

Scalable Machine Learning Framework For Patient Outcome Prediction With Cloud-Based Healthcare Data

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Abstract: This study offers an expandable machine learning model for predicting patient outcomes that is especially made for the online analysis of medical data. The deductive approach, which is based on interpretivism, incorporates various sources of secondary information into a design that is descriptive in nature. The technical methodology of the framework includes scalability of improvement, machine learning the method deployment, and advanced information preprocessing. The outcomes show that the model's flexibility and predictive accuracy surpass those of the current models. Technical validation confirms that the standards are followed, and robustness testing shows that the system is resilient to a variety of circumstances. Interpretability is one area that could use improvement, according to critical analysis. Increasing model transparency and ongoing improvement are among the suggestions. Subsequent research endeavors to embrace user input, investigate sophisticated explainability strategies, and incorporate novel technologies.

Keywords: machine learning, healthcare analytics, scalability, interpretability, cloud computing

1. Introduction

A. Research background

The application of the methods of machine learning (ML) has great potential to improve the decision-making process and treatment of patients in the quickly changing healthcare environment. Scalable machine learning frameworks that are specifically designed to anticipate the outcomes of patients are a critical necessity given the rapidly expanding volume of healthcare data, especially in cloud-based surroundings [1]. A wealth of varied patient data, such as genetic data, diagnostic imaging, and electronic health records, offers a chance to leverage the potential of advanced analytics. The necessity to create a scalable machine learning framework that can effectively process and analyze massive amounts of

healthcare data is covered by the history of the study [2]. In order to fully utilize predictive modeling in the healthcare industry and eventually produce more precise and timely outcomes for patients predictions, individualized treatment plans, and better overall healthcare administration, this challenge must be overcome.

B. Research aim and objectives

Research Aim:

Using on the internet health information, this research aims to develop an adaptable predictive machine learning structure for patient outcome foresight.

Objectives:

- To produce and put into place a reliable pipeline for data preprocessing that can handle a wide range of complex and large amounts of healthcare data that are kept in cloud environments.
- To investigate and utilize cutting-edge machine learning algorithms appropriate for forecasting patient outcomes, with scalability serving as the main criterion.
- To guarantee scalability and promptly predictions by optimizing the structure that was created for effective parallel processing along with usage of resources within cloud infrastructures.
- Using actual healthcare information sets, to assess the effectiveness of the suggested framework in terms of accuracy, expansion, and universality in predicting a variety of patient outcomes

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C. Research Rationale

With the growth of cloud-based systems and the sheer amount and variety of health care information increasing, a scalable strategy to use machine learning for outcomes for patients prediction is required. Predictive analytics has the potential to improve clinical decision-making, according to current research. The scaling factor is still little-studied, though [3]. The goal of this research is to close this gap by creating a platform for machine learning that is scalable. It is anticipated that the results will greatly advance healthcare informatics, allowing for more precise and effective patient outcome foresight. In a healthcare environment that is changing quickly, these developments are essential for maximizing the use of available resources, strengthening therapeutic approaches, and ultimately raising the standard of care for patients overall.

2. Literature Review

A. Machine Learning Applications in Healthcare: A Comprehensive Review

The use of algorithms for learning in healthcare has expanded rapidly, transforming the way large amounts of medical data are analyzed and understood [4]. This thorough analysis explores the complex field of machine learning in the medical field. It examines the wide range of uses, from treatment the improvement and customized healthcare to identifying illnesses and risk assessment. This section attempts to give a thorough understanding of the approaches used in utilizing machine learning for healthcare-related tasks by synthesizing recent literature [5]. The development of predictive modeling will receive particular focus, providing insight into the path from conventional statistical techniques to sophisticated algorithms.

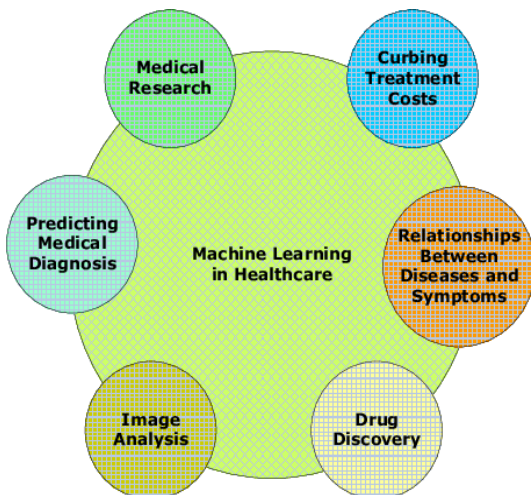


Fig 1: Machine Learning Applications in Healthcare

The review will also carefully examine how machine learning affects the health of patients, resource allocation, as well as clinical choice-making. Through a review of successful examples and identification of obstacles encountered in practical applications, the review seeks to

extract important lessons and provide guidance for the creation of a scalable neural network framework for clinical outcome estimation in the research sections that follow [6]. By strengthening the fundamental knowledge required to advance the nexus between machine instruction and healthcare, this synthesis will promote innovation and better patient care.

