Applied Intelligence and Informatics

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Applied Assistive Technologies and Informatics for Students with Disabilities

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ISSN 2731-9253 ISSN 2731-9261 (electronic)
Applied Intelligence and Informatics
ISBN 978-981-97-0913-7 ISBN 978-981-97-0914-4 (eBook)
https://doi.org/10.1007/978-981-97-0914-4

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

This book is dedicated to all those who strive to make education accessible and inclusive. To the educators, caregivers, and professionals who devote their lives to supporting students with disabilities, your work lights the path to a brighter, more inclusive future.

To the students who face every challenge with courage and determination, you are the true heroes of this story. Your resilience and spirit are a constant source of inspiration.

And to the families and communities who nurture and advocate for these remarkable individuals, your support and love create a world where every student has the opportunity to thrive.

May this book serve as a beacon of hope and a resource of empowerment, reminding us all that in the realm of learning, there are no limits, only possibilities.

With deepest respect and admiration,

Editors

Foreword

As we sit down to write this foreword, we start with acknowledging the transformative power of assistive technologies and informatics in the lives of students with disabilities. This book, a comprehensive guide and a thought-provoking exploration, comes at a time when the world is more connected than ever, yet the need for inclusivity and accessibility in education remains a paramount challenge. The authors of this book have embarked on a journey, to delve deep into the nuances of applied assistive technologies and informatics in education, a field that is not just about technologies and tools, but more importantly, about the doors they open for students who might otherwise be left at the margins of the current educational landscape. This book is not merely academic; it is a clarion call for action, empathy, and understanding the need of students with disabilities. The book doesn't only cover technicalities of assistive technologies and informatics, but also depicts pictures of resilience and determination. It highlights how these technologies serve not only as aids, but also as powerful extensions to augment capabilities of students, enabling them to overcome barriers and achieve their potential to the fullest. The educators, practitioners, and students using this book will be at the forefront of a crucial movement that champions the right to education for all, regardless of the physical or cognitive challenges one might face. As we move forward in this ever-evolving landscape of education, let us all remember the core message that this book conveys: In the realm of learning and personal growth, there should be no hindrances, only facilitations. Every learner deserves a chance to shine, and assistive technologies and informatics play a pivotal role in lighting that path.

Dhaka, Bangladesh — Biswajit Chanda
New Delhi, India — R. Dharmarajan

Preface

Classroom learning aims to strengthen previously learned concepts while simultaneously teaching students new ones. In a classroom where most students are learning at a rapid pace, slow learners with disabilities are more likely to be falling behind. Because of this, there is a lack of deep understanding in many topics, including basic concepts and skills. Students with disabilities must be treated equitably to others in higher education. The use of assistive technology can streamline teaching and learning for these disadvantaged students. This set of students requires further training on enhanced assistive technologies to maximize the benefits of higher education and compete with their peers. Anything software, hardware, or peripherals that aid students with disabilities in overcoming their educational obstacles and developing new skills fall under the umbrella of assistive technology. Students with disabilities can benefit from using assistive technologies to restore their abilities in receiving high-quality education like their peers without disabilities. This book covers different types of assistive technologies for learners with disabilities such as Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), Cerebral Palsy (CP). It aims to present the state-of-the-art theoretical and applied advances of assistive technology to support students disabilities. This book is ideal for researchers at higher educational institutes, non-governmental organizations, assistive technology experts, IT professionals, social workers, inservice and preservice teachers, teacher educators, practitioners, academicians, and students with disabilities.

The book is organised in 16 chapters. A brief description the chapters are as follows:

Chapter 1:

The increasing use of data in education necessitates a focus on data security, integrity, and privacy. Centralised data storage poses threats like data modification, unauthorised access, and single points of failure. Blockchain technology offers access control, decentralised storage, tamper-resistant data, transparency, accountability, and smart contracts. These characteristics make blockchain a potential solution for handling data in higher education. The chapter covers data types, challenges,

and works on data handling in higher education, outlines blockchain's motivation, technical aspects, and projects, and concludes with a future direction.

