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Real Estate App Development Based on AI/VR Technologies

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Abstract: This paper deals with an investigation centered on developing a real estate app on the basis of Artificial Intelligence and Virtual Reality technologies. The study explores the advantages and disadvantages of using Artificial Intelligence and Virtual Reality technologies in real estate. The main focus of the study was on AI/VR applications that have importance for the real estate industry. This paper explains how AI and VR technologies can benefit the real estate market. VR and AI technologies have had a long history in the academic world since the middle of the last century, but not at the same level, due to the lack of large amounts of data and computational power required for both technologies. In recent years, the expansion of IT technologies has helped to remove the technical obstacles, which is why the interest in VR and AI technologies has acutely increased in society and the public over the past several years. Not only the research and abstract ideas of the virtual world but also the feasibility of companies from different industries are becoming more and more relevant. In particular, when it comes to virtual reality, the focus is on 360° images. With special cameras, the entire environment can be captured in a three-dimensional space and then cut together in such a way that the viewer can actually look around in this room and monitor events from his perspective. This opens the possibility of presenting different content in a completely new way. Technical shortcomings currently hamper the feeling of true immersion in virtual worlds. A detailed literature review provides the necessary theoretical basis for artificial intelligence and virtual reality with a particular emphasis on its use in the real estate industry.

Keywords: artificial intelligence; AI chatbot; Internet of Things; virtual reality; 360° images; three-dimensional space (3D); real estate

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1. Introduction

Virtual reality and artificial intelligence will allow humans to completely immerse themselves in technologic progress [1–4]. There are modern technologies that are developing from day to day, and which are beginning to play a significant role in various areas. The key idea is to conceal the real world and interact with the new virtual world. Here, we will present a brief overview of the beginning of these virtual world technologies and explanations of the required development environment.

Concerning available technologies, the Internet of Things has already entered many households. Users are conversing with mobile devices and services powered by highly advanced algorithms. Modern technologies [5–10], including the Internet of Things, blockchain, virtual reality and augmented reality, smarter devices, artificial intelligence, machine learning, extended reality, 3D printing, new energy solutions, 5G, and robotic process automation, have served as a real polygon for significant upgrades to existing ones and the development of new technologies that already make everyday life easier.

The real estate industry is embracing technology [11] to make the buying and selling process more efficient, accurate, and effective for all parties involved.

Several modern technologies [12–15] are currently used in the real estate industry to improve the buying and selling process. In contrast to online property listing platforms and real estate websites which are also becoming increasingly popular, virtual reality and artificial intelligence are currently being used in the real estate industry to improve the buying and selling process.

In this study, we will pay attention to the analysis of research and development of artificial intelligence and virtual reality technologies [16], as well as explore the advantages and disadvantages of these technologies in real estate.

Analysis of VR technology in real estate. The use of virtual reality technologies in the real estate industry has been growing in recent years as more companies are oriented to capitalize on their potential to enhance consumers' buying and selling experience.

The virtual reality world [17–19] is clearer and better than ever. Virtual reality is a simulated computer environment, and special computer peripherals and programs, within which the user is provided with a look at the residence, movement, and observation, are becoming a reality. Users are immersed in feeling like they first come to the simulated reality, primarily by stimulating their vision and hearing. Virtual reality is the most developed type of reality technology. Virtual reality is an artificial environment produced by software and presented to the user such that the user interrupts their belief and accepts it as the right environment. Virtual reality [19] is experienced on the computer through two senses: vision and sound. A 3D image is the simplest form of virtual reality that can be interactively explored on a personal computer, typically by manipulating the keys or the mouse, so that the image's content moves in some way or is zoomed in or out.

A market analysis of VR in the real estate industry [20] shows that using VR technology increases property engagement and interest and helps reduce the number of physical property viewings needed, saving time and money for both buyers and sellers. VR technology improves property listings' accuracy by providing a more detailed and immersive view of properties.

Another benefit of VR technology in real estate [20] is the ability to provide virtual walkthroughs of properties under construction, allowing buyers to understand the finished product and sellers to reduce the number of changes needed after construction is completed.