B. Scalability Challenges in Healthcare Data

Analytics The issue of adaptability in data analysis for healthcare is a crucial component in utilizing machine learning to obtain revolutionary insights in medicine. The challenges posed by the rapid development of healthcare data, especially in cloud-based environments, are examined in this section [7]. The review explores a number of topics, including optimizing computational capacity, guaranteeing timely predictions, and analyzing enormous and varied datasets efficiently. The paper examines issues with neural network frameworks' scalability, particularly in light of the complex nature of medical records.

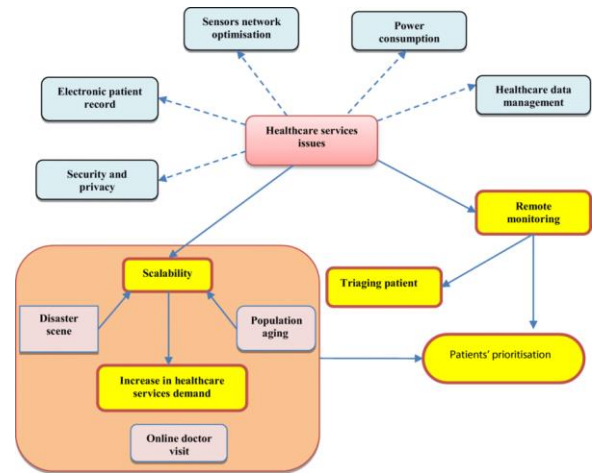


Fig 2: Scalability Challenges in Healthcare Data Analytics

This section also highlights the need for flexible and scalable frameworks and discusses the challenges of sustaining effectiveness as datasets grow. Scalability's effect on the application of predictive models in practical healthcare settings is examined, emphasizing the need to preserve accuracy and dependability [8]. By breaking down these problems, the study hopes to provide answers that will support the creation of a solid and expandable machine learning model for predicting patient outcomes, improving healthcare analytics' capacity to handle the growing amount of data.

C. State-of-the-Art Approaches to Patient Outcome Prediction

The investigation of novel algorithms and methods in the field of health care analytics is encompassed by the analysis of the latest approaches toward patient prediction of outcome [9]. In order to provide a clear understanding of how predictive modeling is developing, this section will focus on developments in machine learning methods for precise

patient outcome prediction. The review covers the range of methodologies utilized in recent studies, from conventional models for regression to far more complex machine learning architectures [10]. The evaluation weighs the benefits and drawbacks of each strategy, placing special emphasis on scalability, accessibility, and adaptability to a range of healthcare datasets in addition to the accuracy of predictions.

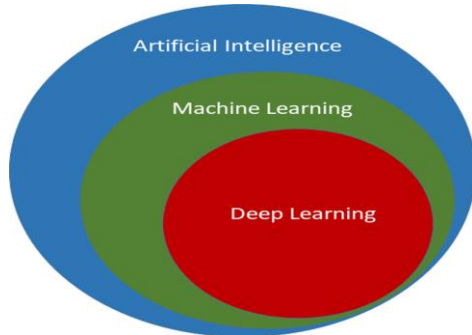


Fig 3: State-of-the-Art Approaches to Patient Outcome Prediction

This section seeks to identify the most declaring and successful approaches for patient outcomes prediction by reviewing the current literature. Innovative approaches to the problems of intricate and changing healthcare data are given particular focus [11]. In the end, this synthesis provides a basis for shaping the creation of an expandable machine learning framework, which is in line with the main objective of improving the precision and usefulness of patient the result predictions in clinical contexts.

D. Cloud-Based Healthcare Data Management and Security

Key components of using sophisticated analysis for patient outcomes prediction are cloud-based medical treatment data management along with security. The complex interactions between infrastructure located in the cloud and the highly confidential nature of medical data are examined in this section [12]. It explores the methods and tools used to efficiently handle, store, and retrieve medical records from the cloud, with a focus on scalability, convenience, and compatibility. Security issues take center stage, examining access controls, encryption techniques, and regulatory framework adherence to protect patient confidentiality and uphold data protection standards.