Chapter 2:

AI is revolutionising higher education by providing personalised support and accommodations for students with disabilities. By assessing individual needs, adapting instructional content, and offering real-time feedback, AI-powered tools can assess individual learning needs, adapt content, and provide targeted interventions. This approach promotes inclusivity, enhances educational outcomes, and empowers students with learning disabilities to thrive in their academic pursuits. This chapter explores how AI can be leveraged to revolutionise higher education, offering equitable opportunities for students with disabilities.

Chapter 3:

Virtual Learning Environments (VLEs) have revolutionised education, particularly for students with intellectual disabilities (ID). VLEs eliminate spatial and cognitive limitations, promote secure learning, and enable students to learn life skills at their own pace. VLEs can enhance academic, job, social, and interview skills, and their constructivism offers step-by-step learning and experiential guidance. This chapter analyses the role of VLE in enhancing learning for higher education students with ID.

Chapter 4:

This chapter explores the transformative role of AI in higher education for students with learning disabilities. It examines the challenges these students face and the limitations of traditional support mechanisms. The focus is on AI-based assistive technologies like NLP and adaptive learning platforms, which provide personalised educational support. The chapter also addresses the importance of ethical considerations in implementing AI solutions, emphasising privacy and data security. Ultimately, it highlights AI's potential to enhance inclusion and empower students, envisioning a more equitable educational future.

Chapter 5:

This chapter delves into the transformative impact of virtual reality (VR) and augmented reality (AR) in fostering inclusive education for students with disabilities. It highlights how VR and AR create immersive and interactive learning experiences, offering personalised and accessible educational content. The text also examines the challenges in implementing these technologies, including cost, infrastructure, and ethical considerations. Emphasising the need for collaboration among educators, developers, and accessibility experts, the chapter underscores VR and AR's potential to revolutionise education for students with disabilities.

Chapter 6:

This chapter explores the critical role of Assistive Technology (AT) in enhancing education for students with disabilities and the elderly. It highlights how AT, though underutilised, can significantly improve independence, academic skills, and vocational opportunities for these individuals. It further examines the current use and implementation strategies of AT, drawing from various databases, journals, and credible sources. It also addresses the challenges in integrating AT effectively in

educational settings. Overall, the chapter emphasises the transformative potential of AT in creating more inclusive and effective learning environments.

Chapter 7:

This chapter introduces the Sign Language Detection System, a cutting-edge application combining machine learning, deep learning, and computer vision to interpret sign language in real-time. Addressing the communication gap between individuals who use sign language and those who do not, this system transcends the limitations of traditional human interpreters, such as availability, cost, and accuracy issues. Focusing on enhancing communication in critical areas like education and healthcare, this chapter details the development of a machine learning model for efficient and accurate sign language recognition. It emphasises the system's role in improving accessibility and promoting technological innovation in sign language interpretation, marking a significant step towards a more inclusive society.

Chapter 8:

This chapter introduces a comprehensive study on assistive technologies in higher education, crucial for supporting students with disabilities. It highlights the diverse range of tools and resources, including software for visual and hearing impairments, solutions for motor skills limitations, and tactile materials like Braille for sensory development. The focus is on how these technologies facilitate access to educational content, improve learning experiences, and cater to individual needs. With continuous technological advancements, the study anticipates emerging, more effective assistive solutions, emphasising the dynamic and evolving landscape of assistive technology in higher education.

Chapter 9:

This chapter introduces a study exploring the application of deep learning techniques in detecting learning disabilities in higher education. It emphasises the prevalence of learning disabilities and their impact on students' academic performance and well-being. The chapter focuses on key deep learning architectures like CNNs and transformer models, highlighting their effectiveness in analysing educational data. The study aims to shed light on the potential of deep learning in enhancing support for students with learning disabilities, underscoring its significance in the educational domain.

Chapter 10:

This chapter outlines a study on the application of computer vision techniques to enhance the educational experiences of students with learning disabilities. It delves into how computer vision, through AI and machine learning algorithms, can interpret visual data to aid in overcoming challenges like visual processing and comprehension. The study focuses on creating adaptive learning environments and personalised educational materials, aiming to improve access and academic outcomes for these students. It highlights the transformative potential of computer vision in addressing the unique needs of learners with learning disabilities.