The VR market in real estate is expected to rise, based on the increasing demand for interactive property viewing experiences. A market analysis of the VR market in real estate for 2022 predicts that virtual reality technology [21] will continue to grow as more companies adopt it to enhance consumers' buying and selling experience. With the situation of the current pandemic, the use of VR technology is likely to increase as it allows virtual tours and online showings, reducing the need for physical interactions.

VR technology in real estate is expected to expand to other areas, such as architecture, design, and construction. VR technology creates virtual walkthroughs [22] of properties under construction, helps buyers visualize the finished products, and helps builders plan new developments.

The VR market in real estate has much potential to improve consumers' buying and selling experience and is expected to continue growing. Real estate companies need to stay up to date with the progress in VR and AR technologies to invest in the necessary equipment and training for their employees to ensure that they provide a seamless and user-friendly experience for their consumers.

The VR market in real estate [22] is expected to continue growing in 2022, driven by increasing demand for more immersive and interactive property viewing experiences. Adopting VR technology will be a key factor for companies to remain competitive in the industry.

Analysis of AI technology in real estate. Artificial intelligence in the real estate industry [23–26] has grown recently as more companies capitalize on its potential to improve efficiency and decision-making.

A market analysis of AI in the real estate industry shows that AI technology [26] helps companies automate repetitive tasks such as property inspections and showings, saving

time and money for agents and clients. AI analyzes huge volumes of data and provides market insights and predictions on property prices, rental rates, and other market trends, which can help real estate professionals make more informed decisions.

Another benefit of AI technology in real estate is its ability to provide personalized and tailored services to clients, such as customized property recommendations and virtual tours based on their preferences and search history. Advancements in AI and machine learning algorithms [7,27,28] have enabled the industry to quickly and accurately analyze big data and use it to improve decision-making.

AI technology is in the middle stage of development. Real estate companies need to ensure that the data they are using are accurate and unbiased so that the results and predictions made by the AI systems are reliable. The AI market in real estate has much potential to improve client services' efficiency, accuracy, and personalization.

Progress in computing has expanded our ability to solve problems at a level users could never have imagined using previously unavailable strategies. Artificial intelligence can revolutionize life by investigating 5G network input information. AI/VR technologies and 5G technology are closely related and key drivers of the 4th industrial revolution. 5G networks will provide the high-speed, low-latency connectivity needed to support the large amounts of data generated by AI systems. This will enable new-use cases such as autonomous vehicles, smart cities, and industrial automation. AI, in turn, will be used to optimize and manage 5G networks and create new services and applications that take advantage of the capabilities of 5G [29]. Together, AI/VR and 5G will enable new levels of automation, efficiency, and innovation across various industries and sectors. 5G networks will provide the necessary bandwidth and low latency to support the real-time streaming of VR content, making it possible for users to experience high-quality, interactive virtual environments. 5G networks will enable new-use cases for VR, such as remote collaboration and training, allowing more users to access VR content simultaneously.

AI/VR technology [24] will also take advantage of 5G's capabilities to develop new-use cases and applications [29,30]. For example, using 5G's high-speed, low-latency connectivity, AI/VR can be used in telemedicine, remote training education, remote control of industrial equipment, and many other fields where a physical presence is not possible or desirable. AI/VR and 5G will enable new levels of immersion, collaboration, and efficiency across various industries and sectors, leading to the 4th industrial revolution.

Businesses from each part of the economy must discover new solutions by making customized products for the end market. Artificial intelligence [31] supports intelligent cities, technology, vehicle, marketing, health, and engineering.

It is not certain what we can expect from virtual reality and what the development of artificial intelligence advances, but it is an interesting research subject. This paper aims to explain the advantages and disadvantages of virtual reality and artificial intelligence and elaborate on its future in real estate.

