An Innovative Framework for AI & ML based Smart EMR Systems in Healthcare Sector

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***Abstract*— Healthcare technology has advanced significantly since the introduction of Electronic Medical Record (EMR) systems in 1972. Nevertheless, many medical professionals still find it difficult to incorporate EMR systems into their routines with ease, even with these developments. The traditional pen and paper methods of Medical Prescriptions are still preferred in busy outpatient settings as they are quick and easy. Despite providing templates and pre-filled formats, current EMR systems still need clinicians to manually enter a great deal of information for every patient contact, including symptoms, clinical findings, investigations, and prescriptions. In addition to adding to physician burnout and workload, this laborious data input process takes time away from providing direct patient care.**

Drawing on recent research, this overview of the literature highlights a number of current EMR systems' shortcomings. The main problem that is brought to light is how time-consuming data entry is and how this interferes with doctors' capacity to provide patient care. This research suggests a novel solution to these problems: an Artificial Intelligence (AI) and machine learning-powered smart electronic medical record system that is integrated with a mobile application. By utilizing machine learning algorithms that learn from every encounter and provide physicians with real-time support, this cutting-edge solution seeks to expedite the data entry process. The goal of the Smart EMR system is to make the doctor-EMR interaction more effective and collaborative by automating repetitive processes and providing intelligent suggestions. The voice-to-text capabilities for quick data entry, adaptive templates that dynamically modify based on patient information, and predictive analytics to foresee clinical needs are some of the key characteristics of the proposed system. The Smart EMR system seeks to reduce physician burnout and boost overall efficiency in healthcare delivery by eliminating manual input and improving user experience. Future topics for study include enhancing machine learning algorithms for tailored patient interactions, guaranteeing privacy and data security, and evaluating the long-term effects on clinical results and physician satisfaction. In order to improve physician productivity and patient care quality in contemporary healthcare settings, AI integration with EMR systems constitutes a paradigm change.

Keywords: AI, EMR, ML framework, Smart healthcare

I. INTRODUCTION

Ever since the first Electronic Medical Record (EMR) system was developed in 1972 [1], we have come very far with the EMR software currently available in the health care sector today. Yet it has been seen that doctors always find it challenging using such EMR software. For doctors on a busy OP (outpatient) day, pen and paper prescriptions are always fast and handy. After going through and analyzing various studies on the current EMR system, we have found certain limitations which make it challenging for physicians to adopt such EMR systems. The most time-consuming steps in using such EMR software is the patients' data entry by the doctor because the doctor need to manually select or type the patients' symptoms, the clinical examination findings, then select the investigations & blood test for the patient and finally type the prescribed medication. Although current software offers many ready-made templets and pre-typed formats, still doctors need to edit information available on these templets for every new patient they see as every patient has different set of complains. The effort required by a doctor in this entire process of data entry into EMR takes away their primary task of patient care. It was found that doctors need to spend more time in clerical job of data entry rather than patient care which causes additional workload on them and physician burnout [2].

Thus, to make this entire process easy for doctors, we are proposing a Machine Learning and AI based Smart EMR system coupled with a mobile application which will target mainly on specific points to make the data entry process fast and handy while the Machine learning AI based algorithm will work in tandem with Physician as a real assistant rather than being a mechanical software.

II. PROBLEM STATEMENT

We tried to analyze the limitations of existing EMR software and why physicians find it cumbersome to adapt it. Here we have detailed on those limitations.

i. The Data Entry Devices – Most of the EMR software require Desktop computers with mouse and keyboard for data entry. It was found that time required in entering patient's symptoms using keyboard require more duration than writing it using pen and paper. This is the first limitation of existing EMR software.

ii. Limitations and expertise in using these devices – It has been found that physicians who are not well versed with typing expertise and system-based work find it

more time consuming in data entry into EMR [3].

iii. Prescribing medications is the most time-consuming process in current EMRs – The number of mouse-clicks required to prescribe a single drug takes more time than a manual handwritten prescription [4][5].

A study showed that Doctors spend an average of 44% of their time on data entry, compared to only 28% on direct patient contact and care [5]. Fig.1 shows a pie diagram from this study depicting the number of mouse clicks required on an EMR software by a physician during a particular shift.

