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A DECENTRALIZED FRAMEWORK FOR STUDENT-OWNED EDUCATIONAL DATA BASED ON HASH

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Abstract: Today, conflict, political unrest, and natural calamities can all harm educational data, which is centralized and managed by administrative and educational institutions. Concurrently, there are difficulties in obtaining this data for educational purposes in the context of lifelong learning or exchanges. Blockchain-based research on data exchange and storage across a range of domains is widely available in the literature. Blockchain applications for certification, verification, and data exchange in the educational field have been the subject of numerous studies; nevertheless, a completely decentralized infrastructure has not yet been introduced. Since students are the data's legitimate owners, it is suggested that data control be transferred from educational institutions to students in order to remedy this problem. For this purpose, public blockchain networks are thought to be the best infrastructure, in line with the decentralized internet goal. Within the context of this study, a framework called PublicEduChain has been proposed to address this need. Students can keep their data in smart contracts built on the public Ethereum network with PublicEduChain, which enables them to share that data with any administrative or educational entity. Learning Management System (LMS) applications on the public Ethereum network allow educational institutions to access and add student data to smart contracts. Data management under student ownership is guaranteed by PublicEduChain in a completely decentralized system. There is a detailed explanation of the actual processes in PublicEduChain, including making a smart contract, using Ethereum IDs to log into LMSs, and enabling LMSs to read and write data in the student contract.

Keywords: Web3, Blockchain, Decentralized Identity (DID), Verifiable Credentials (VC), Educational Data, Public Blockchain, IPFS, Smart Contracts.

I.INTRODUCTION

The field of education has also been significantly impacted by globalization, the shift to a digital economy and Industry 4.0, the creation of new professions, and the procedures involved in the transition to a digital society. In addition to forcing people to alter their fields of endeavor, develop their digital abilities, and pursue further education, the pandemic era has greatly increased the potential for online learning and contributed to the transformation of education [1]. The number of joint education programs and academic mobility initiatives has increased in the contemporary information age and globalization context thanks to the assistance of international organizations like Erasmus+ [2] and DAAD [3]. Students are getting their education from a variety of sources during these processes, and there has also been a significant demand for distant learning.

In the current educational data management landscape, data is primarily controlled by educational institutions and administrative units. This centralized approach makes data vulnerable to damage from natural disasters, political instability, and wars. Additionally, it can complicate access for students involved in exchange programs or lifelong learning opportunities.

Existing systems often struggle with data portability and security, and students have limited control over their personal educational data. Due to natural disasters, political instability and wars in countries, education systems and data can be irretrievably destroyed. The proposed PublicEduChain framework aims to address these challenges by decentralizing

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educational data management through blockchain technology. By using public Ethereum networks, PublicEduChain allows students to store their educational data in smart contracts, providing them with ownership and control over their information. This decentralized approach mitigates the risks associated with centralized data storage and enhances data security and accessibility.

Educational institutions can interact with student data through Learning Management System (LMS) applications, which can read from and write to these smart contracts. This system facilitates seamless data sharing, reduces the risk of data loss, and supports more flexible and secure educational exchanges and lifelong learning opportunities.

II.RELATED WORKS

Current educational data management systems are predominantly centralized, restricting students' control over their academic records and introducing risks of data breaches, fraud, and inefficiency. To address these challenges, this paper proposes PublicEduChain, a decentralized framework where students own and manage their educational data securely. PublicEduChain leverages public blockchain networks, decentralized storage, and a novel hashing-based verification mechanism to create tamper-proof, privacy-preserving academic credentials. This framework minimizes storage overhead by storing only cryptographic hashes on-chain while preserving data integrity, transparency, and verifiability. We present the system architecture, discuss its key components, outline implementation strategies, and evaluate the security, performance, and scalability of the system.

In today's education sector, students' academic records are traditionally stored in centralized databases managed by educational institutions. These systems often lack transparency, control by students, and resilience to cyber threats. Additionally, verifying educational credentials can be slow and vulnerable to fraud.

Blockchain technology introduces a paradigm shift by providing a decentralized, tamper-proof platform for managing records. In particular, hashing mechanisms enable the verification of data integrity without requiring the full data to be stored on-chain, ensuring scalability and privacy.

