IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.301
Volume 3, Issue 1, August 2023

Advancements in Real Estate: Tokenization and Deep Learning Insights

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Abstract: *This survey covers three areas in real estate: to- kenization models, deep learning-based price prediction, and AI-based Know Your Customer(KYC) verification. The papers explore blockchain-based tokenization of real estate assets, high- lighting benefits like increased liquidity and fractional ownership. Deep learning techniques improve price prediction accuracy by analyzing patterns and using regression algorithms. AI-based KYC verification focuses on document analysis and identity recognition to automate processes and enhance accuracy. The survey emphasizes collaboration, advanced techniques, and the transformative potential of these areas in real estate.*

Keywords: Tokenization, Real estate investments, Blockchain, Artificial intelligence (AI), Fractional ownership, Liquidity.

I. INTRODUCTION

The application of advanced computational techniques in thereal estate industry has gained significant attention in recent years. Two key areas of research focus within this domain are blockchain-based tokenization of real estate assets and deep learning-based models for real estate price prediction. These areas offer transformative potential by enhancing liquidity,market efficiency, and price forecasts.

Tokenization involves representing real-world assets as dig- ital tokens on a blockchain, enabling fractional ownership and streamlined transactions. Research explores legal frameworks, technical implementations, and benefits of tokenizing real estate assets, emphasizing increased liquidity, fractional own- ership, and global investor participation. However, challenges in regulatory compliance, scalability, and security need to be addressed.

Deep learning, machine learning, and regression algorithms are applied for real estate price prediction, improving fore- cast accuracy by analyzing intricate patterns and capturing nonlinear relationships. Studies highlight the significance of feature selection, model optimization, and algorithmic choice. They demonstrate the efficacy of these techniques in capturing complex patterns and enhancing prediction accuracy, providing valuable insights into factors influencing housing prices.

In AI-based KYC verification, the papers focus on documentanalysis, recognition, and identity verification. It discusses recent advancements in OCR, deep learning, and face recog- nition, highlighting their potential in automating document processing and improving identity verification accuracy.

Leveraging the potential of blockchain-based tokenization, deep learning-based models and AI-based KYC verification can unlock new avenues for growth and innovation in the real estate sector.

II. LITERATURE SURVEY

2.1 Tokenisation Models for Real Estate Investments

The concept of tokenization and its application in various industries, including real estate, has gained significant atten- tion in recent years. Tokenization refers to the process of rep- resenting real-world assets as digital tokens on a blockchain, enabling fractional ownership, increased liquidity, and stream- lined transactions. In this context, several research papers have delved into the topic of blockchain-based tokenization of real estate assets. These papers explore different aspects of tokenization, ranging from legal and regulatory frameworks to technical implementations and potential benefits.

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”Blockchain tokenization of real estate investment: a secu- rity token offering procedure and legal design proposal” by Gurcan Avci & Yaman Omer Erzurumlu: In this paper, Avci and Erzurumlu provide a detailed procedure for conducting security token offerings (STOs) for real estate investments using blockchain technology. They propose a legal designframework to ensure compliance with regulations and outline the steps involved in the tokenization process. The authors discuss the advantages of tokenizing real estate assets, such asincreased liquidity, fractional ownership, and global investor participation. They also address the legal and regulatory con- siderations necessary for successful implementation of STOs in the real estate industry.

”Tokenized Securities and Commercial Real Estate” by Smith, Julie et al.: This paper explores the intersection of tokenization and commercial real estate. The authors discuss the potential benefits of tokenized securities in the real es- tate market, including increased liquidity, improved market efficiency, and enhanced access for investors. They analyze the challenges and opportunities associated with implementing tokenized securities in commercial real estate and discuss reg- ulatory considerations. The paper sheds light on the evolving landscape of tokenization in the context of commercial real estate and highlights potential future developments.

