Artificial Intelligence in Information Science — Approaches and Effects

الذكاء الاصطناعي في علم المعلومات – المناهج والتأثيرات

BY

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Abstract:

The recent advances in artificial intelligence (i.e., AI) in information science have resulted in unparalleled growth in businesses. This development came from the adoption of smart machines, which integrate mathematics, psychology, computer science, linguistics, and various other features in decision-making. Therefore, this research conducted a comprehensive review of available literature and explored the various approaches to AI and the overall ramifications of such technology. A wide range of literature produced from the 1950s to the present is examined to determine the trends and effects of AI. From the findings, it is determined that different approaches facilitate a machine's ability to rely on previous experiences when making decisions rooted in memory and self-awareness. Examined methods include machine learning, natural language processing, robotic process automation, and computer vision. This research also highlighted both positive and negative implications, which indicate that this is possibly a contentious technology. It concluded that businesses should engage in extensive research to ensure the pros of such technologies outweigh the risks.

Keywords: Artificial Intelligencemachine learning, natural language processing, robotic process automation, computer vision.

المستخلص:

أدت التطورات الأخيرة في الذكاء الاصطناعي في علم المعلومات إلى نمو لا مثيل له في الأعمال التجارية. جاء هذا التطور من اعتماد الآلات الذكية ، التي تدمج الرياضيات وعلم النفس وعلوم الكمبيوتر واللغويات ومختلف الميزات الأخرى في صنع القرار. لذلك ، أجرى هذا البحث مراجعة شاملة للأدبيات المتاحة واستكشف المناهج المختلفة للذكاء الاصطناعي والتداعيات العامة لهذه التكنولوجيا. تم فحص مجموعة واسعة من الأدبيات التي تم إنتاجها من الخمسينيات وحتى الوقت الحاضر لتحديد اتجاهات وتأثيرات الذكاء الاصطناعي. من النتائج ، تم تحديد أن الأساليب المختلفة تسهل قدرة الآلة على الاعتماد على الخبرات السابقة عند اتخاذ قرارات متجذرة في الذاكرة والوعي الذاتي. تشمل الأساليب التي تم فحصها التعلم الآلي ومعالجة اللغة الطبيعية وأتمتة العمليات الروبوتية ورؤية الكمبيوتر. سلط هذا البحث الضوء أيضًا على كل من الآثار الإيجابية والسلبية ، والتي تشير إلى احتمال أن تكون هذه تقنية مثيرة للجدل. وخلصت إلى أن الشركات يجب أن تشارك في بحث مكثف لضمان أن تكون مزايا هذه التقنيات تفوق المخاطر.

الكلمات الرئيسية: الذكاء الاصطناعي ، التعلم الآلي ، معالجة اللغة الطبيعية ، أتمتة العمليات الروبوتية ، رؤية الكمبيوتر.

Introduction:

Artificial intelligence (i.e., AI) is an extensive topic in informational science that concentrates on creating smart machines that reduce human effort. Therefore, the goal of this technological development is to perform duties that are related to human intelligence (Shabbir and Anwer, 2018). AI is an interdisciplinary field with multiple approaches and implications. However, the current advancements in deep learning and machine learning have led to a paradigm shift in a lot of sectors within the technology industry. It is noteworthy that, as technology advances, previous benchmarks that defined AI are becoming increasingly outdated and ineffective. For instance, machines that recognize texts through optimal characters or calculate basic functions are gradually becoming redundant (Cioffi et al., 2020). Most businesses do not believe that they have AI-based systems, because their processes have been replaced by advanced technologies. Nonetheless, AI is constantly developing to meet the needs of different industries. This is the reason why innovators rely on cross-disciplinary approaches during the development stage, whereby they integrate mathematics, psychology, computer science, and linguistics, and other features. The technology has been widely adopted in healthcare, automotive, and financial industries.

