



Blockchain and Artificial Intelligence in Real Estate

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Abstract. Since their development, blockchain and artificial intelligence (AI) technologies have gained substantial momentum and immense adoption in different industries worldwide. The innovations of cryptocurrencies and machine learning algorithms have had significant implications for the growth and advancement of these technologies. The combination of the two presents incredible benefits to organizations in various sectors in terms of harnessing existing data for pattern recognition and insight identification. The technologies have impacted how industries do their businesses. This study includes a systematic review that explores how blockchain and AI, have changed the real estate industry, as well as the way the related businesses can take advantage of the technologies' capabilities to stay afloat within this new technological development. This research adopts the Prisma methodology to explore how the application of blockchain and AI has impacted the real estate sector. The main finding is that in real estate, the combination of blockchain and AI has great potential, especially in modeling data and valuation, storing information in digital formats and securing transactions.

Keywords: Blockchain · Artificial intelligence · Real estate

1 Introduction

Blockchain technologies provide secure ways for people to directly interact via decentralized and highly secure systems without the necessity of intermediaries. On top of their proficiencies, artificial intelligence can complement the technology and deal with most limitations associated with blockchain-based systems.

According to Treiblmaier, blockchain refers to distributed database typically shared between computer network nodes [1]. One of the critical advantages of blockchains is that they guarantee the security and fidelity of data records and generate trust minus the requirement for trusted third parties. Blockchain has introduced significant disruptions to the traditional business and operations processes since the transactions and applications that previously required trusted third parties for the centralized architectures for verification are now operating in a decentralized method with the help of blockchain [2]. Various inherent factors of the blockchain design and architecture provide the characteristics like robustness, transparency, security, and audibility. This is why blockchain is considered a distributed database with the organization of ordered blocks, and the committed blocks

are immutable [3]. More and more organizations are investing in blockchain technology to minimize the design and architecture for the costs of transactions and decentralized, thus becoming transparent, inherently safer, and significantly faster [4]. The number of applications of blockchain technology today explains the importance of blockchain technology. As an example, it is readily being adopted for the application along with cryptocurrencies and is still growing as well. According to a Forbes article by Castillo & Schiffrin, companies' and individuals' investment in blockchain technology is about \$2.9 billion, representing an 89 percent increase from the previous two years [5].

The significant growth pace of the application of blockchain technology can also result in interoperability issues due to the heterogeneity of the different applications. Moreover, the horizon of the application is significantly increasing as the fields and technologies along with which blockchain technology is being implemented are increasing [6, 7].

The increased advancement in technology allows us to do tasks requiring higher levels of intelligence more conveniently. For instance, AI technologies can allow a machine to operate more efficiently and intelligently. According to Bachute & Subhedar, machine learning and deep learning that are critical parts of AI, particularly helping to accomplish its mission of making machines act and think like humans [8]. Machine learning focuses on a particular objective of giving a computer the ability to do a task minus the need for direct programming. In this, a computer system is typically fed structured data and 'learns' to be better at analyzing data and, with time, processing it. After being programmed, computers can indefinitely understand new data sort and act on it without requiring additional human involvement. In this case, structured data can be thought of as data inputs capable of being inputted in rows and columns. A category column in a spreadsheet named 'drinks,' including row entries like 'water' or 'milk,' can be straightforward for a computer working with this form of 'structured' data. With time, the program may start identifying that 'water is a form of drink even after the user stops labeling the data. Such 'self-reliance' is key to machine learning. Machine learning can further be broken down into various forms based on the level of human intervention, for instance [9]:

- 1) Supervised and semi-supervised learning entails the most continuing human involvement. Computers are fed training data and models specially designed to teach how to respond to the data. The models can accurately handle any new dataset following the 'learned' pattern with time.
- 2) Semi-supervised learning involves computers being fed a combination of unlabeled and properly labeled data to search for patterns by itself.
- 3) Unsupervised learning – in this, the computers have the freedom of finding patterns and relations in data as they see fit, typically creating results that would have been invisible by human data analysts.
- 4) Reinforcement learning – this goes a step further ahead of unsupervised and supervised learning by identifying 'consequences' to the computers if they fail to accurately label or understand data.

While machine learning is mainly concerned with a machine's ability to do tasks without explicit programming, deep learning is primarily focused on their thinking and acting capabilities in the face of specific complex tasks.

Blockchain technologies provide secure ways for people to directly interact via decentralized and highly secure systems without the necessity of intermediaries. On top of their proficiencies, AI can complement the technology and deal with most limitations associated with blockchain-based systems. Combining the two (AI and blockchain technology) can be helpful in terms of providing high-performance and valuable results. A decade ago, several researchers focused on diversified applications of blockchain technology, which resulted in a linked structure, defining the various ways blockchain technology can be applied for problem-solving, avoiding double-spending issues, and maintaining the transaction orders [10, 11].