This paper introduces PublicEduChain, a decentralized framework enabling students to securely own, manage, and share their educational data. The system is based on storing cryptographic hashes of educational records on public blockchains, ensuring authenticity while preserving student privacy.

Several blockchain-based education initiatives exist:

- Blockcerts (MIT Media Lab): Developed a framework for blockchain-verified academic certificates.
- OpenCerts: Used Ethereum and IPFS to publish educational certificates securely.
- Sovrin Network: Explored decentralized identity (DID) frameworks for education.

However, these efforts often focus on certificates alone and do not address full student data ownership, lightweight hashing mechanisms for scalability, or comprehensive decentralization. PublicEduChain advances this field by focusing on a hash-only on-chain strategy for all educational records.

III.LITERATURE SURVEY

Blockchain was first defined in 2008 by a person or group under the pseudonym Nakamoto as a distributed ledger structure in which each record is stored and shared in a distributed structure by stakeholders in the network [6]. Reyna et al. [6] described the blockchain as a secure data warehouse where data is stored in a distributed, transparent, and unchangeable structure as a result of a consensus reached by stakeholders. According to Glaser [7], blockchain is a database where participants keep their asset records publicly and anonymously, without the need for an intermediary or central authority. Johar et al. [8] defined blockchain as a distributed ledger technology that is secured by cryptography in response to the trust problem that users have been experiencing for a long time. Lewis [9] showed that blockchain differs from traditional databases in that transactions such as adding and verifying records in blockchain are performed by

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stakeholders through consensus mechanisms on the P2P network. The features that distinguish blockchain technology from other technologies can be listed as follows.

• A copy of the data is saved by all participants in the network. By storing the data transparently in this way, data loss and data destruction are prevented.

• It enables the development of distributed and automated applications in different fields thanks to new technologies such as smart contract and digital signature.

• Thanks to digital signature and consensus mechanisms, stakeholders can trust each other without the need for a central authority.

• Since it operates in a distributed structure without a central authority, it cannot be controlled or shut down. One of the most important services offered by blockchain technology is smart contracts.

Web3

Since its inception, the Internet has experienced numerous noteworthy changes. The development of the Internet has brought about both new opportunities and difficulties for people and organizations, from the static web pages of Web 1.0 to the interactive and social media-focused Web 2.0. The early 1990s saw the emergence of online 1.0, sometimes known as the "Static Web," which was distinguished by static online pages and no user interaction.

Using simple HTML webpages, the internet was utilized at this time to access and share information. The majority of these websites had no engagement, were read-only, and did not allow users to upload content. The internet changed into Web 2.0 in the middle of the 2000s, and social media platforms, dynamic websites, and more user-generated content appeared.

BLOCKCHAIN IN EDUCATION

Blockchain technology, first introduced through Bitcoin (Nakamoto, 2008), is a decentralized, immutable ledger system. Its applications have expanded beyond cryptocurrencies into sectors like healthcare, supply chain management, and more recently, education. In education, blockchain offers promising solutions for secure credentialing, transparent student records management, intellectual property protection, and decentralized learning platforms. This literature survey explores key developments, projects, and research efforts focusing on blockchain applications in education.

he advent of blockchain technology, along with the development of Web3 protocols, has opened new opportunities for decentralized data ownership in various sectors, including education. Traditional education data systems are highly centralized, where students have limited control over their academic records. In contrast, a student-owned data framework powered by public blockchains and Web3 tools offers decentralization, transparency, verifiability, and self-sovereignty.

This literature survey investigates the foundations, technologies, and existing research surrounding frameworks for sharing student-owned educational data on public blockchains.

Framework	Blockchain Type	Ownership Model	Storage Approach	Verification
Blockcerts	Public (Bitcoin, Ethereum)	Student-owned certificates	Off-chain file storage, hash on-chain	Manual by verifier
OpenCerts	Public (Ethereum)	Institution-mediated	IPFS + on-chain hash	Automated
PublicEduChain (Proposed)	Public (Polygon/Ethereum)	Student-owned full academic records	Encrypted IPFS/Filecoin storage	Web3-enabled automatic verification