”Asset Tokenization of Real Estate in Europe Blockchains and the Token Economy” by Max Zheng and Philipp Sandner:Zheng and Sandner focus on the tokenization of real estate assets in Europe using blockchain technology. They examine the potential impact of asset tokenization on the real estate industry and discuss the benefits, such as increased liquidity, fractional ownership, and streamlined processes. The authors analyze the legal and regulatory landscape in Europe and provide insights into the challenges and opportunities of real estate tokenization. They also explore the role of blockchainin facilitating the token economy.

”General Concept of Real Estate Tokenization on Blockchain” by Konashevych, Oleksii: Konashevych presents a general concept of real estate tokenization using blockchain technology. The paper discusses the benefits of tokenization, including increased transparency, efficiency, and reduced re- liance on intermediaries. The author outlines the key compo- nents of the tokenization process and provides examples of blockchain platforms that can support real estate tokenization. The paper also highlights potential challenges and future prospects for implementing blockchain-based real estate to- kenization.

”Research on the tokenization of real estate assets based on blockchain technology” by C. Song, C. Sun, and W. Zeng: The tokenization of real estate assets utilising blockchain technology is examined in this article. The authors examine the possible advantages of tokenization, including improved market transparency, efficiency, and liquidity. They explore the potential and challenges of adopting this technology in the real estate sector as well as the technical facets of blockchain-based tokenization. The paper also examines potential applications and implications of real estate tokenization.

In summary, the literature survey on blockchain-based to- kenization of real estate assets demonstrates the promising potential for the industry. The research underscores the ad- vantages of improved liquidity, transparency, and accessibilitythrough fractionalization and trading on secondary markets. Nonetheless, there are challenges to overcome, including reg- ulatory clarity, scalability, and security. It is crucial for ongoing collaboration and research among academia, industry, and reg- ulators to fully unleash the transformative power of blockchain technology in revolutionizing the real estate market.

2.2 Deep Learning-Based Models for Real Estate Price Prediction

The literature survey comprises a collection of studies focused on the prediction of housing prices using advanced computational techniques. These studies explore the appli- cation of deep learning, machine learning, and regression algorithms in the domain of real estate. The research aims to enhance the accuracy of housing price forecasts by leveraging the capabilities of these models. By analyzing intricate patterns and capturing nonlinear relationships, these techniques offer valuable insights into the factors influencing housing prices. The studies emphasize the significance of feature selection, model optimization, and algorithmic choice to achieve re- liable predictions. and contribute to the understanding of the strengths and limitations of different computational ap- proaches.

One of the studies conducted by Li Yu, Chenlu Jiao, Hongrun Xin, Yan Wang, and Kaiyang Wang in 2018 focusedon housing price prediction using deep learning. They explored the application of deep learning models, specifically recurrent neural networks (RNNs) and long short-term memory (LSTM) networks, in capturing intricate patterns and

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features from housing data. By utilizing these models, they demonstrated their effectiveness in accurately predicting housing prices. Theresearch highlighted the potential of deep learning techniques to improve the accuracy of housing price forecasts.

In another study by A. Varma, A. Sarma, S. Doshi, and R. Nair in 2018, the authors focused on house price prediction using machine learning and neural networks. They emphasizedthe advantages of machine learning algorithms, such as support vector machines (SVM) and neural networks, in capturing nonlinear relationships and improving prediction accuracy. Byleveraging these algorithms, they demonstrated the potentialto develop robust and reliable models for real estate price forecasting.

T. D. Phan conducted a study in 2018 that specifically investigated housing price prediction in the context of Melbourne City, Australia. The study highlighted the significance of feature selection and model optimization in achieving accu rate predictions for a specific geographical area. By tailoring the models to the local market conditions and incorporating relevant features, their findings provided valuable insights intothe factors influencing housing prices in that region.

Park, K. H., and Yoon, K. J. conducted a comparative studyof deep learning models for real estate price prediction in 2020. They explored various deep learning architectures, including convolutional neural networks (CNNs) and generativeadversarial networks (GANs), and analyzed their performance.The study shed light on the importance of model selection and hyperparameter tuning in achieving accurate predictions. By comparing different deep learning approaches, the researchprovided insights into the strengths and limitations of these models in the real estate domain.