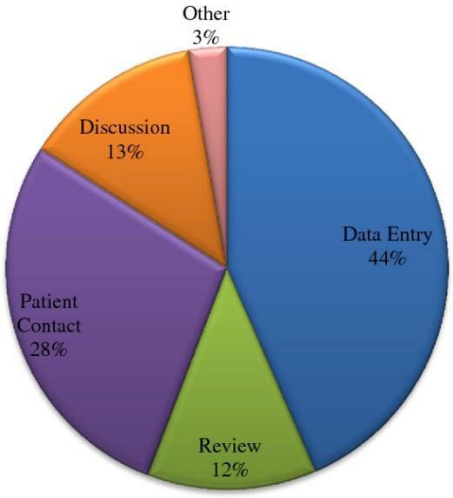

Fig. 1. Calculation of mouse clicks by a physician per hour per shift [5].

Below Table I shows the number of mouse clicks required for different tasks on an EMR software.

Table I. Quantity of mouse clicks for different EMR task [5].

Order a 325-mg aspirin	6
Order a chest x-ray PA and lateral	8
View a test result in old records	11
View and interpret a chest x-ray post anterior and lateral	13
Write and print a single prescription	15
Create and print discharge instructions	20
Document physical examination of a hand-and-wrist injury	40
Document physical examination of back pain	47
Completed EMR right upper quadrant abdominal pain (discharged)	227
Completed EMR palpitations (discharged)	181
Completed EMR chest pain (admitted)	187
Average over selected cases and chief complaints	160

The most time-consuming task on any EMR software is prescribing or indenting medications. Fig.2 shows a sample E-Prescription page on an EMR software where we may see how many fields need to be selected just to prescribe a single drug and the same process needs to be repeated for every single drug a Physician prescribes using an EMR software [6].

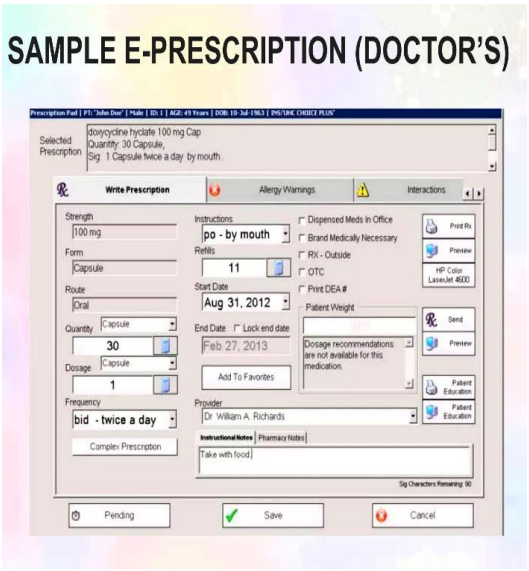

Fig. 2. Showing the number of fields to be selected for prescribing a single drug on an EMR software [6].

The software related challenges faced by physicians and various factors which lead to failure of EMR implementation can be understood by one of the examples of Cedar-Sinai Hospital in USA. Fig.3 illustrates a complex web of factors contributed to the EMR breakdown at Cedars– Sinai Hospital.

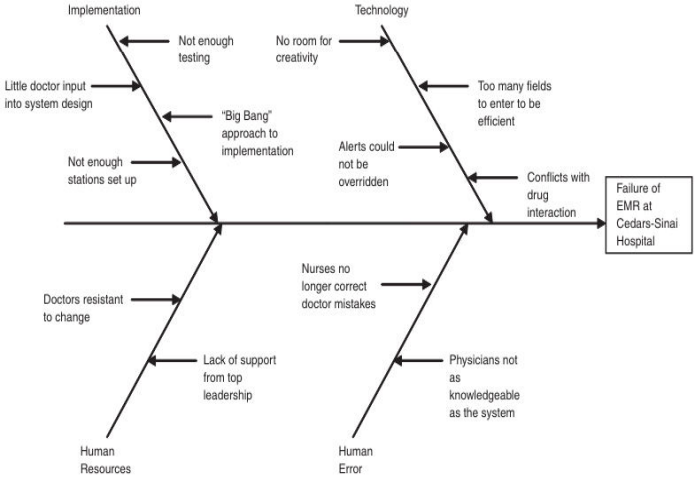

Fig.3. Fishbone diagram illustrating factors contributing to EMR failure at Cedars–Sinai Hospital [7].

