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A Study of Various Applications of Artificial Intelligence (AI) and Machine Learning (ML) for Healthcare Services

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Abstract: The influence of machine learning (ML) and application of artificial intelligence (AI) on the healthcare sector is examined in this study. This study examined numerous actual instances and roles of AI in healthcare in addition to doing a comprehensive analysis of the literature. In the context of health systems, this study also explores how machine learning and software engineering and machine learning interact. The system and technique of programming for AI in healthcare informatics, which we recommended, is a progressive structure for the field of healthcare data innovation (SEMLHI). The four parts of the SEMLHI structure (programming, wellbeing informatics information, AI calculations, and ML) sort out the undertakings in the system as per the SEMLHI method, permitting scientists and designers to look at healthcare informatics programming from a designing point of view and giving engineers another guide for making programming execution and health applications with framework capabilities. To work on the function on system and interoperability of clinical, research centre, and general healthcare frameworks as well as address moral and social issues relating to the confidentiality and security of medical services information with viable equilibrium, valuable insightful instruments, innovations, data sets, and approaches are required. By really separating clinical information for extraction, total the system, and analysis, AI and machine learning (ML) platforms can enhance the healthcare system.

Keywords: Machine learning (ML), Artificial Intelligence (AI), Healthcare system, software engineering, Applications

1. INTRODUCTION

Healthcare frameworks all over the planet are faced with various issues, including rising illness load, multi-morbidity, and inability welcomed on by maturing and segment progress, growing interest for medical care administrations, rising cultural assumptions, and rising wellbeing uses. Failure and low efficiency present another trouble. AI and ML, the most substantial utilization of man-made reasoning (simulated intelligence), furnishes the capability of accomplishing more with less and may act as the catalyst for such a change [1]. It is likewise the most current advancement area in computerized innovation. In recent years, major research in improving health has grown around the idea of precision medicine, which holds considerable potential for patient care. By smartly integrating multi-omics identities with diagnostic, imaging, epidemiological, and demographic details to enable a wide range of earlier interventions for highly developed diagnostics and customising better and more affordable personalised treatment, precision medicine has the potential to advance the conventional symptom-driven practise of medicine (Figure 1) [2].

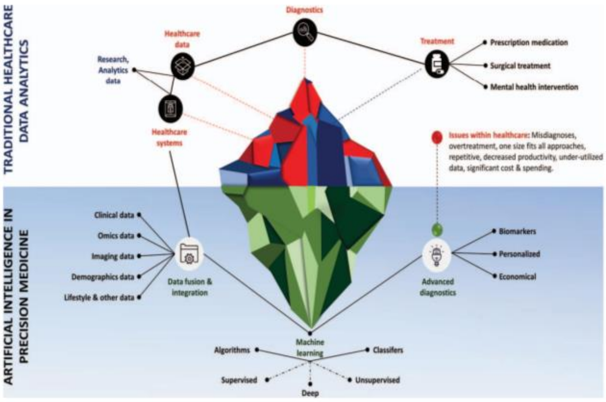

Figure1: Artificial intelligence (AI) application in accuracy of medication and conventional healthcare data analytics, adapted from [2].

Information on a lifestyle of patients, medical history, and encounters with practitioners, lab and imaging techniques, diagnoses, prescription meds, carried out surgical procedures, and providers consulted are all included in healthcare data [3]. By improving the quality and congruity of care, upgrading results while bringing down costs, distinguishing illnesses prior in their movement, and developing a superior comprehension of the basic components by displaying naturally pertinent collaborations through an extensive joining and examination of information, satisfactory, scientific, and wise medical services access information can possibly upgrade the field of medication [4]. This technology is capable of fast learning, forecasting, analysis, drawing conclusions, and even self-correction. It was designed to address many medical issues related to planning, learning, speech recognition, and imaging a certain attribute. AI systems offer training on a given amount of data to forecast improved outcomes and assist in accurately solving complicated problem. By carefully saving patient information and making a data set that can be used for diagnosis, treatment, and standard medical care, artificial intelligence aids health care teams in reducing the amount of time spent documenting patient care. Medical experts must create a stage for information assortment and routine errands in conjunction with software and hardware experts based on the final requirements. Software that is generic is being customised for certain uses. Scanner technologies including X-rays, 3D scanners, Magnetic Resonance Imaging (MRI), and Computed Tomography (CT) all heavily rely on artificial intelligence. These can be utilized to help in understanding navigation. AI suggests a solid eating regimen and behaviours. It successfully handles patient booking and sends arrangement updates [5]. The use of this technology makes the medical industry more effective at resolving a variety of problems and facilitates virtual interactions with clinicians.

