover, and selection to create answers to issues.
(13) Particle Swarm Optimization (PSO): is an optimisation algorithm that draws its inspiration from the social behaviour of fish schools and flocks of birds. The swarm's particles travel about the search area in pursuit of the best answer (Chen, Y. P. et al. (2009). [38]).
(14) Q-Learning: Q-Learning is a popular reinforcement learning algorithm used for making decisions in an environment with rewards and penalties. It learns the optimal action-value function through trial and error (Sabry, M. et al. (2019). [39]).
(15) Deep Q Networks (DQNA deep neural network is used by DQN, a deep learning-based extension of Q-Learning, to approximate the action-value function in reinforcement learning tasks (Sabry, M. et al. (2019). [39]).

These are only a few of the numerous artificial intelligence algorithms that are employed. The choice of method relies on the particular situation and available data. Each algorithm has strengths and limitations.

11. COMPANIES USING AI IN AGRICULTURE :

Several companies [40] are using AI in agriculture to improve efficiency, productivity, and sustainability. Here are some prominent companies:

(1) John Deere: A well-known agriculture machinery manufacturer, John Deere, has been incorporating AI and machine learning into their equipment. They use AI for precision farming, crop monitoring, and data-driven decision-making for farmers.

(2) IBM: Agriculture has used IBM's Watson platform to analyse information from a variety of sources, including weather, soil, and crop conditions. It aids farmers in decision-making and resource efficiency.

(3) Trimble: Trimble provides precision agriculture solutions that use AI and data analytics to assist farmers in optimizing field operations, managing water resources, and monitoring crop health.

(4) Prospera Technologies: Prospera offers AI-driven solutions for agriculture that use computer vision and machine learning to monitor crops, detect diseases, and optimize irrigation practices.

(5) The Climate Corporation (Bayer): This company uses AI to analyze weather data and field conditions to provide personalized insights and recommendations for farmers, helping them make data-driven decisions.

12. OVERVIEW OF COMPANY :

The international technology business IBM (International Business Machines Corporation) has a lengthy history in the sector. It was established in 1911 and through the years has developed into one of the top technology and consulting organisations in the world. With its involvement in a number of areas, including hardware, software, cloud computing, artificial intelligence, and enterprise solutions, IBM has significantly shaped the computer industry.

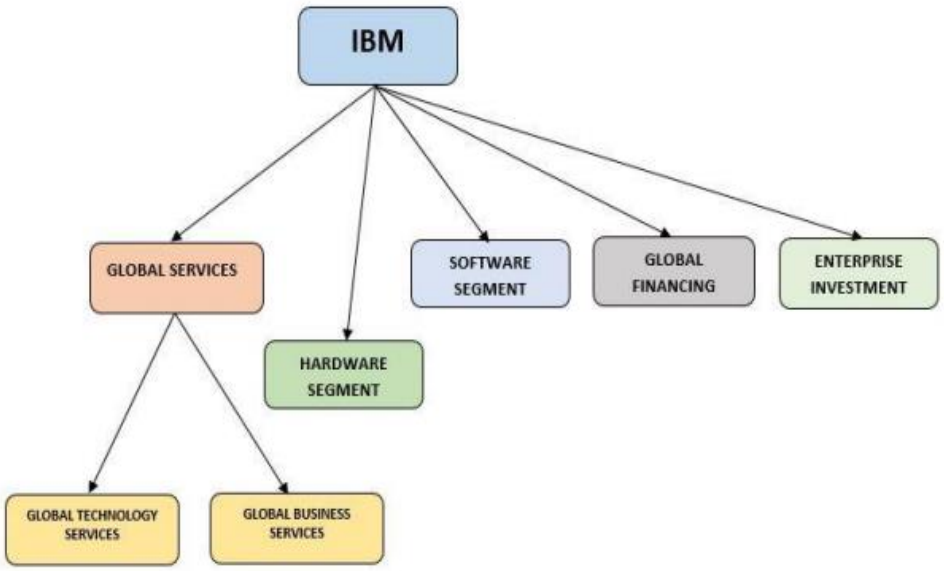

Fig. 4: Services provided by IBM [41]