Data entry into EMR depends on many factors, for instance, the operating system, user friendliness of software interface, internet speed and responsiveness of server, the typing skills of user, the extent of prior training, interruptions caused by patients or colleagues during data entry and various environmental attributes. That's the reason why electronic charting takes 30% longer than paper charts [5].

III. LITERATURE REVIEW

Healthcare has undergone a transformation because of Electronic Medical Records (EMRs), which digitize patient data and increase accessibility. However, a major step forward in improving productivity, accuracy, and usability in healthcare settings is the incorporation of Artificial Intelligence (AI) and Machine Learning (ML) into Electronic Medical Record (EMR) systems. This analysis examines current advancements and client-facing implementations of AI and ML-based Smart EMR frameworks, emphasizing both the advantages and disadvantage of each.

i. **AI and ML Integration in Smart EMR Systems:** The goal of integrating AI and ML technologies into EMR systems is to enhance decision-making and optimize clinical workflows. Large-scale patient data can be analyzed by AI systems to produce predicted insights and individualized therapy suggestions. In their discussion of the application of a deep learning model for automated diagnosis from medical photos in the setting of an EMR, Lee et al. (2020) for example show improved diagnostic efficiency and accuracy.

ii. **Improved Accessibility and User Experience:** Intelligent EMR systems make use of AI to improve patient and provider user experiences. These systems simplify data entry and retrieval by combining speech recognition and natural language processing (NLP) technology. This lessens the workload for clinicians while also enhancing the accessibility and accuracy of data. Smith et al.'s research from 2021 emphasizes how AI-driven chatbots may be used in EMR systems to improve client engagement and happiness by facilitating patient communication and appointment booking.

iii. **Real-time Decision Support and Predictive Analytics:** AI-driven Smart EMR systems provide physicians with real-time decision support capabilities at the point of treatment to help them make well-informed judgments. These systems use historical data and evidence-based guidelines to assess patient data in real-time, spot trends, and recommend the best course of therapy. According to Brown and Jones (2019), the utilization of predictive analytics capabilities not only enhances clinical outcomes but also augments operational efficiency and cost-effectiveness.

iv. **Privacy and Security Issues:** Despite their possible advantages, AI and ML-based smart electronic medical record (EMR) systems give rise to privacy and security issues with patient data. To prevent breaches and unwanted access to private health information, safeguards must be put in place. Scholars have underscored the significance of resilient encryption schemes, access restrictions, and adherence to regulatory norms like GDPR and HIPAA (Green et al., 2023).

v. **Challenges and Future Directions:** A number of obstacles prevent AI and ML-based Smart EMR systems from being widely adopted. These include the requirement for ongoing AI algorithm maintenance and updates, opposition to change among healthcare personnel, and interoperability problems with the current healthcare IT infrastructure. Subsequent study endeavors will concentrate on tackling these obstacles by means of interdisciplinary partnerships, user-centered design concepts, and extended investigations to evaluate enduring therapeutic and financial consequences (White et al., 2022).

Remote Patient Monitoring (RPM) has historically been used to monitor elderly patients at home, chronically ill patients remotely, and patients in remote areas using wearable technology or sensors. However, the non-intrusive features of RPM make it a desirable option for use in hospitals for patients recovering from surgery and critical care units using wireless body sensors. By including noninvasive digital technologies that allow patients to go about their daily lives, it is conceivable to take these monitoring systems to the next level. Machine learning (ML) and artificial intelligence (AI) can be used, as seen in Fig. 4, to assist healthcare professionals in representing patients' health state visually based on vital signs and activity identification. These programs can support clinical decision-making by presenting information relevant to diagnosing, forecasting, and assessing patient health. The potential for AI and machine learning to revolutionize current conventional medical procedures in healthcare is what spurred this review [8].