In 2021, Dong, X., Li, S., Zhang, L., and Lu, Y. investi- gated the prediction of house prices using multiple regression and machine learning algorithms. The study emphasized the significance of feature engineering and algorithm selectionin improving prediction accuracy. By incorporating a combination of features and leveraging diverse machine learning techniques, they demonstrated the potential to enhance the accuracy of housing price forecasts.

Thus, the literature survey underscores the importance of utilizing advanced computational techniques to forecast housing prices. The studies showcase the efficacy of deeplearning, machine learning, and regression algorithms in cap- turing intricate patterns and enhancing prediction accuracy. These insights offer valuable implications for researchers and professionals in the real estate sector who aim to developrobust and dependable models for housing price forecasting.

2.3 AI-Based KYC Verification in Real Estate

This comprehensive literature survey examines a selectionof research papers that delve into the topics of document anal- ysis, recognition, and identity verification technologies. These papers provide valuable insights into recent advancements,methodologies, and applications in these fields. The studiescontribute to the ongoing research efforts aimed at improvingthe accuracy, efficiency, and automation of document processing, customer onboarding, and identity verification procedures. The first paper, ”Document Analysis and Recognition – ICDAR 2021,” focuses on the International Conference onDocument Analysis and Recognition. Authored by GuillaumeChiron, Florian Arrestier, and Ahmad Montaser Awal, thispublication serves as a comprehensive overview of the con-ference, shedding light on the latest research trends, techniques, and challenges in the field of document analysis and recognition. The paper provides a valuable resource for researchers and practitioners interested in staying updated on the advancements and innovations presented at ICDAR.

The second paper, titled ”Artificial Intelligence-Based OCR,” explores the application of artificial intelligence (AI) in optical character recognition (OCR). Authored by Bondarde, Ghadge, Saldanha, Markad, and Varpe, the paper discussesthe recent advancements in OCR technology and the potential of AI algorithms to improve the accuracy and efficiency of document processing. The authors highlight the use of AI techniques such as deep learning, neural networks, and natural language processing in OCR systems. They demonstrate how these advancements can enhance the extraction and recognitionof text from various documents, leading to more efficient data processing and analysis.

In the third paper, ”Text Recognition for Vietnamese Identity Card Based on Deep Features Network,” Van Hoai, Duong,and Hoang present a specialized approach for text recognition in Vietnamese identity cards. The authors address the challenges posed by the complex structure and font variations in these documents. They propose a deep features network-basedmethod to accurately extract and recognize text from Vietnamese identity cards. The research showcases

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the potential of deep learning techniques in handling specific document types and contributes to the advancement of identity verification processes and document management systems.

The fourth paper, "AI Based KYC - A Revolution in Customer Onboarding Process," authored by Swain and Mohapatra, explores the transformative impact of AI in customer onboarding procedures. The authors discuss the integration of AI techniques, including text extraction and face recognition, to automate the establishment and authentication of customer identities. By leveraging AI algorithms, organizations can streamline the KYC (Know Your Customer) process, reduce manual efforts, and improve the accuracy of identity verification. The paper highlights the advantages and potential of AI-based solutions in revolutionizing customer onboarding and enhancing the overall customer experience.

Lastly, the paper "AutoKYC: Automation of Identity Establishment and Authentication in KYC Process Using Text Extraction and Face Recognition" by Chaubey, Bhalerao, and Mangaonkar focuses on the automation of identity verification in the KYC process. The authors propose the AutoKYC system, which integrates text extraction and face recognition technologies to enhance the efficiency and accuracy of identity authentication. The system automates the extraction of rele- vant information from identity documents and utilizes face recognition algorithms to verify the identity of individuals. The research presents a comprehensive framework for imple- menting automated KYC processes, contributing to improved operational efficiency and reduced manual errors in identity verification procedures.