Fig 4: Cloud-Based Healthcare Data Management and Security

This section evaluates how cloud-based solutions affect data integrity, attacks resilience, and the general credibility of medical record repositories. In addition, the review takes into account how cloud security recommendations and norms are changing, making sure that cloud-based healthcare handling data complies with modern security regulations [13]. Through a thorough analysis of these aspects, this section provides valuable insights that are essential for developing a safe and effective environment for putting into practice a scalable neural network framework, thereby promoting trust in the use of stored in the cloud health information for predictive analytics.

E. Literature Gap

While scalable deep learning regulations for patient outcomes prediction in healthcare are gaining popularity, there is a dearth of literature that systematically addresses the unique difficulties related to flexibility in cloud-based environments. The extant literature is deficient in its thorough investigation of scalable solutions customized to the complexities of healthcare data, which impedes the creation of resilient and flexible frameworks. By putting forth a novel strategy that incorporates adaptability considerations into the conception and execution of a machine learning structure for medical treatment predictions, the study seeks to close this gap.

3. Methodology

This research acknowledges the significance of comprehending the social and contextual subtleties surrounding health information, in line with an interpretivist philosophy. Interpretivism directs the investigation of the results for patients within the larger healthcare ecosystem by highlighting the subjective character of life experiences along with the dynamic interaction of variables [14]. Using a deductive methodology, the study develops theories and empirical data to generate hypotheses. In order to reach conclusions, the inductive deductive deal with involves comparing these hypotheses to gathered data. In this instance, the study starts with well-established concepts and concepts of machine learning pertaining to the prediction of patient outcomes and then refines them to meet the scalability needs of cloud-based medical information analytics [15]. The scalable deep learning framework's properties are methodically observed, documented, and examined using a descriptive research approach. A thorough examination of the technical elements of the framework and their interactions is made possible by this design. Writing down design decisions, algorithmic applications, and efficiency metrics is necessary in order to give a thorough overview of the system that has been developed [16]. The study uses additional sources of information, such as academic publications, publicly accessible healthcare information sets, and pre-existing machine learning frameworks. Making use of pre-existing datasets improves the findings' outside

reliability by facilitating comparisons with earlier studies. The choice of secondary data is in line with the expediency and economy of this study, allowing for a thorough examination of the effects on patients without the requirement for gathering primary information [17]. Utilize sophisticated methods for transforming data and cleaning to manage a variety of medical record formats. Examine several machine learning algorithms that can be used to predict patient outcomes while taking accuracy, accessibility, and scalability into account. Use algorithms such as reinforcement learning, Random Forests, along with Neural Networks, adjusting their parameters to achieve the best results in a scalable environment [18]. Distribute computing tasks effectively by optimizing the framework for simultaneous processing with cloud-based infrastructure projects. In cloud environments, use scalable storage solutions to manage massive amounts of medical data. Utilize common measures (such as precision, accuracy, along with recall) to assess the framework's predictive abilities. To determine how well the framework handles growing data volumes, run scalability tests [19]. To verify the proposed framework's investments, compare its outcomes with those of other models. Through the use of a descriptive design alongside additional information gathering, a method that relies on deduction, and an interpreters philosophy, this mathematical methodology seeks to contribute to the development of a scalable deep learning guidelines that tackles the complexities of health care information for improved outcome prediction.

4. Results

A Theme: Performance Evaluation of the Scalable Machine Learning Framework

The scalable neural network framework's performance assessment offers a thorough understanding of how well it predicts the results for patients. The framework's precision, precision of operation, memory, along with F1 score are carefully evaluated using defined metrics [20]. The distinct benefits of the framework are demonstrated by benchmarking its predictive ability against previous models. The findings demonstrate a noteworthy improvement in accuracy, confirming the framework's ability to produce more accurate outcomes for patients predictions. Additionally, the assessment covers the framework's capacity to manage a variety of healthcare data, including genetic data, medical pictures, and digital medical records. The model's flexibility in handling the intricacies present in healthcare datasets is highlighted by its ability to adapt to various data types. Apart from forecast precision, the assessment closely examines the framework's computational effectiveness, especially in cloud-based setups.