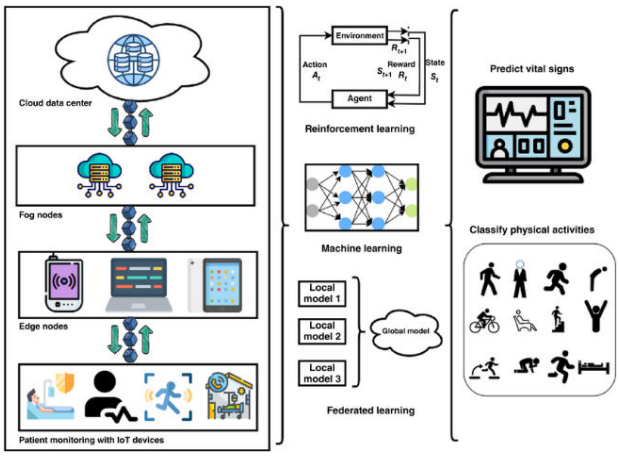

Fig. 4. Artificial intelligence-enabled remote patient monitoring architectures [8]

Numerous hospitals these days are adopting AI based technology to become Smart and Technologically advanced hospitals. AI can help to systematize the information and help in increasing the efficiency of a hospital, patients management and treatment process. AI can help to quickly analyze the patient's investigation reports, radiological images in EMR and with the help of Machine Learning Medical algorithms,

AI can help to create a better patient care and improve the quality of real time healthcare management. Fig.5 shows application of AI in EMR. [9]

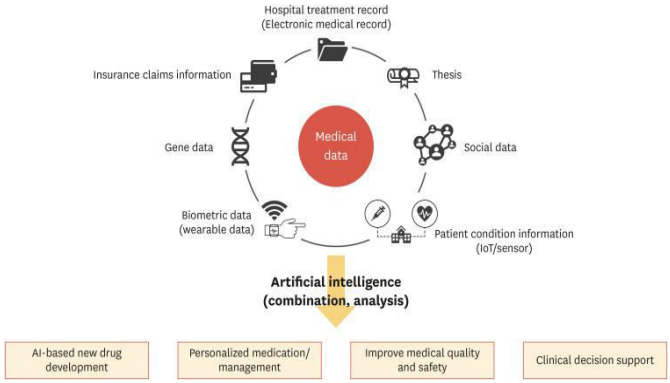

Fig. 5 - Application of electronic medical record **[9]**

Convolutional neural networks (CNNs) as shown in fig.6 are among the innovations in deep learning that have attracted the most interest from researchers due to their superior performance in computer vision tasks. A CNN is a particular kind of deep neural network that uses backpropagation to learn features adaptively, doing away with the requirement for human feature extraction. Deep learning has demonstrated promise for medical imaging tasks in a number of recent studies. [10], [11], and [12]. The applications of a CNN for brain tumor classification [10], COVID diagnosis from chest X-ray pictures [11], and diabetic retinopathy detection [12] have been described by Mzoughi et al., Khan et al., and Qummar et al., respectively.

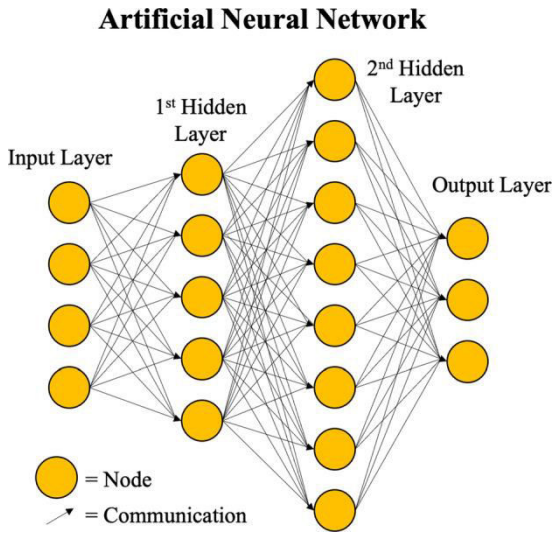

Fig. 6 - Artificial neural network, the basis of deep learning algorithms.[9]

An AI and ML based classification and regression tree for calculation of medication dosage based on patient's BMI and previous health history has been shown in fig.7.

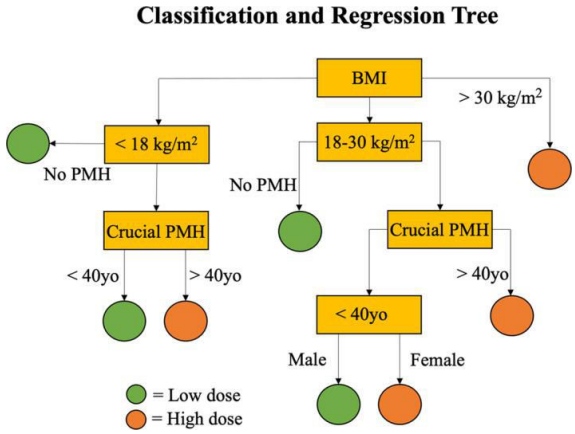

Fig.7 - Classification and regression tree to predict medication dosage. BMI, body mass index; PMH, previous medical history.[9]

III. METHODOLOGY

Here Qualitative Research Methodology has been used to find out the various limitations in adopting current EMRs and how it can be solved with a proposed Smart EMR system coupled with AI and ML.