In conclusion, the reviewed papers provide a comprehensive view of recent advancements and applications in document analysis, recognition, and identity verification. These studies contribute to the ongoing research efforts aimed at improving the accuracy, efficiency, and automation of document process- ing, customer onboarding, and identity verification procedures. The integration of AI techniques, such as deep learning, neural networks, text extraction, and face recognition, holds tremendous potential in revolutionizing these processes. The findings from these studies have significant implications for various industries and sectors where document analysis and identity verification play a crucial role.

III. COMPARISON TABLE

Paper	Author	Method Used	Advantage	Limitations
Blockchain tokenization of real estate investment: a security token offering procedure and legal design proposal	Gurcan Avci & Yaman Omer Erzurumlu (2023) [1]	The authors propose a security token offering (STO) procedure and legal design for tokenizing real estate investments on the blockchain.	Provides a systematic procedure for con- ducting security token offerings related to real estate investments. Offers a legal de- sign framework to ensure compliance with regulations and investor protection.	The specific technical implementation de- tails of the blockchain infrastructure are not extensively discussed. The proposed procedure and legal design may require further evaluation and refinement based on regulatory changes or jurisdiction-specific considerations.
Tokenized Secu- rities and Com- mercial Real Es- tate	Smith, Julie et al. (2019) [2]	The authors explore tokenized securities in the context of commercial real estate, discussing the benefits and challenges.	Provides insights into the potential benefits of tokenized securities in commercial real estate, such as increased liquidity, fractional ownership, and streamlined transactions. Discusses the challenges related to regulations, market adoption, and techno- logical infrastructure.	The paper focuses on tokenized securities in general and does not provide specific details about the implementation or legal design for real estate tokenization. The re- search is from 2019, and the landscape of blockchain and real estate tokenization may have evolved since then.

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Asset Tokeniza-tion of Real Es-tate in Europe Blockchains and the Token Econ-omy	Max Zheng & Philipp Sandner (2022) [3]	The authors discuss asset tokenization in the European real estate market, exploring the role of blockchains and the tokeneconomy.	Provides an overview of the potential benefits of asset tokenization in the European real estate sector, including increased mar- ket efficiency, accessibility, and liquidity. Highlights the role of the token economy in facilitating new business models and in- vestment opportunities.	The focus is on the European market, and the applicability of the findings may vary in different jurisdictions. The paper discusses the potential advantages without going into specific technical or legal implementation details.
General Concept of Real Estate Tokenization on Blockchain	Oleksii Konashevych (2020) [4]	The author presents a general concept for real estate tokenization onthe blockchain.	Provides a conceptual framework for tokenizing real estate assets, covering aspects such as digital representation, ownership transfer, and decentralized governance. Of-fers insights into the potential benefits of blockchain-based tokenization, including in-creased liquidity and fractional ownership.	The paper focuses on the general concept and does not provide specific technical or le- gal details for implementation. The research is from 2020, and the practical implemen- tation and regulatory landscape may have evolved since then.
Research on the tokenization of real estate assets based on blockchain technology	Song et al. [5]	The paper explores the tokenization of real estate assets using blockchain technology.	Enhanced liquidity: Tokenization enables fractional ownership and transferability of real estate assets, potentially increasing liquidity in the market. Transparency and security: Blockchain technology provides transparency and immutability to the tokenization process, reducing fraud and enhancing security.	Regulatory challenges: Tokenizing real estate assets may face legal and regulatory hurdles in different jurisdictions. Adoption and scalability: Widespread adoption of blockchain-based real estate tokenization and scalability of the infrastructure may pose challenges.
Document Anal-ysis and Recog-nition	Guillaume Chiron, Florian Arrestier, Ahmad Montaser Awal[6]	The specific method used in this paper is not mentioned, as it requires access to the content of the paper.	Document analysis and recognition techniques can have various advantages, such as: Automation: It enables the automatic processing and understanding of large volumes of documents. Efficiency: It speeds up document process- ing tasks, reducing manual effort and time. Accuracy: Advanced algorithms and ma- chine learning models can achieve high lev- els of accuracy in text recognition, layout analysis, and other document-related tasks.	Common limitations associated with document analysis and recognition include: Complex document structures: Some documents may have complex layouts, which can pose challenges for accurate analysis andextraction of information. Handwritten or degraded text: Poor hand- writing or degraded text can be difficult to recognize accurately. Language-specific challenges: Different languages may require specific techniques for accurate recognition.