Thanks to technological development, the question arises as to whether we can transfer ownership rights to real estate faster, simpler, more securely, and more cheaply with the help of technology. This paper provides insight into the fields of virtual reality and artificial intelligence with an emphasis on their use in real estate. The work is organized into several sections. Section 1 contains the history of and describes the motivation behind virtual environment research and its application areas. Section 2 includes features necessary for artificial intelligence. Section 3 provides information about artificial intelligence and virtual reality in real estate and some advantages and disadvantages of their use. The last section contains the conclusion of the paper.

2. Materials and Methods

2.1. Virtual Reality Technology

The idea of virtual reality (VR) has always been promising and present among us. We have all seen it already on the screen, and the concept was always more or less the same: put the glasses/device on the head, enter the virtual world, and escape from reality. This

time is when virtual reality will no longer be just an idea, imagination, or a device we have seen on TV. There is a high probability that, in five years, everyone who owns a game console or gaming computer will have a virtual reality headset in his room.

The idea of immersing a man in an imaginary world is ancient. Stanley G. Weinbaum [32] describes a game where individuals can watch holographic footage of virtual stories, including smell and touch, using glasses, making him the first true visionary in this area [33]. While Weinbaum's was just an idea, the first recorded attempt which resembles today's devices was constructed in 1956 by Morton Heiling, under the name Sensorama. Sensorama was a motorcycle simulator that simulated a broad spectrum of stimuli for today's concepts: the image was simulated using video projection and the vibrations and smell of overheated motorcycle tires.

Pandzic et al. [34] state that Heiling's next invention was a head-mounted display patented in 1960. The real pioneer of virtual reality, even computer graphics, is Ivan Sutherland. He made the first functional prototypes of head-mounted display devices that enabled users to view virtual data displayed through the image of the real world. This type of display was one of the first forms of enlarged reality [35]. One of its many revolutionary solutions is an image display that follows the head position.

Pandzic et al. [34] state that Sutherland located head-mounted displays in space using the mechanical and ultrasonic successors of the head position. According to Nasa Ames Simulation Laboratories, in the 1970s, the United States used them to train military pilots. Eric Howlett developed an optical system known as LEEP (Large Expanse, Extra Perspective) in 1975. Although initially designed to view static 3D images, its optical features have become very popular in designing screens worn on the head. LEEP has enabled the viewing of images from screens placed very close to the eyes, with a large angle of view.

Since the 1960s, work at the University of North Carolina has continued on force feedback or haptic feedback, which in the 1980s resulted in the Argonne Remote Manipulator for visualization and the return of force. Twenty years after Sutherland's pioneering work, the use of head-mounted displays was completely in the field of military research. In 1984, Michael McGreevy of NASA developed the first practically usable head-mounted display model, the Virtual Visual Environment Display. His design resulted in the first wide-angle stereo head-mounted display, which was eventually available to the general public [36].

In 1985, Virtual Programming Languages introduced the popular DataGlove glove and the first publicly available head-mounted display model. Its founder, Jaron Lanier, first introduced the term "virtual reality" Researcher Baker states that in the 1990s, Sega and Nintendo were "launching" head-mounted displays for the video game industry. However, the projects were slowly decaying due to management difficulties and poor software.

In 2012, a young man named Palmer Luckey, then a 19-year-old, took several technologies and put them together in a single unit. His first version of the VR headset was quite cumbersome, and the graphics were basic, which is why the experience was very surprising. He launched a Kickstarter campaign, raised USD 2 million, and started production. The Oculus Rift Development Kit 1 was created in collaboration with John Carmack. Facebook recognized the potential of this technology and bought Oculus for USD 2 billion at the beginning of 2014 [36]. It is said that the definition of virtual reality arises from the merging of two worlds, that is, from the combination of virtuality and reality. The origin, or etymology, of the word "virtually" finds its roots in medieval Latin. The medieval words "virtualis" (achievable, possible) and "virtus" (power, excellence, courage, efficiency, ability, virtue, and masculinity) originate from the late 14th century. They are closely related to technology, defining the influence of physical virtues or effective abilities concerning its inherent properties.

