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NATURAL LANGUAGE PROCESSING: HEALTHCARE ACHIEVING BENEFITS VIA NLP

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ABSTRACT

The field of Natural Language Processing (NLP) within computer science presents a complex challenge due to the wide variety of linguistic nuances across different languages. NLP involves dividing language into semantic parts like parts of speech and phrases. Its origins trace back to the early 1940s during World War 2, driven by the need for autonomous language translation machinery. NLP, a part of AI technology, employs tools that concentrate on linguistic-conceptual relationships rather than just textual analysis, structuring and extracting meaningful data from unstructured text. One significant application of NLP is the advancement of the healthcare system. Electronic Health Record (EHR) systems revolutionized medical practice, enabling efficient diagnosis, elimination of errors, and faster treatment initiation. NLP's ability to interpret unstructured data from medical records facilitated quicker and more effective analysis, improving patient care. During the COVID-19 pandemic, EHR systems played a crucial role in coordinating patient care and surveillance. NLP also supports Clinical Decision Support Systems (CDSS), aiding medical decision-making by providing tailored clinical knowledge and patient information. Knowledge-based and non-knowledge-based CDSS utilize artificial intelligence, helping prevent medication errors and improving patient safety. The adoption of Voice Recognition (VR) and speech recognition tools, such as Dragon Medical One, surged among medical professionals globally, enhancing clinical documentation quality and saving time on transcription. NLP's impact extends to clinical trial matching, automating the process of selecting suitable patients based on specific criteria, thereby increasing efficiency, accuracy, and patient safety. The Internet of Medical Things (IoMT) is an emerging technology that connects various healthcare devices and wearable, providing real-time monitoring, improved patient outcomes, and remote patient care. Recent innovations, like the AI-based vision therapy software CureSee and AI's role in detecting Alzheimer's disease, have shown great promise in revolutionizing patient care and early disease detection.

To support these advancements, organizations like SyTrue use AI, machine learning, and NLP to improve payment integrity, risk adjustment, and chart review processes, leading to increased efficiency and higher ROI. Moreover, AI-powered clinical note generation using services like Amazon Transcribe simplifies the conversion of speech to text, enhancing medical documentation and facilitating data-driven decision-making.

In conclusion, the diverse applications of AI and NLP in healthcare have significantly improved the industry, enabling accurate diagnostics, personalized medicine, predictive analytics, drug discovery, remote monitoring, administrative efficiency, and innovative treatment approaches. As AI continues to evolve, its impact on the healthcare system promises to be transformative, leading to better patient outcomes, reduced costs, and improved accessibility to healthcare services.

Keywords - Artificial intelligence, Advanced healthcare systems, Clinical Practice by using AI, medical industry, Clinical decision support.

INTRODUCTION

Natural language processing (NLP) is an extremely difficult task in computer science. Language presents a wide variety of problems that varies from one language to another language. Natural language processing (NLP) is an onerous function in computer science. Scientists divided a language into its semantic parts, such as parts of speech, phrases, etc (1). NLP is a part of AI technology and it was founded in the early 1940s at the time of World War 2 an importance of language translation from one to another has come to light and it was inaugurated as an aspiration to build a form of machinery that could do this sort of task autonomously (2).

There are several tools of NLP which are also emerged through artificial intelligence to concentrate on linguistic-conceptual relationships, rather than primarily textual analysis. Structuring or extracting meaningful data is the principle on which NLP works (3). In earlier times data which used to be provided in form of medical domains was quite challenging to study and make out a useful conclusion from that, but with the use of NLP, it got easier for medical practitioners to analyze the reports related to the medical background like radiologists to see the megapixel size of image of any part of the body part which has to be screened.

ARTIFICIAL INTELLIGENCE-BASED TOOLS INVOLVED IN THE ADVANCEMENT OF THE HEALTHCARE SYSTEM

With NLP, there is a great opportunity to automate many of these tasks. AI-powered speech recognition replaces many documentation tasks with an automatic workflow, listening to the natural patient-doctors conversation and editing out only medically relevant information. Such as Electronic Health Records (EHR).

