© 2025 IJNRD | Volume 10, Issue 3 March 2025 | ISSN: 2456-4184 | IJNRD.ORG

IJNRD.ORG ISSN : 2456-4184
INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG
An International Open Access, Peer-reviewed, Refereed Journal

A Survey on Decentralized Organ Donation Systems with Machine Learning-Based Compatibility Check

[1]Damini Mali, [2]Divya Kudale, [3]Suyash Marathe, [4]Kirti Borhade
[1,2,3] Student, [4] Assistant Professor
[1,2,3,4] Department of Computer Engineering
[1,2,3,4] Nutan Maharashtra Institute of Engineering and Technology, Pune, India

Abstract: While organ donation systems play an important role in saving lifespans, existing intensive models suffer from lack of transparency, data manipulation, and inefficient organ regulation processes. With advances in technology, blockchain technology has been developed as a decentralized solution that ensures security, transparency and immutability in medical data management. At the same time, the algorithms are used for machine learning such as random forests to improve compatibility prediction for donor receivers taking into account several medical and geographical factors. This paper provides a detailed review of the integration of blockchain technology and machine learning in organ donation systems. It explores a variety of blockchain frameworks, including Ethereum, Hyperledger, and user-defined blockchains, and simultaneously analyzes the role of machine learning when tailoring organ compatibility. This study highlights key factors such as blood type, HLA typing, BMI, infection status, urgency, and geographical situation in determining appropriate agreement. This paper discusses the advantages, challenges and limitations of current systems, while simultaneously identifying key areas for future research and development. Find out how blockchain can improve safety, transparency and data integrity, and machine learning will improve the accuracy and efficiency of organ adjustment. Furthermore, this study describes potential improvements and innovative approaches to optimizing integration of these technologies in organ donation systems.

***Index Terms*— Blockchain Technology, Machine Learning, Organ Donation, Random Forest, Donor-Recipient Matching, Smart Contracts, Transparency, Compatibility Prediction, Data Security, Decentralized Systems.**

I. INTRODUCTION

Organ donation is a critical medical procedure that involves transplanting organs from a donor to a recipient experiencing end-stage organ failure. This critical medical procedure has the potential to greatly enhance the recipient's well-being and extend their lifespan. Despite its significance, the organ donation process is often hindered by inefficient donor recipient matching, lack of transparency, and security vulnerabilities in centralized systems. The World Health Organization (WHO) states that the demand for organ transplants worldwide greatly exceeds the available supply, leading to extended waiting lists and a significant number of preventable deaths. The pressing need for secure, transparent, and efficient organ donation systems has prompted researchers to explore emerging technologies such as blockchain and machine learning to overcome these limitations.

Blockchain technology, recognized for its decentralized, transparent and operation-resistant properties, can be important for the transformation of health systems. Blockchain can improve the security of organ donation systems, improve transparency, improve security of organ donation systems, and improve safety. Smart contracts continue to automate organ coordination and allocation processes, reducing the risk of ensuring operation and fair organ distribution.

Meanwhile, machine learning algorithms have significantly improved the accuracy and efficiency of donor recipient matching. By analyzing several medical and demographic factors, machine learning models can predict compatibility more accurately than traditional manual methods. In particular, Random Forest algorithms have become popular due to their ability to process complex data records and provide reliable predictions for medical applications.

This research paper presents a comprehensive review of existing research findings on the integration of blockchain technology and machine learning algorithms in organ donation systems. This paper examines various blockchain frameworks and machine learning models used to predict compatibility and highlight its benefits, limitations, and future research opportunities. The aim is to clearly understand how these technologies can work together to create a safe, transparent and intelligent organ donation system.

II. LITERATURE REVIEW

A. Review of Alowidi and Naemi (2024)

Arowidi and Naemi (2024) proposed a model of machine learning aimed at optimizing donor recipient matching in the kidney portation. The model was trained under past transplant data, employing parameters such as age, blood type, HLA typing, BMI, and geographic location. The results showed that machine learning approaches significantly improve the accuracy of match, reduce rejection rates, and improve patient outcomes compared to traditional methods. However, this study recognized the need for larger data records and continuous model training to improve predictive defects. This paper concluded that machine learning integration in organ donation systems could revolutionize the allocation process by automating compatibility reviews and minimizing human intervention.

