Advancements in Real Estate: Tokenization and Deep Learning Insights

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Abstract: This survey covers three areas in real estate: tokenization 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 the real 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 digital 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 ownership, 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 forecasting 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 document analysis, recognition, and identity verification. It discusses recent advancements in OCR, deep learning, and face recognition, 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 attention in recent years. Tokenization refers to the process of representing real-world assets as digital tokens on a blockchain, enabling fractional ownership, increased liquidity, and streamlined 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.
"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 design framework 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 as increased liquidity, fractional ownership, and global investor participation. They also address the legal and regulatory consider- ations 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 estate 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 regulatory 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 blockchain 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 reliance on intermediaries. The author outlines the key components 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 tokenization.

"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 utilizing 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 tokenization of real estate assets demonstrates the promising potential for the industry. The research underscores the advantages of improved liquidity, transparency, and accessibility through fractionalization and trading on secondary markets. Nonetheless, there are challenges to overcome, including regulatory clarity, scalability, and security. It is crucial for ongoing collaboration and research among academia, industry, and regulators 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 application 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 reliable predictions and contribute to the understanding of the strengths and limitations of different computational approaches.

One of the studies conducted by Li Yu, Chenlu Jiao, Hongrun Xin, Yan Wang, and Kaiyang Wang in 2018 focused on 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
features from housing data. By utilizing these models, they demonstrated their effectiveness in accurately predicting housing prices. The research 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 emphasized the advantages of machine learning algorithms, such as support vector machines (SVM) and neural networks, in capturing nonlinear relationships and improving prediction accuracy. By leveraging these algorithms, they demonstrated the potential to 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 accurate predictions for a specific geographical area. By tailoring the models to the local market conditions and incorporating relevant features, their findings provided valuable insights into the factors influencing housing prices in that region.

Park, K. H., and Yoon, K. J. conducted a comparative study of deep learning models for real estate price prediction in 2020. They explored various deep learning architectures, including convolutional neural networks (CNNs) and generative adversarial 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 researchers provided 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. investigated the prediction of house prices using multiple regression and machine learning algorithms. The study emphasized the significance of feature engineering and algorithm selection in 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 deep learning, machine learning, and regression algorithms in capturing intricate patterns and enhancing prediction accuracy. These insights offer valuable implications for researchers and professionals in the real estate sector who aim to develop robust and dependable models for housing price forecasting.

### 2.3 AI-Based KYC Verification in Real Estate

This comprehensive literature survey examines a selection of research papers that delve into the topics of document analysis, recognition, and identity verification technologies. These papers provide valuable insights into recent advancements, methodologies, and applications in these fields. The studies contribute to the ongoing research efforts aimed at improving the 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 on Document Analysis and Recognition. Authored by Guillaume Chiron, Florian Arrester, and Ahmad Montasser Awal, this publication serves as a comprehensive overview of the conference, 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 discusses the 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 recognition of 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-based method to accurately extract and recognize text from Vietnamese identity cards. The research showcases
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, Bhalaria, 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 relevant information from identity documents and utilizes face recognition algorithms to verify the identity of individuals. The research presents a comprehensive framework for implementing automated KYC processes, contributing to improved operational efficiency and reduced manual errors in identity verification procedures.

In conclusion, the reviewed papers provide a comprehensive review 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 processing, 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

<table>
<thead>
<tr>
<th>Paper</th>
<th>Author</th>
<th>Method Used</th>
<th>Advantage</th>
<th>Limitations</th>
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<tr>
<td>Blockchain tokenization of real estate investment: a security token offering procedure and legal design proposal</td>
<td>Gurcan Avci &amp; Yaman Erzurumlu (2023) [1]</td>
<td>The authors propose a security token offering (STO) procedure and legal design for tokenizing real estate investments on the blockchain.</td>
<td>Provides a systematic procedure for conducting security token offerings related to real estate investments. Offers a legal design framework to ensure compliance with regulations and investor protection.</td>
<td>The specific technical implementation details of the blockchain infrastructure are not extensively discussed. The proposed procedure and legal design may require further evaluation and refinement based on jurisdiction-specific considerations.</td>
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<tr>
<td>Tokenized Securities and Commercial Real Estate</td>
<td>Smith, Julie et al. (2019) [2]</td>
<td>The authors explore tokenized securities in the context of commercial real estate, discussing the benefits and challenges.</td>
<td>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 technological infrastructure.</td>
<td>In general and does not provide specific details about the implementation or legal design for real estate tokenization. The research is from 2019, and the landscape of blockchain and real estate tokenization may have evolved since then.</td>
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<tr>
<td>Topic</td>
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<tr>
<td>Asset Tokenization of Real Estate in Europe Blockchains and the Token Economy</td>
<td>Max Zheng, Philipp Sandner (2022)</td>
<td>Provides an overview of the potential benefits of asset tokenization in the European real estate sector, including increased market efficiency, accessibility, and liquidity. Highlights the role of blockchains and the token economy.</td>
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<tr>
<td>General Concept of Real Estate Tokenization on Blockchain</td>
<td>Oleksii Konashevych (2020)</td>
<td>The author presents a general concept for real estate tokenization on the blockchain.</td>
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<td>Research on the tokenization of real estate assets based on blockchain technology</td>
<td>Song et al. [5]</td>
<td>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.</td>
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<tr>
<td>Document Analysis and Recognition</td>
<td>Guillaume Chiron, Florian Arrestier, Ahmad Montaser Awal[6]</td>
<td>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 processing tasks, reducing manual effort and time. Accuracy: Advanced algorithms and machine learning models can achieve high levels of accuracy in text recognition. Layout analysis, and other document-related tasks.</td>
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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.