The main objective of this research is to explore the applications of blockchain and AI in the real estate sector. To achieve this objective, the study aims to find and discuss the existing literature on applying blockchain and AI technologies in the real estate sector. The works covered in this paper helps to explore and understand the concept of blockchain technology and determine how AI capabilities can be incorporated in blockchain technology-based systems and help facilitate the various processes in the real estate industry. The paper follows the PRISMA method of review to effectively explore materials related to the application of blockchain and AI in real estate and present evidence-based knowledge, which can be used for analysis, discussion, recommendation, and conclusion of the study. In addition, the paper also discusses some of the use cases and typical applications of the integrated approach of blockchain and AI.

2 Methodology

In order to provide a reproducible and transparent systematic literature review on the application of blockchain technology along with AI in Real Estate, the process suggested by Briner and Denyer [12] and the features presented in the PRISMA statement are adopted in this study [13]. This study's systematic literature review technique intends to locate literature relating to blockchain and artificial intelligence applications and choose and synthesize topics based on the research objective thoroughly and systematically. Also, the adopted review technique is based on a repetitive cycle of detecting the appropriate search keywords, assessing the relevant publications, and performing an analysis. An analysis protocol is also defined to outline the process from the protocol execution to gathering data and acquiring materials to be analyzed and studied.

The study adopts the appropriate data collection methodologies, including case studies and literature review, to get the firsthand perception of blockchain and AI technologies application in real estate.

The systematic literature review is carried out during January 2022, there are no time-frame restrictions, and the results are updated during February 2022. Various sources, including journals and online databases, such as Web of Science, ScienceDirect, Scopus, and the JSTOR database, were used to gather relevant information for the study.

The search term used to involve the following:

“Blockchain” AND “Artificial Intelligence” AND “Real Estate”

Moreover, additional search has been done with the usage of referenced work present in the relevant articles, with the help of the snowball effect [14, 15]. The research also includes the grey literature involving the unpublished research by the public or private institutions, and for that, the researcher evaluated the primary 100 hits on Google.

The database returned 272 publications as a result of the original search queries. Duplicates and articles with missing metadata (such as abstracts) were removed to improve the results. As a result, the number of publications dropped to 230. Using the four-eye principle, these were scrutinized and extensively inspected. These articles were then sorted by keywords, abstracts, titles, and content relevancy to blockchain and machine/deep learning marketing applications. The studies are evaluated based on inclusion and exclusion criteria as shown below (see Table 1). The studies are evaluated based on the screening of the title, screening of the abstract, and the screening of the full text as well.

Table 1. Exclusion and inclusion criteria

Selection criteria	Scientific database		Grey literature
Inclusion	Peer-reviewed research articles, book chapters, conference proceedings, review papers		English reports and studies
	Studies without time frame restrictions		No time frame restriction
Exclusion	During title screening	Non-English studies and articles	Generic articles and reports related to the blockchain-based technology
	During abstract screening	Generic articles related to blockchain	
	During full-text screening	Blockchain articles having a software-based orientation	
	During full-text screening	Articles involving technical characteristics and aspects of blockchain technology	

Only 58 publications made it beyond the first round of screening. Most articles describing blockchain and AI technologies' application in other industries such as finance, tourism, medical, agriculture, and others do not explicitly highlight their application implications in real estate, resulting in a significant drop in the number of articles. Only 24 studies were judged to align with the research aim after a comprehensive text reading and were thus retrieved for the final study. Each of these papers was considered relevant to the research and had texts highlighting the function and impact of blockchain and AI in real estate. The procedure of gathering data for the study is depicted in the diagram below (see Fig. 1).

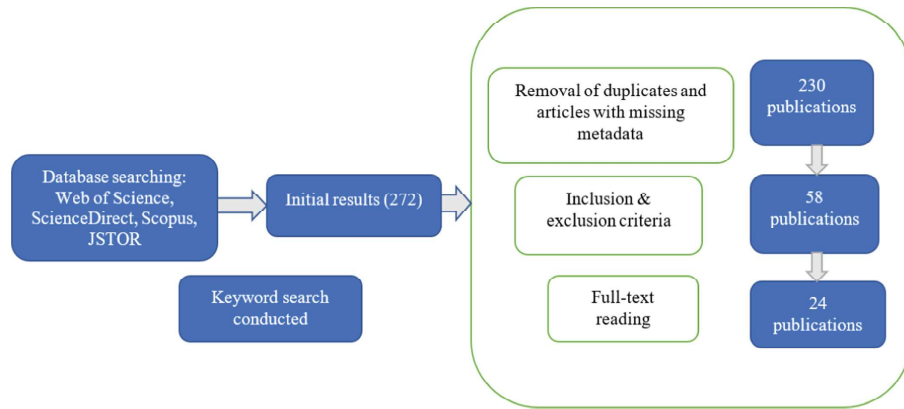


Fig. 1. Schematic representation of data collection.