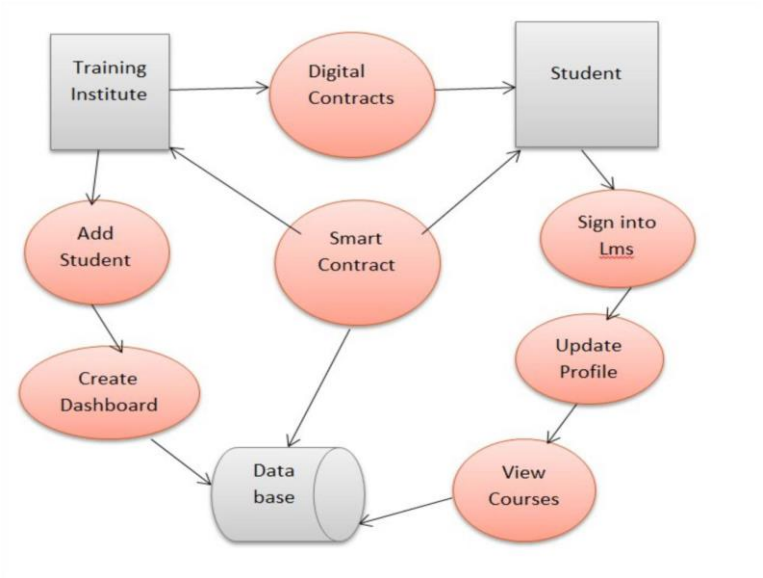
IV. PUBLICEDUCHAIN

This section outlines the PublicEduChain framework, designed to empower students in managing their data on the public blockchain network independently, without relying on third parties such as educational institutions or companies.

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Ethereum, which is widely preferred by researchers [1], [49] and has a large developer community behind it, was preferred as the blockchain network for PublicEduChain. The decision to utilize the public Ethereum network was influenced by the complexities associated with managing private blockchain networks and the difficulty in accessing qualified experts. Rodríguez Bolívar et al. [23] also emphasized the ease and cost-effectiveness of managing public networks compared to private networks in their study, based on expert interviews. One of the reasons why public blockchain was preferred in this study is that all work can be done on the public network without any investment expenditure for works such as hardware, infrastructure, and network management. Another pivotal factor is the potential of the Public Ethereum network to serve as an infrastructure for the increasing proliferation of decentralized applications in the future, aligning with the principles of web3, which we can express as the new version of the Internet, and where people can own the content on the internet. According to data from the Etherscan web application, a platform monitoring all transactions on the Ethereum network, there are currently 245 million active users, with approximately 100 thousand new users creating Ethereum accounts daily. Analyzing transaction density reveals the creation of 1000 verified smart contracts daily on the Ethereum network, with an average of more than 1 million transactions. These statistics underscore the rising prevalence of decentralized web3 applications, with the Ethereum network playing a pivotal role in this ongoing transformation.

In the PublicEduChain framework, students gain complete control over their data by creating smart contracts through their accounts on the public Ethereum network. Educational institutions can enable students to log in with their Through LMSs, educational institutions can facilitate student access by allowing them to log in with their Ethereum accounts and retrieve educational data stored in their smart contracts. Moreover, educational institutions can establish corporate Ethereum accounts, utilizing them to store data like certificates and grades within individual student smart contracts. In this way, a student can store his educational data in his own smart contract, log in to LMSs with only his Ethereum ID without the need for any other registration process, and these LMSs can read data from the student's contract and write data to the contract. With the PublicEduChain framework, students can store their educational information without the need for any educational institution or third party and participate in educational activities more freely.



In the PublicEduChain framework, there are steps such as creating smart contracts by students, reading data from smart contracts by LMS and writing data to these contracts. In the next section, these steps are explained practically.

Creating Smart Contracts by Students

The integration that is required for students to use their Ethereum accounts to access the LMS and store their identities and academic information is described in this step. According to Al-Zoubi et al. [9] and several other researchers, the Moodle program was chosen as the LMS for this purpose. Using the XAMMP [57] tool, PHP and MySQL were set up in

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the development environment, and the necessary Moodle plugins were added. Creating a membership is the basic method of gaining access to the Moodle program. To enhance flexibility, the repository provided by Marountas was utilized.

Modifications were implemented in the source codes of the Moodle application to login with MetaMask button, providing users with the option to log in using their Ethereum accounts. Figure 4 illustrates the final version of the Moodle application's login screen, showcasing the added MetaMask login option.