1. ELECTRONIC HEALTH RECORD SYSTEM

NLP has contributed to providing a few diverse applications and techniques, which have improved smart healthcare systems like **Electronic Health Records systems (EHRs)**. In 1972, the first EMR (Electronic Medical Record System) was developed by the **REGENSTRIEF INSTITUTE in UNITED STATES** and was then welcomed as a major advancement in medical practice which is a comprehensive healthcare system that has revolutionized the world healthcare by improving the ability to diagnose disease and eliminate medical errors and the possibility of collapsing similar false symptoms factors for a particular illness and it also makes the procedure faster hence, treatment begins soon (4). An EHR system is a computerized sort of a patient's medical background history sustained by their medical professionals, as physicians store a large amount of the information of consulting patients as free text. Despite being dilatory of this task, the text notes aren't easily accessible or structured in a way that can be analyzed effectively by computers and NLP allows analytical systems to interpret unstructured data more easily (5). Once it is converted into structured data and hence, health systems can classify patients and summarize their condition on arrival. Rather than wasting precious time, reviewing their EHRs, NLP allows physicians to extract critical insight.

1.2 ADVANTAGES OF ELECTRONIC HEALTH RECORD SYSTEM (EHRs)

- EHR can make it easier for researchers to access and aggregate clinical data.
- This could be used to predict disease progression, complications, mortality, early diagnosis, prevention of several diseases, and so on. (6) (7)

During the time of coronavirus 2019 pandemic (COVID-19), the EHR system was used to circulate the data to coordinate patient care by Tortolero et al and Satterfield et al used it for surveillance and contact tracing (8)

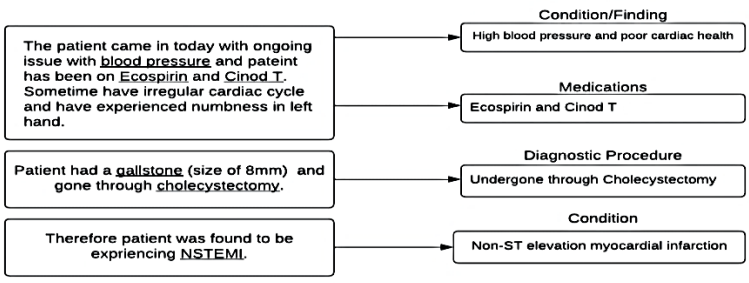

Figure.1 Information extraction from clinical notes: An example of an EHR system

2. CLINICAL DECISION SUPPORT SYSTEM

One of the applications which are also provided by NLP is **the Clinical Decision Support System** (CDSS), a medical selection assist system that is intended to improve healthcare shipping through bettering clinical selections with centered medical knowledge, affected person's information, and other fitness information. A standard CDSS is a software, which is designed for uncomplicated clinical-decision making, by selecting the indicated symptoms of an individual patient, which are matched to a computerized clinical knowledge base and then specific and certain recommendations are presented according to the indicated symptoms to the clinician for making a medical decision, these days CDSS works on the premise of web applications and EHR (Electron Health Record) and CPOE (Computerized Provider Order Entry System), these can be administered by any smart devices like desktop, tablet, smartphone, etc (9). Increasingly, however, CDSS is being developed with functionality to leverage statistics and observations in any other case unobtainable or un-interpretable via humans. CDSS works on two bases:-

2.1 Knowledge-based CDSS:- which works with the help of previous registered knowledge or history of a particular patient. The simple benefits offered by such technology systems are documentation of knowledge, sensible decision support, self-learning, reasoning, and explanation.

2.2 Non-Knowledge-based CDSS:- Non-knowledge-based CDSS range from knowledge-based ones in that, rather than a user-defined perception based, they enforce a structure of artificial genius referred to as machine learning. This is a technique through which a system, as a substitute for consulting a pre-composed encyclopedia, simply "learns" from previous experience and then implements these "lessons" into its database. There are two famous sorts of Non-knowledge based CDSS artificial neural networks and genetic algorithms.