IBM performs a wide range of tasks that generate and provide value as depicted in Fig.4. The global trade landscape has witnessed significant transformations, allowing consumer electronic goods companies to explore new markets worldwide. The introduction of open markets and trade regulations has facilitated the launch and sale of products across different countries, benefiting overseas companies. Moreover, the flexibility in pricing due to exchange rate fluctuations has enabled these companies to offer their products at reasonable prices in various regions. Furthermore, the trend of outsourcing has emerged as a major cost-cutting measure, particularly in the IT industry. Many businesses now prefer to outsource their software development projects, leading to reduced expenses on taxes, benefits, and employee insurance.

This shift towards outsourcing has also spurred the concept of economies of scale, as fixed capital is replaced by contract staffing, resulting in increased production capacity. Additionally, labor laws have become more lenient, fostering a friendlier work culture where employees are actively engaged in various forms of work. Leadership and managerial skills are honed through these programs, driving productivity and efficiency. Moreover, immigration reforms have made it easier for companies to recruit talent from different backgrounds and skill sets, bolstering the workforce in the IT industry. Governments of various countries have also extended political support to the booming IT sector by providing tax incentives and infrastructure assistance.

The rise of new technology, fuelled by cost-saving measures and automation (Al Rashdan, A. Y. et al. (2018). [42]), has led to an increased demand for sophisticated software to support these advancements. Sustainability has become a central focus in the corporate world, leading to the development of applications that promote energy conservation and paperless operations. This has made it possible for new businesses to release creative applications that support these objectives. Embracing diversity in the workforce, with employees from various cultural backgrounds, has proven to enhance operational efficiency and service delivery. With improvements in education standards and an increasing number of enrolments in STEM programs, there is a substantial pool of skilled individuals available to meet the industry's demands, driving technological advancements and achieving complex targets.

The changing demographics, such as an aging population, have contributed to the growing market for personal computers and laptops, which are now essential tools for both work and personal use. The rise of remote work and home-based businesses has further amplified the demand for personal computers and software applications. In the international arena, the global market has become more accessible, allowing IT consulting and software development companies to launch products in multiple languages and explore complex regions. For businesses looking to increase their presence and profit from various markets, this globalisation has created new opportunities (Muzumdar, P. (2013). [43]).

13. FINANCIAL GROWTH DETAILS OF IBM :

IBM's annual revenue has experienced fluctuations over the years from 2010 to 2023. In 2019, the company had a revenue of $55.179 billion, which decreased by 4.39% compared to the previous year. However, there was a 3.93% gain in sales from 2020, or $57.35 billion, which indicated a minor recovery. When IBM's yearly revenue reached $60.53 billion in 2022, up 5.54% from the year before, the upward trend persisted. According to the quarterly figures, IBM's revenue for the quarter ending March 31, 2023 was $14.252 billion, an increase of just 0.39% over the previous year. The twelve months revenue ending on March 31, 2023, was $60.585 billion, indicating a 3.81% increase compared to the same period last year. Despite facing some challenges, IBM demonstrated overall growth during this period, reflecting the dynamic nature of the technology industry and the company's strategies to adapt to changing market conditions [44]. Fig. 5 gives the details about the annual revenue generation.

