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A REVIEW ON ARTIFICIAL INTELLIGENCE (AI) IN PHARMACY

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Abstract
Intelligent technologies will someday replace human talent in many areas or enhance it. Artificial intelligence refers to the intelligence exhibited by software or robotics. It falls within the computer science category. Because artificial intelligence has significantly enhanced human lives in many ways, computer scientists are becoming more and more interested in studying it. Artificial intelligence has greatly improved the performance of industrial and service systems within the past 20 years. With countless applications in business, medicine, and engineering, it has greatly advanced into a science of problem-solving. Over time, artificial intelligence has become more and more prevalent in pharmaceutical technology. This is because technology can be used to save costs and time, as well as to better comprehend the correlations between various formulations and process parameters. Drug discovery, AI tools, manufacturing execution systems, automated control processes, AI to predict new treatment, creation of novel peptides from natural foods, management and treatment of rare diseases, drug adherence and dosage, and obstacles to AI adoption in pharma are all covered in the article. One of the main benefits of artificial intelligence is the shortening of drug development time, which lowers costs and saves time. The challenges facing the pharmaceutical business in deploying AI are also examined in the review.
Keywords: Artificial Intelligence, Drug development, Machine Learning, Pharmaceutical Industry.

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Introduction

Artificial intelligence (AI) is a branch of computer science that deals with the problem –solving with the aid of symbolic programming .it has greatly evolved into a science of problem-solving with huge applications in business, health care, and engineering. [1] The main objective of this artificial intelligence is to identify useful information-processing problems and give an abstract account of how to solve them. Such an account is called a method and it corresponds to a theorem in mathematics. Artificial intelligence is a field that deals with the design and application of algorithms for the analysis of learning from and interpreting data. Artificial intelligence encompasses many branches of statistical and machine learning, pattern recognition, and clustering, similarity-based methods. [2] AI is a flourishing technology that finds application in multiple aspects of life and industry. In recent times the pharmaceutical industry has discovered novel and innovative ways to use this powerful technology to help solve some of the biggest problems facing pharma today. Artificial intelligence in pharma refers to the use of automated algorithms to perform tasks that traditionally rely on human intelligence. Over the last five years, the use of artificial intelligence in the pharma and biotech industry has redefined how scientists develop new drugs, tackle disease, and more.

History of Artificial Intelligence:

History The Logic Theorist was invented by Allen Newell and Herbert A. Simon. The renowned conference was first conducted by Dartmouth College in 1956 [3], The market for artificial intelligence is expected to generate up to 10 times more revenue between 2017 and 2022. The market for natural language processing, which has several applications such as text prediction, speech, and voice recognition, is expected to expand by 28.5% in 2017. Big data and business analytics generated US$ 122 billion in revenue globally in 2015, and it is anticipated that this amount will surpass US$ 200 billion by 2020. Since the 1950s, artificial intelligence has had a turbulent history. When IBM's Deep Blue computer beat chess champion Garry Kasparov in

1997, the perception that it was a field for dreamers began to shift. In 2011, IBM's brand-new Watson supercomputer was successful in taking home the $1 million prize on Jeopardy in the US. Since then, Watson has diversified into the healthcare and pharmaceutical industries, forming a relationship with Pfizer in 2016 to quicken the development of new immuno-oncology drugs. In December 2016, IBM and Pfizer unveiled IBM Watson, a cloud-based platform that provides researchers with the capacity to discover connections across various data sets using dynamic visualizations. [4]

ARTIFICIAL INTELLIGENCE DRUG DISCOVERY:

Testing chemicals against samples of sick cells is a time-consuming process in the drug development process. Further investigation is necessary to identify chemicals that are physiologically active and merit further study. The research teams at Novartis utilize pictures generated by machine learning algorithms to forecast which untested chemicals could be worth further investigation. As new data sets are discovered by computers far more quickly than by traditional human analysis and laboratory experimentation, novel and effective medications can be made accessible sooner while also incurring lower operational expenses than when each substance is manually investigated. [5] The leading pharmaceuticals firms' current AI initiatives include:

- Mobile platform to improve health outcomes –the ability to recommend patients using real-time data collection and thus improve patient outcomes.
- Drug discovery- pharma companies in conjunction with software companies are trying to implement the most cutting–edge technologies in the costly and extensive process of drug discovery.