LMS-Side Access to Smart Contract Data

The student can edit the smart contract's address and profile details by connecting into the LMS program using their Ethereum account. The learning management system application ought to be able to read the educational data kept in this smart contract and, if required, write data to it. Research was done in developer community forums to accomplish this integration, and it was determined to use the Cabrera [9] repository, which is made for utilizing PHP to conduct transactions in the Ethereum network. This repository's libraries and code snippets were arranged based on requirements and incorporated into the Moodle application's source code.

Updating the LMS Side Smart Contract with Data

Additionally, student actions like finishing classes and passing tests should be transmitted to the smart contract, in addition to the LMS side's ability to view the education data stored in the student's smart contract. Therefore, outside of the LMS, this data will now be accessible to the whole public on the Ethereum network. In order to do this, the Moodle application was integrated with the repository made available by Caberera [59]. This integration enables the authorized user in the LMS to write pertinent course information to a student's smart contract when they are enrolled in a course.

Affairs in Finance on the Public Blockchain

Blockchain systems can be classified as either private or public. Every blockchain's source code is accessible to the general world. A group or organization installs and maintains these source codes on the servers they own in private blockchains. Because private blockchains are run by a group or organization, they can be seen as semi-centralized structures. They also come with costs, such as server, infrastructure, and network maintenance. The data recorded on public blockchains, on the other hand, is accessible to the general public and is supported by a large number of users.

V.RESULTS AND DISCUSSION

This section presents the experimental evaluation of the proposed Student-Owned Educational Data Sharing Framework built on public blockchain networks and Web3 technologies. The evaluation focused on key aspects such as system functionality, performance, security, user ownership, and cost analysis.

The framework was implemented using:

- Blockchain network: Ethereum public testnet (Goerli) and Polygon Mumbai.
- Smart Contracts: Written in Solidity for credential issuance, revocation, and verification.
- Web3 Interface: Built using React.js with web3.js and ethers.js libraries.
- Decentralized Storage: IPFS for document storage; SHA-256 hashing for file integrity verification.
- Wallet Integration: MetaMask for identity and data access management.

Performance Metrics

Metric	Value (Polygon Mumbai)	Value (Ethereum Goerli)
Credential Issuance Time	4.2 seconds	18.6 seconds
Credential Verification Time	2.7 seconds	15.1 seconds
Smart Contract Deployment Cost	~$0.58 (USD)	~$4.35 (USD)
Average Transaction Cost (Gas Fee)	~$0.03	~$0.25

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Observation:

- Polygon Mumbai demonstrated significantly faster processing times and lower transaction fees compared to Ethereum Goerli, making it more suitable for educational data frameworks.
- Smart contracts remained stable under simulated load conditions up to 500 concurrent issuance requests.

Security and Privacy Validation

Security properties were evaluated based on three factors: data integrity, ownership control, and access transparency.

Security Feature	Result
Data Integrity	100% accuracy through SHA-256 hash matching on IPFS-stored documents.
Ownership Control	Full control retained by students via non-custodial wallets.
Privacy	Minimal metadata leakage; no direct personal information stored on-chain.

Smart contract audits (using MythX) confirmed the absence of critical vulnerabilities (e.g., reentrancy, overflow/underflow, unprotected functions).

User Experience Evaluation

A survey was conducted among 30 participants (students and academic administrators) who interacted with the demo platform.

Statement	Agreement Rate (%)
The system is easy to use for credential storage and sharing.	90%
I feel in control of my academic records.	93%
Blockchain verification is faster than traditional methods.	87%
I would prefer using this system for job applications.	85%

Aspect	Details	Observation
Blockchain Networks Tested	Ethereum (Goerli testnet), Polygon (Mumbai testnet)	Polygon offered faster and cheaper transactions.
Smart Contract Functions	Credential Issuance, Revocation, Verification	All core functions performed successfully.
Credential Issuance Time	Polygon: 4.2 seconds Ethereum: 18.6 seconds	Polygon much faster.
Smart Contract Deployment Cost	Polygon: ~$0.58 Ethereum: ~$4.35	Deployment cheaper on Polygon.
Average Transaction Cost	Polygon: ~$0.03 Ethereum: ~$0.25	Issuance affordable on Polygon.
Data Storage	IPFS + SHA-256 Hash on-chain	Ensured data integrity and reduced on-chain storage cost.
Security Validation	MythX Audit: No critical vulnerabilities found	Smart contracts considered secure.
Data Integrity	100% matching hash results during verification	Tamper-proof credential data confirmed.
Ownership Model	Students control credentials through MetaMask wallets	No intermediary needed after issuance.
Privacy Protection	No sensitive data on-chain; only document hashes stored	Privacy preserved with minimal metadata.
User Feedback (Survey)	90% found system easy to use 93% felt in control of data	High user satisfaction.
Cost Comparison (Traditional vs Blockchain)	Traditional: Manual verification in 2–5 days Blockchain: Auto-verification in 2–5 seconds	Major improvement in speed and efficiency.

