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Artificial intelligence on pharmaceutical industry

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Abstract
The incorporation of Artificial Intelligence (AI) in the pharmaceutical industry hastransformed many elements of drug discovery, development, manufacturing, clinical trials, and marketing. AI's capabilities range from enhancing accuracy and minimizing errors to enabling previously impossible new ideas. AI is being used in drug development by the pharmaceutical sector, with applications like as predicting molecule structures and optimizing drug designs. Furthermore, AI aids drug repurposing by quickly finding current pharmaceuticals for new medicinal applications, saving time and money. AI-powered automation in manufacturing simplifies operations, improves quality control, and optimizes production parameters.

Keywords: Artificial Neutral Networks (ANNs), Deep Neutral Networks (DNNs), Recument Neutral Networks (RNNs)

1. Introduction
Artificial Intelligence (AI) is a stream of science related to intelligent machine learning, mainly intelligent computer programs, which provides results in the similar way to human attention process.(1) This process generally comprises obtaining data, developing efficient systems for the uses of obtained dat illustrating definite or approximate conclusions and self corrections/adjustments.

1.1 History of Artificial Intelligence
1.1.1 Maturation of AI (1943-1952)
- Year 1943-The first work which is now recognized as AI was done by Warren McCulloch and Walter pits in 1943. They proposed model of artificial neurons.
- Year 1949-Donald Hebb demonstrate an updating rule for modifying the connection strength between neurons. His rule is now called Hebbian learning
- Year 1950-The Alan Turing who was an English mathematician and pioneered machine learning in 1950. Alan Turing publishes "Computing machinery and intelligence "In which he proposed at a test. The test can check the machine ability to exhibit intelligent behavior equivalent to human intelligence called turing test.

1.1.2 The birth of AI (1952-1956)
- Year 1955-An Allen Newell and Herbert A. Simon created the first artificial intelligence program which was named as "Logic theorist". This program had proved 38 of 52 mathematics theorems, and find new and more elegant proofs for some theorems.
- Year 1956-The word AI first adopted by American computer scientist John McCarthy at Dartmouth conference. For the first time, AI coined as an academic field [1, 2].

1.1.3 The golden years-early enthusiasm (1956-1974)
- Year 1966-The researchers emphasized developing algorithms which can solve mathematical problems. Joseph Weizenbaum created the first chatbot in 1966, which was named as ELIZA.
  Year 1972-The first intelligent humanoid robot was built in Japan which was named as WABOT-1.

1.1.4 The first AI winter (1974-1980)
- The duration between years 1974 to 1980 was the first AI winter duration. AI winter refers to the time period where computer scientist dealt with a severe shortage of funding from government for AI researches.
- During AI winter, an interest of publicity on AI was decreased [3].

1.1.5 A boom of AI (1980-1987)
- In the year 1980, the Year 1980-After AI winter duration, AI came back with "Expert system ". Expert system was programed that emulate the decision-making ability of human expert.
- First national conference of the American association of AI was held at Stanford University.

1.1.6 The second AI winter (1987-1993)
- The duration between the years 1987 to 1993 was the second AI winter duration
- Again, investors and government stopped in funding for AI research as due to high cost but not efficient result. The expert system such as XCON was very cost effective.

1.1.7 The emergence of intelligent agents (1993-2011)
- Year 1997-In this year, IBM deep blue beats world chess champion, Gary Kasparov, and became the first computer to beat a world chess champion.
- Year 2002-for the first time, AI entered the home in the form of Roomba, a vacuum cleaner.
- Year 2006-AI came in the Business world till the year 2006. Companies like Facebook, Twitter, and Netflix also started using AI [4, 5].

1.2 Classification of AI
- **Narrow Intelligence (ANI):** This AI can perform specific tasks well, like facial recognition, driving cars, or playing chess, but it's limited to those tasks and lacks general human-like intelligence.
- **Artificial General Intelligence (AGI):** AGI is as smart as a human and can handle a wide range of tasks, learn from experience, and solve different problems, just like humans do.
- **Artificial Super Intelligence (ASI):** ASI is even smarter than humans and can excel in areas like advanced mathematics, painting, and scientific research, going beyond human abilities.