According to Milić [37], the word "virtuality" at that time signified God's presence on earth. It was thought that God was present in an intangible, virtual way that was unavailable to human senses. In the 15th century, the word "virtuality" had the following meaning something that has its essence or effect, although it is not real. That is, virtuality is

something that can produce a certain effect. The meaning virtuality has today, in computer terms, was confirmed in 1959 and is defined as something that does not have physical stability but can be created and displayed by the software.

Michalos et al. [38], Mourtzis et al. [39], Rentzos et al. [40], Dimitropoulos et al. [41] carried out studies in the field of virtual, augmented and mixed reality. Virtuality as a term, then in the definition of virtual reality, is now an area of reality. However, a person is not in reality but in an artificially created environment that can represent beings and things from the real and imaginary world. That is, virtuality represents a copy of reality [42].

Howard [43] states that virtuality is the notion of something that is not real. It is not present in the physical sense but shows an imaginary or real reality that human senses, including vision, touch, hearing, and smell, can experience.

Reality is a concept that is the opposite of virtuality, and it signifies something real and tangible to the human being [44]. It is commonly known that human beings experience the world through the five senses (vision, smell, taste, touch, and hearing) and the perception of reality. However, these are only the most obvious senses since people own much more, such as, for example, a sense of balance. It should be noted that everything a person experiences as reality comes with the help of the senses. Every reality experience is only a combination of sensory information the human brain receives and processes. Since reality can only be experienced through information coming from the environment, the perception of reality also changes according to that information. It is possible to present a particular version of reality that does not actually exist. Still, from a human perspective, it can be perceived as real, and the concept of virtual reality accurately describes the above [42]. Virtual reality and virtual environments (VE) are terms used in the informational world and can be identical. The most commonly used terms are listed, but many more are also used such as Synthetic Experience, Virtual Worlds, Artificial Worlds, and Artificial Reality [45].

All of these terms have the same meaning with many definitions, such as:

- Interactive graphics in real-time with three-dimensional models, combined with display technology, which allow the user to interact with the modeled world and directly manipulate it [46];
- Illusion of contribution in a synthetic environment and external observation of such an environment. Virtual reality is based on three-dimensional, stereoscopic devices and displays that include movement, picture, and soundtrack. Virtual reality is a significant, multisensory experience [47];
- The concept of virtual reality refers to the importing, interactive, multisensory, three-dimensional, computer-generated environment, which requires a combination of different technologies to build the said environment [48];
- Virtual reality allows navigation and preview of the three-dimensional real-time world with six degrees of freedom. Virtual reality is briefly a cloned physical reality [49].

Application. The main applications of virtual reality are in medicine, education, military technology, entertainment, design, and marketing.

Medicine. Medicine is one of the strongest applications of virtual reality. It is used in the field of surgery, both for training and for the planning of surgical procedures. 3D images can be obtained from medical images, an increasingly common case in modern medical devices.

In 2001, the first teleoperation occurred: the surgeon controlled the robotic arm in New York while the patient was in Strasbourg [34]. In psychiatry, virtual reality is used to treat various psychiatric disorders, from fear of flying to post-traumatic stress disorder (PTSD), and outstanding results have been achieved.

VR spaces were created to treat the post-traumatic stress disorder (PTSD) of people serving in the military [50]. This type of treatment is called Virtual Reality Exposure Therapy and is therapy with a long-term exposure approach. It is a cognitive–behavioral intervention in which the patient is virtually exhibited (30–40 minutes per session) various incentives (visual, sound, kinesthetic, and olfactory) to gradually face the experiences that form the basis of his traumatic memory. One of the most important applications is to

achieve empathy and equality. In virtual reality, we can find ourselves in a person's body of the opposite gender or another race and get a detailed insight into what it looks like to be someone else [50].

Military technology. From the beginning, military organizations have been one of the largest investors in virtual reality development, where many virtual reality technologies are embedded in simulators of various military devices.

Education. The representation of virtual reality in education represents a great deal of commitment. Children are interested in traveling to another time or the end of the world (for example, on the Chinese Wall) and seeing what they usually cannot do.