1.1 OBJECTIVES

1. To identify various artificial intelligence (AI) technologies for the healthcare industry;
2. To propose a novel framework for Healthcare informatics by using Software engineering.
3. To study major machine learning (ML) and artificial intelligence (AI) applications for the healthcare system.

1.2 RESEARCH SIGNIFICANCES

This study examines a number of actual instances from the healthcare sector to determine how AI and ML impact care services and administrative procedures. We will be able to suggest a set of tactics to improve the effectiveness of patient care, illness prevention, and hospital operational efficiency thanks to this area of research. In order to find AI and ML-based technologies and its uses in healthcare systems, we conducted a thorough examination of the literature and examined a variety of real-world instances. This study is significant because it offers fresh perspectives on where technology-based on management of service operations is headed. The findings of our study are anticipated to be useful new knowledge for administrators of hospitals, medical staff, curriculum developers for medical schools, managers of education, testing and training, experts in role of human-machine; its responsibilities, confidentiality and cyber security analysts, and experts in medical ethics.

2. LITERATURE REVIEW

2.1 AI IN MEDICINE FOR IMPROVED DISEASE PREVENTION, DIAGNOSIS, TREATMENT, AND DETECTION

The authors stressed the need to embrace changes achieved by mechanical innovation and the prospective introduction of Artificial intelligence into the clinical or healthcare industry in a mode that benefits all healthcare professionals. They concentrated on using AI to eliminate monotonous chores in order to work on quiet doctor relationships and foster the development of emotional intelligence and empathy. The authors concentrated on the implementation of the algorithm of deep learning (DL) with upgraded information stream, which empowers PCs to independently build a mind boggling capability with further developed consistency, given that a lot of information is taken care of as info. They made a deep convolutional neural network (CNN) for skin melanoma location, an image examination device for assessing diabetic retinopathy, a cell phone based computerized reasoning stage to follow adherence in those utilizing direct oral anticoagulants, and a device to abbreviate patient visits [6]. The review's benefits incorporate the possibility to further develop admittance to medical services where experts probably won't be truly present and the capacity to in any case regulate prescription involving an essential consideration doctor and artificial intelligence in emerging countries. However, it is important to address the potential for patient data exploitation as well as the loss of privacy [7].

2.2 ML IN MEDICINE FOR BETTER RELATIONSHIPS BETWEEN PATIENTS AND PROVIDERS

This method focuses on analysing the crucial structural adjustments to the healthcare systems required to fully comprehend the probability of ML in clinical system. It focuses on advancing the ideas of machine learning in medicine field, which might be centred nearby the concept of individualised diagnosis or detection and therapy based on all available data of the patient, caretaker and collective experience. The evidence of-idea models that have been tried thus far were highlighted by the authors as justification, remembering difficulties for laying out an association between current ML models and customary measurable models, the requirement for an immense measure of information to prepare ML classifiers for laying out broad and complex affiliations, and the preparation of clinicians in artificial intelligence for exact information translation. They also discussed how the expanded administrative and billing features in EHRs, like as check boxes, are consuming physicians' valuable time and could hinder them from giving their patients the highest-quality care. They also asserted that the inclusion of ML in EHRs may result in a diminished awareness of errors and automation bias, as well as a potential concern of overreliance. The authors asserted that by training ML classifiers in EHRs for pattern detection, physicians would be able to predict future occasions in high-risk patients, get exact and exhaustive conclusions, and advantage from a speedy web crawler for tracking down the vital data in a patient's diagram, less clicking, voice correspondence, and worked on prescient composing [8].