Chapter 11:

This chapter introduces a comprehensive review exploring the impact of Virtual Reality (VR) on inclusive education, particularly for students with disabilities. It examines VR's role in enhancing accessibility, engagement, and understanding of

educational content, addressing a gap in existing research. The study aims to offer insights and recommendations for developers, educators, researchers, and policymakers in creating effective VR learning environments in higher education. It emphasises the need for comprehensive research to fully grasp VR's potential benefits, challenges, and limitations in fostering inclusive education for individuals with disabilities.

Chapter 12:

This chapter introduces a study that challenges the common misconception in education regarding equal benefits and opportunities for all students. It emphasises that students with disabilities, particularly those with hearing impairments, require specific support to succeed academically. The chapter focuses on the application of assistive technologies like Visual Speech Recognition (VSR) and Audio-Visual Speech Recognition in aiding these students. It delves into the importance of not just decoding text but also understanding the emotional context of speech. The chapter explores state-of-the-art techniques in automatic speech and emotion recognition models, shedding light on their potential to enhance the educational experiences of students with physical disabilities. This exploration underscores the necessity of inclusive educational practices and the role of advanced technology in making education truly accessible to all.

Chapter 13:

This chapter explored the transformative potential of the Metaverse in education, particularly for students with learning disabilities. This chapter delves into how virtual and physical realities merge to create inclusive learning environments. It examines the impact of advanced technologies like virtual reality, augmented reality, and Artificial Intelligence on the educational experiences of these students. By analysing current classifications of learning disabilities and discussing the Metaverse's role in personalised education, aim to provide a comprehensive guide for educators, practitioners, and researchers. This work represents a significant step towards understanding and harnessing the power of digital innovations in fostering inclusive learning in higher education institutions.

Chapter 14:

This chapter introduces an evaluation study on the role of assistive technologies in enhancing accessibility in higher education for students with disabilities. It begins with an exploration of learning challenges and the necessity for inclusive educational practices, emphasising the value of assistive technologies for students with learning disabilities. The study examines the impact of these technologies on diverse educational settings, addressing the prerequisites, effects, and initiatives for integrating technological aids. It also delves into the challenges and potential solutions for employing these aids in academic institutions. Ultimately, the study aims to provide insights into future directions for research and practice in this vital area of education.

Chapter 15:

This work introduces a chapter focused on the practical applications of Artificial Intelligence (AI) and Machine Learning (ML) in higher education, particularly for students with learning disabilities. It acknowledges the dynamic nature of these

technologies and aims to provide broad insights applicable across diverse educational settings. The chapter emphasises fostering inclusive education through AI and ML, addressing the unique challenges faced by these students. It highlights the need for adaptable and forward-thinking strategies to effectively harness AI and ML's evolving potential, aiming to contribute to equitable and empowering educational opportunities.

Chapter 16:

Finally, this chapter introduces a chapter dedicated to exploring the intersection of Industry 5.0 and healthcare, presenting a comprehensive review of recent literature in this field. It focuses on the role of disruptive technologies like Cloud Computing, Blockchain, Big Data, and others in fostering patient-centered smart healthcare systems. The chapter also examines emerging areas such as medical supply chain management and smart additive manufacturing, highlighting current challenges and potential research directions. Aimed at providing valuable insights for the global research community, this study seeks to deepen understanding of Industry 5.0's impact on healthcare.

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Acknowledgment

This book is result of a collaborative work. We express our sincere appreciation to the DiversAsia project (618615-EPP-1-2020-1-UKEPPKA2-CBHEJP) co-funded by Erasmus+ program of the European Union, an outstanding instance of pioneering and all-encompassing practices in the field of education. The project's efforts in promoting inclusivity by implementing inclusive open practices in Asia, particularly, in India and Bangladesh, has played a crucial role in shaping this book. We express our gratitude to the higher education institutions (HEIs) in India and Bangladesh, whose involvement in the DiversAsia project has been crucial. Their commitment to inclusivity in education, particularly for students with physcial and learning disabilities, is not only praiseworthy but also sets a standard for others worldwide. We extend our sincere gratitude to the DiversAsia project's esteemed partners from the United Kingdom, Bulgaria, Belgium, Latvia, Turkey, and Serbia. We extend our heartfelt gratitude to the National Advisory Board members of the DiversAsia project in India and Bangladesh and to all those who have contributed, supported, and engaged with our mission of fostering a community that is both inclusive and empowered by the means of education.