Simulations of various vehicles and aircraft (including military simulations) are certainly among virtual reality's most common practical applications [51]. Maintenance of inaccessible systems [52,53] that they cannot often enter and stay in for a long time can also be practiced virtually. Examples are nuclear power plants and spacecraft. It is used in business communication.

Fun. Virtual reality, with its ability to create illusions, is ideal for the entertainment industry. An increasing number of games are developing for virtual reality, e.g., Minecraft or Witcher 3. Virtual reality is applied in sports and music (nowadays, everyone can be part of the NBA game or on the stage of the concert of his favorite band) and as a virtual overview of the museum and famous tourist destinations.

Design and architecture. In product design and development, virtual prototypes (for example, in the automotive industry) save time and money. In architecture, virtual reality is often used for presentations of future projects. One of the newer technologies is Tilt Brush. It allows users to make 3D virtual reality with a large selection of drawing tools (e.g., stars, light, and fire).

Marketing. Finally, part of virtual reality technology has proven to be a successful tool for promotion and marketing at exhibitions, fairs, and public spaces.

2.2. Artificial Intelligence Technology

Artificial intelligence is one of the computing fields developing the fastest in the last few decades. Along with this rapid development, growth and expectations from this discipline are growing. While some areas of computing are already considered to be wound up and not expecting new significant penetrations, artificial intelligence results are only expected, even though many "intelligent" systems are exceptionally well functioning. This may be explained by the fact that these "intelligent" systems [35], in addition to vulnerable external manifestations, work on principles that we cannot usually think of as intelligent. Of course, artificial intelligence only gains attractiveness, and new experiments and theoretical research represent a path to new applications in various areas. Since artificial intelligence development has always been based on the complementary linking of theory and experimentation, future development requires the expansion and consolidation of theoretical knowledge—above all, of mathematical as well as knowledge of specific areas of application—as well as adequate formalization.

Usually, under intelligence, we mean the ability to adopt, remember, and handle certain knowledge. In any case, we may consider that intelligence implies at least two abilities: memorizing and processing knowledge. A person or machine without knowledge cannot be considered intelligent. Also, an intelligent cannot be considered a person or machine with vast "static" knowledge or data but without the ability to handle and solve related problems. There are also other aspects of intelligence. One of them is the speed of knowledge processing, which, when it comes to computers, depends not only on the conclusion procedure but, of course, on the technical characteristics of a particular computer. The ability to learn—knowledge gained is also one of the aspects of intelligence—is essential, though it can be included in the ability to solve the problem.

Artificial intelligence is subdivided in computing. AI research aims to develop programs (software) that will enable computers to behave in a way that could be characterized by intelligence. The first research is linked to the roots of computing itself. The idea

of creating machines capable of carrying out various tasks intelligently was the central concern of computational scientists. They opted to explore artificial intelligence throughout the second half of the twentieth century. Today, intelligence research experts focus on expert systems, limited-domain translation systems, human speech recognition, written texts, automated proofing theorem, and constant interest in generating generally intelligent, autonomous agents. In broader terms, intelligent intelligence signifies an artificial artifact's capacity to carry out functions that are the characteristics of human thinking.

Artificial intelligence represents the ability of a digital computer or computer-controlled robot to achieve tasks generally linked with intelligent actualities [54].

According to Goertzel and Wang [55–57], there are four possible views on artificial intelligence systems. First are systems that think like humans and systems that reason. These two categories deal with thought processes and reasoning. On the other hand, the other two categories, which are systems that act like people and systems that act rationally, deal with behavior. Categories such as human reasoning and human behavior measure performance in the context of matching with human performance, while rational reasoning measures success compared to the ideal concepts of intelligence that we call rationality.

Goertzel and Wang organized AI into four categories [55–57]:

- Systems that think like humans—a new attempt to make computers think, i.e., machines with a mind [58];
- Systems that think rationally—learning mental skills through computer models [59];
- Systems that act as people—research how to compel computers to better do the things that people now do [60];
- Systems that act rationally—AI deals with the intelligent behavior of artificial devices [61].