2.3 HE ADVANCEMENT OF HEALTHCARE AND ARTIFICIAL INTELLIGENCE/ML

Recently, researchers emphasised the outline and utilization of simulated intelligence and ML in medical services for the extraction of large information and helping specialists in offering better consideration conveyance. They discussed utilizing support vector machines (SVM) and profound learning-based models to section and examine physiological information, estimate ailment movement, and make diagnoses in radiology. Authors highlighted methods, such as creating efficient models to help with diagnosis based on data that reflect particular diseases, and image examination and transformation to doctors' supervisory abilities. Authors also brought up ethical issues with the use of ML, particularly with regard to big data governance and management and the future of work [9].

2.4 MEDICAL AI FOR ACCELERATING THE DEVELOPMENT OF BIG DATA ANALYTICAL TECHNIQUES AND EXPANDING THE AVAILABILITY OF HEALTHCARE DATA

In a study, various AI applications in healthcare were examined, along with possible future results. The focus of present AI research in healthcare, according to the authors, is mostly on a small number of diseases, such as cancer, brain diseases, and cardiovascular diseases. They highlighted the fact that current healthcare systems lack a structure for the application of AI and do not offer incentives for data exchange. Other categorised applications of AI include SVM to decide model boundaries and recognize imaging biomarkers, NLP for text handling and arrangement, and DL for indicative imaging. Algorithms of ML can concentrate and bunch valuable data from a huge patient populace to assist with continuous inductions for wellbeing risk cautions and wellbeing result expectations, perform head part investigation, and decrease demonstrative and remedial blunders [10].

2.5 ANALYTICS OF DATA AND MACHINE LEARNING FOR EHR ILLNESS IDENTIFICATION

For big data analytics to be successful, managing vast volumes of data is quite difficult. In order to recognize an extensive variety of clinical disorders and diagnoses from the massive EHR database, which contained data on test results, management plans, codes of billing, historical information, etc., a team of researchers employed an Algorithms of ML for organized and unstructured huge data examination. In order to discover the presence of pseudoexfoliation syndrome (PXF), authors first used their method for the recognizable proof of planned indicators and watchword associations in the EHR by applying NLP, least outright shrinkage, and determination administrator. The revealed results depended on the algorithm's positive and negative prescient qualities, which were additionally supported by glaucoma specialists. The application of their method for predictive analytics and data mining in numerous additional applications was used by the authors to emphasise the system's potential [11].

2.6 DEEP LEARNING IN THE MEDICAL FIELD

A common ML strategy is deep learning, which has been significantly improved in modelling tools, analytic development of system, and healthcare. This survey examined potential medical care applications in view of various driving variables, including the technology of EHR and smearing ML for organizing and breaking down informational indexes, integrative heterogeneous information examination utilizing profound learning, and applying profound learning for speculation age by recognizing patterns in digital imaging (such as ophthalmology, radiotherapy, pathology, radiology, and dermatology). Authors foresaw the successful use of ML leading to safe, humanistic, effective, and efficient treatment in the forthcoming [12].

Table 1: Healthcare applications of ML and AI in real time [2].

Algorithms of AI and ML	E.g. in Healthcare
Support Vector Machine (SVM)	Analysis and classification of symptoms to boost diagnostic precision. Locating biomarkers for imaging of mental and neurological illness. Detection of mental illness. SVM with cross-validation for the analysis of clinical, molecular, and genomic data in oral cancer.
Deep Learning	Analysing pictures to look for diabetic retinopathy. Analysis of CT scans for the detection and segmentation of liver and lung cancers. MRI heart ventricle image analysis for the purpose of diagnosing cardiac abnormalities. Generating glioma survival estimates by studying genetic marker and histology imaging data.
Decision Tree	Alternative treatment plans for cancer patients. Determine who might be in need of telehealth services. Patient decision-making is aided by content analysis. Help people comprehend prenatal lifestyle changes.
Random Forest	Detection of mental illness. Monitoring wireless medical sensors. Estimating the possibility of an emergency admission. Patient mortality prediction in the intensive care unit (ICU).
Naïve Bayes	Using time-to-event and censored data, predict risk. Alzheimer's disease prediction using genome-wide information. Identifying audit targets for health performance-based financing. Cardiovascular disease decision support system.
K-nearest neighbour	The model's diagnostic performance. Sorting medical datasets. Breast cancer pattern classification for diagnosis. Using information from the EHR and published literature, forecast pancreatic cancer.
Genetic Algorithm	Breast cancer is diagnosed by finding microcalcifications on mammograms. Creating non-invasive methods for the detection of cervical cancer. Analysis of cancer cell line microarray data. Examining the connection between the mortality of cervical cancer and soil trace elements.