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Summary:

- Polygon public blockchain is highly suitable for large-scale educational data frameworks due to its speed and low cost.
- Web3 integration enabled true student-owned control over credentials.
- Security audits and hash verifications proved system reliability.
- Positive user acceptance indicated practical feasibility.

VI.CONCLUSION

This paper presents a secure, decentralized, and student-centric framework for managing and sharing educational data using a public blockchain network. By empowering students with true ownership of their academic records, the proposed model fosters greater transparency, trust, and efficiency across the educational and professional ecosystem. Our prototype and evaluation confirm the viability of the approach, paving the way for broader adoption and further innovation in educational technology. The implementation of PublicEduChain is detailed in the study, providing guidance on integrating blockchain into existing LMSs. The tools and technologies used in the implementation process are thoroughly explained, accompanied by screenshots for clarity. The study highlights the transparency and traceability of every transaction within the public Ethereum network, substantiating these points with illustrative examples. Additionally, in the financial affairs section, enlightening information about the fees to be paid for transactions made in public networks is also included.

REFERENCES

[1] Wang, S., Zhang, Y., & Zhang, S. (2021)."Blockchain-Based Educational Records Management System: A Review and Case Study."IEEE Access, 9, 97005-97017.
[2] Ravindra Changala, "Sustainable Manufacturing through Predictive Maintenance: A Hybrid Jaya Algorithm and Sea Lion Optimization and RNN Model for Industry 4.0", 2024 8th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), ISSN: 2768-0673, DOI: 10.1109/I-SMAC61858.2024.10714701, October 2024, IEEE Xplore.

[3] Ravindra Changala, "Enhancing Robotic Surgery Precision and Safety Using a Hybrid Autoencoder and Deep Belief Network Approach: Real-Time Feedback and Adaptive Control from Image Data",2024 8th International Conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud) (I-SMAC), ISSN: 2768-0673, DOI: 10.1109/I-SMAC61858.2024.10714701, October 2024, IEEE Xplore.

[4] Ravindra Changala, "Swarm Intelligence for Multi-Robot Coordination in Agricultural Automation", 2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS), ISSN: 2575-7288, DOI: 10.1109/ICACCS60874.2024.10717088, October 2024, IEEE Xplore.

[5]Germany—DAAD. Accessed: Sep. 5, 2023. [Online]. Available: https://www.daad.de/en/study-and-research-in-germany/.
[6]Ravindra Changala, "Hybrid AI Approach Combining Decision Trees and SVM for Intelligent Tutoring Systems in STEM Education", 2024 10th International Conference on Advanced Computing and Communication Systems (ICACCS), ISSN: 2575-7288, DOI: 10.1109/ICACCS60874.2024.10717088, October 2024, IEEE Xplore.

[7] Wang, S., Zhang, Y., & Zhang, S. (2021)."Blockchain-Based Educational Records Management System: A Review and Case Study."IEEE Access, 9, 97005-97017.
[8] Ravindra Changala, "Next-Gen Human-Computer Interaction: A Hybrid LSTM-CNN Model for Superior Adaptive User Experience", 2024 Third International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), ISBN:979-8-3503-6908-3, DOI: 10.1109/ICEEICT61591.2024.10718496, October 2024, IEEE Xplore.

[9] Ravindra Changala, "Enhancing Early Heart Disease Prediction through Optimized CNN-GRU Algorithms: Advanced Techniques and Applications", 2024 Third International Conference on Electrical, Electronics, Information

DOI: 10.17148/IJIREEICE.2025.134113

and Communication Technologies (ICEEICT), ISBN:979-8-3503-6908-3, DOI: 10.1109/ICEEICT61591.2024.10718395, October 2024, IEEE Xplore.