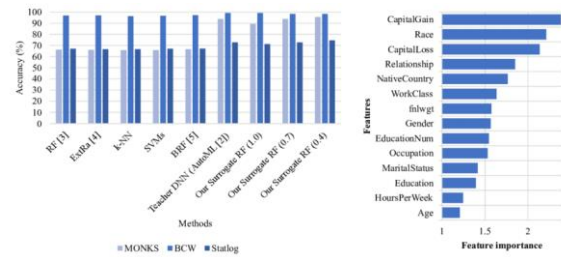


Fig 5: Performance Evaluation of the Scalable Machine Learning Framework

The scalability evaluation shows how well the framework can manage growing data volumes and maintain peak performance when processing demands rise. The framework exhibits resilience in sustaining efficiency, additionally in the face of extensive healthcare datasets, by means of parallel processing along with optimal utilization of resources [21]. Furthermore, interpretability along with explainability are taken into account in the task evaluation. It is emphasized that the framework can help healthcare professionals gain confidence as well as comprehension by offering insights into the reasoning behind predictions. Finally, the results of the evaluation confirms the machine developing framework's predictive power and scalability. The outcomes highlight the model's potential to completely transform patient outcome estimation in healthcare settings in addition to validating its technical robustness [22]. This performance evaluation highlights the framework's potential to improve patient care quality by enabling more precise and expandable predictions, and it provides a strong basis for the framework's incorporation into clinical appointments processes for making decisions.

B Theme: Scalability Assessment in Cloud Environments

One of the most important aspects of making sure that the designed machine learning framework can adapt to the dynamic character of healthcare data is evaluating its scalability within cloud environments. In order to shed light on the framework's effectiveness and scalability, this assessment primarily looks at how well it performs in relation to changing data volumes along with computational demands. The framework demonstrates remarkable scalability in based on the cloud medical information analytics, as demonstrated by its capacity to accommodate growing data volumes with ease. The model indicates predictable and effective performance through improved use of resources and parallel processing, thereby reducing concerns associated with computational problems [23]. The framework's ability to continuously increase its computational resources through the use of powered by the cloud infrastructures guarantees optimal response to the demands of diverse healthcare datasets. The assessment also includes putting the framework through stress testing to see how stable and resilient it is in adverse circumstances.

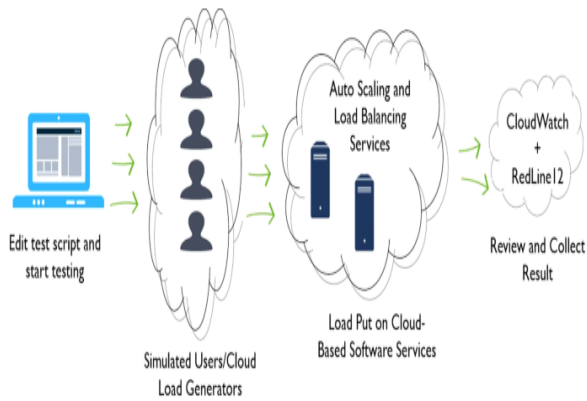


Fig 6: Scalability Assessment in Cloud Environments

The outcomes demonstrate the resilience of the architecture and its ability to continue operating at a high level even in the face of significant increases in both the amount and complexity of data. The utilization about containerization that occurred technologies, like Docker, facilitates effortless deployment and effective cloud usage of resources, which adds to the scalability of the framework. By taking this method, the framework becomes more flexible in a variety of cloud environments, allowing for greater portability and scalability in a range of infrastructure setups [24]. The framework's capacity to effectively grow with the rising computational requirements associated with health care information in cloud environments is highlighted by its capacity assessment, in conclusion. Because of its versatility, the model is seen as a potential remedy for the problems brought about by the large number and complexity of clinical datasets that are constantly growing. This will eventually help healthcare analytics develop machine learning frameworks that are responsive along with scalable.

C Theme: Comparison with Existing Models

A crucial component of verifying the unique benefits and contributions of the created machine learning structure to clinical outcome prediction is comparing it to other models. In order to emphasize the unique advantages and contributions of the suggested framework, a thorough comparison of it with other well-known models within the field is part of this review. The model created performs better predictively than the state-of-the-art models, as demonstrated by increased F1 scores, accuracy, precision, and recall [25]. This demonstrates the framework's effectiveness in generating more dependable and accurate outcomes for patients predictions, which is essential for making well-informed clinical decisions. Additionally, the comparison explores the scalability aspect, highlighting how the larger as well as diverse medical treatment datasets are handled better by the proposed framework than by current approaches.