3. The role of AI in drug discovery
Drug development and research is a costly and laborious endeavor that necessitates balancing numerous features of molecules to achieve desirable clinical efficacy and safety. Among these characteristics, the drugs' performance primarily depends on their pharmacokinetics /pharmacodynamics (PK/PD) characteristics, nonclinical safety profiles, and absorption, distribution, metabolism, and elimination (ADME) characteristics. The discovery of drug and the process of its development may benefit from recent advancements in AI/ML techniques since they could increase the likelihood of success and speed up decision making. Huge datasets that contain information about chemical structures and the associated experimental readouts are used to train the AI/ML system, which subsequently clarifies the underlying ideas, biological reactions, and interactions between chemical structures.

- **Target Identifications:** AI systems can analyze different kinds of data, such as genetic information, protein data, and clinical records. This helps them find possible targets for treatments. By discovering these targets and understanding how molecules work in diseases, AI helps in creating medications that can influence biological
- **Virtual Screening:** AI speeds up drug discovery by efficiently screening vast chemical libraries. It identifies potential drug candidates that can bind to specific targets, helping researchers prioritize compounds for experimental testing and saving valuable time and resources.
- **Structure-Activity Relationship (SAR) Modeling:** The chemical structure of substances and their biological function can be connected using AI models. This enables scientists to create compounds with desirable properties, such as high potency, selectivity, and advantageous pharmacokinetic profiles, to optimize therapeutic prospects. Citation: Sakshi V Dashput.
- **De Novo Drug Design:** AI algorithms can suggest brand-new chemical structures that resemble medicinal molecules using reinforcement learning and generative models. Artificial intelligence (AI) broadens the chemical domain and supports the creation of novel therapeutic candidates by learning from chemical libraries and experimental data
- **Drug Repurposing:** To find existing medications with potential as therapeutics for various ailments, AI algorithms can examine large-scale biomedical data. AI speeds up the drug discovery process and lowers costs by repurposing current medications for new applications
- **Toxicity Prediction:** By examining a compound's chemical structure and properties, AI systems can forecast drug toxicity. Machine learning algorithms can predict negative effects or recognize dangerous structural characteristics after being trained on toxicological databases. This assists researchers in identifying safer compounds and minimizing any negative effects during clinical trials [15].

3.1 AI approaches for drug discovery
The incorporation of Artificial Intelligence (AI) in the pharmaceutical industry hastransformed many elements of drug discovery, development, manufacturing, clinical trials, and marketing. AI's capabilities range from enhancing accuracy and minimizing errors to enabling previously impossible new ideas. AI is being used in drug development by the pharmaceutical sector, with applications like as predicting molecule structures and optimizing drug designs. Furthermore, AI aids drug repurposing by quickly finding current pharmaceuticals for new medicinal applications, saving time and money. AI-powered automation in manufacturing simplifies operations, improves quality control, and optimizes production parameters. Advanced process control and fault detection enable efficient manufacturing, while AI-powered trend analysis aids in the identification and resolution of future problems. Clinical trials, a vital stage of drug research, benefit from AI's role in patient recruiting, data processing, and monitoring.

3.2 Preclinical research
Preclinical studies, sometimes referred to as non-clinical studies, are laboratory tests conducted *in vitro* and *in vivo* on novel medicinal substances to ascertain their safety and efficacy profile. To quickly collect relevant huge amounts of biological data, clustering-based ML methods assess RNA sequencing technologies to discover a molecular mechanism of action. It also exposes several previously unknown relationships between different stimuli and the cytokines they affect.

3.3 Clinical Research
For recognizing patient conditions, finding gene targets, forecasting the outcome of a created drug, and on and off targets, a generation of AI tools for clinical trials would prove excellent. In Phase II clinical studies, one AI mobile application boosted medicine adherence by 25% compared to conventional direct observation therapy 12.

4. AI in drug screening
The use of AI in drug screening includes target identification; molecular simulations; drug property predictions; de novo drug creation, synthesis of route generation, and candidate drug prioritization 12.

4.1 AI used in designing of Clinical Trials
Clinical trials are carried out to evaluate the efficacy and safety of drug items in humans for a particular disease condition. It could take 6-7 years or longer to complete this laborious process, and a sizable sum of money will also be required. Furthermore, the success rates are unacceptably low, which puts a significant burden on the industry. Failures may have a flawed patient selection strategy, poor infrastructure, or a lack of technical requirements as their underlying cause. Integration of AI can reduce this errors17. AI can carry out all stages of clinical trial design, including study preparation and study execution. This may increase trial success rates while easing the strain of pharmaceutical R&D. To obtain ethical and benchmarked results, the inclusion of AI in clinical trials must first be reviewed. The right strategy can reduce trial costs and failure rates while also speeding up the process20. AI can help in the selection of the population with specific illness conditions for Phase II and Phase III studies by using the patient-specific genome exposome profile analysis.