IBM Annual Revenue (Millions of US $)		IBM Quarterly Revenue (Millions of US $)	
2022	$60,530	2023-03-31	$14,252
2021	$57,350	2022-12-31	$16,691
2020	$55,179	2022-09-30	$14,107
2019	$57,714	2022-06-30	$15,535
2018	$79,591	2022-03-31	$14,197
2017	$79,139	2021-12-31	$16,694
2016	$79,919	2021-09-30	$13,251
2015	$81,741	2021-06-30	$14,218
2014	$92,793	2021-03-31	$13,187
2013	$98,367	2020-12-31	$1,925
2012	$102,874	2020-09-30	$17,560
2011	$106,916	2020-06-30	$18,123
2010	$99,870	2020-03-31	$17,571

Fig. 5: IBM Revenue 2010-2023 [44]

Over the next three years, IBM is expected to experience significant earnings growth. However, it is projected that IBM's revenue will grow at a slower rate (3.5% per year) compared to the broader US market (forecasted at 7.5% per year). Additionally, IBM's high growth revenue is anticipated to grow at a rate lower than 20% per year. During Q1 2022, IBM brought in $14.19 billion in sales. Revenue by business segment of IBM depicted in Fig. 6 [45]:

Segment	Revenue in Q1 2022	Contribution in Q1 2022
Consulting	4829	34.0%
Financing	154	1.1%
Infrastructure	3219	22.7%
Other	224	1.6%
Software	5772	40.7%
Total	14198	100.0%

Fig. 6: IBM's Revenue by business segment [45].

14. ORGANIZATION DETAILS :

Any organisation needs an organisational structure (Ashton, D. N. (2004). [46]) because it offers a clear framework for defining roles, responsibilities, and reporting relationships. It guarantees effective workflow, accountability, and reduces effort duplication. A clearly defined framework encourages improved teamwork and communication among staff, which boosts output. It makes job and decision delegation easier, maximising the utilisation of resources and encouraging specialisation.

Inefficiencies, bottlenecks, and disputes can also be found and resolved with the use of a clear organisational structure, which boosts overall operational effectiveness. It makes it possible for workers to comprehend their career trajectories and prospects for progress inside the organisation, which boosts motivation and retention. A solid framework also links individual goals to the company's goals, creating a sense of belonging and shared vision among staff members.

A professionally run organisation presents a credible external image to stakeholders including clients, investors, and shareholders. It enables flexibility and reactivity to shifting market circumstances and enables the business to scale and expand sustainably. Last but not least, a well-organized structure helps with regulatory compliance, ensuring that laws and industry standards are followed. In general, a company needs a strong organisational structure to survive and prosper in a cutthroat industry.

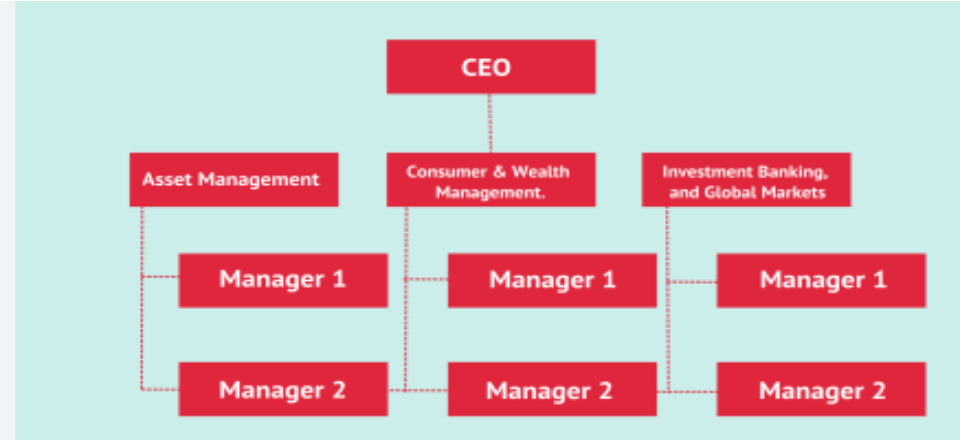

Fig. 7: IBM Organization Structure [47]

Details about the key players in the organisational structure are given in figure 7 [47].