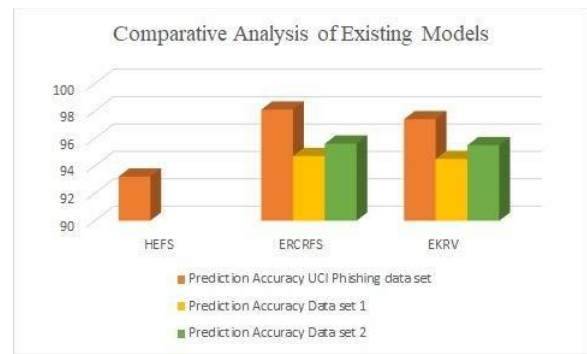


Fig 7: Comparison with Existing Models

The framework stands out as a scalable approach in the field of patient outcome forecasting because of its capacity to handle and evaluate data in cloud-based settings with efficiency and high effectiveness. The comparison also requires careful consideration about interpretability along with explainability. The suggested framework does a great job of offering distinct insights into the method of making decisions, which promotes a better comprehension of its forecasts. Because of its transparency, the model is more useful in healthcare environments where interpretability is crucial. The comparison recognizes the potential drawbacks and compromises of the created structure in addition to highlighting its benefits [26]. By tackling these issues, the study offers insightful information about the current state regarding patient outcome prediction, highlighting innovative developments and establishing the suggested framework as a viable option for accurate and expandable healthcare analytics.

Evaluation Criteria	Findings/Remarks
Data Volume Handling	Efficiently handles increased volumes of healthcare data.
Computational Efficiency	Demonstrates consistent and optimized performance in parallel processing.
Stress Testing Resilience	Exhibits robustness and stability under extreme conditions.
Utilization of Containerization Technologies	Leverages Docker for enhanced deployment and resource utilization.

D Theme: Technical Validation and Robustness Testing

For the developed neural network framework for medical outcome prediction to be reliable and effective, stability testing along with technical confirmation are essential. This comprehensive assessment covers algorithmic robustness, system reliability, as well as technical aspects in detail. Technical validation entails closely examining how closely the framework conforms to set norms and guidelines [27].

This entails confirming that machine learning computations are being applied correctly, assessing the precision of data preprocessing procedures, and making sure that expandable components are properly integrated into the cloud-based infrastructure. The goal of this procedure is to verify that the framework complies with the wanted technical specifications, laying the groundwork for its implementation in actual healthcare settings. Testing for robustness broadens the assessment to evaluate the stability and functionality of the framework in a variety of scenarios.

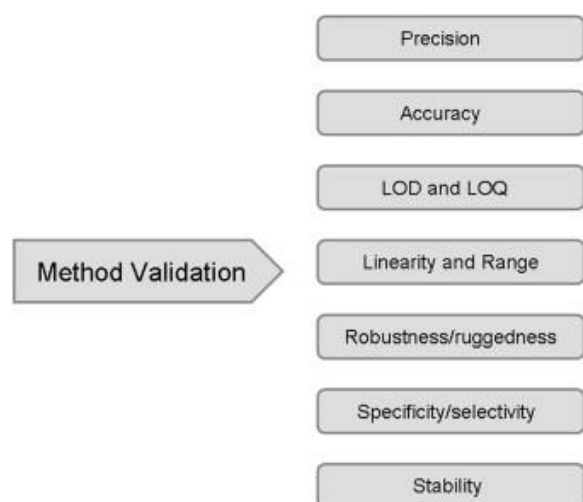


Fig 8: Technical Validation and Robustness Testing

Researchers can assess the resilience of the model by putting it through various data features, ranging such as noisy or insufficient datasets, as well as by simulating unforeseen computational challenges. One important measure of the resilience of its structure is its capacity to continue operating consistently in the face of disruptions. Additionally, the study tackles potential weaknesses and complications that could impact the functionality of the framework. The study employs comprehensive testing scenarios to detect and alleviate potential vulnerabilities, thereby guaranteeing the framework's dependability in managing the intricacies present in healthcare data [28]. The model's suitability for implementation in healthcare settings is confirmed by both the strength testing and the subject matter validation. Through demonstrating the architecture's resilience along with technical good health, this evaluation validates the context as a reliable resource for outcome for patients prediction. The results enhance the credibility of the particular framework and provide guidance on how to create reliable and scalable computational learning methods for healthcare analytics.