Contents

Chapter 1
Blockchain for Handling the Data in Higher Education

Gokul Yenduri, Rajesh Kaluri, Dharmendra Singh Rajput, Kuruva Lakshmanna, Thippa Reddy Gadekallu, and Azham Bin Hussain

Abstract Data and digital resources are being used more and more in education. In modern education, data security, integrity, and privacy are crucial. The educational system maintains a vast quantity of personal data, including student records, certificates, and academic accomplishments, in a central location. Data modification, unauthorised access, and single points of failure are all possible threats in these centralised data storage locations. This requirement to protect this sensitive data is a significant challenge that must be addressed. The access control provided by blockchain technology protects sensitive data from unauthorised access. Its decentralised storage guarantees that the data is stored in numerous locations and is accessible. The data stored in the blockchain is tamper- resistant because any change must be authorised by consensus among all participating nodes. Transparency and accountability on the blockchain enable stakeholders to keep track of the history of data modifications, and smart contracts on the blockchain enable automated and transparent processes, thereby reducing the need for manual intervention and augmenting precision. These characteristics make blockchain a possible solution to the challenges associated with handling data in higher education. The chapter begins with an introduction to the types of data in higher education, a discussion of various challenges in handling data in higher education, and a review of works on handling data in higher education. It is followed by an overview of blockchain, the motivation to implement blockchain, various technical aspects, and projects, and ends with a conclusion and future direction.

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R. Kaluri et al. (eds.), *Applied Assistive Technologies and Informatics for Students with Disabilities*, Applied Intelligence and Informatics,
https://doi.org/10.1007/978-981-97-0914-4_1

Keywords Blockchain · Higher education · Data handling

1.1 Introduction

The higher education industry has been greatly influenced by recent technological breakthroughs [1]. The present educational system effectively manages a substantial volume of personal data in a centralised manner, including student records, certifications, and academic accomplishments. The security, reliability, and privacy of the data are significantly threatened by any kind of attack. The long-term storage of sensitive data of this kind will have a significant impact on the trustworthiness of data within the higher education sector, necessitating a solution [2]. The use and examination of emerging technologies, such as blockchain, in higher education has attracted significant attention. Despite its roots as the underlying technology for cryptocurrencies, blockchain technology has grown substantially and is now employed in various sectors. Blockchain technology has the potential to enhance data management, security, and accessibility within the context of higher education. The use of blockchain technology has the potential to encourage a fundamental transformation, leading to improved data governance and a broader range of possibilities [3, 4].

The potential of using blockchain technology in the realm of higher education lies in its ability to effectively handle the need for decentralised data management and facilitate interoperable transactions. By using the characteristics of trustworthiness, immutability, and traceability, blockchain exhibits significant potential as a feasible solution within this particular environment [5]. The use of blockchain technology in the context of higher education enhances data management through its tamper-resistant and transparent attributes. The use of blockchain technology has the potential to enhance the management, dissemination, and availability of higher educational data using its decentralised and immutable data storage capabilities [6].

The structure of this paper's organisation is as follows: Sect. 1.2 presents a preliminary overview of blockchain. Section 1.3 discusses the literature survey and contributions. The technical aspects are presented in Sect. 1.4. In Sect. 1.5, we highlighted some projects. Finally, we conclude the paper in Sect. 1.6, summarising the key findings of this review.

1.2 Preliminary

This section provides a complete overview of blockchain, types of blockchain, and how they work.