2.3. The Approach Based on Turing's Test

Alan Turing [62,63] proposed the operationalization of the question, "Can machines think?". The question "Can a machine think?" is replaced with the "imitation game". The experiment compares the performance of the superior intelligent machine and man based on queries [64]. To pass the complete Turing test (Figure 1), the computer must master the following: computer vision and robotics. The game includes three participants (A, B (respondents), and C (examiner)) with different goals: A and B are the opposite genders. The goal of player C: asking the question to determine the gender of the respondents. The goal of player B: assist examiner C. Player A's goal: indicate incorrect identification to C.

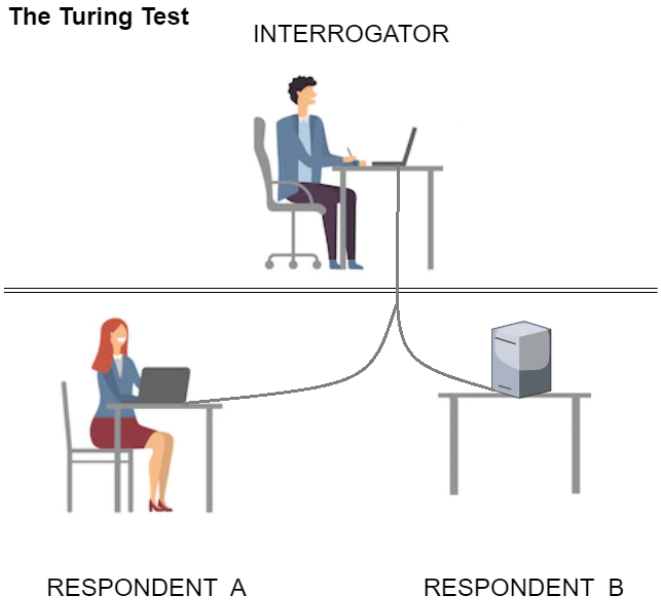

Figure 1. Turing test.

The experiment is repeated, and the success rate of the C is measured. Turing indicates that the machine is intelligent if the number of errors is the same.

Types of Artificial Intelligence

According to Warwick [64], there are two types of artificial intelligence (AI):
Type 1:

1. Narrow AI intelligence focuses on just one task, a phenomenon where machines that are not too intelligent work independently (Figure 2).
2. Strong AI intelligence is based on machines that independently think and perform tasks as human beings. To recognize this form of intelligence, Turing [62,63] has developed a test by which the computer is intelligent if more than 30% of people indirectly communicate with it, and they cannot determine whether it is a man or a machine.
3. Superintelligence is a type of intelligence that is smarter than people and can be reached in the foreseeable future.

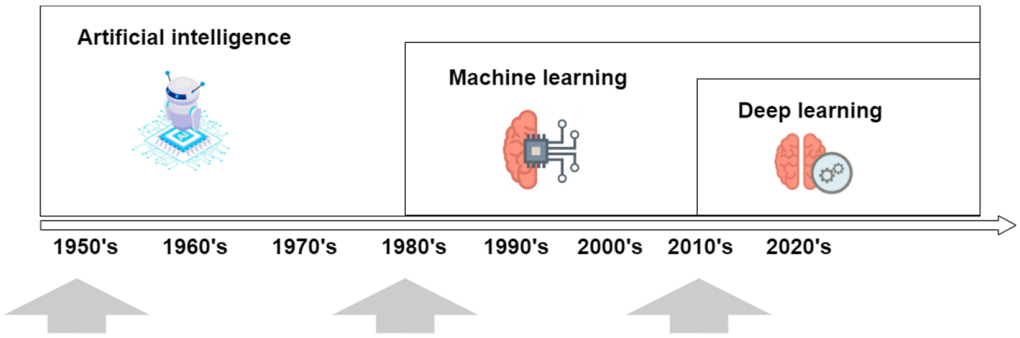

Figure 2. Artificial Intelligence.

