Indonesian Journal of Electrical Engineering and Computer Science
Vol. 34, No. 3, June 2024, pp. 1698~1707
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v34.i3.pp1698-1707

An efficient healthcare system by cloud computing and clustering-based hybrid machine learning algorithm

Palayanoor Seethapathy Ramapraba[1], Moorthy Radhika[2], Sokkanarayanan Sumathi[3], Jayavarapu Karthik[4], Nachiappan Senthamilarasi[5]
[1]Department of Electrical and Electronics Engineering, Panimalar Engineering College, Chennai, India
[2]Department of Information Technology, R.M.D. Engineering College, Chennai, India
[3]Department of Electronics and Communication Engineering, Sri Sairam Engineering College, Chennai, India
[4]Department of Computer Science and Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India
[5]Department of Computer Science and Engineering, Sathyabama Institute of Science and Technology, Chennai, India

Article Info

Article history:

Received Oct 20, 2023
Revised Feb 1, 2024
Accepted Mar 16, 2024

Keywords:

Cloud computing
Clustering algorithms
Deep learning
Ensemble algorithm
Genetic algorithm

ABSTRACT

Cloud computing, deep learning, clustering, genetic, and ensemble algorithms in healthcare are gaining popularity. This research highlights the relevance and complex repercussions of this integration. Cloud computing is transforming healthcare by providing scalable data storage and application access. It streamlines data exchange between hospitals, researchers, and institutions. Deep learning allows healthcare systems to use artificial intelligence for diagnostics, predictive analytics, and customized medication. Clustering algorithms segment patients, improving therapy and intervention customization. Genetic algorithms can optimize healthcare processes like treatment planning and resource allocation. Ensemble algorithms combine multiple models to improve predicted accuracy, enabling strong healthcare decision-making. This connection has several benefits. Healthcare systems become more efficient and scalable, resulting in cost-effective resource allocation. Access to patient data and apps promotes collaborative research and real-time healthcare. Deep learning algorithms can recognize complex medical data patterns, improving illness diagnosis and treatment results. Clustering algorithms streamline customized healthcare by stratifying individuals by clinical variables. Genetic algorithms optimize resource allocation, assuring healthcare resource efficiency. Ensemble algorithms improve predicted accuracy and clinical decision support system dependability. Its efficiency, accessibility, and prediction accuracy are positives, but security, resource constraints, interpretability, and ethical issues are obstacles.

Corresponding Author:

Palayanoor Seethapathy Ramapraba
Department of Electrical and Electronics Engineering, Panimalar Engineering College
Chennai, Tamil Nadu, India
Email: ramaprabatamilselvan@gmail.com

1. INTRODUCTION

However, it is important to remember that a constant intake of patients characterizes cloud healthcare systems. Improving the system's efficiency also depends on fairly distributing work among physicians [1]. Medicine, medical-surgical supplies, medical equipment, sterile items, food, and other consumables are all examples of physical objects that fall within the purview of healthcare logistics, including the receipt and distribution of these items inside a healthcare facility [2]. The concept of "vehicular fog computing" adapts fog computing for use in the transportation sector. Therefore, we can support more ubiquitous vehicles, improve communication efficiency, and get around the problems with traditional vehicular networks like slow response times, poor location awareness, and the like [3]. Digital transformation is greatly aided by cutting-edge technologies like AI, big data (BD) and analytics (A), blockchain, cloud computing, the internet of things (IoT), and the industrial IoT. Businesses are hastening their digital transformation efforts because of the many advantages of doing so. Therefore, organizations using DT must prioritize cybersecurity measures to protect their systems from cybercriminals [4].

The complex problem of cloud encryption may be approached from various angles, each tailored to the specific models of cloud services. In contrast to infrastructure as a service (IaaS), where the client has more authority and responsibility for security measures, SaaS has fewer risks since the customer has less say over the underlying infrastructure [5]. This section investigates the value of encryption in cloud service models [6]. Many academics have shown an interest in creating AI-based decision support tools for public institutions and private businesses. It is common practice to use the auto regressive integrated moving average (ARIMA) model, a time-series forecasting model. Stationary time-series analysis often uses ARIMA-based models despite the usual ARIMA-based technique being inefficient in practice for nonstationary time series [7]. Although there are benefits to utilizing a shortened scale in practice, the time-consuming selection process has prevented its broad adoption. Most methods require the researcher to manually select the most useful retained items based on the same conceptual and psychometric factors used in developing the full-length scale [8].

The structure of this work is prepared as follows. An efficient healthcare system by cloud computing and clustering-based hybrid machine learning (ML) Algorithm is introduced in Section 2. Section 3 explains the results and discussion of healthcare system by cloud computing and clustering-based hybrid machine learning, and section 4 concludes the work.

The healthcare industry is no exception to the widespread adoption of big data initiatives, launched by organizations from a wide range of fields [9]. The growth of IoT devices offers a wide variety of opportunities. At the same time, widespread access to healthcare is essential for improving people's health and well-being [10]. Coronavirus disease-19 is an infectious condition brought on by the severe acute respiratory syndrome coronavirus 2. The severe acute respiratory syndrome coronavirus 2 is a novel coronavirus that has never been seen in humans before [11]. The Omicron coronavirus was recently discovered in Africa and Indonesia, and the WHO reported it. Patients who test positive for the newly discovered Omicron BA.4 and BA.5 subvariants in Indonesia have a low risk of developing the disease. This trend began in early June 2022. Eighty percent of those with this will get well without extra care. About 1 in 6 persons may progressively acquire pneumonia or respiratory difficulties [12].