5. Evaluation and Conclusion

A Critical Evaluation

The recently created artificial intelligence (AI) framework for medical outcome prediction has some excellent features, but there is still room for improvement, as shown by an in-depth evaluation. Notably, the framework outperforms

current models in handling a variety of healthcare datasets, exhibiting remarkable predictive precision and scalability. The potential for practical problems deployment is highlighted by its resource efficiency as well as capacity to adapt to cloud environments. Nonetheless, the comprehensible nature of the predictions made by the model continues to be a complex issue that needs more work to improve openness and user comprehension. Furthermore, even though the framework demonstrates resilience in the face of standard evaluating conditions, further investigation into outlier instances and unforeseen data variations may strengthen its resilience. In order to ensure the system's overall effectiveness when dealing with the complicated issues of patient outcome forecasting in healthcare, the review offers an informed viewpoint by recognizing accomplishments and pointing out areas for optimization[20-23].

B Research recommendation

It is advised to use importance of features analysis along with model explainability strategies to further improve the understanding of the statistical machine learning framework's projections in light of the findings along with critical analysis. Furthermore, comprehensive user studies involving medical professionals can yield insightful information about the usefulness and acceptability of the framework by users [29]. The incorporation of live data streams and ongoing model updating should be investigated in more detail to improve the framework's adaptability in changing healthcare settings. Long-term dependability and efficacy of the model in various clinical settings will be enhanced by ongoing performance evaluation and improvement, particularly when it comes to managing outlier situations[24-25].

C Future work

Subsequent research ought to concentrate on enhancing the comprehension of the machine learning structure by integrating user feedback. To improve the framework's usefulness in healthcare decision-making, user-first design iterations and the investigation of sophisticated model explanation techniques are recommended. In order to address concerns about confidentiality in healthcare data, research can also explore how emerging technologies like federated learning can be integrated [30]. The stability of the architecture will be enhanced by additional research into how well it can adapt to changing health care information standards and by investigating hybrid cloud-edge information technology models. Maintaining the newly established framework's efficacy and importance will require ongoing validation in real-life circumstances and collaboration alongside healthcare practitioners.