Historical Context

AI was initially introduced in the 1950s, as several classical philosophers attempted to explain human thinking and actions using symbolic systems. In 1956, researchers at a convention at Dartmouth College, New Hampshire, coined the term "artificial intelligence" (Haenlein and Kaplan, 2019). Between 1974 and 1980, numerous reports criticized this concept, forcing the United States government to cut off all funding and research in this field. In an attempt to compete against Japan who made major milestones in AI in the 1980s, the British government revived the concept through funding (Haenlein and Kaplan, 2019). However, the field experienced major setbacks between 1987 and 1993 due to the collapse of the market for general-purpose computers and reduced funding. Nonetheless, IBM continued with research, which resulted in major milestones. In 1997, its Deep Blue computer became the first innovation to defeat a chess champion—grandmaster Garry Kasparov (Shabbir and Anwer, 2018). Ever since, government institutions worldwide have increasingly funded the field, resulting in constant advancements. Currently, AI applies to a wide range of intellectual tasks in the automotive, healthcare, entertainment, literature, and financial sectors.

Approaches

Businesses classify AI based on a machine's capacity to use past experiences during future decision-making, which is rooted in memory and self-awareness. As noted, IBM's Deep Blue became the initial computer to identify the different pieces in a chessboard (Shabbir and Anwer, 2018); however, Deep Blue could not predict future decisions. While the computer system is useful, it cannot adapt to situations. Further, some machines use past experiences by using limited memories installed on them to predict decisions. For instance, AI has been applied in the automotive industries, particularly in autonomous cars. Notably, manufacturers install memory chips to help cars "recall" the past during navigation (Haenlein and Kaplan, 2019). Memories are not stored permanently, as observations are usually dynamic. Also, some recent machines have substantial levels of sense and consciousness. In other words, they understand the state of things, including emotions and actions, and can infer the right course of action. Overall, leading approaches for achieving these functions include machine learning, natural language processing, robotic process automation, and computer vision. These are shown in the figure below.

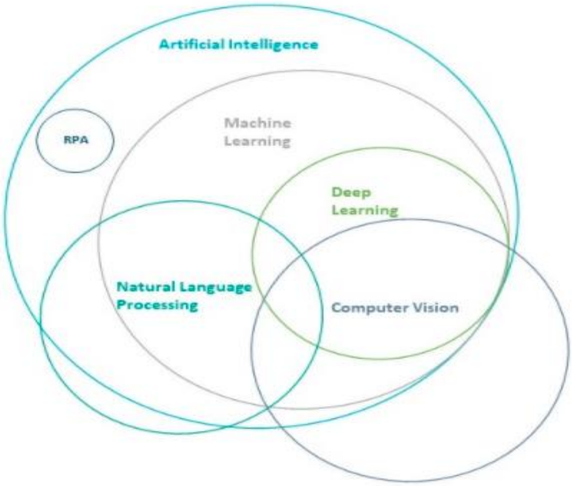

Figure 1. Approaches to AI

Machine Learning:

Machine learning is one of the leading approaches to AI, which uses numerical optimization or statistical methods to derive models from available information. The derivation process does not program all computing steps or model parameters. Rather, a principal feature of this technique is the use of probabilities to depict uncertainties existing in real-world problems. There are three major classifications of machine learning, namely supervised, unsupervised, and reinforcement learning (Shabbir and Anwer, 2018). Supervised learning requires labelled data in computational models. On the other hand, unsupervised learning requires unlabeled data to determine patterns in models, while reinforcement learning does not require labelled data. Instead, reinforcement learning requires action-based information, such as punishment or rewards, in training computational models. Also, the tasks implemented in machine learning systems have different categories. The first category stems from goals, which identifies various tasks, including classification, prediction, and clustering (Woschank et al., 2020). In line with classification, its objective is to categories and define a target. For example, a land parcel can be classified as agricultural or commercial. Based on clustering, the intent is to determine the propensity for clusters; for instance, the number of vehicles in a location to detect traffic jams. The last task—prediction—forecasts unknown values, such as the expected temperatures in a geographical location, based on previous information and using regression models. Other tasks conducted by machine learning systems include novelty detection, visualization, and data generation.