The international diabetes federation (IDF) reports that Indonesia has the seventh-highest rate of diabetes mellitus worldwide. Data reduction, hypothesis generation, hypothesis testing, and group-based prediction are the four main applications of clustering. Clustering algorithms may evaluate the data without a label because of their inherent ability to detect patterns in the data. The K-mean clustering algorithm is the most popular choice for clustering because of its simplicity, speed, and flexibility. The K-means algorithm's clustering performance deteriorates when the cluster center remains fixed on the local optimum. Therefore, excellent clustering results need a strong centroid initialization [13]. This allows us to enjoy life, have hope for the future, and treat others with dignity and respect. Those who take care of their mental health can better enjoy life to the fullest, both physically and psychologically, and form satisfying bonds with others [14]. In recent years, wireless sensor networks (WSNs) have garnered much attention. The development of microelectromechanical system (MEMS) technology has led to the proliferation of more sophisticated sensors. These sensors cost less, have less computing and processing capabilities, and are smaller than regular sensors. A WSN is a group of interconnected, multipurpose devices that share a base station (BS). To do their jobs, these programs need to receive data from a monitoring process and send it to a remote computing facility [15]. When people don't have access to WSN, they put off getting the care they need and are more likely to use expensive emergency rooms to deal with health issues that may have been prevented or addressed at a lesser cost. Environmental costs rise dramatically without healthcare industry number (HIN). The lack of HIN results in significant financial effects [16].

Integrating time series data with field data, such as water quality, provides a more accurate representation of the state of the coral reef ecosystem [17]. When malaria parasites are present in a patient's blood, the patient experiences malaria symptoms. Infected female anopheles mosquitoes are responsible for transmitting the parasites to humans, where they thrive in red blood cells (RBCs) and eventually spread to other cells. The world health organization (WHO) says that malaria is a worldwide health problem, especially in tropical regions. One may examine a micron-sized piece on a microscope slide using a zooming microscope, encouraging more investigation [18]. It might be easier for hospitals to satisfy the needs of their patients if they have access to real-time data on their admissions and discharges, especially if nearby facilities have fewer patients. Improved knowledge and comprehension of novel computational techniques are needed to improve the quality of services (QoS) by allowing healthcare providers to choose the best way that fits their needs [19]. These include rivers, canals, streams, lakes, floodplain wetlands or beels (ox-bow lakes and back swamps), reservoirs, ponds, tanks, and even dry lakes and ponds. The fish's respiratory system, digestive system, salt balance, and capacity for reproduction are all controlled by the water quality in which they swim. Therefore, the water quality utilized in an aquaculture firm is crucial to its success or failure [20]. There are indicators that the tourist sector may return to pre-pandemic levels of activity as vaccinations become more widely accessible and travel restrictions are progressively relaxed. The widespread effects of the coronavirus epidemic have resulted in a dramatic drop in tourism [21]. Wearers experience significant mental stress because to the inability to assess their physical condition accurately. Many people find disposable masks uncomfortable because of the constant pressure on their face and ears. Therefore, the issues and limits of the aforementioned disposable masks must be considered while deciding on the features of future mask designs [22].

Due to climate change, human activities, and pests, the natural Larch pine forests in the Greater Khingan Mountains are in a condition of system instability, diminished vitality, and forest area decline. These shifts have led to an increase in the frequency of extreme weather events like dust storms, which have hurt the local ecosystem and slowed economic growth. As a result, academics in adjacent disciplines have shifted their attention to elucidating tree traits and assessing forest health [23]. Data from the IoT, precision medicine, and Industry 4.0 are examples of complex, massive datasets with time series annotations. As it is, academics and data scientists face a problem when attempting to make sense of this massive amount of temporal data. The machine learning method has a simple implementation [24]. The data collected may subsequently be utilized to develop algorithms or classification models for stress vulnerability prediction [25]. The humanitarian supply chain (HSC) is a dynamic and dynamically changing system with many moving parts. Numerous information technology (IT) developments during the last decade have reshaped conventional corporate procedures. An effective supply chain information system has been linked to several positive outcomes. Take data as an example. The bullwhip effect is reduced by collaboration, leading to increased productivity [26]. Electrophysiological (PPG) signals evaluate peripheral (i.e., foot and hand) circulation. PPG sensors generally use an avalanche photodiode as the detector and a light emitting diode as the light source. Congestive heart failure is the leading cause of arrhythmias. PPG is safe for delicate skin since it does not need direct skin-to-surface contact. The eigenstructure is determined using a spectral analysis of PPG [27]. The cloud database is a flexible and simply accessible data supervision which saves up access, data storage, and analysis [28].

2. PROPOSED METHOD

The suggested healthcare system combines cloud computing, deep learning, clustering, genetic, and ensemble algorithms. This integration improves data management, patient analysis, resource allocation, and decision-making. Healthcare firms may safely store and access massive data and computing resources using cloud technology. Deep learning models will identify early illness and personalized therapy, while clustering algorithms will separate individuals for customized treatment. Genetic algorithms will improve hospital operations, while ensemble algorithms will improve clinical decision support. This system will transform healthcare delivery by improving patient outcomes and cost-effective management while addressing data security, computing resources, interpretability, and ethics. The objective of this study is to comprehensively investigate the intricate dynamics of integrating cloud computing technology into the healthcare sector, offering an in-depth analysis of its advantages and disadvantages. The study aims to present a novel perspective that contributes to both fields by delving into the emerging intersection of cloud computing and healthcare. The study seeks to identify and evaluate the manifold benefits cloud computing can bring to healthcare operations, encompassing enhanced data storage, accessibility, scalability, and collaborative capabilities. Ultimately, the study endeavors to enrich academic, professional, and decision-making landscapes by offering valuable insights that shape the discourse surrounding the amalgamation of cloud computing and healthcare.