TABLE I

OVERVIEW OF RESEARCH CONTRIBUTIONS IN ORGAN DONATION SYSTEMS

Year	Gap Identified	Benefits	Demerits	Future work
2024	Lack of advanced machine learning models for compatibility prediction	Improved accuracy in donor-recipient matching	Limited dataset size	Incorporate federated learning and larger datasets
2024	Need for multi-organ transplant prediction	High accuracy for multi-organ transplants	High computatio nal cost	Optimize model efficiency and scalability
2024	Limited feature selection in donor-recipient matching	Enhanced compatibility prediction	Small sample size	Integrate more clinical and demographic features
2023	Security vulnerabilities in centralized systems	Enhanced transparency through blockchain	Scalability issues	Design scalable blockchain architecture
2023	Lack of real-time compatibility assessment	Real-time donor-recipient matching	High infrastructure requirements	Implement IoT-based real-time health data integration
2023	Limited privacy in centralized systems	Improved privacy with decentralized systems	High initial implementa tion costs	Explore homomorphic encryption methods
2022	Lack of global organ allocation network	Secure cross-border organ allocation	Regulatory challenges	Collaborate with policymakers to design regulatory frameworks
2022	Inefficient post-transplant monitoring	Enhanced post-transplant care with ML	Data privacy concerns	Develop privacypreservin g machine learning models
2022	High rejection rates in lung transplantation	Early complication detection	Limited generalizability	Expand dataset to include diverse patient populations

B. Review of Tanchip et al. (2024)

Tanzip et al. (2024) proposed a machine learning-based model to predict choice choice and to promote multi-organ transplantation within organ-procured tissues. In this study, we trained a variety of ML models, including random forests, gradient boosts, and neural networks, using orchid data records with over 133,000 donor records. The main focus is predicting the feasibility of multi-organ transplants based on recipient history, organ quality and urgency. This study highlighted the importance of machine learning for organ allocation optimization, while also taking into account the complexity of multi-organ implantation. Despite their success, the authors found that further testing is needed to improve the interpretability of the model, including realtime data processing.

C. Review of Vidya et al. (2024)

Vidya et al. (2024) proposed an ML-driven organ donation system that integrates support vector machines (SVMs) and K-means clustering to automate donor coordination. The system takes into account medical parameters such as blood type, organ type, level of urgency, and tissue compatibility. The clustering algorithm group is based on the emergency level, while the SVM model performs a final compatibility review. Experimental results show high accuracy and recall rates, demonstrating the effectiveness of the model in automating donor selection. However, the authors highlighted the need for much more different data records to improve model generalization. This study concluded that integrating an ML-based system into an organ donation platform can significantly streamline the allocation process and improve transplant outcomes.

D. Review of Ghosh and Dutta (2023)

Ghosh and Dutta (2023) have announced Indriya, a blockchain-based donation system based on Hyperledger fabric. The system uses intelligent contracts to automate organ coordination and allocation, ensuring data transparency and security. The system's architecture includes distributed identity management. This will allow authorized staff to access patient data. This paper concluded that blockchain could significantly improve trust in organ donation systems, but that further improvements in regulatory acceptance performance and acceptance are needed.

E. Review of Pawar and Wankhade (2023)

Pawar and Wankhade (2023) explored the application of blockchain technology in managing organ donation. The system used intelligent contracts to automate donor receivers and prevent fraud. In this study, the role of blockchain was highlighted in improving transparency, security and trust in interest groups. The authors implemented legitimate blockchain networks to obtain verifiable organ donation records. However, this study found high computing efforts related to blockchain transactions. Future research is recommended to improve the energy efficiency and scalability of blockchain-based organ donation systems.

F. Review of Jeong et al. (2023)

Jeong et al. (2023) proposed a private blockchain-based system to improve privacy and transparency of organ donation systems.The system encrypts donor and receiver data using the AES encryption standard (Advanced encryption standard) so that only certified entities can access sensitive information. The blockchain network contains an immutable record of all organ transactions, preventing data manipulation. This study showed that the system significantly improved the storage and reliability of privacy and reliability. However, the authors confirmed the need to integrate zero-knowledge evidence to further improve privacy without compromising transparency.

G. Review of Tribhuvan et al. (2023)

Tribhuvan et al. (2023) developed a custom blockchain-based organ management system that integrates machine learning for predicting donor recipient compatibility. The system uses a random forest algorithm for compatibility reviews and stores all transactional data on a legitimate blockchain. Hybrid systems increase the efficiency, security and transparency of the organ allocation process. This study concluded that the combined use of blockchain and machine learning can significantly improve the fairness and accuracy of organ donation systems. However, the authors emphasize the need for a wider range of data records and interoperability standards to expand the applicability of the system.