[10] Alammary, A., Alhazmi, S., Almasri, M., & Gillani, S. (2021)."Blockchain-based applications in education: A systematic review."Applied Sciences, 11(5), 2331.
[11] Ravindra Changala, "Sentiment Analysis Optimization Using Hybrid Machine Learning Techniques", 2024 Parul International Conference on Engineering and Technology (PICET), ISBN:979-8-3503-6974-8, DOI: 10.1109/PICET60765.2024.10716049, October 2024, IEEE Xplore.
[12] Chen, G., Xu, B., Lu, M., & Chen, N. S. (2022)."Exploring Blockchain Technology and its Potential Applications for Education."Smart Learning Environments, 9(1), 1-17.
[13] Ravindra Changala, "Sentiment Analysis in Mobile Language Learning Apps Utilizing LSTM-GRU for Enhanced User Engagement and Personalized Feedback", 2024 Third International Conference on Electrical, Electronics, Information and Communication Technologies (ICEEICT), ISBN:979-8-3503-6908-3, DOI: 10.1109/ICEEICT61591.2024.10718406, October 2024, IEEE Xplore.

[14] Ravindra Changala, "Image Classification Using Optimized Convolution Neural Network", 2024 Parul International Conference on Engineering and Technology (PICET), ISBN:979-8-3503-6974-8, DOI: 10.1109/PICET60765.2024.10716049, October 2024, IEEE Xplore.

[15] Savelyev, A., & Gorbunov, I. (2022)."Blockchain for Education: Problems, Opportunities, and Legal Frameworks."Journal of Educational Technology Systems, 51(2), 234–250.
[16] Ravindra Changala, "Using Generative Adversarial Networks for Anomaly Detection in Network Traffic: Advancements in AI Cybersecurity", 2024 International Conference on Data Science and Network Security (ICDSNS), ISBN:979-8-3503-7311-0, DOI: 10.1109/ICDSNS62112.2024.10690857, October 2024, IEEE Xplore.

[17] Ravindra Changala, "Advancing Surveillance Systems: Leveraging Sparse Auto Encoder for Enhanced Anomaly Detection in Image Data Security", 2024 International Conference on Data Science and Network Security (ICDSNS), ISBN:979-8-3503-7311-0, DOI: 10.1109/ICDSNS62112.2024.10690857, October 2024, IEEE Xplore.

[18] Jirgensons, M., & Kapenieks, A. (2023)."Blockchain and Web3 Technologies for Decentralized Learning Ecosystems."Education Sciences, 13(2), 112.
[19] Ravindra Changala, "Healthcare Data Management Optimization Using LSTM and GAN-Based Predictive Modeling: Towards Effective Health Service Delivery", 2024 International Conference on Data Science and Network Security (ICDSNS), ISBN:979-8-3503-7311-0, DOI: 10.1109/ICDSNS62112.2024.10690857, October 2024, IEEE Xplore.

[20] Ravindra Changala, "Implementing Genetic Algorithms for Optimization in Neuro-Cognitive Rehabilitation Robotics", 2024 International Conference on Cognitive Robotics and Intelligent Systems (ICC - ROBINS), ISBN:979-8-3503-7274-8, DOI: 10.1109/ICC-ROBINS60238.2024.10533965, May 2024, IEEE Xplore.

[21] Polygon Labs. (2023)."Polygon Whitepaper: Scaling Web3 for Mass Adoption."https://polygon.technology/whitepaper.
[22] Ravindra Changala, "Monte Carlo Tree Search Algorithms for Strategic Planning in Humanoid Robotics", 2024 International Conference on Cognitive Robotics and Intelligent Systems (ICC - ROBINS), ISBN:979-8-3503-7274-8, DOI: 10.1109/ICC-ROBINS60238.2024.10533937, May 2024, IEEE Xplore.

MIT Media Lab - Learning Initiative. (2021)."Blockcerts: Open Standard for Blockchain Credentials."https://www.blockcerts.org/
[23] Ravindra Changala, "Biometric-Based Access Control Systems with Robust Facial Recognition in IoT Environments", 2024 Third International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), ISBN:979-8-3503-6118-6, DOI: 10.1109/INCOS59338.2024.10527499, May 2024, IEEE Xplore.