There are various machine learning models available to researchers and corporations, including regression, random forest, decision tree, and artificial neural network (Woschank et al., 2020). Though these models apply to geographical data, they do not address the uniqueness of the phenomena. Particularly, they fail to consider different factors, such as spatial autocorrelation and non-stationarity. Even so, certain models like regression, Empirical Bayesian Kriging (EBK), and spatial Principal Component Analysis (sPCA) address these issues with geographical data (Cioffi et al., 2020). An example of such issues is spatial weights. Additionally, certain classic models, including geographically weighted regression (GWR), can be applicable for machine learning, as they can be trained in a dataset and tested in others.

Deep learning refers to a subset of machine learning that uses deep neural networks (i.e., DNNs) for predictive analysis. DNN is considered a type of artificial neural network (i.e., ANN), which has numerous layers between its input and the output. Each layer has connecting units, referred to as neurons, which transport the input through multiple layers and produce a non-linear output (Singh et al., 2007). In recent years, a lot of interest has been generated in deep learning because of its excellent performance. Its performance is based on a large variety of labelled datasets, including high-performance computing, HPC, and ImageNet (Shabbir and Anwer, 2018). It is a subset of machine learning, which makes it is possible to complete tasks like clustering, classification, and prediction. Deep learning systems also operate using different neural networks, including recurrent and convolutional neural networks (RNN and CNN, respectively) and long short-term memory (LSTM). Overall, the combination of neural networks and machine learning enhances the understanding of artificial intelligence. Furthermore, it is a major development in contemporary intelligence systems.

Convolutional Neural Networks (CNNs)

Generally, CNN replicates the features of visual cortex and is often applied to advanced elements of computer vision. In symbolic systems, computer vision is based on images that adhere to the pre-set criteria for specific object designations; for instance, shapes, width, and height relationships (Woschank et al., 2020). A broader set of parameters can be accessed in CNN-based computer vision. Also, their relative weight can be adjusted, based on any specific circumstances. Thus, image classification can be adjusted according to the angle and the relative distance from a point (Singh et al., 2007). For instance, the human head appears different from different angles; however, it remains the same. Similarly, fingers and toes constitute a person. Nonetheless, an individual must recognize each part and compare them with different sections to classify it as human. This comparative approach, rooted in a multiplicity of factors, denotes the nature of CNN. This approach is applicable for various processes, including drug discovery, natural language processing, and games.

Recurrent Neural Networks (RNNs)

An RNN is a form of ANN that relies on time series or sequential data. The types of deep learning algorithms deployed are related to temporal or ordinal problems, including speech recognition, language translation, natural language processing, and image captioning. This approach is mainly applied in well-known applications, such as voice search applications, Siri, and Google Translate (Woschank et al., 2020). A significant feature is that information processing does not exclusively flow through layers from input to the output. Rather, the RNN typically has feedback loops within the layers, thereby contextualizing data processing, which is identical to the approach used by the human mind to arrange thoughts (Singh et al., 2007). Its process includes the development of a memory type that enables information to affect outputs temporally and dynamically. For instance, in speech recognition, RNNs assist with modification of individuals' details, while natural language processing assists with deciphering an individual's voice, based on the history of used words.

Long Short-Term Memory (LSTM)

It is noteworthy that LSTM is a form of RNNs, which learns order dependence in prediction problems. A fundamental feature of complex problem domains like speech recognition and machine translation is the ability to learn order dependence (Singh et al., 2007). In a nutshell, LSTM units build on the inherent promise of RNNs by improving memory capacities. However, in circumstances with a large number of layers, it could be challenging to refer to the previous layers in RNNs. LSTM units resolve this, as they ensure that the categorization of information stems from short-term or long-term. In so doing, the units enable RNNs to selectively refer to information and loop it back into the right memory. This approach applies to robotics, speech recognition, sign language translation, grammar learning, and business process management (Woschank et al., 2020). The rationale for these applications is that they are effective in capturing short-term and long-term dependencies without experiencing optimization challenges that are prominent in RNNs.