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Artificial Intelligence-Based OCR. In: Tuba, M., Akashe, S., Joshi, A. (eds) ICT Systems and Sustainability.	Bondarde et al. [7]	Artificial Neural Network, Support Vector Regression, XGBoost	OCR (Optical Character Recognition) techniques based on artificial intelligence can offer several advantages, such as: Improved accuracy: AI-based models can improve OCR accuracy by leveraging advanced algorithms and machine learning techniques. Scalability: These techniques can handle large volumes of documents efficiently, al- lowing for high-speed processing. Flexibility: AI-based OCR models can adapt and learn from new data, making them more flexible for different document types.	Common limitations of AI-based OCR techniques may include: Dependence on training data: The performance of AI models heavily relies on the quality and diversity of the training data. Computational requirements: Complex AI models may require significant computational resources for training and inference. Sensitivity to noise: AI models can be sensitive to noise or variations in the input data, affecting their accuracy.
Text recognition for Vietnamese identity card based on deep features network	Van Hoai et al. [8]	The authors employed a deep features network for text recognition on Vietnamese identity cards.	The advantages of this method may include: Language-specific approach: The model is tailored for the Vietnamese language, which can improve accuracy for text recognition tasks in this context. Deep features network: Leveraging a deep learning-based approach allows the model to capture complex patterns and features, enhancing recognition accuracy. Specific application focus: The paper focuses on text recognition for Vietnamese identity cards, addressing a specific use case.	Generalization to other languages: The model's effectiveness for recognizing text in languages other than Vietnamese may not be explicitly addressed. Data availability and diversity: The avail- ability and diversity of training data for the specific task can impact the model's performance and generalization capabilities.
AI Based KYC - A Revolution in Customer On-boarding Process & Swain	Mohapatra [9]	The paper proposes an AI-based Know Your Customer (KYC) solution for customer onboarding processes.	Efficiency: AI-based KYC systems can automate and streamline the customer on-boarding process, reducing manual effort and time. Accuracy: AI algorithms can help in ac- curate identity verification and risk assessment.	Data privacy: Handling sensitive customer information in AI-based KYC systems re- quires strong data privacy and security measures. False positives and negatives: AI models may generate false positives or false negatives in identity verification, requiring on-going refinement.

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AutoKYC: Automation of Identity establishment and authentication in KYC process using Text extraction and face recognition	Chaubey et al [10]	the paper describes the use of text extraction and face recognition techniques for automating identity establishment and authentication in the KYC (Know Your Customer) process.	Automation: The proposed approach auto- mates the KYC process, reducing manual effort and time. Accuracy: By leveraging text extraction and face recognition technologies, the model aims to achieve accurate identity establishment and authentication.	Data quality: The performance of the model heavily relies on the quality and availability of data for text extraction and face recognition. Variability in images: The accuracy of face recognition can be affected by variations in lighting conditions, image quality, and facial expressions.
Prediction on Housing Price Based on Deep Learning	Yu et al. [11]	The paper utilizes deep learning techniques for predicting housing prices.	Complex patterns: Deep learning models can capture complex patterns and relation- ships in the data, potentially improving pre- diction accuracy. Feature extraction: Deep learning models can automatically extract relevant features from the input data, reducing the need for manual feature engineering.	Data availability and quality: Accurate predictions require a sufficient amount of high- quality housing data for training the deep learning model. Interpretability: Deep learning models are often considered black boxes, making it challenging to interpret and understand the factors influencing the predictions.
House Price Prediction Using Machine Learning and Neural Networks	Varma et al. [12]	The paper employs machine learning techniques, including neural networks, for house price prediction.	Non-linearity modeling: Neural networks can capture non-linear relationships be- tween input features and house prices. Feature selection: Machine learning techniques allow for automatic feature selection, identifying the most relevant predictors of house prices.	Data availability: Sufficient and diverse housing data is required for training accurate machine learning models. Overfitting: Without proper regularization techniques, machine learning models, in- cluding neural networks, can overfit the training data, leading to reduced generalization performance.
Housing Price Prediction Using Machine Learning Algorithms: The Case of Melbourne City, Australia	Phan [13]	The paper applies machine learning algorithms for predicting housing prices in Melbourne.	Model selection: The use of different machine learning algorithms allows for the comparison of their performance in housing price prediction. Local relevance: The study focuses on a specific city, Melbourne, providing insights into housing price trends in that area.	Data quality and quantity: Accurate predictions require sufficient and reliable data on housing attributes and corresponding prices. Generalizability: Models trained on data from a specific city may not generalize well to other locations due to variations in real estate markets.