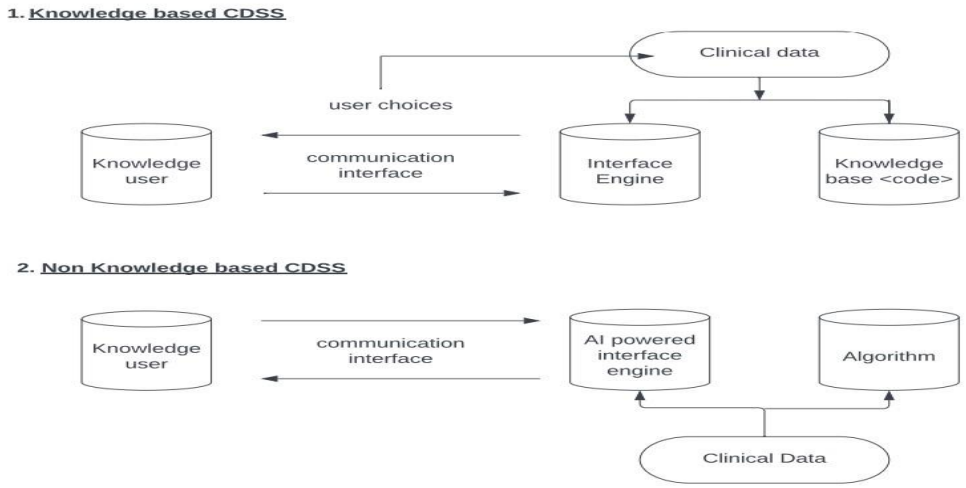

Figure.2 Showing the interaction of Knowledge-based CDSS between Non-Knowledge-based CDSS: This image shows that they are made up of three main components: the data available, the algorithm used to model the decision (which is non-knowledge-based), and the rules that are programmed into the system (which are knowledge-based). a second inference engine Apply the programmed and AI-determined rules, data structure, and patient clinical data to produce an output or action that is presented to the end user, such as a physician, through the (3) communication mechanism, which can be a website, application, or EHR frontend interface. (9)

2.3 FUNCTION AND ADVANTAGES OF CDSS

CDSS utilizes artificial intelligence and machine learning. The main approach of CDSS is to rule out the possibilities of medication, and diagnosis errors which provide consistent, reliable information and improves the efficiency of the treatment procedure.

Such as errors in medication comprising wrong drug interaction, which has been extremely common and prevailing. Per year 7000 to 9000 patient dies of medication error in UNITED STATES and approximately $40 Billion exceeds to treat the patients who are suffering from medication error issues. (10)

2.4 ISSUES TO CONCERN:-

There are different taxonomies for different medication errors which are proposed by **Joint Commission, the World health organization,** and **National Coordination Council for Medication Error Reporting and Prevention.**

- Deteriorated drug errors from compromised storage.
- Drug utilization process error from the administration, dispensing, or monitoring.
- Prescribing Errors. (10)

All the problems which are stated above can be minimized by the using **Clinical Decision Support System** because it provides:-

- Computerized clinical-related alerts and reminders are provided to patients.
- Condition Specific order and sets
- Data Reports and summaries
- Documentation Template
- Diagnostic support
- Contextually relevant reference information

Improvement has been observed in document quality saving time from the workflow of medical transcription by using AI-based tools such as **Dragon Nuance.** (11)

3. DRAGON MEDICAL ONE

Dragon Nuance is a speech recognition tool, which plays a major role in maintaining electronic medical records by direct dictation through medical professionals. Any report can be dictated and it recognizes each word accurately at 99%. Format, correct, and navigate notes quickly and easily using natural language commands to optimize workflows. This application can be accessed by using any device as a microphone.

According to the case study of **LEON MEDICAL CENTER**, which states that it strives for the highest documentation standard, using automated tools has helped to increase efficiency and speed, as well as patient and physician satisfaction because it frees up time that would have been spent on computers and allows them to spend more time with patients.

- 89% adoption rate among the licensed dragon one medical user.
- 90% of clinicians say it meets their needs extremely well

Therefore approximately all of clinicians are highly satisfied with Artificial intelligence based applications provided for the job (12).

Since 2018, All over the world, the adoption of VR (Voice Recognition) has significantly increased among internationally trained physicians in comparison to the physicians trained in the United States and according to age, physicians less age use VR more than in contrast to aged physicians (13).

4. CLINICAL TRIAL MATCHING

Clinical trial matching is a process that is based on specific criteria such as age, gender, medical records, and stages of a particular disease which is supposed to be reviewed. It is run by medical investigators and researchers, and this can also be called **interventional studies** or **Observational studies.** For a few years, we have been using some technologies to modify the use of artificial intelligence in every sector and one of them is the health sector to reduce the burden as well as to rectify the errors. (14)

The clinical trial processes have got a bit easier to handle with the use of NLP-based algorithms, which can pre-plan the criteria of the clinical trial matching. Choosing the appropriate group of patients for inclusion is the first step in enhancing clinical study performance. To reduce disruptive patient safety events, efficient methods for spotting adverse events in close to real-time are crucial. Since there are more and more health data accessible, these procedures have gotten harder. Since 2016, healthcare organizations have experienced a staggering 878% increase rate in health data, according to Dell EMC. (15)