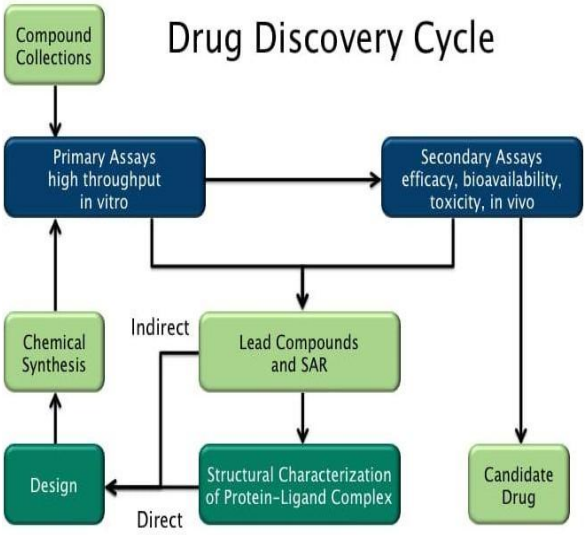

Fig.1.Drug Discovery Cycle

Objectives of AI:

1. Creation of Expert: Systems it entails the development of automated systems that behave intelligently and provide people with recommendations on the best course of action.
2. Implementation of Human Intelligence in Computers: Similar cognitive patterns will be developed in computers as a result, enabling them to behave like people and make the right decisions when faced with challenging challenges. Through the use of algorithms, this will enable automated operations and lower the workload for humans.
3. Multi-Domain Application: Computer science, cognitive science, statistics, psychology, engineering, ethics, the natural sciences, healthcare, space technology, logic, linguistics, and other fields will all benefit from AI. [6]
4. Applications in Computer Science: Numerous mechanisms, including Search and Optimization, Logic, Control Theory, Language Analysis, Neural Networks, Classifiers, Statistical Learning Methods, and Probabilistic Methods for Uncertain Reasoning, are developed with the aid of AI to address a wide range of challenging issues in the field of computer science.

ADVANTAGE:

1. The pharmaceutical business now has access to artificial intelligence to handle issues that were previously beyond the scope of straightforward data analysis.
2. AI can do particular activities with greater accuracy, which lowers costs while boosting productivity.
3. AI provides useful insights that will significantly enhance the results of clinical studies.
4. In-depth understanding of market dynamics, consumer behavior, and how they interact.
5. It helps the industry choose patients for clinical trials and enables businesses to identify any problems with compounds much earlier when it comes to efficacy and safety.
6. It enhances the performance of antivirus detection systems and encourages the development of new artificial intelligence algorithms.
7. It also helps in terms of the industry's selection of patients for clinical trials.
8. In comparison to humans, AI would make fewer mistakes if it were designed correctly. They would be incredibly quick, accurate, and precise. [7]

Disadvantages:

1. Since AI can't think for itself and can only follow instructions, it mostly lacks human touch.
2. It is effective in corrupting the next generation.
3. Can be adjusted to mass destruction first.
4. If robots begin to replace humans in all occupations, unemployment will result.
5. Can be expensive to construct, maintain, and reconstruct [8]

6. When used improperly, machines may quickly cause devastation. At the very least, many people dread that.
7. Humans are dependent on AI and lose their mental faculties, as has already been partially observed with cell phones and other technology.
8. AI as robots has the potential to surpass humans and enslave humanity.

ARTIFICIAL INTELLIGENCE CLASSIFICATION:

AI may be divided into two categories.

A) Based on the caliber

B) B) based on the existence (See Table 1)

Table 1: Classification of AI

According to the Calibre	Poor intellect Limited artificial intelligence General artificial intelligence Superhuman artificial intelligence
According to Presence	superhuman Artificial intelligence Limited memory Type 2 system Type 3's foundation is the theory of mind. Self-awareness of type 4

- The following categories apply to AI systems according to their caliber:

1. Artificial narrow intelligence (ANI) or weak intelligence:

This system is created and trained to carry out a certain activity, such as traffic signaling, driving a car, playing chess, or facial recognition. Examples include social media tagging and Apple SIRI's virtual personal assistant.