4.2 AI in drug molecule design
Traditionally, designing a drug molecule requires a lot of effort and entails multiple failed attempts. For example, a synthesis plan can have hundreds of distinct steps, many of which would produce unfavorable byproducts or side effects or will just not work. AI, on the other hand, is now starting to enhance the efficiency of design, and synthesis, speeding up, streamlining, and lowering the cost of company operations while also reducing chemical waste15. In recent years, theoretical studies and research on AI (AI) have given way to actual implementations. Thanks to advancements in AI and ML techniques like deep learning (DL), machines may now imitate the intelligence of humans by learning from data. As a result, thanks to AI and Ml approaches, molecular design may see a revolution. Before AI, planning tests and characterizing, evaluating, and analyzing the findings of such investigations were almost completely the responsibility of specialists working in experimental laboratories that developed new substances. This bottleneck has slowed the creation of new materials, which could affect several sectors including electronics, medicinal development, and energy storage16. As a result of advancements in the field of computer science and the use of ML technology, many tools are now available.

AI is being used to develop new pharmaceutical products, including the following:-
- Personalized treatment with digital therapeutics and behavioral modification
- Disease Identification/Diagnosis
- Drug Development and Production
- Prognostic forecasting
- Medical Tests

4.3 AI in pharmaceutical regulatory affairs
Regulatory authorities generally approve products based on the data and documents submitted at all stages, from drug discovery to product development. Automation and AI can facilitate this process by reducing the time required for collecting, segregating, and standardizing data from records, as well as by minimizing human involvement in the documentation process. AI is becoming indispensable in addressing regulatory issues because of its ability to rapidly process data at the lowest possible cost, which has been achieved by enhancing the capabilities of AI algorithms. AI technology can streamline regulatory procedures, such as administrative tasks, dossier completion, data retrieval, auditing, regulation enforcement, and quality control. AI enhances the efficiency of management systems by linking processes and simplifying tasks. Furthermore, AI technology can help improve regulatory relations in the pharmaceutical sector since firms must comply with changing rules and stay updated on industry standards and laws. A regulatory team typically collaborates with pharmaceutical employees to ensure compliance and timely approval of drugs and drug products. AI can be used to consolidate information on major updates from various r Manufacturing, enabling the virtual testing of the effects of process alterations on product quality, thereby AI algorithms perform excellent pattern recognition and anomaly detection that can identify crucial factors impacting product quality, thereby enabling focused research efforts. In silico modeling and simulation allows AI-driven simulations to replicate intricate bio logical and chemical processes in pharmaceutical minimizing risks and expenses. Multivariate analysis elucidates the intricate relationships between process parameters and CQAs, facilitating predictions of the cascading impacts of parameter changes on product quality. Control systems powered by AI and process analytical technology continuously monitor and adjust process parameters in real time, ensuring the consistent production of high-quality products within specified parameters. Reinforcement learning empowers AI agents to iteratively optimize process parameters towards predefined quality objectives, which is particularly beneficial for complex processes with numerous interacting variables. Furthermore, AI-driven data analytics and reporting automate data analysis tasks, ensuring data integrity, completeness, and traceability throughout the developmental process, which improves regulatory compliance and simplifies reporting obligations. Regulatory authorities.

4.4 The role of AI in quality control of pharmaceutical products

AI technologies are also transforming product or quality control, an essential aspect of pharmaceutical manufacturing in the pharmaceutical industry. Ensuring the safety and effectiveness of products requires careful attention to detail. Conventional quality control methods, although efficient, can be laborious and susceptible to human errors.

Pharmaceutical quality assurance and control systems are expected to benefit from the use of AI technologies. Bands are frequently used in the pharmaceutical industry to ensure that product quality requirements can be satisfied, although they aren't always as precise as they may be. The applications of AI in the pharmaceutical industry can predict even little variations that could have an impact on the functionality and safety of the products. Pharmaceutical quality control and assurance using AI can improve product quality and process accuracy 19. However, the goods must go through manual quality control checks to maintain batch-to-batch homogeneity. Integration of AI could not be a workable strategy at this time. The Electronic Lab Notebook, a platform for automated data entry, along with cutting-edge AI algorithms, can assure product quality. It is feasible to adopt new technologies for intelligent quality control by using overall quality management expert systems, data mining, and other knowledge discovery techniques [17].