Natural Language Processing (NLP)

NLP is an AI-based approach that gives computing devices the capacity to read, comprehend, and interpret language. Therefore, NLP assists computers with measuring sentiments and determining the sections of the human language that are significant (Moreno and Redondo, 2016). This is a challenging task for computers, as they handle large quantities of unstructured information. There are also additional issues, including the absence of real-world intent or context, and the lack of rules. In recent years, the evolution of AI has made NLP overly sophisticated, particularly for innovators. However, most computer users have not realized this, though they use NLP daily. For instance, several tools, including spell checkers, spam filters, autocomplete, and voice text messaging, use NLP (Khurana et al., 2017). The sophistication of the technique stems from multiple rules. Indeed, computers find it difficult to understand the multiple rules that dictate data processes. Some are often abstract and high-level rules, while others are low-levelled. As such, computers find it difficult to understand words and the implied ideas in delivering messages.

The features of NLP include the application of algorithms to extract and identify language rules. The aim is to convert unstructured language data into a form that can be understood by a computer (Moreno and Redondo, 2016). Considering texts, computers generally use algorithms to extract the meanings related to every sentence, and during the process, they can retrieve vital information. However, a computer system could fail to comprehend the meaning of a phrase or sentence properly, resulting in obscure results. A good example is a humorous incident in the 1950s when the approach failed to translate a sentence in the Bible properly in English and Russia. The sentence was: "The spirit is willing, but the flesh is weak" (Singh et al., 2007). The translation to Russian and then to English read as: “The vodka is good, but the meat is rotten.”

NLP uses syntactic and semantic analysis as the principal techniques for completing tasks. The syntax is focused on the arrangement of the words in a phrase or sentence to make grammatical sense (Moreno and Redondo, 2016). Based on this approach, the technique examines if a language complies with the grammatical rules. Therefore, it considers lemmatization, word segmentation, parsing, and morphological segmentation, among others. Semantics is the meaning implied by a text (Khurana et al., 2017). Semantics is one of the challenging aspects of NLP because some elements have not yet been entirely resolved. Nevertheless, it applies algorithms to comprehend the interpretation or meanings of words, and the structure of sentences. Common techniques in NLP include natural language generation, named entity recognition, and word-sense disambiguation.

Robotic Process Automation (RPA)

RPA involves the use of software solutions to replicate repetitive activities. The objective of automation is to design machines that carry out repetitive and monotonous tasks, thereby increasing overall productivity (Kumar and Balaramachandran, 2018). Also, automation enhances efficiency and creates cost-effective outcomes.

Today, most corporations use neural networks, graphs, and machine learning for automation. Considering that machines reduce human intelligence, it can be deduced that RPA lessens fraudulent cases. Notably, RPA differs from other automation processes as it allows businesses to apply it selectively, based on cost and time. Contrary to traditional automation solutions, this approach is non-intrusive and leverages infrastructural benefits, without disrupting underlying systems (Cioffi et al., 2020). As a result, businesses realize compliance and cost efficiency, because RPA does not require old systems to be replaced with new ones.

Generally, most businesses use RPA to automate workflow, back-office processes, and infrastructure, which are typically -labor intensive. The software applied usually interacts with in-house applications, user portals, and websites. The use of software robots is identical to the conventional notions of manufacturing automation, where technology is focused on only a section of a workflow (Kumar and Balaramachandran, 2018). Besides, this concept may sound like the applications of macros and screen-scraping; however, RPA is far more advanced than these tools. For example, macros adhere to pre-determined scripts of linear and fixed commands. On the other hand, RPA has the flexibility to learn how to enhance a system's capabilities and respond to changes accordingly. Besides, the technology simplifies how individuals automate duties, as it allows multiple interactions simultaneously.