3. METHODS

First, the data were confirmed and any outliers were eliminated using authentic information gathered over the course of the previous three years from a hospital run by the Palestinian Authority. Following that, the established framework was used to analyse the remaining data. Software, a machine learning (ML) model, data of health informatics, and machine learning algorithms (MLA) made up the four elements of the Software Engineering for Machine Learning in Health Informatics (SEMLHI) structure [13].

3.1 METHODOLOGY OF SEMLHI

The SEMLHI technique is applied while creating health-related software. The software can be defined and developed using a variety of approaches, including the waterfall methodology, agile methodology, and spiral methodology, for classic applications. A developer now has advanced road map for generating health apps with system functionalities and software implementation thanks to the SEMLHI approach. According to the next section's explanation, this framework has 10 stages that run from describing the problem through the stage of growth and ends with the outputs.

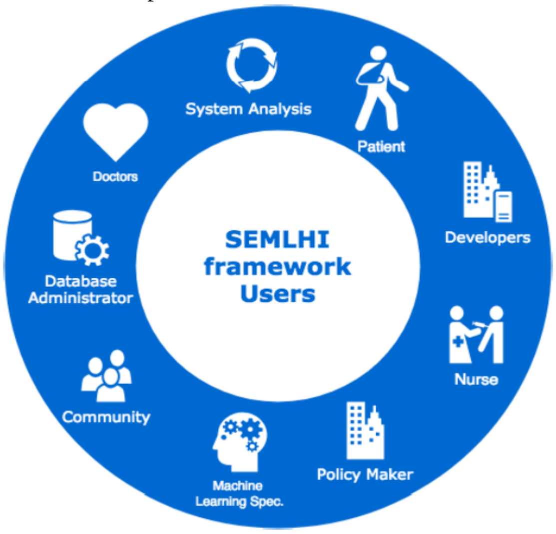

Figure2: Users of SEMLHI framework, adapted from [13].

3.2 FRAMEWORK FOR SEMLHI

SEMLHI frameworks contain elements that make it easier to analyse a health dataset and were designed expressly to make it easier to construct software applications. As shown in Figure 2, several users will either work directly with approach frameworks as programmers or system analysts or indirectly by applying the findings. The conceptual structure for the suggested framework is shown in Figure 3, along with the method for interacting with the hardware and operating system.

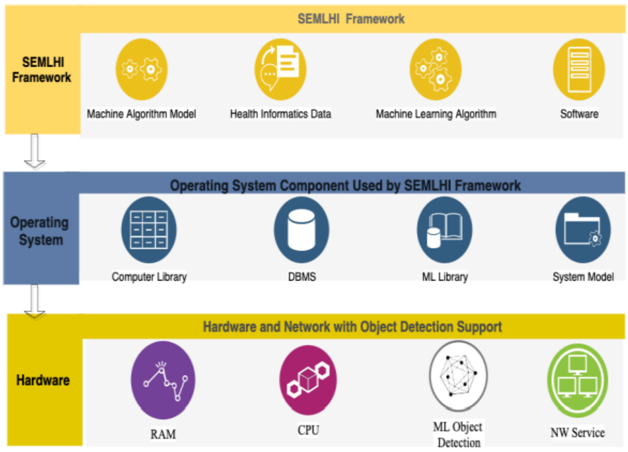

Figure3: Fundamental Framework of SEMLHI, adapted from [13].