(1) **President and CEO:** Arvind Krishna (Wikipedia. [48]), a business executive and the chairman and CEO of IBM, is Indian-American. As of April 2020, he has been the CEO of IBM. He became the company's chairman in January 2021. In 1990, Krishna began working at IBM's Thomas J. Watson Research Centre. After being elevated to Senior Vice President in 2015, he was given the chance to

oversee the IBM Cloud & Cognitive Software and IBM Research businesses. He played a significant part in the purchase of Red Hat, the largest acquisition in the company's history.

(2) **Senior Vice President and Chief Financial Officer:** James J. Kavanaugh is in charge of managing IBM's global finance operations. In his function as CFO, he is in charge of accounting and controllership, tax, internal audit, investor relations, corporate strategy, and corporate development. Additionally, he oversees IBM Financing. Mr. Kavanaugh was chosen for this position in January 2018 [49].

15. CLIENTS OF IBM SERVICES :

To numerous clients in diverse industries, IBM offers a broad range of services. These include things like technology solutions (Lasher, D. R. et al. (1991). [50]), cloud computing, artificial intelligence, and consultancy. Here are a few well-known customers of IBM services (Lasher, D. R. et al. (1991). [50]), along with brief summaries of their partnerships [51].
(1) Walmart: IBM and Walmart worked together to create a blockchain-based solution for enhancing the supply chain traceability of food items. By enabling quick tracking and product authentication, this ground-breaking system contributes to improving food safety and lowering potential health hazards [51].
(2) Maersk: To develop a blockchain platform called TradeLens, IBM teamed up with the international shipping firm Maersk [51]. This platform intends to increase efficiency, security, and transparency in the shipping and logistics sector in order to streamline and digitize global trade processes.
(3) Caesars Entertainment: Caesars Entertainment has improved client experiences in its resorts and casinos by utilizing IBM's AI technology, Watson. Watson helps to personalize customer encounters, make suggestions, and raise the standard of services as a whole [51].
(4) Coca-Cola European Partners: To improve maintenance and asset management throughout its bottling and distribution operations, Coca-Cola European Partners has implemented IBM's Maximo Asset Management solution [51]. This lessens downtime and increases operational effectiveness.
(5) AT&T: IBM and AT&T have worked together to improve AT&T's network capabilities by utilizing IBM's cloud infrastructure and services. This alliance seeks to offer cutting-edge solutions, like as 5G and edge computing, to enable the digital transformation of diverse industries [51].
(6) IBM has collaborated with Delta Airlines to create a predictive maintenance system that makes use of IoT and AI technology [51]. This system helps anticipate repair requirements, cut down on delays, and enhance overall flight operations by analyzing data from aircraft sensors.
(7) Banco Bradesco: One of the biggest banks in Brazil, Banco Bradesco, has received technology and consulting services from IBM (Lasher, D. R. et.al. (1991). [52]). The modernization of the bank's IT infrastructure, improvement of customer experiences, and expansion of digital banking capabilities have been the main goals of this collaboration.
(8) American Cancer Society: The American Cancer Society has used IBM's Watson AI technology to support cancer research and treatment decision-making. In order to offer insights and suggestions for individualized treatment approaches, Watson assists in the analysis of enormous volumes of medical literature and patient data (Lasher, D. R. et.al. (1991). [52]).
(9) The Weather Company: After being purchased by IBM, The Weather Company now uses its sophisticated weather forecasting capabilities to give reliable and fast weather information to people, organizations, and governments all around the world, assisting in disaster preparation and resource allocation [53].
(10) IBM and KONE have partnered to use IoT and AI technology for preventive equipment maintenance [53]. KONE is a leader in the world of elevator and escalator systems. This partnership contributes to the effective and safe operation of escalators and elevators in diverse buildings.
These instances demonstrate how IBM's various services and technologies are used in a variety of industries to address particular problems and spur innovation for its clients.