The study delves into the benefits and drawbacks of incorporating cloud computing solutions within healthcare settings through a comprehensive analysis. Real-world case studies and practical examples showcase the tangible application of cloud technology in healthcare. At the same time, a spotlight on privacy and security concerns addresses the unique challenges of storing sensitive patient data in the cloud. Tailored recommendations consider healthcare regulations, offering insights for organizations implementing cloud solutions. The study sheds light on the potential transformative effects by examining the impact on patient care, clinical outcomes, and future healthcare trends. Ethical considerations, collaboration enhancement, and interdisciplinary insights contribute to a holistic view of the subject. Through its multidisciplinary approach, the study advances academic and professional understanding and equips stakeholders with valuable insights for informed decision-making, ultimately shaping the landscape where cloud computing and healthcare converge.

2.1. Harnessing the synergy of deep learning and cloud computing in healthcare

The intersection of deep learning and cloud computing in the healthcare sector is a watershed moment with far-reaching implications for the future of many fields of medicine. This integration ushers in a new age of capabilities, one that uses state-of-the-art technology to expand the horizons of healthcare insights. Accurate diagnoses, preventative healthcare methods, and individualized therapies are all within reach as medical practitioners learn to harness these talents. Redefining patient care, elevating research paradigms, and navigating unknown medical frontiers are all within reach if the healthcare industry can maximize the synergy between deep learning and cloud computing. Figure 1 shows patient evaluation and assignment modules. The sample begins with four patients' assessments. The anticipated diagnostic time and available doctor listings are generated. In the patient assignment module, we optimize to reduce doctor diagnosis time differences. The patients are then diagnosed by their physicians.

In (1) shows the convolution operation equation. In convolutional neural networks (CNNs), convolution is a fundamental operation. This equation defines how a filter (kernel) K is convolved with an input image I to create feature maps. It involves element-wise multiplication and summation of pixel values in the input and the filter, sliding the filter over the image. CNNs excel at extracting hierarchical features from images, which is crucial in medical image analysis.

$$(I^{*}K)(x,y) = \sum_{i=1}^{m}\sum_{j=1}^{n} I(x+i, y+j).K(i,j) \tag{1}$$

Healthcare is one area where cloud computing and sophisticated algorithms might have a profound impact. Cloud computing allows medical facilities to safely store and provide quick access to large amounts of patient data, giving doctors and nurses instantaneous access to up-to-date information. Telemedicine and remote patient monitoring are becoming more commonplace because of cloud computing and algorithms, expanding access to healthcare for more people. Furthermore, the ability to extract useful insights from massive datasets is made possible by the power of data analytics and predictive modeling, powered by advanced algorithms, providing healthcare clinicians with significant tools for early illness identification, epidemic prediction, and individualized treatment recommendations. This integration has great potential for enhancing healthcare delivery, research, efficiency, and effectiveness. Figure 2 presents the percentages achieved in each subfield of the deep learning algorithm for healthcare data analysis by 2015, 2018, and 2020. It demonstrates healthcare integration trends of advanced algorithms such as ensemble algorithms, genetic algorithms, clustering techniques, deep learning use, and cloud computing integration technologies over time.