For software engineers, the operating system components utilised by the framework interact with our frameworks, and all software controls the hardware of the devices using the chief system device that the structure used. Software, a model of machine learning (ML), algorithms of ML, and data of health informatics made up our framework's four modules. Figure 4 demonstrates how each module works with the others to form a framework.

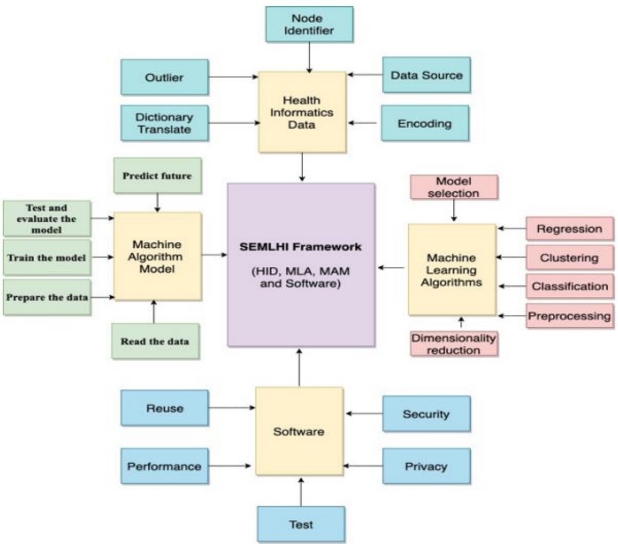

Figure4: Components of SEMLHI framework, adapted from [13].

3.2.1 DATA FROM HEALTH INFORMATICS

Data are crucial to machine learning (ML), and the most crucial decision is how to convey and visualise knowledge. The sample of our dataset has ten columns and 52,000 rows (cases). It was necessary to change a dataset of health informatics data (HID) methods into numerical features in order to use it. Other data, such as negative ages and exceptionally big integers, have missing, duplicate, or null values that could impair the effectiveness of our ML method. To lessen the amount of incorrectly interpreted data utilised by Bayesian inference, HID converts all value in a column to a no. during label encoding by using data sources and a dictionary for translation. Data was analysed using a node identifier as a standard procedure, and trends were found using patient-specific investigation identifiers.

3.2.2 ALGORITHMS OF ML

Machine learning algorithms (MLAs) are used to increase system convergence without losing information, optimise a model's network structure, and process the boundaries that could characterize a model [14]. K-nearest neighbours (KNN) [15] is a supervised learning technique that can be applied to classification and prediction issues. Instead than using just one object category, KNN bases its decisions on the prevailing categories of k items. The resultant technique will administer the "mark information" for this algorithm of KNN with different names and assess our result on the grounds that the SEMLHI system was utilized to make every one of the information in our example of datasets. KNN was utilized for directed learning though k-implies was utilized as unsupervised or unaided learning. Millions of labelled data points can be found in datasets that can be analysed using k-Means. A good and quick solution for many issues, approximate nearest neighbours (ANNs) typically outperforms KNN support vector machines (SVMs) by a factor of 10X to 100X.

3.2.3 MODEL OF MACHINE ALGORITHM

In order to address or forecast health-related events, AI empowers us to extricate significant highlights from a dataset [16]. There are five sub modules that make up the machine algorithm model (MAM) part: read information, information planning train the prototypical, test and survey the prototype, and gauge novel information. The dataset was analysed using the primary MAM component according to the requirements. Classification methods will be utilised for the selection if the dataset contains more than 50 labelled samples; else, cluster techniques will be employed.

4. RESULTS AND DISCUSSIONS

Results were analysed on the basis of SEMLHI methodology, healthcare data informatics based on age and categories with some variables, algorithms of machine learning, model of machine algorithm and software used for the prediction of accuracy. The findings of the assessment b/w our technique, the Vee [17], and the Agile [18] methodology are shown in Table 2.