16. TYPES OF AI SERVICES BY IBM USED IN AGRICULTURE :

To increase production, sustainability, and efficiency in agriculture, IBM has created a number of AI services. By compiling and evaluating data from a variety of sources using AI technologies, these

services help farmers make better decisions. Here are a few IBM services that apply artificial intelligence in agriculture [54].

(1) The Watson Decision Platform for Agriculture is an AI-powered platform (Freeman, D. et.al. (2017). [55]) that combines a variety of data sources, including crop data, satellite imaging, and IoT devices. It offers advice and suggestions to farmers on how to manage crops more effectively in terms of irrigation, pest control, planting times, and other areas. The tool helps farmers make data-driven decisions by using machine learning algorithms to forecast crop diseases, weather trends, and yield potential.

(2) IoT and Precision Agriculture: IBM's IoT technologies [56] are applied to agriculture to gather information from sensors placed in equipment, livestock, and fields. These sensors track the temperature, humidity, and other external variables as well as the moisture content of the soil. This data is processed by AI algorithms to produce accurate field maps, which farmers can use to analyze changes in soil conditions and adopt tailored planting, fertilizing, and irrigation methods. This results in higher crop yields and optimal resource utilization.

(3) Plant Disease Detection: IBM has created artificial intelligence (AI) algorithms (Kumar, R. et.al. (2020). [57]) that can examine photos of crops to look for disease and pest indicators. These models can recognize minute alterations in plant appearance that can point to the presence of illnesses by applying machine learning and image recognition techniques. Early identification enables farmers to respond quickly, stopping the spread of illnesses and reducing crop losses.

(4) Weather forecasting and climate analysis: IBM's AI services (Kumar, R. et.al. (2020). [57]) provide cutting-edge weather forecasting and climate analysis capabilities that aid farmers in preparing for severe weather conditions like heavy rain or droughts. These systems offer precise predictions by combining historical weather data and the most recent conditions, enabling farmers to modify their plans and safeguard crops from unfavorable weather effects.

(5) Crop Yield Prediction: To assess crop production potential, AI-driven crop yield prediction models use data from satellites, drones, and field sensors (Mostaco, G. M. et.al. (2018).[58]). These models offer insights into possible yields by examining elements including weather patterns, soil quality, and planting methods. This knowledge can be used by farmers to plan harvests, allocate resources, and improve marketing tactics.

(6) Supply Chain Optimization: By examining data pertaining to transportation, storage, and distribution, IBM's AI solutions help to optimize the agricultural supply chain (Manopiniwes, W. et.al. (2014). [59]). These services aid in minimizing waste, lowering transportation costs, and ensuring prompt delivery of fresh products to markets by anticipating demand trends and enhancing routes.

(7) IBM's AI services (Kumar, R. et.al. (2020). [60]) can evaluate historical and current market data to provide insights into industry patterns, consumer preferences, and price movements. These insights can help farmers decide which crops to grow, when to harvest them, and when to put them on the market in order to optimize profits.

In conclusion, IBM's AI services (Kumar, R. et.al. (2020). [60]) for agriculture provide a wide range of functions, including data analysis, prediction, and decision support. With the help of these technologies, farmers can streamline their processes, better utilize their resources, and efficiently address problems brought on by varying weather patterns and market circumstances.

17. SWOC ANALYSIS :

Strength, Weakness, Opportunities, and Challenges is abbreviated as SWOC (Rajeshwari, M. et.al. (2020). [61]). It is frequently used to evaluate an organization's internal capabilities. Scientific studies employ SWOC analysis to understand PESTLE analysis as outer institutionalism, ABCD analysis as internal organizational analysis, and SWOC analysis (Rajeshwari, M. et.al. (2020). [61]) as a conceptual framework. SWOC evaluations from numerous businesses in a range of market segments have been released as academic studies (Madhushree, R. R. et.al, (2018). [62]. & Aithal, P. S. (2017). [63]). SWOC evaluations from numerous businesses in a range of market segments have been released as academic studies (Sathyan, S. et.al, (2021). [64]. & Netravathi, P. S. et al. (2021). [65]). Here is the SWOC analysis of IBM:

Strengths:

(1) Legacy and Reputation: IBM has a long history of being a leader in computing innovation and technology. The corporation has remained a dominant force in the sector thanks to its well-known brand and rich history [66].
(2) Diversified Portfolio: IBM offers a large selection of goods and services to both businesses and private customers. Due to its diversified portfolio, the company is able to handle numerous markets and adjust to shifting market trends.
(3) Enterprise Solutions: IBM is a major player in the market for enterprise solutions, offering solutions in fields including blockchain, cloud computing, data analytics, and cybersecurity. The company's revenue stream has depended on these services [67].
(4) Research and growth: IBM makes significant investments in this area, enabling it to stay on the cutting edge of technological growth. The company has been able to provide innovative goods and solutions thanks to its dedication to innovation.

Weaknesses:

(1) Challenges in the transition: IBM encountered difficulties when switching its business strategy from traditional hardware and software sales to cloud-based solutions and services.
(2) Decline in Some Business areas: In recent years, some of IBM's established business areas, including hardware, have seen reductions, which has had an effect on overall revenue [67].
(3) Complex Organizational Structure: The company's enormous size and complex organizational structure may make decisions take longer to make and make it more difficult to adjust to changes in the market.
(4) Competition is fierce: IBM competes against both established technological behemoths and up-and-coming entrepreneurs in highly competitive markets.
(5) Aging Workforce: IBM has a sizable number of long-term employees, which could make it difficult to keep up with the quickly evolving technological trends [68].

Opportunities:

(1) Growing Demand for Flexible and Scalable IT Infrastructure: IBM's focus on cloud computing and hybrid cloud solutions is in line with this demand.
(2) Artificial intelligence and machine learning: IBM's experience in these fields opens doors for businesses in the manufacturing, healthcare, and financial sectors.
(3) Quantum computing: IBM is in a strong position to take use of the promise of quantum computing for a variety of applications thanks to its expertise in the field [68].
(4) Data Security and Privacy: Growing worries about data security and privacy present opportunities for IBM to design and provide cutting-edge cybersecurity solutions.
(5) Partnerships in the Industry: Innovative products and services can result through partnerships with other technological firms, start-ups, and industries [69].

Challenges:

(1) Market Competition: A large number of businesses compete for market share in the technology sector. IBM is up against competition from major tech behemoths like Microsoft, Amazon, Google, and Oracle as well as more niche, smaller businesses [70].
(2) Moving to the cloud: Despite considerable advancements in cloud computing achieved by IBM with its IBM Cloud platform, it struggled to catch up to competitors like Amazon Web Services (AWS) and Microsoft Azure.
(3) Legacy Hardware Business: As more businesses switch to cloud-based solutions and software-defined infrastructure, demand for IBM's conventional hardware business has been dropping in recent years [69].
(4) Leadership and Strategic Shifts: Like any large enterprise, IBM has gone through leadership transitions and strategic changes that may have an effect on the performance and direction of the business [70].

Despite certain difficulties, IBM is still a significant force in the technology and consulting sectors. The company's future success in a constantly changing market will depend on its capacity to leverage its strengths, capitalize on emerging technology, and handle its obstacles.

18. CONCLUSION :

IBM has revealed to be a strong and significant technology company with a global presence. With its broad range of services, IBM can meet the needs of a wide range of customers, demonstrating its flexibility and knowledge. The organization of the company, which is well-structured, supports effective service delivery and has experienced years of excellent financial growth. Despite its advantages, IBM nonetheless faces difficulties like escalating competition and shifting market dynamics. However, IBM is well-positioned to overcome these challenges and maintain its trajectory of development and innovation in the fast-moving technology sector by capitalizing on its strong brand reputation, technological innovation, and strategic relationships.

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