1.2.1 Blockchain

A blockchain is a decentralised and distributed digital ledger with a shared record of transactions or information to be maintained by multiple parties. In recent years, blockchain has seen tremendous growth in today's digital technologies. It eliminates the role of the mediator by gaining trust among the participants in sharing and exchanging information, ensuring transparency, security, and immutable infrastructure. With its potential to revolutionise various industries, blockchain is being explored for applications ranging from finance and supply chain management to healthcare and voting systems. By providing a decentralised and tamper-resistant infrastructure, blockchain has the potential to reshape how we exchange and verify data, opening up new possibilities for efficiency, transparency, and trust in the digital age [5].

1.2.2 Types of Blockchain

Blockchain has three major types: public, private, and consortium blockchains [7].

Public blockchains: Public blockchains are open to anyone and allow any participant to join the network, validate transactions, and contribute to the consensus process. They are decentralised and permissionless, meaning that no central authority controls access to the network. Public blockchains are transparent, as anyone can view and verify the transactions stored on the blockchain. Bitcoin and Ethereum are examples of public blockchains.

Private blockchains: Private blockchains, also known as permissioned blockchains, are restricted to a specific group of participants who have been granted permission to access and participate in the network. These participants are typically known and trusted entities, such as organisations or consortiums. Private blockchains offer greater control and privacy compared to public blockchains, as access to the network is limited. They are commonly used in enterprise settings, where privacy and scalability are important considerations.

Consortium blockchains: Consortium blockchains are a hybrid model that combines elements of both public and private blockchains. A consortium or a group of organisations working together runs them. Consortium blockchains allow a limited set of participants to maintain and validate the blockchain, making them more efficient and scalable than public blockchains. Consortium blockchains are often used in industries where collaboration between multiple organisations is required, such as supply chain management or healthcare.

1.2.3 Blockchain Working

Blockchain works by utilising a combination of cryptographic principles, decentralised networks, and consensus algorithms to maintain a secure and transparent ledger of transactions or information. Here is a simplified explanation of how blockchain works [8].

Distributed network: Blockchain operates on a network of computers, often referred to as nodes, which can be owned and maintained by different individuals or organisations. These nodes communicate with each other to maintain a shared ledger.

Blocks: Transactions or data are grouped into blocks, which are essentially containers for information. Each block contains a unique identifier called a cryptographic hash, which is generated based on the data within the block [9].

Linking blocks: Each block in the blockchain contains a reference to the hash of the previous block, forming a chain of blocks. This linkage ensures the integrity and chronological order of the transactions.

Consensus mechanism: To validate and agree on the contents of each block, blockchain networks employ consensus mechanisms. Common consensus algorithms include proof of work (PoW) and proof of stake (PoS). These mechanisms require network participants (nodes) to solve complex mathematical problems or stake their cryptocurrency holdings to propose and validate new blocks [10].

Verification and validation: Once a block is proposed, it undergoes verification by the network participants. The nodes validate the proposed block and its transactions against predefined rules and cryptographic algorithms. If the majority of the nodes reach a consensus that the block is valid, it is added to the blockchain.

Immutability: Once a block is added to the blockchain, it becomes extremely difficult to alter or delete the information contained within it. This immutability is achieved through cryptographic hashing and the distributed nature of the network, making the blockchain resistant to tampering or fraud [11].

Transparency: The blockchain ledger is transparent, meaning that anyone in the network can view the transactions stored on it. While the identities of participants are typically pseudonymous, the details of transactions and their timestamps are accessible to all network participants.

Security: Blockchain employs cryptographic techniques to secure the data and transactions on the network. This includes using public-key cryptography, digital signatures, and hash functions to ensure confidentiality, integrity, and authenticity of the information.

1.3 Recent Works

Higher education has benefited from the adoption of blockchain technology as it has produced innovative solutions to problems with data management, credential authentication, and secure data transfer. Numerous studies have explored the

potential effects of blockchain technology on the educational sector, outlining the potential for higher standards of security, efficiency, and transparency. The key findings and contributions from those works are briefly summarised as follows:

Patrick Ocheja et al. introduced the blockchain of learning logs (BOLL), which enables students to transfer their learning data securely and verifiably across universities. The issue that learning data analytic systems encounter while providing individualised experiences to new learners is resolved by BOLL. With the consent of the students and/or the university that originally held the learning logs, BOLL allows current platforms to access learning logs from other institutions by keeping digital hashes of learning activities and controlling access rights using smart contracts on the blockchain. This paper's major contribution is an investigation into the use of BOLL to link learning data across institutions. The article compares the benefits of BOLL over other tools of a similar kind and provides an outline of the implementation's resource needs [12].