The paper focuses on the general concept and does not provide specific technical or legal details for implementation. The research is from 2020, and the practical implementation and regulatory landscape may have evolved since then.

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.

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 and extraction of information. Handwritten or degraded text: Poor handwriting or degraded text can be difficult to recognize accurately. Language-specific challenges: Different languages may require specific techniques for accurate recognition.
Artificial Intelligence-Based OCR

In: Tuba, M., Akashe, S., Joshi, A. (eds) ICT Systems and Sustainability.

Text recognition for Vietnamese identity cards 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.

AI Based KYC - A Revolution in Customer On-Boarding Process

Mohapatra [9]

The paper proposes AI-based Know Your Customer (KYC) system solutions for customer onboarding processes. Efficiency: AI-based KYC systems can automate and streamline the customer onboarding process, reducing manual effort and time. Accuracy: AI algorithms can help in accurate identity verification and risk assessment. Data privacy: Handling sensitive customer information in AI-based KYC systems requires strong data privacy and security measures. False positives and negatives: AI models may generate false positives or false negatives in identity verification, requiring ongoing refinement.

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, allowing 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.

- 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 availability and diversity of training data for the specific task can impact the model’s performance and generalization capabilities.

- Data privacy: Handling sensitive customer information in AI-based KYC systems requires strong data protection measures. False positives and negatives: AI models may generate false positives or false negatives in identity verification, requiring ongoing refinement.
<table>
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<tr>
<th>AutoKYC: Automation of Identity establishment and authentication in KYC process using Text extraction and face recognition</th>
<th>Chaubey et al. [10]</th>
<th>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.</th>
<th>Automation: The proposed approach automates the KYC process, reducing manual effort and time. Accuracy: By leveraging text extraction and face recognition techniques, the model aims to achieve accurate identity establishment and authentication. Variability in images: The accuracy of face recognition can be affected by variations in lighting conditions, image quality, and facial expressions.</th>
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<tr>
<td>Prediction on Housing Price Based on Deep Learning</td>
<td>Yu et al. [11]</td>
<td>The paper utilizes deep learning techniques for predicting housing prices.</td>
<td>Complex patterns: Deep learning models can capture complex patterns and relationships in the data, potentially improving prediction accuracy. Feature extraction: Deep learning models can automatically extract relevant features from the input data, reducing the need for manual feature engineering. Data quality and quantity: Accurate predictions require a sufficient amount of high-quality housing data for training the deep learning model. Interpretabiliy: Deep learning models are often considered black boxes, making it challenging to interpret and understand the factors influencing the predictions.</td>
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<tr>
<td>Housing Price Prediction Using Machine Learning Algorithms: The Case of Melbourne City, Australia</td>
<td>Phan [13]</td>
<td>The paper applies machine learning algorithms for predicting housing prices in Melbourne.</td>
<td>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.</td>
</tr>
<tr>
<td>Paper</td>
<td>Predicting House Price Based on Multiple Regression and Machine Learning Algorithms</td>
<td>The paper uses multiple regression and machine learning algorithms for house price prediction.</td>
<td>Flexibility: Machine learning algorithms can handle a variety of input features and adapt to different data patterns. Feature importance: Machine learning algorithms can provide insights into the importance of different features in predicting house prices.</td>
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### 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 verification 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 activities, 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 volumes 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 handle regulatory compliance, interpretability of AI models, data quality concerns, and adaptability to different jurisdictions. Future 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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REFERENCES