RPA is applicable in different fields and at varying levels. For instance, in human resources, it lessens organizations' manual steps, which are usually time-consuming. Also, RPA can be used to streamline various processes, such as onboarding and compensation, by reducing human intervention (Cioffi et al., 2020). It is also valuable for procurement, particularly in invoice processing and requisition-to-purchase orders. For instance, invoice processing is a repetitive process; therefore this technology could help to reduce human effort (Kumar and Balaramachandran, 2018). The major benefit of invoice processing is the opportunity to create a robust audit trail for accountability. Besides, in contact centers, RPA could aid call agents in tracking specific problems without having to monitor all applications. Therefore, agents can easily navigate to a complete profile of a client, with all the required historical details. The table below depicts these applications, based on industries and functions.

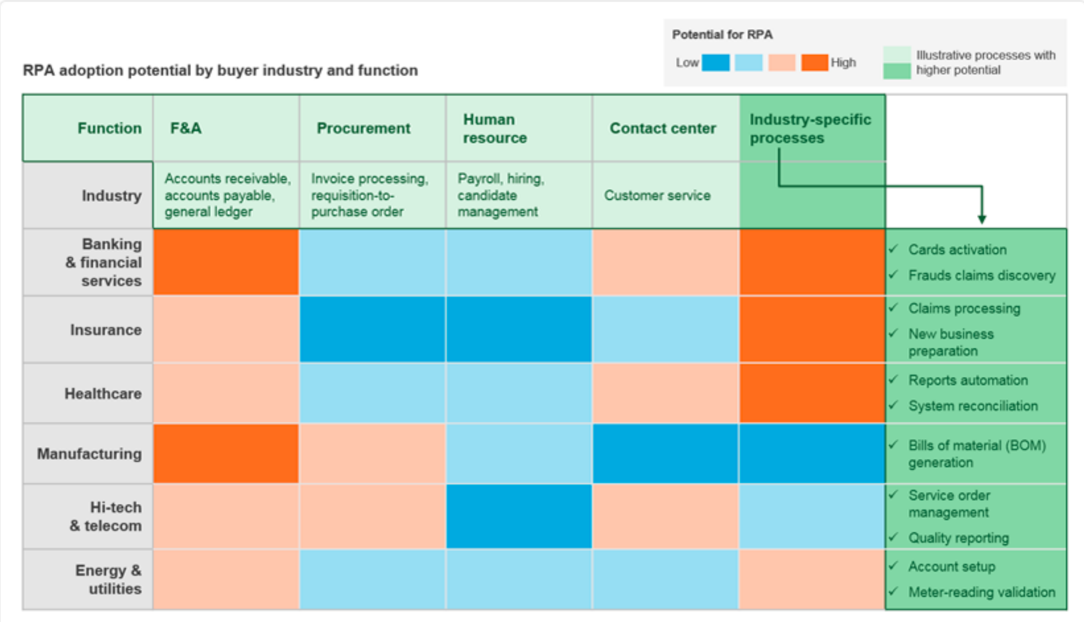

Figure 2. Processes relevant to RPA

Computer Vision

According to Shabbir and Anwer (2018), computer vision is "a subset of mainstream artificial intelligence that deals with the science of making computers or machines visually enabled, they can analyze and understand an image." It identifies and, occasionally, locates objects in digital videos and images. Considering that most animals process videos and images with their visual cortex, a lot of researchers have embraced its structure and used this for building neural network models (Wiley and Lucas, 2018). Though the research in this area began in the 1950s, the advances within the last 20 years have been remarkable. The overall aim is image recognition, and currently, some systems achieve an accuracy of 99% (Khan and Al-Habsi, 2019). Also, most systems can operate effectively on mobile devices.