Meng Han et al. presented a novel blockchain-based method in order to establish a system in which individuals can be the administrators of their official educational records and readily share such information with others. A key characteristic of the blockchain is its decentralised nature. In contrast to accounts or records maintained by departments, colleges, universities, government agencies, and other institutions, the blockchain does not require a third party to complete or modify educational data. Using a system that integrates the cutting-edge capabilities of blockchain technology, educational institutions can now issue certificates that serve as proof of completion or achievement. The proposed architecture provided the necessary capabilities for higher education and a variety of additional applications [13].

For educational ecosystems, which include participants like students, teachers, and government organisations, sharing student credentials is essential. However, the procedure is often weak and unsafe. By offering a safe, immutable, authentic, tamper-proof, privacy-preserving, and readily shareable method, blockchain technology can help lower security worries. Puja Sarkar et al. provide a safe off-chain storage technique to scale the procedure. The performance and scalability of the architecture are evaluated using a decentralised application built on Ethereum technology [14].

The management of documents presents considerable difficulties for educational institutions, including misplaced documents, wastage of time and resources, and missed deadlines. Sheela Rani et al. developed a blockchain-based file tracking system and a platform for college students' data governance using the Chameleon Hash Function and the Advanced Encryption Standard (AES) algorithm. By using a secret key obtained from the file's contents to encrypt files and metadata, the Chameleon Hash Function adds an extra layer of protection. In higher education institutions, the AES algorithm optimises file tracking and data governance by providing features like access control, audit trails, and secure file sharing. In higher education institutions, this safe environment provides trustworthy information management and effective data exchange [15].

Shaikh et al. provided a secure blockchain hyperledger sawtooth-enabled consortium analytical approach for smart educational accreditation credential

assessment. Using machine learning methods, the model examines each candidate's university qualifications as well as their track record of trustworthiness. It analyses and stores these elements in distributed storage using a secure hash encryption (SHA-256) blockchain consortium network. The protection of accreditation credentials and storage requirements, such as candidate registration, updating of certificate-related accreditation credentials, and transaction preservation in immutable storage, are automated by chaincodes. The model mimics the dataset used as an educational benchmark and offers reliable performance in challenges involving credential administration and certification credibility [16].

In a decentralised environment facilitated by blockchain technology, transactions and data are verifiable and permanent. The EduCTX platform is a reliable, decentralised credit and assessment system for higher education that is founded on the European Credit Transfer and Accumulation System (ECTS). It provides students, higher education institutions (HEIs), and stakeholders with a unified perspective. Muhamed et al. proposed a solution based on the open-source Ark Blockchain Platform. EduCTX processes, manages, and controls ECTX tokens, which represent credit for successfully completed courses. HEIs are the peers of the blockchain network. The goal of the EduCTX initiative is to eliminate language and administrative barriers while creating a globally effective, simple, and pervasive environment. The platform encourages participation in the EduCTX programme and blockchain network by HEIs [17].

In summary, the above-mentioned studies contributions highlight numerous ways that blockchain technology is being used in the field of higher education. Due to its fundamental characteristics of security, transparency, and immutability, blockchain technology has the potential to revolutionise all aspects of the educational environment. These capabilities make it possible for secure data transfer, verification of credentials, decentralised credit systems, and effective document management.

1.4 Technical Aspects

This section provides an overview of various technical aspects related to data handling in higher education, like data acquisition, sharing, storage, interoperability, and privacy preservation as depicted in Fig. 1.1.

1.4.1 Data Acquisition

Introduction: Data acquisition is the process of collecting or gathering data from different sources. The process of data acquisition involves capturing, recording, and storing data. This captured data can be used for further analysis, processing, or in different applications. Data that is captured can be of different types, like numerical,