Type 2 (based on functionality):

1. Reactive machines are one of the basic forms of AI. It has no memory and cannot use previously collected information for future actions.
2. Limited memory by which AI systems use experience to make future decisions. Cars that have the ability to drive themselves are designed in this way.
3. Theory of Mind should be able to understand human emotions, beliefs, thoughts, and expectations and socialize. Although there are many shifts in this field, this type of AI has not been completely achieved.
4. Self-awareness is a type of AI that is super-intelligent, conscious, sensible, and reasonable. In other words, a complete human being. This AI type does not exist yet, but it will be the AI milestone when it is achieved.

2.4. Artificial Intelligence (AI) and Virtual Reality (VR) in Real Estate

Artificial intelligence and virtual reality are currently being used in the real estate industry to enhance customers' buying and selling experience and improve the efficiency of real estate professionals.

AI analyzes large amounts of data and provides insights into property values [28], market trends, and customer preferences. This allows real estate professionals to make data-driven decisions and provide personalized recommendations to their clients. AI-powered chatbots and virtual assistants support customer service [24] and lead generation, enabling real estate professionals to manage their time and resources better.

Conversely, VR is being used to provide immersive virtual tours of properties [22], allowing customers to explore properties remotely and in detail. This technology can be used for residential and commercial properties, and it can help shorten the decision-making process for potential buyers and reduce the number of physical visits to the property.

VR can also be used for architectural visualization and design, helping developers and architects to showcase their projects to potential buyers and investors.

The current state of AI and VR in real estate [8,16,28] is rapid growth and experimentation, with many companies and organizations exploring new ways to use these technologies to improve the customer experience and streamline their operations.

Today, the scope of information available for making decisions exceeds human possibilities—we have information overload. Therefore, many companies deal directly with analyzing and presenting the best options and then advise us in making the best decision at a certain price for their services. Whether we rely on people or machines, we are talking about data mining in drawing up knowledge (or samples) from complex available data. Artificial intelligence systems are particularly suitable for such tasks because they can store large amounts of data from which they can extract every kind of relationship to develop patterns, relationships, and meaningful links. Today's algorithms now use this ability in cognitive computing in what is called deep learning.

The labor market is changing due to the emergence of artificial intelligence [31], increased automation, the Internet of Things, and a combination of these technologies. Artificial intelligence allows companies to become more efficient by expanding into new areas of the broader market. As a result of the vast amount of available data and the increase in computer power, AI has entered all spheres of life and completely changed the business world. The man on the production line was slowly replaced by automated machines from the industrial revolution. Even in cases where the human person has not been completely replaced, one gradually begins to rely more and more on machines to help him work. Among the jobs machines will perform are real estate dealers.

2.4.1. Neural Networks for the Forecasting of Real Estate Prices

Neural networks could be used to predict real estate prices [65–67]. These algorithms are based on the structure and function of the human brain and can be trained to identify patterns and trends in large amounts of data. When applied to real estate, neural networks can be trained on historical data, such as property prices, sales data, and economic indicators, to predict future real estate prices. These predictions can be based on factors such as location, property type, and market conditions.

One of the advantages of using neural networks for forecasting real estate prices is their ability to handle large amounts of data and make predictions based on multiple factors. Neural networks can also be trained to recognize patterns and trends that may not be immediately obvious to humans, which helps to improve the accuracy of price predictions.

Another advantage of using neural networks for real estate price forecasting is their ability to adapt and improve over time. As new data becomes available, neural networks can be retrained to incorporate the new information and improve their predictions.

The accuracy of predictions made by neural networks for real estate prices depends on the quality and relevance of the data used to train the model. Real estate markets [68,69] are affected by various external factors that can be difficult to predict, such as government policies, natural disasters, etc.

Overall, neural networks can be a powerful tool for forecasting real estate prices, but it is important to be aware of their limitations and to use them in conjunction with other methods and human expertise.