Table2: Comparison of methodologies

	Vee	SEMLHI	Agile
Logic	Breadth first	Depth first	Depth first
Scope	Large and complex	Medium and large	Small
Delivery	On-shot	On-shot	incremental
Flexibility	Rigid	Very high	Very high
Assumption	Stable info	Independent iteration	Independent iteration
Emphasis	Specification	Risk	Customer
Iteration	Slow	Very quick	Very quick

4.1 ANALYSIS ON THE BASIS OF DATA HEALTH INFORMATICS

Fisher's exact tests and Chi-square were used to address imperfect statistics in unsupervised clustering and identify the patterns differentiating between pair clusters [19]. Since each patient's medical records contain an ICD code that can have an impact on any region of the retina, we employed ICD-10 with various labels to help us anticipate disease. However, there isn't a classification scheme in place at the moment [20] to separate posterior (macular) from anterior (peripheral) data. We propose that these categorizations were distinguished by D and refractive characteristics, showing the diversity of illness types.

The lab test outcome database's D most frequent diagnostic cases were targeted using electrocardiogram data, where D={d1, d2, d3,..., dn}, where d is an illness that was relevant to a finding code and n is the no. of illness classes determined by the k-means method with multiple marks. The multilevel learning k-nearest neighbour algorithm's pseudocode is shown in Algorithm 1.

Algorithm 1 k-Nearest Neighbor Algorithm for Multi-level Learning by Using Correlation, Diagnosis Code, and Label Weight With Frequency

input: Heterogeneous data source, number of k, correlation n. training set;
label of x
while *While condition* **do**
1- for all heterogeneous datasets, we will work on correlating multiple labels, adding one label for i = 1 to t and then joining the table for i = 1 to t, join table
2- apply ML to one label based on Freq. DG weight, and Lowes accuracy
3- create new role based on step 2
4- apply new role to all new schema; create new role if micro = sen, and if test = normal, then mml = 3
5- classify ML based on DC category
6. predict new disease based on role created;
end

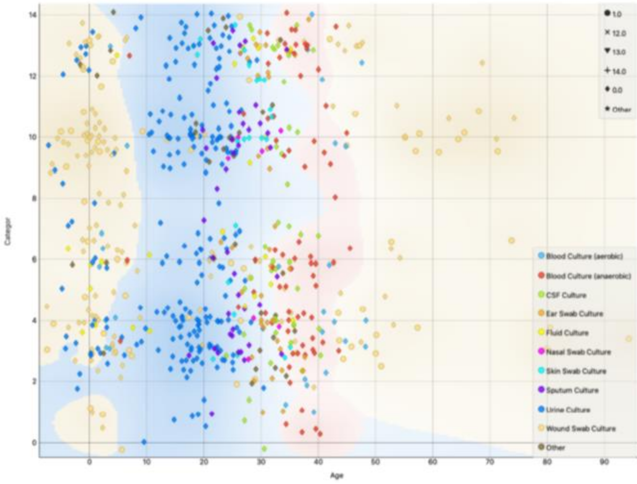

Figure5: Summary of category and age features along with other factors (ICD-10, gender, and results of test) [13].

By using a 30-laboratory test to represent the 850 case categories in the sample test data, this module generates a new dataset with 850 rows and 20 columns. The ages are summarised in Figure 5 with category features grouped by the outcomes of laboratory tests.

4.2 ANALYSIS ON THE BASIS OF ALGORITHMS OF MACHINE LEARNING

Each case in supervised learning must be assessed by a function f using: A→B to compared with mark A or B as per the capability '*f*' by assessing E and contrasting them with gain from the preparation set *n.f* of n rows (cases) *n(d)*. These data are not labelled when learning is done unsupervised. Dimensional reduction is used in the analysis to apply the data [21]. The evaluation phase of the method *f* uses the training set (*t*), which consists of n objects (*t*) = *xi* ϵ *A: 1≤ i≤ 0* that can be in category *n* of class *C1, ck ϵA, by* applying the algorithm to the set, where *ck* accepts the input *x* ϵ *Cj: 1≤j≤k.*

4.3 ANALYSIS ON THE BASIS OF CLASSIFIER MODEL

Utilizing the MAM component of the SEMLHI structure, 5 algorithms were employed to forecast the lab test outcomes based on the original data. Over expert knowledge-based approaches, ML methods and algorithms can perform better [20]. ML algorithms employ both supervised learning and unsupervised learning techniques. Prior to choosing the best algorithms to use for the module of MLA, we decide which methods to employ. This decision is based on a mathematical analysis of several criteria. Table 3 displays the accuracy results for the various algorithms used (KNN classifier, logistic regression, random forest classifier, multinomial NB, and linear SVC).