H. Review of Gotlieb et al. (2022)

Gotlieb et al. (2022) conducted a comprehensive review of machine learning in solid organ transplantation, examining techniques such as random forests, logistics regression, donor recipients, and neuronal networks to monitor post-transplant surveillance. The review highlighted that ML algorithms can significantly improve accuracy and predict post-implantation complications. However, the authors identified the lack of standardized data records and the need to describe the KI model as a major challenge for wider acceptance.

I. Review of Gholamzadeh et al. (2022)

Gholamzadeh et al. (2022) Systematically checked techniques for machine learning to improve lung transplant outcomes. This study showed that deep learning models surpassed traditional methods for predicting patient post-transplant and survival.

J. Review of Yoon et al. (2017)

Yoon et al. (2017) Confident Match proposed a personalized donor recipient matching system based on ML. Patient-specific characteristics using age, HLA typing, and medical history to optimize compatibility prediction. This study showed that ConfidentMatch surpassed traditional matching methods for predicting columns in ported columns. However, the authors found that the system requires continuous model training and further validation on larger datasets to improve prediction accuracy.

III. METHODOLOGY

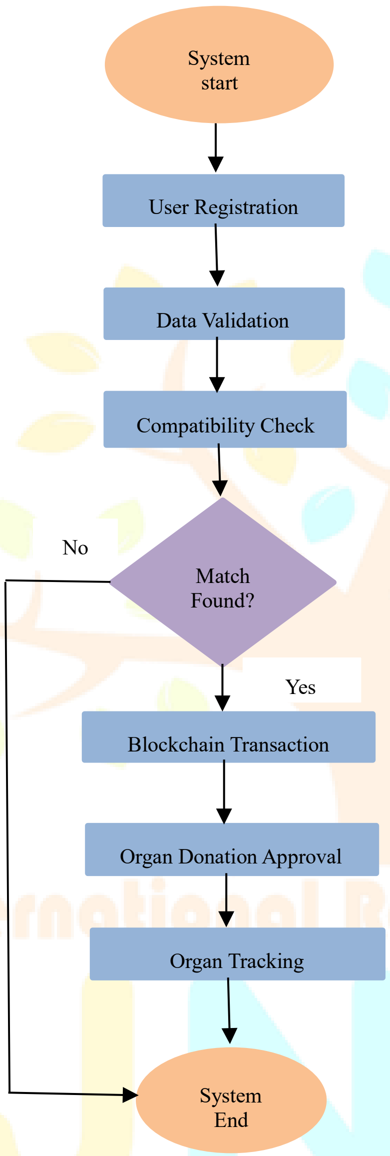

Fig. 1. Flowchart of Proposed System

The proposed organ tracker system methodology is divided into several phases, as shown in the flow diagram.

User Registration: Certified Person Registration - Donor and Recipient Information.
Data Validation: Review of user identity and medical documents.
Compatibility Testing: Machine learning models demonstrate compatibility based on medical and demographic factors.
Match found?: If a match is not found, the system returns to the compatibility check phase.
Blockchain Transaction: As soon as a match is found, the system begins a blockchain transaction for secure storage.
Organic donation permission: Medical authorities approve organ donation.
Organ tracking: Blockchain systems pursue the transport and delivery of organs. **System End:** The process closes with a successful organ transplant.

IV. EXISTING SYSTEM

Existing organ donation systems address centralized framework conditions primarily managed by a variety of interest groups, including hospitals, organ procurement organizations and government agencies. These systems are functional, but suffer from considerable limitations that affect efficiency, transparency and reliability. The key challenges are based on manual processes and outdated response criteria, which affect the allocation process and patient outcomes.

1. **Matching Inefficiency:** The donor recipient matching process is typically performed manually. Compatibility assessments are based on basic parameters such as blood layers and subsidies that do not address more advanced medical factors. Important indicators such as HLA typing, cross-match testing, and patient history of human leukocyte antigens (HLAs) are often overlooked, increasing the risk of implantation and resulting in suboptimal results.

2. **Absence of Real-Time Updates:** The lack of real-time updates in the system leads to delayed organ allocation. Due to the temporal characteristics of organ transplantation it can be life-threatening. Furthermore, the lack of an automatic mechanism of organ distribution exacerbates inefficiency, slows down processes and reduces the ability to respond.

3. **Transparency Issues:** Transparency in assignment decisions remains an important issue. Patients and their families often feel excluded from the process and do not have enough information to understand how decisions are made. This impermeable openness undermines trust, promotes dissatisfaction and undermines confidence in the system.

4. **Vulnerability of Centralized Architecture:** If relying on centralized systems, significant weaknesses are introduced. Centralized databases are susceptible to cyberattacks, unauthorized access, and data injuries that can put sensitive patient and donor information at risk. Furthermore, the lack of distributed decision-making can increase the risk of data manipulation and corruption, and can distort organ allocation.