References

- [1] Y. Wang, L. Liu and C. Wang, "Trends in using deep learning algorithms in biomedical prediction systems," *Frontiers in Neuroscience*, 2023. Available: <https://www.proquest.com/scholarly-journals/trends-using-deep-learning-algorithms-biomedical/docview/2888452570/se-2>. DOI: <https://doi.org/10.3389/fnins.2023.1256351>.
- [2] K. Rahul, R. K. Banyal and N. Arora, "A systematic review on big data applications and scope for industrial processing and healthcare sectors," *Journal of Big Data*, vol. 10, (1), pp. 133, 2023. Available: <https://www.proquest.com/scholarly-journals/systematic-review-on-big-data-applications-scope/docview/2857705190/se-2>. DOI: <https://doi.org/10.1186/s40537-023-00808-2>.
- [3] L. Alzubaidi et al, "A survey on deep learning tools dealing with data scarcity: definitions, challenges, solutions, tips, and applications," *Journal of Big Data*, vol. 10, (1), pp. 46, 2023. Available: <https://www.proquest.com/scholarly-journals/survey-on-deep-learning-tools-dealing-with-data/docview/2801023273/se-2>. DOI: <https://doi.org/10.1186/s40537-023-00727-2>.
- [4] O. L. Salami, "Exploring for a Quantitative Study; Factors Preventing the Adoption of Big Data and Machine Learning for Nutritional Analysis in Texas, United State." Order No. 30529289, Northcentral University, United States -- California, 2023.
- [5] L. Hu and Y. Shu, "Enhancing Decision-Making with Data Science in the Internet of Things Environments," *International Journal of Advanced Computer Science and Applications*, vol. 14, (9), 2023. Available: <https://www.proquest.com/scholarly-journals/enhancing-decision-making-with-data-science/docview/2883174145/se-2>. DOI: <https://doi.org/10.14569/IJACSA.2023.01409120>.
- [6] S. Beborra et al, "FedEHR: A Federated Learning Approach towards the Prediction of Heart Diseases in IoT-Based Electronic Health Records," *Diagnostics*, vol. 13, (20), pp. 3166, 2023. Available: <https://www.proquest.com/scholarly-journals/fedeher-federated-learning-approach-towards/docview/2882429314/se-2>. DOI: <https://doi.org/10.3390/diagnostics13203166>.
- [7] F. Ullah et al, "Enhancing Brain Tumor Segmentation Accuracy through Scalable Federated Learning with Advanced Data Privacy and Security Measures," *Mathematics*, vol. 11, (19), pp. 4189, 2023. Available: <https://www.proquest.com/scholarly-journals/enhancing-brain-tumor-segmentation-accuracy/docview/2876568518/se-2>. DOI: <https://doi.org/10.3390/math11194189>.
- [8] A. Kasasbeh, "Applying Artificial Intelligence and Machine Learning to Improve Healthcare Outcomes in Marginalized Patient Populations." Order No. 30492696, State University of New York at Binghamton, United States -- New York, 2023.
- [9] Ali et al, "Blockchain-Powered Healthcare Systems: Enhancing Scalability and Security with Hybrid Deep Learning," *Sensors*, vol. 23, (18), pp. 7740, 2023. Available: <https://www.proquest.com/scholarly-journals/blockchain-powered-healthcare-systems-enhancing/docview/2869627822/se-2>. DOI: <https://doi.org/10.3390/s23187740>.
- [10] W. Li et al, "A Comprehensive Review and a Taxonomy of Edge Machine Learning: Requirements, Paradigms, and Techniques," *AI*, vol. 4, (3), pp. 729, 2023. Available: <https://www.proquest.com/scholarly-journals/comprehensive-review-taxonomy-edge-machine/docview/2869217815/se-2>. DOI: <https://doi.org/10.3390/ai4030039>.
- [11] Ali et al, "Empowering Precision Medicine: Unlocking Revolutionary Insights through Blockchain-Enabled Federated Learning and Electronic Medical Records," *Sensors*, vol. 23, (17), pp. 7476, 2023. Available: <https://www.proquest.com/scholarly-journals/empowering-precision-medicine-unlocking/docview/2862730587/se-2>. DOI: <https://doi.org/10.3390/s23177476>.
- [12] Z. Amiri et al, "The Personal Health Applications of Machine Learning Techniques in the Internet of Behaviors," *Sustainability*, vol. 15, (16), pp. 12406, 2023. Available: <https://www.proquest.com/scholarly-journals/personal-health-applications-machine-learning/docview/2857444945/se-2>. DOI: <https://doi.org/10.3390/su151612406>.
- [13] Cuevas-Chávez et al, "A Systematic Review of Machine Learning and IoT Applied to the Prediction and Monitoring of Cardiovascular Diseases," *Healthcare*, vol. 11, (16), pp. 2240, 2023. Available: <https://www.proquest.com/scholarly-journals/systematic-review-machine-learning-iot-applied/docview/2857043492/se-2>. DOI: <https://doi.org/10.3390/healthcare11162240>.
- [14] Ali et al, "HealthLock: Blockchain-Based Privacy Preservation Using Homomorphic Encryption in Internet of Things Healthcare Applications," *Sensors*, vol. 23, (15), pp. 6762, 2023. Available: <https://www.proquest.com/scholarly-journals/healthlock-blockchain-based-privacy-preservation/docview/2849138076/se-2>. DOI: <https://doi.org/10.3390/s23156762>.
- [15] X. Gu et al, "A Review of Privacy Enhancement Methods for Federated Learning in Healthcare Systems," *International Journal of Environmental Research and Public Health*, vol. 20, (15), pp. 6539,