Table3: Accuracy evaluation of different models of ML [13]

Name of the Algorithm	Accuracy
Linear SVC	0.564566
Multinomial NB	0.517013
KNN classifier	0.487694
Logistic regression	0.560412
Random forest classifier	0.488955

To assess the efficacy of the ML models, we compared the performance of our strategy with that of previously published systems. After applying the various algorithms to 850 examples, the accuracy results were determined. The linear SVG approach had values of roughly 0.77, which was superior to the KNN classifier, random forest classifier, multinomial NB, and logistic regression techniques.

4.4 SOFTWARE ANALYSIS

Security processes are employed by incorporating security exercises and apparatuses in the improvement progression of software, utilising requirement of security governance, and providing developers with training. The encryption algorithm has a substantial influence on development of software, quality, cost, and maintenance.

5. CONCLUSION AND FUTURE SCOPE

By ingeniously examining organized clinical information that is accessible en masse and volumes, presenting up to this point unfathomable difficulties in information capacity, handling, trade, and length, and working on how we might interpret science, exploiting edge, new ML and AI based huge information examination stage advancement can possibly change the clinical field and work on the quality and progress of medical services. The results showed the progress of the enhanced a single shot conveyance component. To look at the exactness of the ICD-10 discoveries utilizing conditions furthermore, to assess the precision of the prototypes of ML with an example size of 850 patients, laboratory test outcomes were collected using five algorithms for the MAM portion on the SEMLHI architecture. According to the MAM results, the SVG was roughly 0.77.

The recommendations made in this study are focused on how technologies based on AI are currently being utilized, which might restrict the knowledge of the maximum capacity of emerging technology. This study has offered some guidelines for the efficient usage and administration of AI through a survey of the previous studies and authentic uses of Artificial intelligence systems in healthcare organisations. Our study is intended to encourage more thorough theoretical and empirical investigation into the optimal ways to apply AI systems to patient care and public health prevention.

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AUTHORS' CONTRIBUTIONS

All authors contributed toward data analysis, drafting and revising the paper and agreed to be responsible for all the aspects of this work.

DECLARATION OF CONFLICTS OF INTERESTS

Authors declare that they have no conflict of interest.

DECLARATIONS

Author(s) declare that all works are original and this manuscript has not been published in any other journal.

REFERENCES

[1] Badawi, O., Brennan, T., Celi, L. A., Feng, M., Ghassemi, M., Ippolito, A., ... & MIT Critical Data Conference 2014 Organizing Committee. (2014). Making big data useful for health care: a summary of the inaugural mit critical data conference. JMIR medical informatics, 2(2), e3447. https://doi.org/10.2196/medinform.3447

[2] Ahmed, Z., Mohamed, K., Zeeshan, S., & Dong, X. (2020). Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine. Database, 2020. https://doi.org/10.1093/database/baaa010

[3] Ahmed, Z., & Liang, B. T. (2019, March). Systematically dealing practical issues associated to healthcare data analytics. In Future of Information and Communication Conference (pp. 599-613). Springer, Cham.

[4] Beam, A. L., & Kohane, I. S. (2018). Big data and machine learning in health care. Jama, 319(13), 1317-1318. https://doi.org/10.1001/jama.2017.18391

[5] Upadhyay, A. K., & Khandelwal, K. (2019). Artificial intelligence-based training learning from application. Development and Learning in Organizations: An International Journal. https://doi.org/10.1108/DLO-05-2018-0058

[6] Fogel, A. L., & Kvedar, J. C. (2018). Artificial intelligence powers digital medicine. NPJ digital medicine, 1(1), 1-4. https://doi.org/10.1038/s41746-017-0012-2