According to working mechanisms, a computer vision algorithm depends on CNNs, which use pooling and loss of layers. In the process, they simulate visual cortexes, while the convolutional layer acts as a series of overlapping regions. The pooling regions operate as forms of non-linear down-sampling (Khan and Al-Habsi, 2019). In fully connected layers, neurons typically connect to all activations. A loss of layer computes how network training results in a deviation between the "true" and predicted labels. During the process, a cross-entropy or Softmax loss is required for clarification. A couple of approaches can be used to train datasets. The most prominent strategy is MNIST, which is an approach that has 70,000 handwritten digits (Wiley and Lucas, 2018). Of these 70,000, 60,000 are used for training, while 10,000 are for testing. Other prominent strategies are Fashion-MNIST and CIFAR-10, which are 10-class datasets. There is also SVHN, which is a set of 600,000 images of actual house numbers from Google Street View.

Therefore, it is apparent that computer vision has unique applications. For instance, Amazon has introduced 18 AmazonGo outlets to enable customers to bypass the queuing system and pay for products immediately (Wiley and Lucas, 2018). In essence, it uses computer vision cameras that notify its employees when customers take products off the shelves. It also identifies items that are removed or returned from a shopping cart. Facebook also uses this approach with its facial recognition capability known as DeepFace. The company utilizes its users' features to allow them to automatically tag images posted on their profiles. Despite the increase in feedbacks citing security reasons, the company only allows recognition for users to be able to proceed. Computer vision is also applicable to the automotive industry. Various companies, including Google and Tesla, have been using Adaptive/Dynamic Cruise Control in manufacturing autonomous cars (Khan and Al-Habsi, 2019). The technology helps drivers to maintain safe distances from other cars.

Effects of AI

The implications of AI are visible on various platforms, including AI-enabled chat sports online, predictions on e-Commerce platforms, and auto-search engines. Thus, the positive effects of AI applications are numerous due to their propensity to revolutionize professional sectors. However, there are certain negative implications, which makes the field somewhat contentious.

Positive Effects

Zero Human Error

AI adoption has increased across various domains, and this is mainly because it eliminates human intelligence. Eliminating the probability of human errors implies an increasing chance of getting accurate results. The use of machines, particularly robots in RPA, results in accurate decisions that are based on the data that was previously collected over a period (Soni.et al , 2019). This accuracy stems from the use of algorithm sets designed to register current trends. Recently, Google shared the news about the significance of machine learning on its AI blog. It commended the approach for effectively predicting the weather. It has expressed interest in coining the term ‘Nowcasting’, which is a function that will provide weather updates six hours in advance. It believes that a simple methodology with reduced information will result in accurate predictions for events such as precipitation or thunderstorms.

Zero Risks

As noted, one of the primary goals of AI is to reduce human intelligence, particularly in extreme circumstances. Replacing humans with machines to conduct duties in such situations reduces dangers to humans. As a result, lately, scientists have been using machines, especially robots, to deal with natural calamities, and this has led to reduced pressure on humans and faster recovery. For instance, Google and Harvard formed an initiative to create an AI system to forecast the aftershock location after an earthquake (Soni et al., 2019). The goal was to warn residents of impending earthquakes and prevent property destruction or loss of lives. To achieve this, scientists studied roughly 130,000 earthquakes and aftershocks, as well as their neural networks on 30,000 events (Geisel, 2018). Their neural networks generate more accurate information for locating aftershocks, compared to the traditional means, thereby reducing potential dangers to humans.

24/7 Availability

In the United States, an individual works an average of 4 to 6 hours daily, excluding breaks. For optimum productivity, humans should have some breaks for refreshment. This way, they are ready for new assignments, and, at times, even have weeklies to ensure they maintain a work-life balance (Soni et al., 2019). On the other hand, AI does not require much human effort, as machines work constantly. In other words, they do not require breaks due to boredom or tiredness, unlike humans. Once Google realized these benefits, the company created a contact center rooted in AI to enhance their overall customer experience. Since then, the helpline has continuously aided with addressing the issues and queries of customers round the clock. Similarly, Amazon Lex is a 24/7 call center that has intelligent conversations with customers. It uses similar technology like Amazon Alexa, thereby recognizing customers' intents, posing related questions, and offering appropriate answers. Overall, AI ensures there is constant availability of services globally, irrespective of the varied time zones.