4.1 ADVANTAGES OF USING AI IN CLINICAL TRIALS

Natural language processing (NLP) has various benefits for clinical trials:

1. **Efficiency gain:** NLP automates the process of retrieving critical data from clinical trial documentation, including adverse events, drug doses, and patient outcomes. Eliminating the need for manual data input can free up time and resources for other work.
2. **Increased accuracy:** By properly extracting information from clinical trial papers using NLP algorithms, the danger of human error associated with manual data entry is decreased.
3. **Improved data analysis:** NLP can assist researchers in finding patterns and trends in vast datasets, enabling them to draw conclusions and decide on study design and patient treatment with confidence.
4. **improved patient safety:** Real-time medication interactions and adverse events may be identified with the use of NLP.

NLP may be used in clinical trials to enhance patient outcomes, aid decision-making by researchers and physicians, save expenses, and boost productivity overall. NLP may be used in clinical trials to enhance patient outcomes, aid decision-making by researchers and physicians, save expenses, and boost productivity overall (16)

4.2 CLINICAL TRIAL STUDY

There was a study conducted on Patients from Brigham and Women's Hospital (BWH), and Faulkner Hospital (FH), a community hospital, both in Boston, Massachusetts, participated in this research. Both locations are part of the LiiRA project. With an EHR cohort of 3359 patients at BWH and 642 patients at FH who completed chart review, our suggested approach was developed and tested. All patients had one or more RAICDs, such as ICD10 M05* and M06*, ICD10 714* (aside from 714.3), and ICD9 714*. The LiiRA research staff manually reviewed each patient's record to ascertain their eligibility status using the LiiRA recruitment criteria. From 2016 to 2020, manual ES was carried out at both facilities for every patient. Patients must have RA, be older than 35, and be fluent in English to be eligible for Enrolment in the LiiRA trial. Based on the LiiRA exclusion criteria, they did not accept patients with any of the following conditions: Receiving a statin or biologic disease-modifying anti-rheumatic medication within six months of the chart review date, having a history of melanoma, psoriatic arthritis, lymphoma within five years of the review date, being pregnant within a year of the review date, having active wheezing from asthma, having active HIV, having active hepatitis B or C, or having active tuberculosis are all contraindications.. (17),

	Structured features	Unstructured features	Timeframe				
			6 Months	1 Year	2 Year	5 Years	All Years
Inclusion	Age						
	English-fluency						
	RA_{ICD}	RA_{NLP}		✓	✓		✓
Exlision	JRA_{ICD}	JRA_{NLP}		✓	✓		✓
	PSA_{ICD}	PSA_{NLP}		✓	✓		✓
	$Melanoma_{ICD}$	$Melanoma_{NLP}$		✓	✓		✓
	TB_{ICD}	TB_{NLP}		✓	✓		✓
	$Astma_{ICD}$	$Astma_{NLP}$		✓	✓		✓
	$HepatitisB_{ICD}$	$HepatitisB_{NLP}$		✓	✓		✓
	$HepatitisC_{ICD}$	$HepatitisC_{NLP}$		✓	✓		✓
	HIV_{ICD}	HIV_{NLP}		✓	✓		✓
	$bDMARDs_{MED}$	$bDMARDs_{NLP}$	✓				
	$Statin_{MED}$	$Statin_{NLP}$	✓				
	$Pregnancy_{ICD}$	$Pregnancy_{NLP}$		✓			
	$Lymphoma_{ICD}$	$Lymphoma_{NLP}$				✓	
HU		NOTE COUNT					✓

Abbreviations: *bDMARD, biologic disease-modifying anti-rheumatic drug; *NLP, concept count from notes; *Med, total medication code count; *ICD, total ICD9, and ICD10 code counts; JRA stands for juvenile rheumatoid arthritis, Ps-A for psoriatic arthritis, LiiRA for lipids, inflammation, and cardiovascular risk in rheumatoid arthritis, TB for tuberculosis, and RA for rheumatoid arthritis. EHR stands for electronic health record. BWH stands for Brigham and Women's Hospital. HU stands for healthcare utilization.

The results imply that developing precise models to estimate the outcomes of complicated diseases using EHR data is feasible and that these models may be shared across hospitals with various EHR systems and patient groups. The most accurate models in the future could be those created from sizable patient populations that have been pooled, allowing everyone access to the most reliable models that have been trained on the broadest and most varied patient populations imaginable. The techniques used to create models that forecast the activity of the RA illness may be instructive for other medical disorders with quantifiable consequences.