2. Strong AI, often known as artificial general intelligence (AGI),:

It also goes by the name Human-Level AI. It can make intellectual capacity in humans simpler. As a result, it can solve problems when presented with new tasks. AGI is capable of doing all that humans can.

3. ASI (Artificial Super Intelligence):

It is brainpower, which is more active than intelligent people in areas such as sketching, mathematics, space exploration, etc.; in disciplines ranging from science to art. The spectrum is from a computer being only slightly more intelligent than a person to a trillion times smarter. Andern Hintze. [13]

AI scientists categorized the AI technology depending on whether it was already in use or not. These are what they are:

- Type 1: A reactive machine is the name given to this sort of AI system. Consider the IBM chess program Deep Blue, which defeated Garry Kasparov in the 1990s. On a chessboard, it can recognize the checkers and make predictions, but it lacks the memory to draw on previous experiences. It was made specifically for those uses and is useless in other circumstances. Google's Alpha Go is another illustration.
- Type 2: A limited memory system is the name given to this kind of AI system. This technology can analyze prior data to solve current and upcoming issues. Some of the decision-making processes in autonomous cars are only created using this way. The observed behaviors, such as lane changes for vehicles, are recorded using the observations. The observations are not permanently stored in the memory.
- Type 3: The term "theory of mind" is used to describe this kind of AI system. It implies that everyone has thoughts, ideas, and wants that influence their decision-making. This AI doesn't exist.
- Type 4: These are referred to as self-awareness. The AI systems are sentient and have a feeling of self. If the machine has self-awareness, it recognizes its situation and makes use of the concepts stored in other people's minds. This AI does not exist. [9]

Artificial Intelligence And Robotics:

Robotics and artificial intelligence have a shared origin and a long history of interaction and scholarly debate. One may counter that not all machines are robots and that artificial intelligence is interested in virtual agents. Robots are produced as hardware and artificial intelligence is a hypothesis. The two are related because a software agent that receives data from these sensors, decides what to do next, and then directs the actions to be taken in the real world is what controls the robot. It is widely used in robotics. Patients will also look at potential drug options as they become more involved in their healthcare decisions. Pharmaceutical firms may further ensure that the appropriate information is delivered at the appropriate time to allow informed dialogues between providers and patients by using target audience marketing. The era of linked pharma has arrived. However, advancement is not always smooth and is most likely to be "lumpy." AI technology is well on its way to becoming widely used and has a vast range of applications that can enhance technology at many different levels and produce far better, quicker patient results. [10]

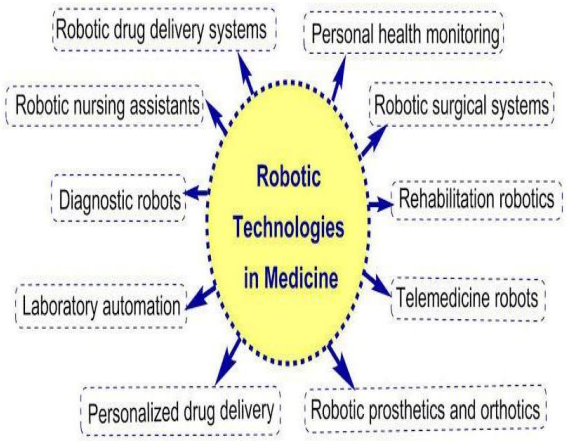

Fig.2: Robotic Technologies in Medicines

TOOLS OF AI:

1. **Robot pharmacy:**

The UCSF Medical Center employs robotic technology for the manufacture and monitoring of pharmaceuticals to enhance patient safety. They claim that the system has accurately prepared 3,50,000 doses of medicine. The robot is significantly superior to humans in terms of size and its capacity to administer precise drugs. The manufacture of hazardous chemotherapy medications for oral and injectable use is one of the capabilities of robotic technology. The UCSF pharmacists and nurses now have more freedom to focus on providing direct patient care and collaborating with the doctors, allowing them to make the most of their knowledge.

Fig.3

2. **MEDi Robot:**

Medicine and engineering designing intelligence is abbreviated as MEDi. AI-based tools the community health sciences professor at the University of Calgary in Alberta, Tanya Beran, served as the project leader for the creation of the pain management robot. After working in hospitals where children cry during medical procedures, she had the notion. Though the robot cannot think, plan, or reason, it may be made to appear to have AI by first establishing a connection with the kids and then explaining what to expect during medical treatment.