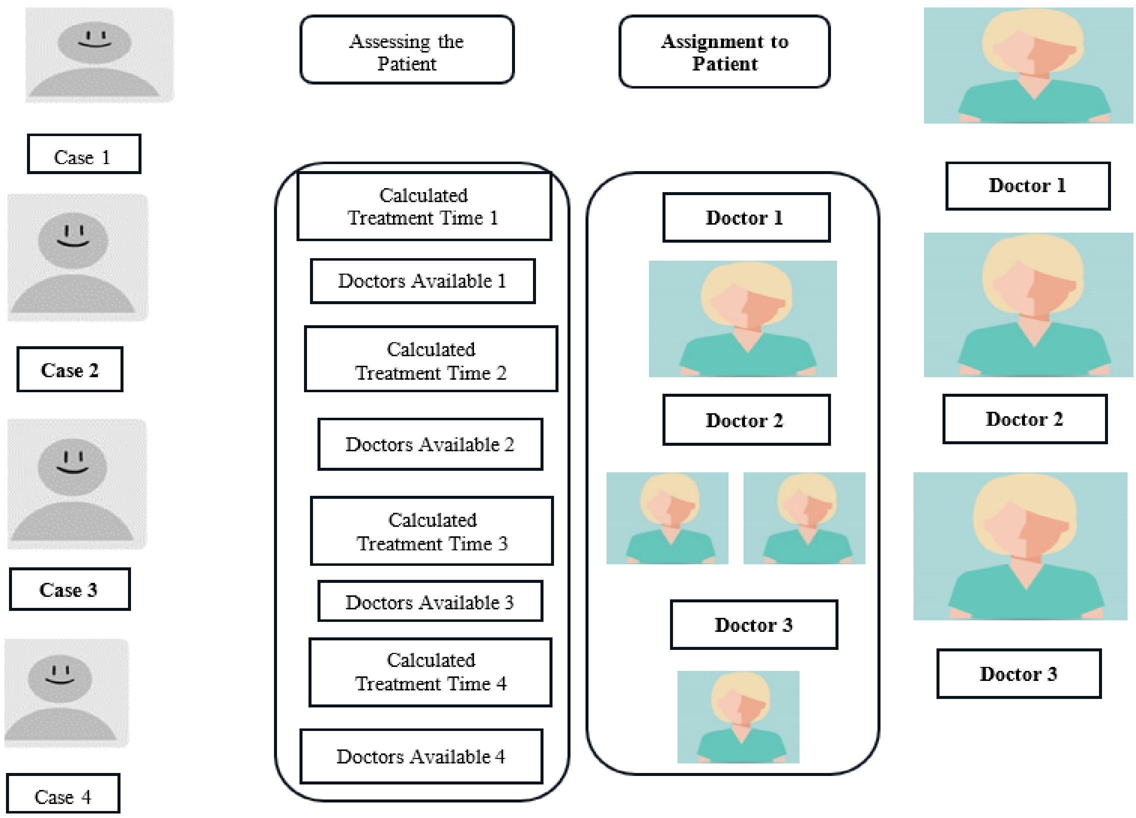

Figure 1. Patient's diagnosis by physicians

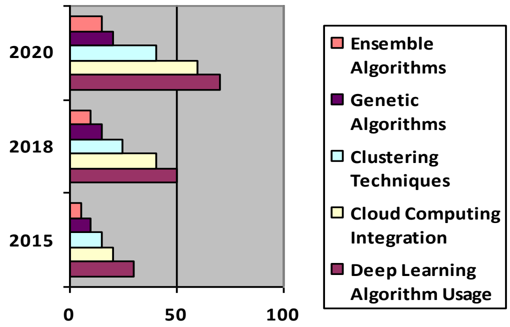

Figure 2. Yearwise consumption of deep learning algorithm from 2015-2020 of cloud computing in healthcare

Table 1 briefly contrasts deep learning and clustering algorithms. Clustering finds data patterns without labeled examples, whereas deep learning uses neural networks to analyze complicated data. The former requires more resources, whereas clustering is computationally lighter and may reveal data structures.

Table 1. Comparison between deep learning algorithms and clustering algorithms

Aspect	Deep learning algorithms	Clustering algorithms
Explanation	Neural networks in deep learning detect patterns, excelling in images language.	Similarity-based clustering aids unsupervised pattern recognition and data separation.
Applicability	Suitable for sophisticated pictures, audio, text, and video.	Effective at detecting data structures like marketing consumer segments.
Training complexity	Needs plenty of data, time, and processing.	Computationally less demanding, making them better for huge datasets.

2.2. Role of clustering algorithms and cloud computing in healthcare

The healthcare system is changing due to data segmentation, which is shaping individualized therapies, and data insights, which are fueling research efforts. Patient care, research progress, and navigating the complexities of medical difficulties may all be amplified by integrating cloud computing and clustering algorithms into the healthcare ecosystem. Improving Data Subgrouping When combined with cloud computing, clustering algorithms provide a robust system for categorizing medical records.

In (2) deals with K-Means clustering. It assigns data points (x_i) to the nearest cluster center (c_j) based on their distances. The Euclidean distance equation calculates the distance between a data point and a cluster center in a multi-dimensional feature space. This equation is crucial for determining cluster assignments.

$$D(x_i, c_j) = \sqrt{\sum_{k=1}^{n}} (x_{ik} - c_{jk})^2 \quad (2)$$

Training data for supervised machine learning should be labeled. The training data for a supervised learning system that is tasked with classifying handwritten digits might consist of examples of handwritten digits labeled with their correct digit. From training data, assisted learning algorithms develop a model to predict fresh data. Supervised machine learning may anticipate results for incoming datasets similar to labeled datasets. Supervised models employ labels to generate correct models. Examples of supervised learning difficulties follow. Figure 3 diagrammatically shows a supervised machine learning program.

Clustering algorithms and cloud computing will continue to play important roles in the changing landscape of healthcare analytics between 2015 and 2020, as seen in Figure 4, which visually depicts this ecosystem. As can be seen from the steadily increasing percentages, clustering algorithms have seen a notable increase in popularity throughout this time period. This rise indicates that their use and relevance are growing in the field of healthcare data analysis. The use of clustering algorithms in conjunction with cloud computing has resulted in the simplification of data segmentation and administration, which has increased the accuracy of healthcare analytics. Consequently, healthcare professionals now have access to more detailed information, which paves the way for data-driven decision-making, efficient resource allocation, and, ultimately, the delivery of enhanced patient care. This complementary relationship between clustering and cloud technology exemplifies the disruptive influence that they will have on the healthcare industry.

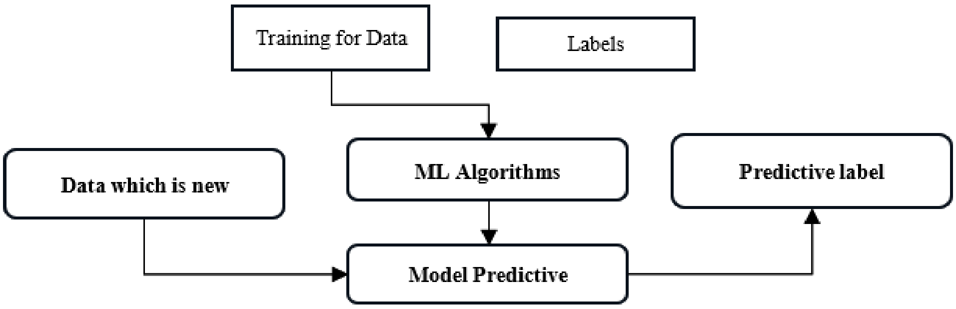

Figure 3. Instructional machine learning

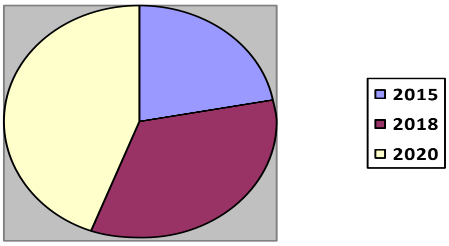

Figure 4. Yearwise healthcare consumption (2015-2020) - integration of clustering algorithms and cloud computing in healthcare

The advantages and disadvantages of using cloud computing in the medical field are outlined in detail in Table 2, which can be seen below. Scalability allows healthcare providers to easily modify their resources in response to changing patient needs, resulting in improved operational efficacy. A significant aspect of modern medicine is the prevention of data loss via data backups. Before moving to the cloud, however, it is necessary to address issues around data security, data breaches, the dependability of vendors, and seamless connectivity with already installed systems. To guarantee a smooth and risk-free transition, healthcare organizations need to consider and assess all of these aspects carefully.