[7] Labovitz, D. L., Shafner, L., Reyes Gil, M., Virmani, D., & Hanina, A. (2017). Using artificial intelligence to reduce the risk of nonadherence in patients on anticoagulation therapy. Stroke, 48(5), 1416-1419. https://doi.org/10.1161/STROKEAHA.116.016281

[8] Rajkomar, A., Dean, J., & Kohane, I. (2019). Machine learning in medicine. New England Journal of Medicine, 380(14), 1347-1358. https://doi.org/10.1056/NEJMra1814259

[9] Jones, L. D., Golan, D., Hanna, S. A., & Ramachandran, M. (2018). Artificial intelligence, machine learning and the evolution of healthcare: A bright future or cause for concern?. Bone & joint research, 7(3), 223-225.

https://doi.org/10.1302/2046-3758.73.BJR-2017-0147.R1

[10] Jiang, F., Jiang, Y., Zhi, H., Dong, Y., Li, H., Ma, S., ... & Wang, Y. (2017). Artificial intelligence in healthcare: past, present and future. Stroke and vascular neurology, 2(4). https://doi.org/10.1136/svn-2017-000101

[11] Stein, J. D., Rahman, M., Andrews, C., Ehrlich, J. R., Kamat, S., Shah, M., ... & Hanauer, D. A. (2019). Evaluation of an algorithm for identifying ocular conditions in electronic health record data. JAMA ophthalmology, 137(5), 491-497. https://doi.org/10.1001/jamaophthalmol.2018.7051

[12] Naylor, C. D. (2018). On the prospects for a (deep) learning health care system. Jama, 320(11), 1099-1100. https://doi.org/10.1001/jama.2018.11103

[13] Moreb, M., Mohammed, T. A., & Bayat, O. (2020). A novel software engineering approach toward using machine learning for improving the efficiency of health systems. IEEE Access, 8, 23169-23178. https://doi.org/10.1109/ACCESS.2020.2970178

[14] Khomh, F., Adams, B., Cheng, J., Fokaefs, M., & Antoniol, G. (2018). Software engineering for machine-learning applications: The road ahead. IEEE Software, 35(5), 81-84. https://doi.org/10.1109/MS.2018.3571224

[15] Salvador-Meneses, J., Ruiz-Chavez, Z., & Garcia-Rodriguez, J. (2019). Compressed k NN: K-Nearest Neighbors with Data Compression. Entropy, 21(3), 234. https://doi.org/10.3390/e21030234

[16] Moreb, M., Mohammed, T. A., & Bayat, O. (2020). A novel software engineering approach toward using machine learning for improving the efficiency of health systems. IEEE Access, 8, 23169-23178. https://doi.org/10.1109/ACCESS.2020.2970178

[17] Weilkiens, T., Lamm, J. G., Roth, S., & Walker, M. (2022). Model-based system architecture. John Wiley & Sons. https://doi.org/10.1002/9781119746683

[18] Al-Zewairi, M., Biltawi, M., Etaiwi, W., & Shaout, A. (2017). Agile software development methodologies: survey of surveys. Journal of Computer and Communications, 5(05), 74. https://doi.org/10.4236/jcc.2017.55007

[19] Zhou, Y., Zhao, L., Zhou, N., Zhao, Y., Marino, S., Wang, T., ... & Dinov, I. D. (2019). Predictive big data analytics using the UK Biobank data. Scientific reports, 9(1), 1-10. https://doi.org/10.1038/s41598-019-41634-y

[20] Steele, A. J., Denaxas, S. C., Shah, A. D., Hemingway, H., & Luscombe, N. M. (2018). Machine learning models in electronic health records can outperform conventional survival models for predicting patient mortality in coronary artery disease. PloS one, 13(8), e0202344. https://doi.org/10.1371/journal.pone.0202344

[21] Clifton, D. A., Gibbons, J., Davies, J., & Tarassenko, L. (2012, June). Machine learning and software engineering in health informatics. In 2012 first international workshop on realizing ai synergies in software engineering (raise) (pp. 37-41). IEEE. https://doi.org/10.1109/RAISE.2012.6227968