3. **Erica robot:**

A researcher at Osaka University named Hiroshi Ishiguro created the new care robot Erica in Japan. It was created in cooperation with Kyoto University, the Advanced Telecommunications Research Institute International, and the Japan Science and Technology Agency (ATR). It speaks Japanese and has facial features that combine those of Europe and Asia. [11]

4. **TUG robots:**

Robots called Aethon TUG are made to autonomously move around the hospital and transport large items like trash and linen as well as prescriptions, meals, specimens, and resources. It features two variants, including fixed and secured carts and an interchange base platform for carrying racks, bins, and carts.

5. **Berg:**

One of the leading companies using AI in its numerous operations is Berg, a biotech company with headquarters in Boston. It has an AI-based drug discovery platform with a sizable patient database that is used to locate and validate the many disease-causing biomarkers, and it then chooses treatments based on the data acquired.

6. **Optimization of formulation using ANN:**

Design of a new network helps in, choosing the Self-organizing feature maps (SOFMs) network model. To forecast the output responses use of the functions like TanhAxon, SigmoidAxon, LinearTanAxon, Linear SigmoidAxon, and Axon can used. Differing activations task can be presented by performance parameters like mean squared error (MSE), minimum absolute error, correlation coefficient, and predicted output of the selected network models. [12]

Partnerships between artificial Intelligence and Pharmaceutical Companies and areas of Collaboration in Drug Development.

Table 1: Companies and areas of Collaboration in Drug Development.

SR.NO	PHARMA	AREA OF COLLABORATION	ARTIFICIAL INTELLIGENCE
1	Astellas Pharma	Drug repurposing	Biovista
2	Bayer pharma	To track real data via smartphones and other wearable technologies	Xbird
3	Roche	To target personalized medicine using medicine learning and large-scale genome	Bina

		sequencing	
4	Sumitomo danippon pharma	To identify new treatments for psychiatric diseases	Exscientia
5	GlaxoSmithKline	To discover novel and selective small molecule	Exscientia
6	GlaxoSmithKline	To identify novel biological targets and pathway	Insilico medicine
7	Abbvie	To announce the mechanism of AI-based patient monitoring platform can improve adherence.	Aicure

FUTURE SCOPE OF ARTIFICIAL INTELLIGENCE:

- AI used in science and research.
- AI in cyber security.
- AI in data analysis.
- AI in health care etc.
- AI in transport, AI in home.

- AI in academia and industry Science has made significant progress with AI. Large amounts of data can be handled by artificial intelligence, which can process information more

quickly than human brains. This makes it ideal for studies where the sources have large amounts of data. In this area, AI has already made strides.

AI TO PREDICT NEW TREATMENTS:

Verge is using automated data gathering and analysis to tackle the main problems in drug discovery. In other words, they are taking an algorithmic approach to map out hundreds of genes that play complex roles in brain diseases like Alzheimer‟ 's, Parkinson‟ 's, or ALS. Verge‟ 's hypothesis is that gathering & analyzing gene data will positively impact the drug discovery phase starting with the preclinical trials. The idea is that Verge can use AI to monitor the impact that specific drug treatments have on the human brain starting with the preclinical phase. As a result, drug manufacturers can get a better picture early on about the effectiveness of a drug on human cells. More specifically, Verge uses artificial intelligence to keep track of the impact of certain therapies on the human brain with a particular focus on the preclinical phase. [8]

Development of Novel Peptides from Natural food

The Irish start-up Nerites leverages AI and other novel technologies to facilitate the discovery of new and more robust food and healthy ingredients. BASF (Baden Aniline and Soda Factory”) will take advantage of this partnership to develop novel functional peptides derived from natural foods. In practice, BASF uses Nuritas AI and DNA analysis capabilities to predict, analyze, and validate peptides from natural sources. The main goal of BASF is to discover and deliver to market peptide-based therapies that‟will help treat conditions like diabetes.

Treatment And Management Of Rare Diseases:

Advances in AI renewed interest in rare disease treatments. Currently, there are over 350 million people with over 7,000 rare diseases around the world. However, it‟'s not all gloom and doom for patients with rare diseases as Heal, a UK-based biotech firm, has secured $10 million in Series A funding to use AI to develop innovative drugs for rare conditions. There Chon, another Swiss biotech company that leverages AI to develop drugs for the treatment of rare genetic diseases, has received $60 million in funding.