Table 2. Advantages and disadvantages of cloud computing in healthcare

Description	Advantages	Disadvantages
Scalability/Data Security	Cloud computing lets healthcare providers extend processing and storage.	Off-site patient data storage faces unauthorized access, breaches, and privacy compliance.
Cost Efficiency/Reliability	Cloud computing lets healthcare providers extend processing and storage.	If the internet connection goes down, patient care may suffer.
Accessibility/Vendor dependency	Cloud-based medical data and applications allow remote doctor collaboration.	Internet connections might cause downtime, affecting medical care.

3. RESULTS AND DISCUSSION

It takes a well-orchestrated sequence of steps to put a medical procedure into practice for a patient. In the first step, a complete evaluation of the patient is executed, including a review of the patient's medical history, a physical examination, and any other diagnostic procedures that may be necessary. Once the evaluation is finished, the data is analyzed by doctors to determine a diagnosis. The ultimate objective is comprehensive medical treatment with the patient's best interests in mind. Smart systems, such as Artificial Intelligence (AI), ML, IoT, and cloud computing, are used to process this accumulated patient data further further. After this procedure, better patient records are prepared based on the analyzed data collected. Ultimately, this leads to ecstatic fulfillment on the part of the consumer or patient.

Figure 5 presents a breakdown of the evolution of medical infrastructure into its component pieces and investigates these parts. Collecting information and documenting history are the first steps in the process. Collecting personal data, including prior diseases, current medicines, and the family's medical history, is a necessary stage in this process. The diagnosis and therapy planning are constructed using this information as the foundation. Streamlining this process is made possible, in large part, by the integration of electronic health records (EHRs), which also helps to ensure that patient data is accurate and easily available. From that point on, medical practitioners are in a position to make educated judgments, prescribe treatments, and monitor patient progress, all of which eventually contribute to better healthcare outcomes and patient-centered care.

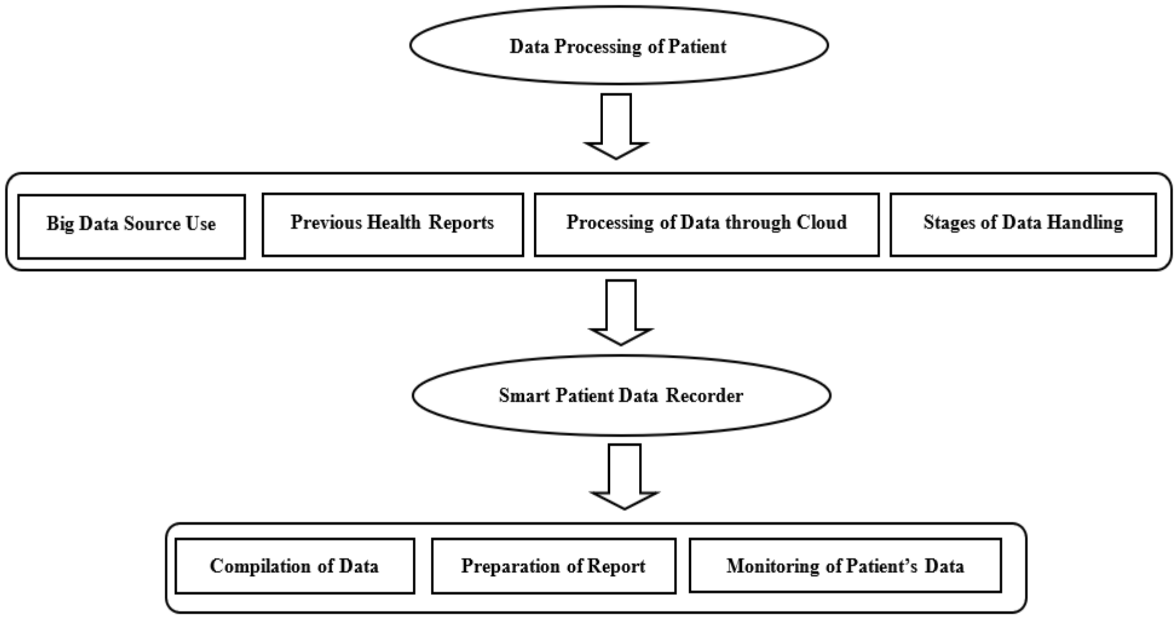

Figure 5. Working steps for implementing medical process

3.1. Harmonizing genetic algorithms and cloud computing in healthcare

A paradigm shift in how healthcare data is analyzed and optimized is on the horizon, thanks to genetic algorithms and cloud computing integration. There is great promise in integrating these technologies, which has the potential to alter the course of medical research and the way patients are treated. The healthcare industry is entering a transformational age as optimization algorithms optimize solutions, customized medicine thrives, and drug development speeds up. Customizing medical care plans personalized medicine is easier with genetic algorithms and cloud computing. Genetic algorithms may pinpoint the most effective therapy courses when applied to patient data. By tailoring care to each person, we can improve health outcomes and provide doctors with more effective treatment methods. Doctors can better provide patients with accurate diagnoses and effective treatment plans with this analytical skill.