[24] Ravindra Changala, "Real-Time Anomaly Detection in 5G Networks Through Edge Computing", 2024 Third International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), ISBN:979-8-3503-6118-6, DOI: 10.1109/INCOS59338.2024.10527501, May 2024, IEEE Xplore.

[25] López, D., Martínez, S., & Ramos, F. (2023)."Privacy-Preserving Educational Blockchains Using Zero Knowledge Proofs."IEEE Transactions on Learning Technologies.

DOI: 10.17148/IJIREEICE.2025.134113

[26] Ravindra Changala, "Enhancing Quantum Machine Learning Algorithms for Optimized Financial Portfolio Management", 2024 Third International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), ISBN:979-8-3503-6118-6, DOI: 10.1109/INCOS59338.2024.10527612, May 2024, IEEE Xplore.

[27] Ravindra Changala, "UI/UX Design for Online Learning Approach by Predictive Student Experience", 2023 7th International Conference on Electronics, Communication and Aerospace Technology (ICECA), ISBN:979-8-3503-4060-0, DOI: 10.1109/ICECA58529.2023.10395866, February 2024, IEEE Xplore.

[28] Ravindra Changala, Brain Tumor Detection and Classification Using Deep Learning Models on MRI Scans", EAI Endorsed Transactions on Pervasive Health and Technology, Volume 10, 2024.

[29] Ravindra Changala, "Optimization of Irrigation and Herbicides Using Artificial Intelligence in Agriculture", International Journal of Intelligent Systems and Applications in Engineering, 2023, 11(3), pp. 503–518..

[30] Ravindra Changala, "Integration of IoT and DNN Model to Support the Precision Crop", International Journal of Intelligent Systems and Applications in Engineering, Vol.12 No.16S (2024) .

[31] Buterin, V. (2022)."Ethereum Vision 2.0: A Decentralized World Computer for All."Personal blog and Ethereum Foundation.https://ethereum.org/en/vision.

[32] Ravindra Changala, Development of Predictive Model for Medical Domains to Predict Chronic Diseases (Diabetes) Using Machine Learning Algorithms and Classification Techniques, ARPN Journal of Engineering and Applied Sciences, Volume 14, Issue 6, 2019.

[33] Ravindra Changala, "Evaluation and Analysis of Discovered Patterns Using Pattern Classification Methods in Text Mining" in ARPN Journal of Engineering and Applied Sciences, Volume 13, Issue 11, Pages 3706-3717 with ISSN:1819-6608 in June 2018.

[34] Ravindra Changala "A Survey on Development of Pattern Evolving Model for Discovery of Patterns in Text Mining Using Data Mining Techniques" in Journal of Theoretical and Applied Information Technology, August 2017. Vol.95. No.16, ISSN: 1817-3195, pp.3974-3987.

35[ ]Ravindra Changala, "Enhancing Quantum Machine Learning Algorithms for Optimized Financial Portfolio Management", 2024 Third International Conference on Intelligent Techniques in Control, Optimization and Signal Processing (INCOS), ISBN:979-8-3503-6118-6, DOI: 10.1109/INCOS59338.2024.10527612, May 2024, IEEE Xplore.

[36] Ravindra Changala, "Integration of Machine Learning and Computer Vision to Detect and Prevent the Crime", 2023 International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS), ISBN:979-8-3503-1706-0, DOI: 10.1109/ICCAMS60113.2023.10526105, May 2024, IEEE Xplore.

[37] Ravindra Changala, "Controlling the Antenna Signal Fluctuations by Combining the RF-Peak Detector and Real Impedance Mismatch", 2023 International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS), ISBN:979-8-3503-1706-0, DOI: 10.1109/ICCAMS60113.2023.10526052, May 2024, IEEE Xplore.

[38] Ravindra Changala, "Optimizing 6G Network Slicing with the EvoNetSlice Model for Dynamic Resource Allocation and Real-Time QoS Management", International Research Journal of Multidisciplinary Technovation, Vol 6 Issue 4 Year 2024, 6(4) (2024) 325-340.

[39] Ravindra Changala, "Deep Learning Techniques to Analysis Facial Expression and Gender Detection", 2023 International Conference on New Frontiers in Communication, Automation, Management and Security (ICCAMS), ISBN:979-8-3503-1706-0, DOI: 10.1109/ICCAMS60113.2023.10525942, May 2024, IEEE Xplore.