Drug-Adherence & Dosage:

Abbvie partnered with New York-based Acura to enhance drug trial vigilance and improve drug adherence. In this collaboration, Abbvie used the facial and image recognition algorithm of the AiCure mobile SaaS platform to monitor adherence. To be more specific, the patients take a video of themselves swallowing a pill using their smartphones, and the AI-powered platform confirms that indeed the correct person swallowed the right pill. And the results were amazing, improving adherence by up to 90%. Genpact‟'s AI solution has been used severally in clinical trials to change the dosage given to specific patients to optimize the

results. In this partnership, Bayer takes advantage of Genpact‟'s Pharmacovigilance Artificial Intelligence (PVAI) to not only monitor drug adherence but also detect potential side effects much earlier.

Using Ai to Make Sense of Clinical Data & To Produce Better Analytics:

Apple's Research kit makes it easy for people to enroll in clinical trials and studies without having to go through physical enrollment. It‟is a clinical research ecosystem designed around its two flagship products, the iPhone and the Apple Watch. Duke University, for instance, uses patient data collected by these Apple devices and AI-driven facial recognition algorithms to identify children with autism. Research kits have made it easy to make better sense of collected health data.

Finding More Reliable Patients Faster For Clinical Trials:

Although there's a lot of patient data out there, recruiting the right patients for clinical trials is a difficult process for big pharma. For instance, finding and enrolling ideal candidates can make clinical trials last an average of 7.5 years, costing between $161 million and $2 billion per drug. Unfortunately, 80 percent of clinical trials fail to meet deadlines. With over 18,000 clinical studies currently recruiting candidates in the US, the $65 billion clinical trial market needs an overhaul. Extracting useful data from patients‟ records is perhaps the biggest challenge for pharmaceutical companies. Thankfully, that"'s where AI and machine learning come into the picture.

Challenges To Adoption Of Aiin Pharma:

While AI has extensive potential to help redefine the pharmaceutical industry, the adoption itself is not an easy walk in the park.

Challenges that pharma companies face while trying to adopt AI:

- The unfamiliarity of the technology – for many pharma companies, AI still seems like a “black box” owing to its newness and esoteric nature.
- Lack of proper IT infrastructure – that “is because most IT applications and infrastructure currently in use were developed or designed with artificial intelligence in mind. Even worse, pharma firms have to spend lots of money to upgrade their IT system.
- Much of the data is in a free text format – that means pharma companies have to go above and beyond to collate and put this data into a form that “can be analyzed. Despite all these limitations, one thing is for certain: AI is already redefining biotech and pharma. And ten years from now, Pharma will simply look at artificial intelligence as a basic, everyday, technology.

Artificial Intelligence in Pharma is a good idea:

The pharmaceutical industry can accelerate innovation by using technological advancements. The recent technological advancement that comes to mind would be artificial intelligence, the development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages. An estimate by IBM shows that the entire Healthcare domain has approx. 161 billion GB of data as of 2011. With humongous data available in this domain, artificial intelligence can be of real help in analyzing the data and presenting results that would help out in decision making, saving Human effort, time, and money and thus help save Lives. Epidermic outbreak prediction; using machine learning /artificial intelligence one can study the history of epidemic outbreaks, analyze social media activity, and predict where and when the epidermis can be affected with considerable accuracy.

Apart from the fore mentioned use-cases, there are numerous others: Personalizing the treatment helps build new tools for the patient, physicians, etc.

Clinical trials research: Applying predictive analytics to identify candidates for the trial through social media and doctor visits.