The use of genetic algorithms and cloud computing in healthcare analytics is detailed in Figure 6, which depicts the state of the field between 2015 and 2020. During this period, one thing that stands out is how much more important genetic algorithms have become due to the considerable expansion of the function they play. They have emerged as a crucial component in resolving difficult optimization issues in the healthcare industry, such as treatment planning and genomics analysis. Concurrently, cloud computing has developed as a key component in healthcare data administration, providing the safe storage and scalable processing of enormous amounts of healthcare information.

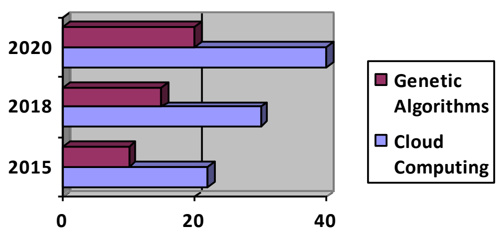

Figure 6. Yearwise healthcare consumption (2015-2020) and integration of genetic algorithms

Cloud computing in healthcare may be advantageous in almost every department. The deployment strategy for cloud solutions is equally crucial to their success. In the eyes of the medical community at large, cloud computing offers unparalleled assistance. The fitness function is shown in (3), which measures how effectively a solution operates in the problem space. This might mean the success of a therapy, the precision of a diagnosis, or the final result for a patient. When the fitness value is high, the quality of the solution has improved.

$$Fitness\ (x) = Evaluation\ (x) \tag{3}$$

3.2. Harmonizing ensemble algorithms and cloud computing in healthcare

Combining ensemble algorithms with cloud computing ushers in a new age of revolutionary data analysis and clinical decision-making when applied to healthcare. This convergence of technology completely alters the landscape of healthcare information, increasing precision and enhancing the effectiveness of treatment plans for individual patients. The healthcare industry is entering a new era marked by the optimization of prediction models, the enhancement of clinical decision-making, and the amplification of research. The healthcare industry is on the cusp of a revolutionary shift toward data-driven accuracy because of the convergence of ensemble algorithms and the power of cloud computing.

4. CONCLUSION

Cloud computing, deep learning, clustering, genetic algorithms, and ensemble algorithms are all examples of state-of-the-art technology that have been incorporated into healthcare and have triggered a significant revolution. Data-driven and patient-centered care has entered a new age thanks to this shift. Cloud computing's rise as a central tenet has enabled healthcare organizations to deploy a flexible and safe data infrastructure. Deep learning, a branch of AI, has helped medical professionals get valuable insights from previously inaccessible, unstructured medical data, such as patient records and photographs. The diagnosis accuracy and treatment planning have been greatly improved by this technology, leading to better patient outcomes. Clustering algorithms have been essential in helping the healthcare industry categorize patient groups and spot patterns in massive datasets. Patient care has been greatly enhanced while expenses have been kept to a minimum because this segmentation facilitated individualized treatment programs and the allocation of available resources. Medical decision-making has been aided by genetic algorithms, which are inspired by the mechanisms of natural selection.

REFERENCES

[1] X. Pang, Y. F. Ge, K. Wang, A. J. M. Traina, and H. Wang, "Patient assignment optimization in cloud healthcare systems: a distributed genetic algorithm," *Health Information Science and Systems*, vol. 11, no. 1, pp. 1–12, Jun. 2023, doi: 10.1007/s13755-023-00230-1.

[2] S. Selvarasu, K. Bashkaran, K. Radhika, S. Valarmathy, and S. Murugan, "IoT-Enabled Medication Safety: Real-Time Temperature and Storage Monitoring for Enhanced Medication Quality in Hospitals," in *2023 2nd International Conference on Automation, Computing and Renewable Systems (ICACRS)*, pp. 256–261, Dec. 2024, doi: 10.1109/icacrs58579.2023.10405212.

[3] D. Toradmalle, P. Shinde, S. Singh, T. Ahuja, and Y. Rane, "A Comparison of Optimization Algorithms for Task Allocation in Vehicular Fog Computing," *International Journal on Electrical Engineering and Informatics*, vol. 15, no. 1, pp. 134–149, Mar. 2023, doi: 10.15676/ijeei.2023.15.1.9.

[4] R. K. Vanakamamidi, N. Abirami, C. Sasi Kumar, L. Ramalingam, S. Priyanka, and S. Murugan, "IoT Security Based on Machine Learning," in *2023 2nd International Conference on Smart Technologies for Smart Nation, SmartTechCon 2023*, pp. 683–687, Aug. 2023, doi: 10.1109/SmartTechCon57526.2023.10391727.

[5] F. Abdali-Mohammadi, M. N. Meqdad, and S. Kadry, "Development of an IoT-based and cloud-based disease prediction and diagnosis system for healthcare using machine learning algorithms," *IAES International Journal of Artificial Intelligence*, vol. 9, no. 4, pp. 766–771, Dec. 2020, doi: 10.11591/ijai.v9.i4.pp766-771.

[6] A. Haleem, M. Javaid, R. Pratap Singh, and R. Suman, "Medical 4.0 technologies for healthcare: Features, capabilities, and applications," *Internet of Things and Cyber-Physical Systems*, vol. 2, pp. 12–30, 2022, doi: 10.1016/j.iotcps.2022.04.001.

[7] C. Butpheng, K. H. Yeh, and H. Xiong, "Security and privacy in IoT-cloud-based e-health systems-A comprehensive review," *Symmetry*, vol. 12, no. 7, p. 1191, Jul. 2020, doi: 10.3390/sym12071191.