Artificial intelligence has revolutionized clinical trial matching by providing the automation of most of the important parts of clinical trials like accurate recruitment of patients, Protocol designing, Data Management, Risk Management, and Drug Development. (18)

5. INTERNET OF MEDICAL THINGS (IOMT):-

The Internet of Things (IoT) deals with various interconnected computing devices, machines, objects, humans, or animals with unique IDs and is capable of transferring data within the network without human intervention. It comprises the monitoring and control systems that make it possible for houses to be smart, such as thermostats and IoT-enables heating, ventilation, air conditioning, and thermostatic equipment and it also includes wearable devices, implantable devices, and sensors that can monitor vital signs such as heart rate, blood pressure, and blood glucose levels. These devices are often connected to smartphones or other mobile devices, which can transmit the data to healthcare providers or other authorized individuals.

Transportation, healthcare, industrial automation, and energy response to natural and man-made disasters are some further areas where IoT may be applied. An AI system gives a computer or robot the capacity to carry out tasks that would typically be completed by people. Additionally, it can employ implanted or wearable sensors to monitor health indicators, enabling enhanced user experience and real-time illness management and prevention. Giving security measures is crucial because SHS works with private medical information (19).

5.1 There are several benefits of IoMT listed below

- Improved patient outcomes - IoMT devices provide real-time monitoring of patients, allowing healthcare providers to respond quickly.
- Increased efficiency - IoMT devices automate healthcare processes, saving time and workload.
- Better patient engagement - IoMT devices provide patients with access to their health data.
- Enhanced Preventive Care - IoMT devices can help healthcare providers identify patients at risk of developing conditions and take preventive measures.
- Remote Patient Monitoring - IoMT devices enable healthcare providers to remotely monitor patients, especially those with mobility issues.

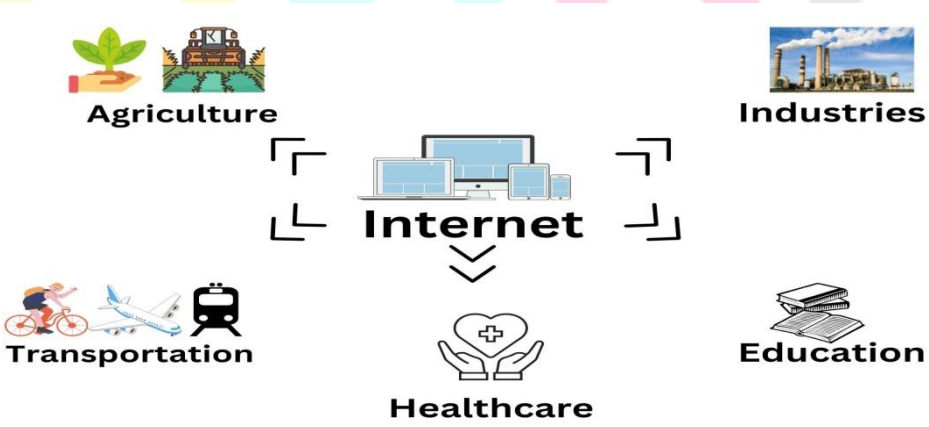

Figure 3. Overall perspective highlighting the function of IoT across several fields. (20)

In conclusion, the Internet of Things (IoT) is a developing technology that offers improvements and improved solutions in the medical sector, including accurate medical record-keeping, sampling, device integration, and illness causes. It assists in lowering the risk of surgery in difficult instances and aids in the early detection of changes in crucial COVID-19 patient parameters. It may also be used to keep track of patients' calorie intake and medical care, which will improve healthcare delivery during the COVID-19 pandemic.

6. CLINICIAN NOTE GENERATION USING AMAZON CONNECT AND AMAZON TRANSCRIBE

Advanced machine learning techniques are used by Amazon Transcribe, a cloud-based service, to convert speech to text. Here is a broad explanation of how it operates –

- **Input:-** To utilize the Amazon Transcribe service, a user must upload an audio file in one of the accepted file types (such as MP3, WAV, FLAC, etc.).
- **Speech Recognition:-** An advanced automated speech recognition (ASR) engine is used by Amazon Transcribe to evaluate the audio and convert it to text. To recognize words and phrases in the audio stream, the engine makes use of deep neural networks and other machine learning methods.
- **Language Identification:-** The language of the audio file will be automatically detected and translated if the language is not chosen by the user in Amazon Transcribe.
- **Punctuation and Formatting:-** To make the transcribed text simpler to read, Amazon Transcribe additionally capitalizes and inserts punctuation.
- **Custom Vocabulary:-** Users can provide Amazon Transcribe a unique vocabulary to increase accuracy for terms relevant to a certain business or domain.
- **Output:-** Through an API, the user receives the transcript as a JSON or plain text file. A real-time output option is also available to the user while the audio is being processed. (21)

Overall, organizations and developers that need to convert audio recordings into text frequently use Amazon Transcribe because it provides a dependable and affordable option for doing so fast and efficiently, hence contributing to improving the healthcare system.