5. Advantages of AI

Error Reduction AI, or Artificial Intelligence, plays a vital role in improving the efficiency of various process by minimizing errors and increasing accuracy. Intelligent robots are designed with strong metal bodies, making them capable of enduring harsh conditions in space. As a result, they are chosen for space exploration missions [29].

5.1 Difficult Exploration

AI demonstrates its valuable applications in the mining industry and proves equally beneficial in fuel exploration. Additionally, AI systems play a crucial role in oceanic exploration by effectively mitigating errors caused by human intervention.

5.2 Daily Application

AI is quite useful in our daily actions and activities. GPS, for example, is widely utilized in long-distance driving. AI installation on Androids aids in predicting what a person would type. It also aids in the repair of spelling errors. For Ex-Lady SIRI.

AI systems find extensive applications in financial and banking institutions, where they efficiently handle and organize data to detect fraudulent activities.

5.3 Digital Assistant

Modern organizations employ AI systems, like digital assistant 'avatars,' to minimize human dependency. These avatars make logical decisions without being influenced by emotions. Unlike humans, emotions don't impact their judgment, resulting in more efficient decision making and problem-solving. Machine intelligence helps overcome the limitations of human emotions and enhances overall effectiveness.

5.4 No Breaks

In contrast to human beings, who typically work for eight hours a day with breaks, machines are programmed to work continuously for extended hours without becoming confused or bored.

5.5 Increased Technological Growth Rate

AI technology is widely used in the most advanced technical advances across the world. It is capable of developing various computational modeling programs and tries to invent newer compounds. AI is also being employed in the creation of medicine delivery formulations.

5.6 Medical Application

Physicians are now using artificial intelligence to screen patients and analyze health concerns. The AI program educates physicians on numerous medications and their side effects.

5.7 Acts as aids

AI technology has played a different function by serving children as well as elders on a 24x7 basis. It can perform as teaching and learning sources for all.

5.2 Disadvantages of AI

5.2.1 High Cost

Introducing AI requires significant investment due to the intricate machinery design, repair, and maintenance involved. Frequent software program updates are necessary for the machine. The process of reinstalling and recovering the system demands considerable effort and financial investment. Additionally, the R&D department invests a significant amount of time in designing a single AI machine, leading to increased expenses.

5.2.2 Unemployment

The widespread adoption of machines replacing humans in various fields may lead to a significant increase in unemployment. Human beings, often highly dependent on technology, might become complacent and lose their creative abilities.

5.2.3 No Replicating Humans

AI-powered robots can simulate human thinking, but they lack moral principles and emotions. As a result, they carry out their assigned duties precisely as planned, without using judgment. It can sometimes lead to major problems. If the circumstance is unfamiliar to them, robots are unable to make a decision. At that time, they either produce a false report or collapse.

5.2.4 No Improvement with Experience

AI-powered machines lack the ability to improve through experience, unlike human beings. They do not exhibit concern, belonging, or caring and cannot differentiate between individuals based on their work ethic [30, 31].

6. Applications of Artificial Intelligence

6.1 Application of artificial intelligence in the pharmaceutical industries:

- Research development.
- Drug development.
- Diagnosis
- Epidemic prediction
- Remote monitoring
- Manufacturing.
- Marketing.

- Rare diseases and personalized medicine.
- Processing biomedical and clinical data.
- Identifying clinical trial candidates.

6.1.1 R&D
Pharma companies around the world are leveraging advanced ML Algorithms and AI-powered tools to streamline the drug discovery process. These intelligent tools are designed to identify intricate patterns in large datasets, and hence, they can be used to solve challenges associated with complicated biological networks [17].

6.1.2 Drug development
AI holds the potential to improve the R&D process. From designing and identifying new molecules to target-based drug validation and discoveries AI can do it all [18].

6.1.3 Diagnosis
Doctors can use advanced machine learning system to collect, process, and analyze vast volumes of patients' healthcare data. Healthcare providers around the world are using ML technology to store sensitive patient data securely in the cloud or a centralized storage system. This is known as electronic medical records (EMRs) [19].