Fast Decisions

The application of AI results in the development of machines that make faster data-driven decisions compared to humans. Most opponents have posed the question, "Why trust decisions are derived from machines?" The answer is that such decisions are devoid of bias and emotions (Geisel, 2018). Involving humans in processes often compromises the overall speed, due to the need to understand issues, while constantly striving to provide solutions to several challenges (Soni et al., 2019). In such circumstances, a person breaks down, which could result in uncompleted processes or conversations, based on sensitivity. However, machines provide rational and practical decisions based on the data provided. This creates more result-oriented and accurate decisions at a faster pace. An excellent example is IBM's Deep Blue computer, which makes decisions swiftly, based on probabilities. Humans cannot work on several probabilities like machines.

Negative Effects

High Initial Costs

The adoption of AI in organizations often introduces high costs during the initial stages. For instance, in the case of RPA, the costs are enormous considering that robotic engines are complex. Asides from the installation costs, a lot of maintenance and repair is necessary, adding to the overall costs (Dirican, 2015). Besides, most innovators are constantly changing their systems to enhance the reliability and validity of their services and products, to remain competitive. Also, businesses must keep up with constant software updates to match their constantly changing environment. Furthermore, when software or hardware breakdown occurs, the procurement costs are significantly high, compromising the overall operations of a business.

Lack of Creativity

The main objective of AI is to eliminate human intelligence, and this is why it focuses on programming machines, implying humans cannot think "outside the box." Essentially, programmed machines always address a situation based on available information and past experiences (Dirican, 2015). Therefore, there is no opportunity for creativity, unless when programmed. A good example of the lack of creativity is Forbes reports. The company uses Quil (a robot) to write its earnings reports. It feeds data to the robot, which, in turn, analyses it to generate the findings. However, their findings lack any human perspective, indicating that they are not relatable (Chen et al., 2016). Therefore, the use of machines eliminates the creative touch that is vital for explaining events and using examples to support findings.

Loss of Jobs

AI is gradually eliminating jobs associated with repetitive tasks. Most start-ups are searching for solutions that have minimal human interference, as they look forward to risk-free and error-free operations. More so, machines are faster than humans, making them more effective. This has resulted in reduced job opportunities in various roles, such as data entry, customer services, and inventory processing. It is noteworthy that robots have taken most service roles due to their effectiveness and continuous availability (Geisel, 2018). This could be a future trend, as it is estimated that robots will replace roughly 30% of human labour by 2030. Statistically, approximately 400 to 800 million job roles will be lost, which could have adverse implications on living standards (Chen et al., 2016). This is why labour unions, including the Communication Workers Union in the United Kingdom, have been criticizing the development of RPA systems. They believe such plans will result in job losses, thereby creating massive unemployment.

Ethics

During its advanced stages, opponents believe that AI technology will pose ethical challenges. Most innovators argue that machines are advancing with regards to their senses and consciousness. This raises the question: "At what stage will a machine be considered conscious, sensible, and sentient to be entitled to human rights?" Though this stage may be far-fetched, it is essential to consider ethical issues related to current AI systems (Dirican, 2015). Another ethical consideration stems from costs. Currently, monopoly is possible because only large corporations control technology, including IBM, Twilio, Alphabet, and Microsoft (Geisel, 2018). The owner of the information collected by AI systems is not yet apparent, neither is how such information should be ethically managed.

Conclusion

Researchers at a convention at Dartmouth College coined the term "artificial intelligence" in 1956 to replace human intelligence. From the research conducted in this paper, it can be deduced that AI has revolutionized various industries, including healthcare, automotive, finance, and entertainment. The recent advances mainly stem from the contributions of the US, the UK, and Japanese governments through funding. The principal AI-based approaches are machine learning, NLP, RPA, and computer vision. It has had both positive and negative impacts. The positive effects include zero human errors and risks, 24/7 availability, and fast decisions. On the other hand, negative implications include high initial costs, the lack of creativity, job loss, and ethical considerations. Therefore, a lot of research is vital to ensure that its merits outweigh its limitations.

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