[8] S. S. Nagvanshi, I. Kaur, C. Agarwal, and A. Sharma, "Nonstationary time series forecasting using optimized-EVDHM-ARIMA for COVID-19," *Frontiers in Big Data*, vol. 6, Jun. 2023, doi: 10.3389/fdata.2023.1081639.

[9] S. L. Rosa, E. A. Kadir, Q. H. Abbasi, A. A. Almansour, M. Othman, and A. Siswanto, "Patient Monitoring and Disease Analysis Based on IoT Wearable Sensors and Cloud Computing," in *International Conference on Electrical, Computer, Communications and Mechatronics Engineering, ICECCME 2022*, pp. 1–6, Nov. 2022, doi: 10.1109/ICECCME55909.2022.9988546.

[10] J. F. Andry, G. D. Rembulan, E. L. Salim, E. Fatmawati, and H. Tannady, "Big Data Analytics in Healthcare: COVID-19 Indonesia Clustering," *Journal of Population Therapeutics and Clinical Pharmacology*, vol. 30, no. 4, pp. 290–300, Jan. 2023, doi: 10.47750/jptcp.2023.30.04.028.

[11] A. P. Begum and P. Selvaraj, "Alzheimer's disease classification and detection by using AD-3D DCNN model," *Bulletin of Electrical Engineering and Informatics*, vol. 12, no. 2, pp. 882–890, Dec. 2023, doi: 10.11591/eei.v12i2.4446.

[12] W. Bovenizer and P. Chetthamrongchai, "A comprehensive systematic and bibliometric review of the IoT-based healthcare systems," *Cluster Computing*, vol. 26, no. 5, pp. 3291–3317, Oct. 2023, doi: 10.1007/s10586-023-04047-1.
[13] A. Lee, J. Mhatre, R. K. Das, and M. Hong, "Hybrid Mobile Cloud Computing Architecture with Load Balancing for Healthcare Systems," *Computers, Materials and Continua*, vol. 74, no. 1, pp. 435–452, 2023, doi: 10.32604/cmc.2023.029340.
[14] S. Anam, Z. Fitriah, N. Hidayat, and M. H. A. A. Maulana, "Classification Model for Diabetes Mellitus Diagnosis based on K-Means Clustering Algorithm Optimized with Bat Algorithm," *International Journal of Advanced Computer Science and Applications*, vol. 14, no. 1, pp. 653–659, 2023, doi: 10.14569/IJACSA.2023.0140172.
[15] Gading Sectio Aryoseto, Is Mardianto, and Anung B. Ariwibowo, "Recommendation System for Mental Health Article on Circle Application," *Intelmatics*, vol. 3, no. 1, pp. 1–6, Jan. 2023, doi: 10.25105/itm.v3i1.16343.
[16] M. S. Jabbar, S. S. Issa, and A. H. Ali, "Improving WSNs execution using energy-efficient clustering algorithms with consumed energy and lifetime maximization," *Indonesian Journal of Electrical Engineering and Computer Science*, vol. 29, no. 2, pp. 1122–1131, Feb. 2023, doi: 10.11591/ijeecs.v29.i2.pp1122-1131.
[17] F. Al-Quayed, M. Humayun, and S. Tahir, "Towards a Secure Technology-Driven Architecture for Smart Health Insurance Systems: An Empirical Study," *Healthcare (Switzerland)*, vol. 11, no. 16, p. 2257, Aug. 2023, doi: 10.3390/healthcare11162257.
[18] M. Hafizt, N. S. Adi, M. Munawaroh, S. Wouthuyzen, and A. S. Adji, "Coral Reef Health Index Calculation From Remote Sensing Data: a Review," *International Journal of Conservation Science*, vol. 14, no. 1, pp. 267–284, Mar. 2023, doi: 10.36868/IJCS.2023.01.17.
[19] H. A. Nugroho and R. Nurfauzi, "A combination of optimized threshold and deep learning-based approach to improve malaria detection and segmentation on PlasmoID dataset," *Facets*, vol. 8, pp. 1–12, Jan. 2023, doi: 10.1139/facets-2022-0206.
[20] N. Nigar, A. Jaleel, S. Islam, M. K. Shahzad, and E. A. Affum, "IoMT Meets Machine Learning: From Edge to Cloud Chronic Diseases Diagnosis System," *Journal of Healthcare Engineering*, vol. 2023, pp. 1–13, Jun. 2023, doi: 10.1155/2023/9995292.
[21] F. Zhou, H. Ding, and X. Ding, "Providing an Improved Resource Management Approach for Healthcare Big Data Processing in Cloud Computing Environment," *International Journal of Advanced Computer Science and Applications*, vol. 14, no. 7, pp. 746–757, 2023, doi: 10.14569/IJACSA.2023.0140782.
[22] Z. Liu, F. Masui, J. Eronen, S. Terashita, and M. Ptaszynski, "A New Approach to Extracting Tourism Focus Points from Chinese Inbound Tourist Reviews after COVID-19," *Sustainability (Switzerland)*, vol. 15, no. 11, p. 8748, May 2023, doi: 10.3390/su15118748.
[23] Z. Chen, X. Zhang, and J. Lee, "Combining PCA-AHP Combination Weighting to Prioritize Design Elements of Intelligent Wearable Masks," *Sustainability (Switzerland)*, vol. 15, no. 3, p. 1888, Jan. 2023, doi: 10.3390/su15031888.
[24] A. Ri and H. An, "Health assessment of natural larch forest in arxan guided by forestry remote sensing integrated with canopy feature analysis," *Frontiers in Environmental Science*, vol. 11, May 2023, doi: 10.3389/fenvs.2023.1171660.
[25] K. Karthika, S. Dhanalakshmi, S. M. Murthy, N. Mishra, S. Sasikala, and S. Murugan, "Raspberry Pi-Enabled Wearable Sensors for Personal Health Tracking and Analysis," in *International Conference on Self Sustainable Artificial Intelligence Systems, ICSSAS 2023 - Proceedings*, pp. 1254–1259, Oct. 2023, doi: 10.1109/ICSSAS57918.2023.10331909.
[26] A. Patil, V. Shardeo, A. Dwivedi, and S. K. Paul, "An integrated framework for digitalization of humanitarian supply chains in post COVID-19 era," *International Journal of Disaster Risk Reduction*, vol. 87, p. 103574, Mar. 2023, doi: 10.1016/j.ijdrr.2023.103574.
[27] B. Meenakshi, B. Gopi, L. Ramalingam, A. Vanathi, S. Sangeetha, and S. Murugan, "Wireless Sensor Networks for Disaster Management and Emergency Response using SVM Classifier," in *2023 2nd International Conference on Smart Technologies for Smart Nation, SmartTechCon 2023*, Aug. 2023, pp. 647–651, doi: 10.1109/SmartTechCon57526.2023.10391435.
[28] A. Deepa, R. Latha, T. S. Kumar, N. K. Manikandan, J. Preetha, and S. Murugan, "IoT-Based Wearable Devices for Personal Safety and Accident Prevention Systems," in *2023 2nd International Conference on Smart Technologies for Smart Nation, SmartTechCon 2023*, pp. 1510–1514, Aug. 2023, doi: 10.1109/SmartTechCon57526.2023.10391691.