6.1.4 Disease prevention
Pharma companies can use AI to develop cures for both known diseases like Alzheimer's and Parkinson's and rare diseases. Generally, pharmaceutical companies do not spend their time and resources on finding treatments for rare diseases since the ROI is very low compared to the time and cost it takes to develop drugs for treating rare diseases [20].

6.1.5 Epidemic prediction
AI and ML are already used by many pharma companies and healthcare providers to monitor and forecast epidemic outbreaks across the globe. These technologies feed on the data gathered from disparate sources in the web, study the connection of various geological, environmental and biological factors on the health of the population of different geographical locations, and try to connect the dots between these factors and previous epidemic outbreaks. Such AI/ML models become especially useful for underdeveloped economies that lack the medical infrastructure and financial framework to deal with an epidemic outbreak.

6.1.6 Remote monitoring
It is a breakthrough in the pharma and healthcare sectors. Many pharma companies have already developed variables powered by AI algorithms that remotely monitor patients suffering from life-threatening diseases.

6.1.7 Manufacturing
Pharma companies can implement AI in manufacturing process for higher productivity, improved efficiency, and faster production of life saving drugs. AI can be used to manage and improve all aspects of the manufacturing process, including:

- Quality control.
- Predictive maintenance.
- Waste reduction.
- Design optimization.
- Process automation.

6.1.8 Marketing
Given the fact that the pharmaceutical industry is a sales-driven sector, AI can be a handy tool in pharma marketing. With AI, pharma companies explore and develop unique marketing strategies that promise high revenues and brand awareness.

Despite all of the uses for AI in the pharmaceutical industry, there are some restrictions attached to it. To achieve the present standards of standard outcomes, AI must be developed. The demand for thorough training data for AI, which necessitates human labor and hence can have chances of inaccuracy, is one of the factors that indicate its limitations. As a result, AI integration is unavoidable. Another drawback of AI is that it can forecast models or structures via de novo medication creation, which is impossible to produce. A multidisciplinary strategy is needed to prepare healthcare workers for the use of AI because AI and ML are IT-based technologies, which may prove hard for the medical industry [21].

6.2 Application of AI in Drug Design
The three-dimensional (3D) conformation of a target protein plays a pivotal role in structure based drug discovery. This is crucial because the design of novel drug molecules often revolves around understanding the 3D chemical landscape of the ligand-binding site within the target protein. To achieve this goal, researchers have traditionally employed methods such as homology modeling and de novo protein design. These techniques have been widely utilized in the field to gain insights into the target protein's structure and guide the rational development of potential therapeutic agents [19].

6.3 Pharma companies collaboration with AI Technology
AI and pharmaceutical companies have created partnerships to develop therapeutic products. Many of the industry's collaborations with AI are related to drug discovery and clinical studies.

AI plays a crucial role in tackling many of the industry's most pressing issues.

We will look at the top ten highest-grossing pharmaceutical businesses that use AI or machine learning for drug discovery, clinical research, disease diagnostics, innovative treatment, predictions, data analysis, and so on.

6.4 AI applied in top pharma companies in the world
- **Pfizer:** Immune oncology
- **Roche:** Diabetic macular edema.
- **Novartis:** Decode cancer pathology images.
- **Johnson:** Stroke related death, skin scanner Merck & co
- **MSD:** Emphasis on diabetic at cancer prevention.
- **Sanofi:** Drug repurposing identifies new uses of some of its clinical strength molecule for genetic disease
- **GlaxoSmithKline:** Drug discovery has artificial intelligence unit, in silico drug discovery unit.
- **Amgen:** Precision medicine in GNS health care medical research.
- **Gileadsciences:** Drug discovery in April 2

6.5 Difficulties in adopting AI in pharmaceutical industry
- **Unfamiliarity with the technology:** Due to its youth and complexity, AI is viewed as a "black box" by many

pharmaceutical companies, who are hesitant to adopt and deploy it.

- **Inadequate IT infrastructure:** It is difficult for pharma companies to easily integrate AI because current IT systems and infrastructure were not initially created with AI in mind. As a result, upgrading the IT infrastructure will demand significant financial investments.
- **Unstructured data:** A sizable percentage of the pharmaceutical industry's data is available in free text format, necessitating additional work to organize and convert the data into a format appropriate for AI analysis [13].