7. RECENT INNOVATIONS

7.1 Vision Therapy Software (CureSee) :-

It is the world's first AI-based vision therapy website. CureSee is an artificial intelligence (AI) based software vision therapy program to treat diseases like **Amblyopia**, **Squint Eye**, and **Convergence Insufficiency.**

It is a non-surgical treatment that acts like physical therapy to improve the coordination of the eye and brain.

Since these disorders cannot be cured with contact lenses, glasses, or surgery, cureSee aims to treat individuals with these problems. (22)

7.2 Detection of Alzheimer's Disease by Using AI

Alzheimer's disease causes a person to lose their capacity for rational thought and accurate memory. Alzheimer's disease develops when the brain experiences changes that may ultimately result in the loss of brain cells. The alterations include the accumulation of amyloid plaques, and aberrant protein clumps that obstruct communication between two cells.

Alzheimer's disease can be brought on by a mix of hereditary and environmental causes in addition to age-related variables. A gene called APOE, which may be passed down from generation to generation and eventually increase the chance of developing Alzheimer's disease, is important from a genetic perspective. Alzheimer's illness may benefit from artificial intelligence since it can identify Alzheimer's disease in its earliest stages might be seen as a benefit to the condition. With the use of AI, ML, which is a subset of AI, may also identify different diseases and lessen their effects. Comparison of the images of Alzheimer's disease and other diseases on a deep learning-based MRI equipment. Deep learning is an AI function that mimics how the human brain processes data and builds patterns to be used in decision-making. The MRI picture of a diseased individual is rotated in DL in order to go forward, and this finally results in patient analysis. Alzheimer's disease cannot be completely cured, but its severe effects can be slowed down via AI. Previously, clinicians would note on patient reports the region of the brain where the illness is present, but with the use of machine learning, patient reports are now tagged with the location of the brain region where amyloid protein builds up. The technique of PET (positron emission tomography) is also used to assess the concentration of certain chemicals in the brain. (23)

Conclusion:- Artificial intelligence (AI) has benefited the healthcare system in numerous ways, from enhancing diagnostics and personalized therapy to anticipating results and automating administrative work. These innovations have

the potential to completely change the healthcare sector, resulting in better patient outcomes, lower costs, and more accessibility to care.

This review article focuses and delineates different applications of Artificial Intelligence in healthcare and how it has improved healthcare system. The use of artificial intelligence has grown throughout time, which has improved the healthcare system in a variety of ways, some of which are depicted here.

1. **Improved Diagnostics:-** Large amounts of data may be analyzed by AI systems to aid in more precise diagnosis by clinicians. For instance, AI-powered medical imaging can more correctly detect early stage illnesses like cancer than conventional approaches, resulting in more effective therapy.
2. **Personalized Medicine:-** By taking into account a patient's genetics, medical history, and lifestyle, AI may assist customize treatment strategies for them. Less side effects and more focused therapy are the results of this strategy.
3. **Predictive Analytics:-** AI algorithms are able to forecast patient outcomes, spot high-risk patients, and stop unfavourable outcomes. The management of chronic diseases, when early intervention might improve results, makes particular use of this technology possible.
4. **Remote Monitoring:-** AI-enabled wearables and sensors can monitor patients from a distance while gathering information on their vital signs and other health indicators. This device can recognize changes in a patient's state and notify medical staff so they can react.
5. **Drug discovery:-** Massive volumes of data may be analysed by AI algorithms to find prospective therapeutic targets and forecast the efficacy of novel medications. This method lowers the cost of bringing new pharmaceuticals to market and expedites the drug development process.
6. **Administrative Efficiency:-** Administrative tasks including keeping electronic health records, scheduling visits, and processing insurance claims may all be automated by AI. The patient experience is enhanced overall thanks to this technology, which lessens the administrative strain on healthcare professionals.

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