5. **Systemic Inequities:** Inefficiency within the current system also creates body inequality. Patients from disadvantaged backgrounds may be subject to hurdles when accessing the organ donation process to widen health differences. Without a robust mechanism to ensure fairness, the system is at risk for certain groups.

6. **Technological Gaps:** Existing frameworks lack integration with enhanced digital tools and technologies such as blockchain for transparency, AI for predictive analytics, and IoT for real-time data monitoring. Unavailable with this technology creates gaps in system performance, adaptability, and scalability.

V. CHALLENGES

Organ donation systems face several challenges that hinder their efficiency and equity. Centralized systems are susceptible to cyber attacks and unauthorized access, affecting the security and privacy of sensitive medical data. Furthermore, patients and families are often excluded and feel suspicious. Traditional matching methods are not only time consuming, but also susceptible to errors and are based on manual processes that delay critical porting procedures. Limited use of compatibility metrics, such as basic factors such as blood type and subsidies, prevents accurate agreement with donor recipients and increases the risk of rejection. Furthermore, the lack of real-time updates and automated mechanisms extends the organ allocation process. This can be fatal in time-sensitive situations. Centralized databases also have significant risks for data manipulation, which can affect organ distribution equity.

Inequalities in accessing systems affect patients who are under-balanced, but outdated technology and logistical inefficiency contribute to organ waste. The misunderstanding of the public and lack of awareness of organ donation exacerbate the organ snap crisis, while the lack of global standardization creates challenges regarding cross-border sharing. Elimination of these systemic problems is important to improve outcomes and establish a transparent, more efficient and integrative framework for organ donation.

VI. A REVIEW OF DATASETS USED FOR ORGAN TRACKER

This project uses three main data records to ensure an accurate match with the donor recipient.

1. **Donor Dataset:**
   Attributes: Donor ID, Age, Blood Type, Organ Type, HLA Typing, BMI, Organ Size, Infectious Status, Geographic Location, Health Condition.
   Description: This data record contains comprehensive medical and demographic information about organ donors. Including HLA types and infection status ensure compatibility with recipient needs and minimizes the risk of organ rejection.

2. **Recipient Dataset:**
   Attributes: Recipient ID, Age, Blood Group, Organ Type, HLA Typing, BMI, Infectious Status, Urgency Level, Waiting Time, Geographic Location, Health Condition.
   Description: This data record contains detailed recipient information, allowing the model to prioritize emergency cases and maintain compatibility criteria at the same time.

3. **Compatibility Dataset:**
   Attributes: Combination of donor and recipient features to evaluate match scores.
   Description: This data record is used to train a random forest model to predict compatibility values and optimize contract efficiency. These data records combinations play an important role in improving the accuracy, transparency and efficiency of organ regulation in organ tracker systems.

VII. RESULTS

The proposed organ tracker system is expected to bring about significant advances in relation to security, transparency, equity and efficiency of organ donation and transplant processes through the integration of blockchain technology and machine learning. The main outcome is improved security and data integrity, ensuring that donor and recipient information is manipulated and accessible by authorized medical professionals.

This is achieved through blockchain-based encryption and decentralized data storage. This eliminates the risk of fraudulent changes or fraudulent organizations. The system promotes trust and fairness in organ allocation by using intelligent contracts for transparent decision-making. Compatibility values for machine, learning ability compatibility ensure that organ adjustment is based on medical needs and biological factors that reduce distortion and manual intervention.

In addition, an agreement between automatic rankings and random forest algorithms improves organ allocation accuracy and efficiency, reduces patient waiting times and increases successful transplant rates. The real-time donor and reciprocal matching function also ensures that organs are assigned quickly and minimizes organ waste. For hospitals and medical professionals, the platform provides a user-friendly interface for seamless data entry, donor coordination and real-time monitoring. Blockchain scalability ensures that systems can support more and more users and healthcare facilities without encountering performance.

In the end, organ trackers aim to transform the organ donation ecosystem by providing a safe, transparent and efficient framework that improves the success rate of implantation and promotes trust in the system.

VIII. FUTURE SCOPE

The integration of blockchain technology and algorithms for machine learning in organ donation systems paves some promising pathways for future research and development. Potential areas of future work include:

- **Federated Learning Models:** The use of federated learning to improve data protection by activating model training for decentralized data records without revealing sensitive information.

- **Cross-Border Organ Allocation Networks:** Development of a global distributed network for organ allocation to promote international donor recipient matching.