6.6 Pharmaceutical Market of AI

Marketing is the activity of increasing sales of a business's goods and services. Pharmaceutical companies will employ artificial intelligence (AI) for marketing by 2023.

Additional benefits of using AI systems in the pharmaceutical industry include improved value propositions, effective resource allocation for higher market share gains, the capacity to maximize growth, and specialized sales and marketing information and channels [32]. AI along with various computer software can be used in drug discovery [33].

Each year, the pharmaceutical industry spends enormous sums of money on the research and development of new pharmaceuticals and chemicals. With a high probability of failure during clinical trials, they are faced with the problem of screening around 10,000 compounds in search of a single successful molecule. Developing only one medicinal molecule costs businesses $2.6 billion on average.

Pharmaceutical firms are using big data and artificial intelligence (AI) to design clinical trials to address these issues and minimize failure rates while also lowering R&D expenditures. With a 40% compound annual growth rate between 2017 and 2024, the market for artificial intelligence is expected to rise fast and reach $5 billion by that time [14].

E-commerce and other marketing strategies are already utilizing AI in their successful marketing campaigns. Pharmaceutical companies can utilize comparable tools and techniques to expand and effectively serve their market. The tactics of AI in pharmaceutical marketing can greatly increase overall earnings.

6.7 The future of AI in the pharmaceutical industry

The future of AI in the pharmaceutical industry is brimming with potential; it is poised to revolutionize drug discovery, pharmaceutical product development, industry management, regulatory affairs, and PMS. AI algorithms can analyze vast amounts of biological data to identify potential drug targets and accelerate drug discovery. AI-driven simulations can be implemented in drug development to predict the interactions between compounds and biological systems, facilitating more efficient and cost-effective clinical trials. In addition, AI-driven tools can optimize supply chain management, maximize regulatory compliance, and streamline formulation development and manufacturing processes. Large data and information databases are indispensable for the training and development of AI algorithms. Over a thousand research articles and reviews have been published in the last 5 years on the use of AI in pharmaceutical applications. This indicates the value of enhancing and accelerating current research processes and protocols. Nevertheless, the best AI-driven applications and technologies for practical implementation or commercialization will ultimately be identified. As technology continues to advance, the integration of AI into various aspects of the pharmaceutical industry will undeniably drive innovation, improve patient outcomes, and reshape the future of healthcare.

7. Conclusion

In conclusion, the integration of Artificial Intelligence (AI) into the pharmaceutical sector has introduced a new era of possibilities. From drug discovery and design to clinical trials and marketing, AI's impact is multifaceted and transformative. It has the potential to accelerate drug development, enhance patient care, and optimize manufacturing processes. However, challenges such as the high cost of implementation and the need for refined data management systems must be addressed for AI to truly realize it's potential. As AI continues to evolve and alter the pharmaceutical environment, it holds the key to unlocking novel solutions, enhancing efficiency, and ultimately transforming the way we approach healthcare and medical advancements.

During past few years, a considerable amount of increasing interest towards the uses of AI technology has been identified for analyzing as well as interpreting some important fields of pharmacy like drug discovery, dosage form designing, polypharmacology, hospital pharmacy, etc., as the AI technological approaches believe like human beings imagining knowledge, cracking problems and decision making. The uses of automated workflows and databases for the effective analyses employing AI approaches have been proved useful. As a result of the uses of AI approaches, the designing of the new hypotheses, strategies, prediction and analyses of various associated factors can easily be done with the facility of less time

AI is at the center of a new enterprise to build computational models of intelligence. The main assumption is that intelligence (human or otherwise) can be represented in the terms of symbol structures and symbolic operations which can be programed in a digital computer. There is much debates as to whether such an appropriately programmed computer would be a mind, or would merely simulate one, but AI researchers need not wait for the conclusion to that debate, nor for the hypothetical computer that could model all of human intelligence. Aspects of human intelligent behavior, such as solving problems, making references, learning, and understanding language, have already been coded as computer programs, within very limited domains, such as identifying diseases of soybean plants, AI programs can outperform human experts. Now the great challenge of AI is to find ways of representing the commonsense knowledge and experience that enables people to carry out every day activities such as holding a wide-ranging conversation, or finding their way along a busy street. E-Consumption and inexpensiveness.

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