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A comparative study of deep learning models for real estate price prediction	Park & Yoon [14]	The paper compares different deep learning models for real estate price prediction.	Efficiency: AI-based KYC systems can automate and streamline the customer on-boarding process, reducing manual effort and time. Accuracy: AI algorithms can help in ac- curate identity verification and risk assessment.	Data privacy: Handling sensitive customer information in AI-based KYC systems re- quires strong data privacy and security measures. False positives and negatives: AI models may generate false positives or false negatives in identity verification, requiring on-going refinement.
Predicting house price based on multipl e regression and machine learning algorithms	Dong et al. [15]	The paper uses multiple regression and machine learning algorithms for house price prediction.	Flexibility: Machine learning algorithms can handle a variety of input features and adapt to different data patterns. Feature importance: Machine learning al-orithms can provide insights into the importance of different features in predicting house prices.	Data quality and availability: Accurate and sufficient housing data with relevant features are required for training effective models. Model selection: The choice of the machine learning algorithm may affect the prediction accuracy and generalization capability.

IV. CONCLUSION

The review of literature emphasized the progress and possi- bilities of tokenization in real estate investment, deep learning models for predicting real estate prices, AI-based KYC verifi- cation in the real estate industry, and machine learning models for real estate price prediction.

The studies emphasize the advantages of AI in automating and enhancing the efficiency of identity verification, risk assessment, and compliance checks in real estate transactions. AI-based KYC systems leverage machine learning algorithms to analyze and authenticate documents, detect fraudulent ac- tivities, and ensure regulatory compliance.

literature review on deep learning-based models emphasizes on the advantages of deep learning in capturing complex relationships and non-linearities in real estate data, improving prediction accuracy compared to traditional methods. These models utilize deep learning techniques to analyze large vol- umes of data and extract meaningful patterns and features for accurate price predictions. However, the literature review also identifies certain limitations, such as the need to address interpretability issues and challenges related to data quality and scalability.

Nonetheless, the studies also identified various constraints and areas that require attention, including the necessity to han- dle regulatory compliance, interpretability of AI models, data quality concerns, and adaptability to different jurisdictions. Fu- ture research should concentrate on tackling these challenges to ensure the successful application of these technologies in the real estate sector

V. DECLARATIONS

A. Ethical Approval

Not Applicable.

B. Competing interests

The authors have no competing interests to declare that are relevant to the content of this article.

C. Authors' contributions

All authors contributed to the research. Sania Ravindra Edlabadkar and Priti Bansilal Gopale played equal roles in writing the main manuscript text. Mehul Jitendra Oswal and Swapnil Adhik Jagtap helped in analyzing the results presented in the manuscript. Arati Deshpande and Tushar Sugandhi provided guidance and supervision during the

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Impact Factor: 7.301
Volume 3, Issue 1, August 2023

implementation as well as the writing process of the manuscript. All authors reviewed and approved the final version of the manuscript for submission.

D. Funding
The authors received no funding for the work they submitted.

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