The literature review method of data collection adopted in this case helps extract a body of information related to applying blockchain and artificial intelligence technologies in real estate from various sources. As a data collection tool, the literature review in this report includes activities like identifying, recording, understanding, meaning making and conveying information. The information collected here is done comprehensively.

3 Discussion

To begin with, blockchains store electronic information in digital formats. Block-chain is renowned for its fundamental role in a cryptocurrency system to maintain secure and decentralized transactions records. While they are closely related, Treiblmaier states that the data structure is a critical difference between blockchains and typical databases [1]. Blockchains gather information in a group, referred to as a block, which holds collections of information. A block includes a respective storage capacity. After it is complete, it is closed and connected to the previously entire blocks, creating chains of data referred to as the blockchains. All following new information after that newly added block is compiled into freshly made blocks that will consequently be added to the chain, as well, once complete [16]. Databases typically include data in the form of table structures. On the other hand, Blockchains, like its name implies, is structured into blocks threaded together. Inherently, those data structures make irreversible timelines of data when executed in decentralized manners. When blocks are filled, they are saved and become a part of that timeline. After adding them to the chains, all blocks are allocated particular time stamps. Leible et al. state that a blockchain is usually managed by peer-to-peer networks for use as publicly distributed ledgers, whereby nodes jointly follow protocols for communicating and validating a new block [17]. Today, there are private blockchains that can be used for business purposes. These blockchains have received mixed thoughts; for instance, Hampton referred to it as nothing more than ‘snake oil’ without appropriate security models [18]. On the other hand, others still argue that if a permissioned blockchain is carefully designed, it can be more decentralized and, thus, more secure practically than a permission-less one.

The models used in AI are modeled after the human brain and present very sophisticated approaches to machine learning to tackle various challenges. It includes inbuilt complex, multi-layered “deep neural networks” that facilitate data passing between nodes in vastly connected systems. Although it requires a lot of data for ‘feeding and building’ these systems, they can start generating results immediately with relatively minimal to no human intervention requirement after everything is in place [19]. The two primary forms of deep learning algorithms are convolutional neural networks and recurrent neural networks. The former are specially designed algorithms for working with imageries. The convolution part refers to the processes that apply weight-based filters within all elements of images to help computers understand and respond to elements in the individual picture.

Malhotra states that this can be rather useful when a user needs to scan various images for a particular feature or item, e.g., pictures of the sea floors for a sign of shipwrecks or an image of a multitude for a specific face of a person [19]. According to Sokolov, this discipline concerned mainly with analyzing and comprehending computer images and videos can be referred to as ‘computer vision, and been a rapidly growing area over the past decade [20].

Blockchain and AI bring innovative capabilities to the sector of real estate. As a database, blockchains store electronic information in digital formats. Blockchain facilitates the recording and distribution of digital information, which can not be edited, destroyed, deleted, or altered in any way whatsoever [21]. This means that applying the technology can, for one, help in securing records of transactions in the real estate sector since they are unalterable, undeletable, and indestructible.

The blockchain platform introduces a form of tokenism in real estate [22]. The platform documents, stores, and verifies ownership tokens making it easier to buy, sell, and trade [23]. According to an article published in Rebellion Research, the commercial real estate industry has been operating under some form of secrecy when it comes to aspects such as rental rates, valuations, and prices of properties to keep a competitive edge [24]. Blockchain applications offer a way for real estate companies to effectively store and process the massive amounts of data existing in the industry. Currently, vast amounts of data are being kept in physical brokers’ and builders’ offices. Through blockchain and AI companies can migrate manual operations, from upcoming projects brochures to ‘stacking’ malls and other building plans, administration related paperwork, contracts, and other legal documents to digital formats, which can be quickly processed. From the customers’ standpoint, the presence of conveniently accessible information showcasing preferable residential and commercial properties simplifies the clients’ journey toward buying, sell or leasing decisions.

With increasing levels of digitization, however, clients are demanding transparency. To ease the distribution of property related information on the internet, real estate firms have adopted blockchain technology to replace transactions rooted in trust with those proved by mathematics [24].