BIOGRAPHIES OF AUTHORS

Palayanoor Seethapathy Ramapraba Professor and Head of the Department of Electrical and Electronics Engineering has the teaching Experience of 22 years with 12 years of research experience. Her research interest is Image Processing, Medical Imaging, Embedded, Internet of things, and Renewable Energy. She has graduated from SRM Easwari Engineering college, Madras university Chennai in Electrical and Electronics Engineering (2000). She has obtained her Masters in Sathyabama University Chennai (2006) and Ph.D. Degree also in Sathyabama University Chennai. She has Started her education carrier in the year 2000 as a Lecturer. She has accomplished an ground breaking Research on the early "Diagnosis of Cervical Cancer using Colposcopic Images". This Astute research has brought her the pride of owning Doctorate in Engineering and Biotechnology. She has Jubilantly participated in numerous national and international conferences conducted by reputed organizations. She has published several Papers in International (18) and National (14) and also presented a paper in international conference and National Conferences (20). She is the member of IEEE, Life member of ISTE, IETE and IEI. She has received outstanding women and young women scientist awards. She can be contacted at email: ramaprabatamilselvan@gmail.com.

Moorthy Radhika is an Assistant Professor in Department of Information Technology at R.M.D. Engineering College. She obtained her Bachelors of Technology degree in Information Technology from Bhajarang Engineering College and Master of Engineering degree in Computer Science and Engineering from Velammal Engineering College. She currently pursuing her Ph.D. degree from Anna University. Her areas of interest include big data, machine learning, database management system, and data structure. She has published 5 papers in International Journal and Conference. She can be contacted at email: radikamoorthi@gmail.com.

Sokkanarayanan Sumathi Professor in department of ECE at Sri Sairam Engineering College, Chennai. She having 27 years of teaching experience and her area of specialization includes Biometrics, Image processing, signal processing and embedded system. She obtained her B.Tech in Electronics Engineering at MIT Campus, Anna University, Chennai. She has obtained her M.E in Applied Electronics at Sathyabama University and PhD Degree also in Bimodal Person Authentication System using Multi-biometrics from Sathyabama University. She has Published about 50 papers in National and International Conferences and Journals (Scopus Indexed) and 16 Patents. Acted as a reviewer and technical committee member for many International Conferences. Receiving fund from AICTE, /DST/BRNS/ TNSCST, etc for organizing various workshops, Seminars, STTP, Value added course, national conference and international conference. She is working on research project grant from BRNS for a collaborative Project with IGCAR, Kalpakkam. Received Grant for Product Development under the scheme of COVID-19 Research at NITs and IIEST, Shibpur, MHRD. She can be contacted at email: Sumathisumathi.ece@sairam.edu.in.

Jayavarapu Karthik completed his B.Tech (CSE) from J.N.T. University, Kakinada in 2010 and M.Tech (CSE) from J.N.T. University, Kakinada in 2012. He completed his Ph.D. in Annamalai University and currently working as an Associate Professor in Department of Computer Science & Engineering, Koneru Lakshmaiah Education Foundation, Vaddeswaram, Andhra Pradesh, India. He has published and presented many research papers in reputed international Journals, IEEE conferences and Indian Patents it's also available online. His main research work focuses on data mining and machine learning. He has 11 years of teaching experience. He can be contacted at email: jayavarapukarthik@kluniversity.in.

Nachiappan Senthamilarasi is currently working as Assistant professor in the Department of Computer Science and Engineering in Sathyabama Institute of Science and Technology, Chennai. She has completed her M.Tech (CSE) in Vel Tech Dr. RR & Dr.SR Technical University in 2013 and pursuing Ph.D. in Anna University. She is having 9.6 years of experience in teaching engineering students. Her area of interest is in Internet of things, Networking and image processing. She has published more than 15 papers in international journal and conference proceedings. She is one of the authors of five engineering books. She has awarded for "Best faculty of the year" under sub category published Research-where papers have been accepted in high ranking/indexed journals of the CSI TechNext India conference 2019-Awards to Academia. She can be contacted at email: senthamilarasi.n.cse@sathyabama.ac.in.