Limitations:

1. Electronic documents that need to be streamlined must first be cleaned up since they are disorganized and dispersed over several databases.
2. Transparency: Given the difficulty of artificial intelligence-based procedures, consumers require transparency in the health care they get.
3. Medical data is confidential and legally accessible, according to data governance. It's crucial to obtain public approval. Pharma businesses are renowned for being conservative and change-resistant. To provide the greatest treatment possible, we must eradicate the stigma. [14]

Benefits and Issues:

- Effective use of incomplete data sets,
- Rapid analysis of data,
- Ability to accommodate constraints and preferences and ability to generate understandable rules.
- Enhancement of product quality and performance at low cost,
- Shorter time to market,
- Development of new products,
- Improved customer response,
- Improved confidence.
- AI would have a low error rate compared to humans if coded properly. They would have incredible precision, accuracy, and speed.
- They won't be affected by hostile environments, thus able to complete dangerous tasks, explore in space, and endure problems that would injure or kill us.
- This can even mean mining and digging fuels that would otherwise be hostile to humans.
- Replace humans in repetitive, tedious tasks and many laborious places of work.
- Predict what a user will type, ask, search, and do. They can easily act as assistants and can Recommend or direct various actions.
- An example of this can be found in the smartphone.
- Can detect fraud in card-based systems, and possibly other systems in the future.
- Organized and managed records.
- Interact with humans for entertainment or a task as avatars or robots.
- An example of this is AI for playing many video games.
- Robotic pets can interact with humans. It can help with/ depression and inactivity.
- Can fulfill sexual pleasure.
- They can think logically without emotions, make

rational decisions with fewer or no mistakes can assess people.

- This can be for medical purposes, such as health risks and emotional state. Can simulate medical procedures and give info on side effects.
- Robotic radiosurgery, and other types of surgery in the future, can achieve precision that humans can't.
- They don't need to sleep, rest, take breaks, or get entertained, as they don't get bored or tired.
- Can cost a lot of money and time to build, rebuild, and repair. Robotic repair can occur to reduce time and humans needing to fix it, but that'll cost more money and resources.
- Storage is expansive, but access and retrieval may not lead to connections in memory as well as humans could.

Applications of Ai in Healthcare:

The healthcare business uses medical artificial intelligence applications in the ways listed below.

1. AI for Drug Discovery:

Pharmaceutical businesses have been able to accelerate their drug discovery process with the use of AI technologies in healthcare. On the other hand, it automates the process of identifying targets. In addition, AI in Healthcare 2021 supports medication repurposing by analyzing off-target chemicals. As a consequence, AI drug development accelerates the procedure and minimizes repetitive work in the AI and healthcare industries. There are several treatments that top biopharmaceutical firms have developed. Pfizer is using IBM Watson, a system based on machine learning, to assist it in finding immuno-oncology therapies. [32] It has been utilized specifically for signal and image processing, as well as for making predictions about changes in function, including bladder control, epileptic seizures,
and strokes. [33] Public health and epidemiology are a third advantage of AI for healthcare. AI can help identify infectious epidemics of diseases including influenza, dengue fever, TB, and malaria. Zika virus and the current COVID-19 pandemic transmission patterns have both been predicted using artificial intelligence (AI).

2. AI in clinical practice:

Data collection, storage, normalization, and tracing are significant uses of AI in the healthcare industry. Deep genomics searches for mutations and connections to the disease by identifying patterns in massive databases of genetic data and medical records. A new generation of computational methods is being developed to show doctors what will happen within a cell when genetic variation, whether natural or therapeutic, modifies the DNA. Clinical trials for the development of drugs can often last more than ten years and cost billions of dollars.

3. AI in diagnosis and targeted genomic treatments

4. AI is used in hospital-based healthcare systems in a variety of ways, including arranging dose forms for particular patients and choosing appropriate or available administration methods or treatment plans.

5. Accuracy of medicine:

The influence of AI on genetic evolution and genomics is positive. Advanced Genomics. An AI system is effective for identifying patterns in genomic data and medical records that point to disease-causing mutations and connections. This technique provides clinicians with information on what happens within a cell when genetic variation modifies DNA.

Conclusion:

Due to the complex current problems and promising future, AI would aid the world by identifying a pharmaceutical core for medication research & development in healthcare such as ANN, CFD, & Robotics. Artificial intelligence insights may be utilized to more precisely define patients and expected outcomes. These conclusions were drawn using facts from the actual world. Because of this, artificial intelligence has opened up enticing opportunities for pharmaceutical firms that are developing a new generation of computational tools that can tell doctors what will happen within a cell when DNA is altered by genetic variation. We should be able to go forward while being aware of and understanding the repercussions of every technological advancement. We should welcome this change and accept it by using AI and striving toward a better society since, in my opinion, we are living in the era of AI revelation.

Author contributions

All authors are contributed equally**.**

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Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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