With blockchain technology, users can carry out transactions without the need for a central authority. Blockchain is radically advancing the real estate sector by enabling the recording of all information in an immutable manner [25]. The technology eliminates third parties and brokers in real estate transactions making the entire process simple and

transparent. According to a report, blockchain technology with its ability to create an immutable trail, increase trust, and data exchange, is preferred by industries such as real estate [26].

Moreover, blockchain in real estate is associated with cost reduction, increased transparency, and irrevocable documentation of processes [27]. But considering that the technology is still new and complex, there are challenges in terms of acceptance and implementation in companies. Blockchain allows optimization of retail and commercial property sales increases access to real estate funds and investment opportunities and streamlining of payments [28].

Liebkind observes that blockchain has opened up ways to change real estate transactions which are often conducted offline [29]. The author mentions that smart contracts in blockchain platforms have made it possible to tokenize assets like real estate. Companies worldwide are using smart contracts and ledgers offered by blockchain to carry out transparent and efficient real estate transactions [30, 31].

In real estate, prices mainly change every now and then after a property changes hands [32]. These changes usually result in high costs and huge volumes of transactions which can be hard to track and can even result in infrequent and inaccurate observations for some assets. In between a transaction, a real estate professional and investor needs to depend on valuations - the most possible prices to be acquired within the market, had the properties been put up for sale.

Although a valuation can be pretty straightforward, a lot more might be required when similar properties in the form of hedonic variables (also referred to as comparable) are transacted in the market near the valuation date [21]. When there are no consistent, similar transactions, the likely price of a property (whether commercial or residential) has to be calculated using a valuation process. While various processes can be used for the same, sophisticated econometric models such as the combination of blockchain and artificial intelligence would be able to provide even more accurate estimates of possible levels of discount rates and cashflows on top of providing the valuation. AI holds great promise for real estate valuation in providing high quality, timely, and accurate real estate data [33].

With the amounts of data existing related to real estate, implementing a balanced mix of modeling and data can be crucial for property valuation and other purposes. Although it requires a lot of data for ‘feeding and building’ these AI systems, they can start generating results immediately with relatively minimal to no human intervention requirement after everything is in place.

The capabilities provided by the technologies can also significantly influence the selling or buying decisions based on the perceived and analyzed present state of the real estate cycle and its expected future direction [34].

These advanced valuation techniques afforded by AI can analyze by simulating the player’s thought processes to come up with decisions.

For instance, regression algorithms account for property characteristics like location, age, room count, size, and other aspects of home quality such as swimming pool, air conditioning, and granite countertops. Supposing that the property can be seen as a collection of different characteristics or structural attributes (hedonic pricing method),

the property's valuation can be acquired by aggregating the contributory value of every feature [35].

Some of the features that can and are predicted using AI include:

- 1) Sale prices: Redfin and Zillow utilize machine learning algorithms to make accurate real estate price estimations, according to Soper [36];
- 2) Rental prices: HomeUnion came up with a tool referred to as RENTestimate for this [37];
- 3) Temporary rental prices: the pricing system used by Airbnb utilizes mathematical models that learn the likelihood of guests to book certain listings, on a particular date, at an assortment of diverse prices [38].

4 Conclusions

This study looks at how blockchain and AI can be applied in the real estate sector. Automating the various real estate processes using blockchain and AI means less time consumption, lesser human errors, and quality data analysis and predictions. AI improves the quantity and quality of information by efficiently processing it for superior decision-making and valuation purposes.

The combination of blockchain and AI provides several benefits to the real estate sector in securing transactions, extracting vast amounts of related data, analyzing the data, and making accurate assumptions based on the analysis. Enhanced computation power of computers supported with AI can make it simpler to grasp moving parts. Moreover, the integration of blockchain technology, which allows individuals to digitize data assets, can help reduce costs and labor in the real estate industry, through disintermediation. Currently, the sector does not have any standard way of holding data; data is stored in various forms. For instance, commercial real estate markets and lease documents are mostly not standardized, presenting challenges in evaluating information in different files.

Moreover, the discussed technologies can improve the real estate industry through property management, whereby everyday processes done by landlords, property managers, and tenants are streamlined using AI and blockchain capabilities. Landlords can also easily find appropriate tenants, find vendors and offer alerts for regular management and maintenance tasks. From a client's perspective, these technologies can help them find the suitable properties based on AI-powered recommendations presented through AI algorithms. What's more, payments will be made through blockchains to facilitate safe and secure transactions.

For a future study, a deeper look into the positive and negative implications of the technologies on the firms and customers can further help promote the idea of employing blockchains and AI in real estate.

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