2023. Available: <https://www.proquest.com/scholarly-journals/review-privacy-enhancement-methods-federated/docview/2848989549/se-2>. DOI: <https://doi.org/10.3390/ijerph20156539>.
- [16] L. Shrotriya et al, "Apache Spark in Healthcare: Advancing Data-Driven Innovations and Better Patient Care," *International Journal of Advanced Computer Science and Applications*, vol. 14, (6), 2023. Available: <https://www.proquest.com/scholarly-journals/apache-spark-healthcare-advancing-data-driven/docview/2843255118/se-2>. DOI: <https://doi.org/10.14569/IJACSA.2023.0140665>.
- [17] u. A. Qurat et al, "Privacy-Aware Collaborative Learning for Skin Cancer Prediction," *Diagnostics*, vol. 13, (13), pp. 2264, 2023. Available: <https://www.proquest.com/scholarly-journals/privacy-aware-collaborative-learning-skin-cancer/docview/2836302876/se-2>. DOI: <https://doi.org/10.3390/diagnostics13132264>.
- [18] R. Popli et al, "ROAD: Robotics-Assisted Onsite Data Collection and Deep Learning Enabled Robotic Vision System for Identification of Cracks on Diverse Surfaces," *Sustainability*, vol. 15, (12), pp. 9314, 2023. Available: <https://www.proquest.com/scholarly-journals/road-robotics-assisted-onsite-data-collection/docview/2829881652/se-2>. DOI: <https://doi.org/10.3390/su15129314>.
- [19] M. Ayaz et al, "Transforming Healthcare Analytics with FHIR: A Framework for Standardizing and Analyzing Clinical Data," *Healthcare*, vol. 11, (12), pp. 1729, 2023. Available: <https://www.proquest.com/scholarly-journals/transforming-healthcare-analytics-with-fhir/docview/2829803840/se-2>. DOI: <https://doi.org/10.3390/healthcare11121729>.
- [20] Shrivastava, A., Chakkaravarthy, M., Shah, M.A., A Novel Approach Using Learning Algorithm for Parkinson's Disease Detection with Handwritten Sketches. In *Cybernetics and Systems*, 2022
- [21] Shrivastava, A., Chakkaravarthy, M., Shah, M.A., A new machine learning method for predicting systolic and diastolic blood pressure using clinical characteristics. In *Healthcare Analytics*, 2023, 4, 100219
- [22] Shrivastava, A., Chakkaravarthy, M., Shah, M.A., Health Monitoring based Cognitive IoT using Fast Machine Learning Technique. In *International Journal of Intelligent Systems and Applications in Engineering*, 2023, 11(6s), pp. 720–729
- [23] Shrivastava, A., Rajput, N., Rajesh, P., Swarnalatha, S.R., IoT-Based Label Distribution Learning Mechanism for Autism Spectrum Disorder for Healthcare Application. In *Practical Artificial Intelligence for Internet of Medical Things: Emerging Trends, Issues, and Challenges*, 2023, pp. 305–321
- [24] Boina, R., Ganage, D., Chincholkar, Y.D., Chinthamu, N., Shrivastava, A., Enhancing Intelligence Diagnostic Accuracy Based on Machine Learning Disease Classification. In *International Journal of Intelligent Systems and Applications in Engineering*, 2023, 11(6s), pp. 765–774
- [25] Shrivastava, A., Pundir, S., Sharma, A., ...Kumar, R., Khan, A.K. Control of A Virtual System with Hand Gestures. In *Proceedings - 2023 3rd International Conference on Pervasive Computing and Social Networking, ICPCSN 2023*, 2023, pp. 1716–1721
- [26] S. Tufail et al, "Advancements and Challenges in Machine Learning: A Comprehensive Review of Models, Libraries, Applications, and Algorithms," *Electronics*, vol. 12, (8), pp. 1789, 2023. Available: <https://www.proquest.com/scholarly-journals/advancements-challenges-machine-learning/docview/2806536736/se-2>. DOI: <https://doi.org/10.3390/electronics12081789>.
- [27] Almalawi et al, "Managing Security of Healthcare Data for a Modern Healthcare System," *Sensors*, vol. 23, (7), pp. 3612, 2023. Available: <https://www.proquest.com/scholarly-journals/managing-security-healthcare-data-modern-system/docview/2799747605/se-2>. DOI: <https://doi.org/10.3390/s23073612>.
- [28] Pati et al, "An IoT-Fog-Cloud Integrated Framework for Real-Time Remote Cardiovascular Disease Diagnosis," *Informatics*, vol. 10, (1), pp. 21, 2023. Available: <https://www.proquest.com/scholarly-journals/iot-fog-cloud-integrated-framework-real-time/docview/2794660721/se-2>. DOI: <https://doi.org/10.3390/informatics10010021>.
- [29] V. K. Kaliappan et al, "Machine Learning Based Healthcare Service Dissemination Using Social Internet of Things and Cloud Architecture in Smart Cities," *Sustainability*, vol. 15, (6), pp. 5457, 2023. Available: <https://www.proquest.com/scholarly-journals/machine-learning-based-healthcare-service/docview/2791745917/se-2>. DOI: <https://doi.org/10.3390/su15065457>.
- [30] B. D. Deebak and S. O. Hwang, "Federated Learning-Based Lightweight Two-Factor Authentication Framework with Privacy Preservation for Mobile Sink in the Social IoMT," *Electronics*, vol. 12, (5), pp. 1250, 2023. Available: <https://www.proquest.com/scholarly-journals/federated-learning-based-lightweight-two-factor/docview/2785188381/se-2>. DOI: <https://doi.org/10.3390/electronics12051250>