The data is collected from secondary sources such as various conference papers and journal articles. All the content is duly cited along with figures referred.

IV. PROPOSED SYSTEM

The new proposed software and app will tackle these three crucial steps which are most time consuming in current EMR software.

The first step involves Patient's history collection and data entry- The Anamnesis Vitae (Past Medical History) and Anamnesis Morbi (Current Medical History).

It has been noticed that patients might have many things to narrate to their health care providers but when they go inside a doctor's cabin and start face to face conversation, many times they forget to tell some crucial and significant points about their existing health conditions. They may miss the chronology of their symptoms or may not know which information is more crucial in diagnosis and which is not. If we make this entire history collection processes done by patient themselves before seeing a physician, this can significantly reduce a Physician time in data entry, at the same time they don't miss any crucial information as well. This process can be done by the patient themselves or with the help of physician assistants before a patient sees a physician.

Patients will download the mobile application of the EMR software and create their Login ids. They will fill their demographic data, allergic history, significant past medical and surgical history, what was the first symptom, and what were subsequent associated symptoms. It may sound overwhelming for a patient to do this task but instead of manual data entry, this can be done by Speech-to-Text integrated software so that if they narrate their symptoms, it

gets typed into EMR. Smart EMR will also have inter-language translation option, thus when a patient narrates symptoms in their native language also it gets translated into English and gets recorded in the EMR which has been depicted in Fig.8.

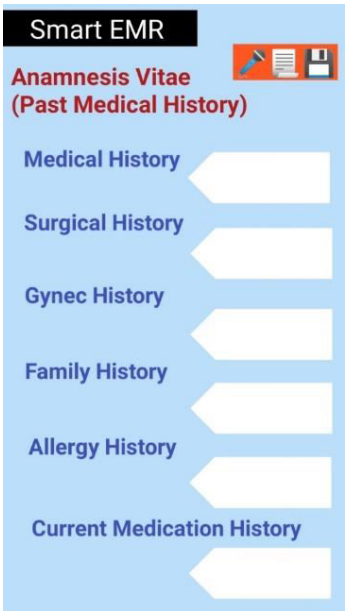

Fig. 8. Anamnesis Vitae Page on EMR Application

Many time It has been seen that patient's bring logs of their past medical reports and old prescriptions and discharge summaries and it really takes a lot of time and patience for a doctor to go through all those records to find some significant information from the past history of a patient. Doctors usually manually brush through patient's old reports to find any significant abnormality in the past reports, the time spent on going through these reports depends upon the volume of report a patient brings. If the volume is more, there is always a possibility that physician might miss a significant past medical history. But this process can also be automated using AI which can save a crucial amount of physician's time and effort.

Patients can take snaps of their previous reports and health records and upload them into EMR, which will be converted old reports from image to text format using the AI enabled software. Once done the AI based algorithm will analyze these past medical reports and create a timeline of patients' past medical history, for example the Heamoglobin level or Kidney parameters and its variations over a period of months or years. This data will be analyzed in the background and the significant abnormalities will be highlighted by the software. This will create a systematic past medical timeline of the patient showing how many years back he started to develop kidney issues, or a drop of hemoglobin etc. as depicted in Fig.9.