- **Real-Time Compatibility Prediction:** Collects real-time health data to assess the dynamic compatibility of IoT devices and wearables.

- **Enhanced Smart Contracts:** Design of more advanced smart contracts for multi-factor compatibility testing and dynamic prioritization.

- **Improved Data Encryption:** Research homologous encryption techniques to further protect sensitive medical data.

- **Integration with Health Information Systems:** Connecting existing health information systems for seamless data exchange with blockchain-based Orgelle donation platform.

- **Ethical and Regulatory Frameworks:** Developing a regulatory framework for blockchain-based organ donation systems.

By fighting these future directions, organ trackers can revolutionize the organ donation process, making them safer, transparent and more efficient.

IX. CONCLUSION

The integration of blockchain technology and machine learning algorithms represents a transformative solution to the challenges of organ donation systems. By combining blockchain transparency, security, and immutability with machine learning predictive performance, the proposed system improves donor recipient coordination, reduces rejection rates of organs, and ensures fair distribution of organs. This article highlights how technologies such as random forest algorithms and intelligent contracts can revolutionize organ allocation, making processes more efficient and reliable. Future research can further improve the system by addressing scalability issues, improving data protection measures, and expanding the system of cross-general organ allocation networks. The introduction of such advanced technologies provides the potential to significantly improve patient outcomes and promote public confidence in the organ donation system.

REFERENCES

[1] Alowidi, N., Ali, R., Sadaqah, M., & Naemi, F.M.A., 2024. Advancing Kidney Transplantation: A Machine Learning Approach to Enhance Donor–Recipient Matching. Diagnostics, 14(2119).

[2] Reddy, Y.G., InduSree, M., Lavya, M., & Pushpa, M., 2024. Blockchain-Based Organ Donation Management System. International Journal of Modern Engineering Research and Technology, 16(1).

[3] Divya, N.S., Bhuvana, P., Reddy, Y.P., & Reddy, G.A., 2024. Organ Donation and Transplantation Using Ethereum Blockchain. International Journal of Creative Research Thoughts (IJCRT), 12(5).

[4] Tanchip, C., Noaeen, M., Kazari, K., & Shakeri, Z., 2024. Predicting Donor Selection and Multi-Organ Transplantation within Organ Procurement Organizations Using Machine Learning. medRxiv Preprint.

[5] Vidya, D., Khetre, P., Gavade, C., & Jadhav, S., 2024. ML Powered Organ Donation System. International Journal of Research Publication and Reviews, 5(5), 11019-11024.

[6] Tribhuvan, G.B., Doke, A.R., Palve, J.R., & Dumbre, A.S., 2023. Management for Organ Donation and Transplantation by Using Custom Blockchain. IJCRT, 11(11).

[7] Waykule, V.V., Kothawade, R., Nikam, R., Khandelwal, H., & Sharma, P., 2023. Online Organ Donation System Using Blockchain. International Journal of Creative Research Thoughts (IJCRT), 11(6).

[8] Jeong, J., Kim, D., Lee, Y., Jung, J-W., & Son, Y., 2023. A Study of Private Donation System Based on Blockchain for Transparency and Privacy. IEEE Xplore.

[9] Pawar, N.N., & Wankhade, N.R., 2023. Survey Paper on: "Organ Donation Using Blockchain." International Journal of Advanced Research in Science, Communication and Technology (IJARSCT), 3(1), 134-137.

[10] Gotlieb, N., Azhie, A., Sharma, D., Spann, A., Suo, N-J., et al., 2022. The Promise of Machine Learning Applications in Solid Organ Transplantation. npj Digital Medicine, 5(89).

[11] Gholamzadeh, M., Abtahi, H., & Safdari, R., 2022. Machine Learning-Based Techniques to Improve Lung Transplantation Outcomes and Complications: A Systematic Review. BMC Medical Research Methodology, 22(331).

[12] Ghosh, S., & Dutta, M., 2023. Indriya: Building a Secure and Transparent Organ Donation System with Hyperledger Fabric. arXiv Preprint, arXiv:2307.02416

[13] Yoon, J., Alaa, A.M., Cadeiras, M., & van der Schaar, M., 2017. Personalized Donor-Recipient Matching for Organ Transplantation. University of California, Los Angeles.

[14] Bhosale, A., More, R.,Jagtap, A., & Patil, R., 2021. Online Organ Donation System. International Journal f Advanced Research in Computer and Communication Engineering (IJARCCE), 10(5).

[15] Rastogi, S., Tiwari, S., & Mane, M., 2019. Online Organ Donation Management System. International Journal of Innovative Research in Technology (IJIRT), 5(10), 445-447