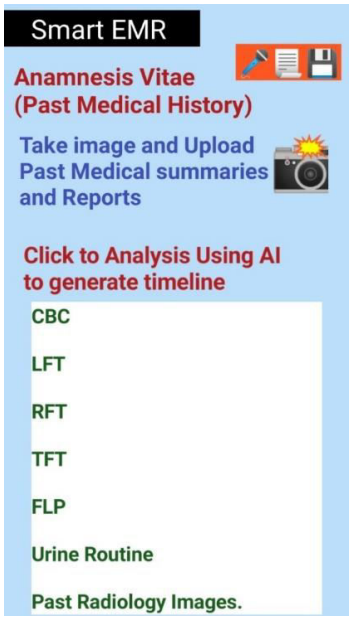

Fig. 9. Snapshot of Anamnesis Vitae Page on EMR Application, uploading and analyzing past medical records of a patient

Next the app will display a simple diagram of a human body, the patient or physician assistant only needs to tap the area on the screen for the body system they want to select. Let us say a patient comes with Respiratory Tract Infection, they will select the respiratory system from the diagram and instead of manually typing the symptoms, give speech-based commands and the speech-to-text conversion software will type the information in the app as depicted in Fig.10.

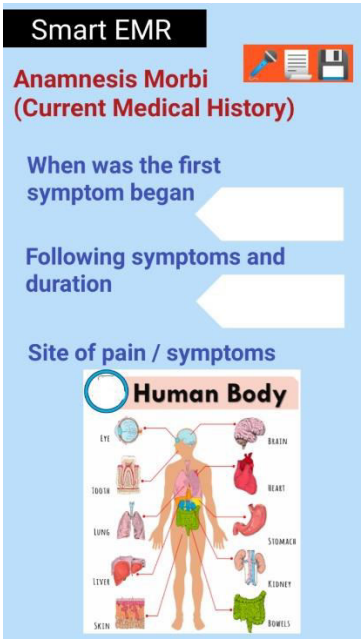

Fig. 10. Anamnesis Morbi Page on EMR Application [13]

With all this preliminary workup, by the time a patient

enters a doctor's cabin, his entire past history, current symptoms will be displayed on the physician's mobile device. Physicians may verify or edit this information. Once saved the background AI based algorithm will suggest possible differential diagnosis and necessary investigations to the Physician as depicted in Fig.11.

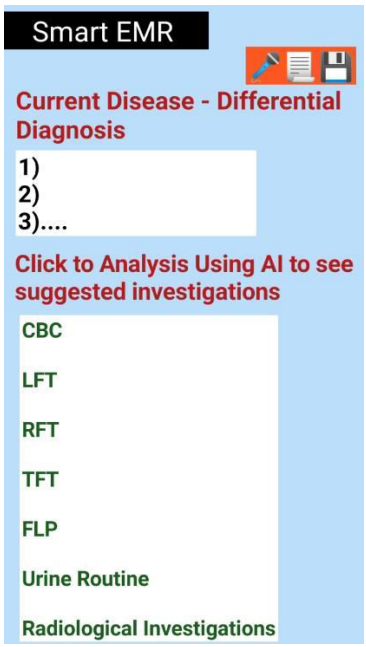

Fig. 11. Differential Diagnosis and AI suggested investigations on EMR Application

In the next step doctor just needs to give verbal commands for the blood tests and investigations he wants for his patient and the AI based EMR app will select those investigations for the patient. This entire automated process of data entry will help doctors save a lot of time. And once this information is saved into EMR database the same is transmitted to lab and patient may undergo the investigations and X-Ray, ECGs etc. as ordered by the physician. All these reports are digitally updated into patients' record in EMR database.

As the patient reviews the physician after completing all investigations, the physician can check all reports in the app on mobile or tablet device itself. Finally for typing the medication prescription, the app will again offer speech to text conversion mode of entry, thus doctor just need to give oral commands with the name of medications, dosage etc and this gets typed automatically. Although there is always an option for manual modification of this information before the doctor finally saves the prescription as depicted in Fig.12.

Fig. 12. Final Diagnosis and Prescription page on EMR Application

Thus, the entire process will be very time saving for doctors and will also cut short the need for desktop devices. As the doctors will be able to use their mobile based devices linked with internet and cloud-based storage system, this will reduce the total cost of setting up EMR in any hospital as compared to high-cost Desktop PCs based conventional EMR systems of today.

Once the entire data is saved in the EMR, the machine learning algorithm will come into play. As a doctor examines a greater number of patients, with every passing day the machine learning algorithm will start to analyze a particular physician's pattern of patient examination, the set of blood test and investigation he usually suggests and the disease-wise medication he usually writes. Once the machine learning system starts to understand the doctor, this smart EMR will be able to pick up the doctors' preferences and the most routinely prescribed medications by a particular doctor. As various patterns are detected by the AI system of smart EMR software, over a period, the EMR system will start to recognize the preferences of each doctor linking it with their user ID and will start to help the doctor by providing suggested data for data entry while examining new patients. This will make the data entry process even faster. As the physician enters the final diagnosis for a patient into EMR, the system will analyze this information and will automatically suggest the preferred medications, any medications alerts, medication interaction information etc to make the prescription process faster. Thus, the physician can select from this automatically suggested medication list and add any additional medication he wants to prescribe. Thus, for physicians, typing prescriptions will become easier and faster.

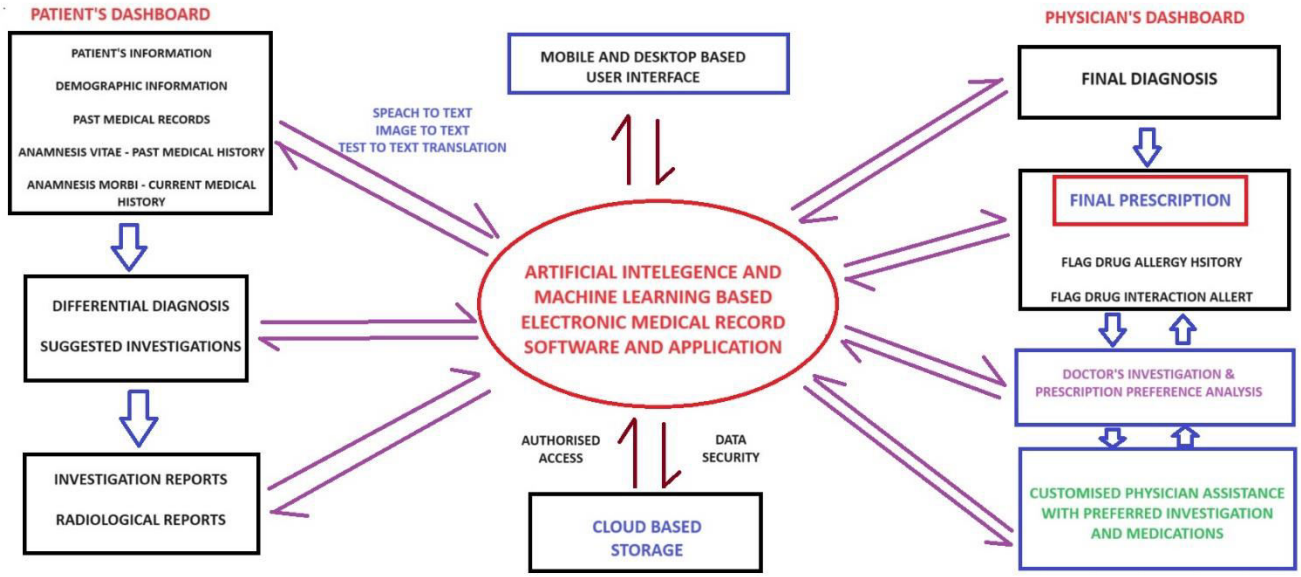

Fig. 13 – Schematic diagram of AI and ML based EMR

A revolutionary change toward efficient and individualized healthcare delivery is represented by the incorporation of AI and ML technologies into Smart EMR systems. These systems can save healthcare costs, increase patient happiness, and improve clinical results by utilizing real-time decision assistance, powerful analytics, and improved user interfaces. For implementation to be successful, it is necessary to handle privacy concerns, ensure compatibility, and overcome resistance to technological adoption. Realizing the full potential of AI and ML-based Smart EMR systems in contemporary healthcare settings requires ongoing study and innovation in this area.

V. CONCLUSION

The machine learning based EMR system will promise to save a lot of time which was otherwise lost in data entry in conventional EMR systems and will also help to make the prescription process simpler and faster. As this system becomes more and more advanced, the physician and the machine adapt to each other, the EMR data entry process will be revolutionized. In due course of time, we will move from cumbersome EMRs of today to an Artificially intelligent EMR of tomorrow. The future EMR will not be just a mere software, but function more like a personal assistant to a physician. And once we reach that point, it will be the ultimate success of a futuristic EMR system.

VI. ACKNOWLEDGEMENTS

Authors would like to extend their acknowledgement to the management of Middle East College, Oman and Apollo Hospitals, Chennai, for extending support and cooperation towards the completion of this research paper.

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