Several types of neural networks are used for forecasting real estate prices, including the following [67–70]:

- Feedforward Neural Networks (FFNN) are the simplest type of neural network. FFNNs can be trained to make predictions based on historical data and are commonly used for regression problems such as price forecasting.
- Convolutional Neural Networks (CNN) are networks designed to process image and spatial data. CNNs can be used to analyze images of properties, such as virtual tours, and make predictions about the property's price or other attributes.

- Long-Short Term Memory Networks (LSTM) are a type of RNN that can remember information over a long period, making them suitable for analyzing sequential data with long-term dependencies, such as real estate prices and market trends.
- Recurrent Neural Networks (RNN) are networks designed to process sequential data, such as time series data. RNNs can be trained to analyze historical data and predict future trends, making them suitable for real estate price forecasting.
- Generative Adversarial Networks (GAN) consist of a generator and a discriminator that work together to generate new data similar to the training data. GANs can be used to generate new properties and their prices, which can be used to augment the training data for other neural networks.

The development of neural networks did not go far in the past, but the methods built on them are widely used in technical sciences, economics, and social sciences. Their application in the economy is mainly related to predicting future values observed and can relate, for example, to forecast supply and demand, predicting the price of shares on a certain day, and forecasting real estate prices.

The choice of neural network architecture depends on the specific problem and available data. Some architecture may perform better than others, depending on the problem and data characteristics. The appropriate evaluation metrics, such as mean squared error, are to evaluate the model's performance and finetune it if necessary.

The success of neural networks, except for forecasting purposes, is significantly used for classification. Neural networks are one of the methods of artificial intelligence, and they are used in the mathematical form and structure of the human brain to develop a data processing strategy.

According to a survey by Topuzović [71], a neural network was created that, based on input variables, predicts real estate prices in the suburbs of Boston using neural networks. Their price is predicted based on thirteen input variables describing the conditions in which the property is located. A multilayer perceptron algorithm was used, and the results of the most successful neural network showed that the network realizes a high accuracy in price prediction. Based on the study by Topuzović [71], it can be concluded that neural networks and artificial intelligence can contribute to better quality data processing. Today, it is still standard practice to use regressive statistical methods for data analysis. However, in most cases, thanks to AI, data can be analyzed much faster and better and, in the end, a more accurate result is achieved. If we want to predict the interest rate or the price of real estate, we will rarely observe the data in a linear relationship. It is the most significant power of neural networks, and it lies in robust algorithms that allow linear and nonlinear data processing. In the learning phase, the network calculates the weighted (fixed) relationship between the input and the output (target) variables and thus establishes a nonlinear relationship between them. Such a way of observing data allows us to see some new laws in the observed data. The observed neural network predicts the price of real estate near Boston with an average deviation of 0,2%. This means that the price predicted by the neural network based on input variables can deviate to a maximum of 0,2% of the actual price. Numerous scientists continue to explore how to increase reliability and reduce error, and to develop new algorithms and neural network architectures. Topuzović [71] points out that, by further collecting data on the movement of real estate prices, considering a more significant number of input variables and further developing even more robust algorithms, we will be able to develop further a model to express the relationship of individual variables and their impact on the price. It will be possible to set up a model that will, almost with negligible error, predict the price of real estate in the future.

2.4.2. Real Estate-Related Applications of Artificial Intelligence

The real estate industry is a dynamic sector that is always full of innovation. Thanks to artificial intelligence, many industries are transforming and innovating. Artificial intelligence demonstrates its potential to transform the industry with solutions that alter everything from asset management to commercial transactions. By analyzing the data,

artificial intelligence can help investment executives decide which asset fits into which fund.

Five examples of artificial intelligence in real estate [25–27,72–75] are the following:

- Automation to enhance portfolio management;
- AI chatbots to improve property selling;
- Analytical tools to automate buildings;
- Machine learning to reduce consumption;
- Automated data rooms for deals involving commercial real estate.

3. Results and Discussion

3.1. Development of Real Estate App

The real estate industry has adopted this developing technology to help the client buy and sell an apartment in a way that has never been possible before.

Real estate app development based on AI and VR technologies provides a range of benefits for real estate professionals and consumers. These apps can use the latest advancements in AI and VR technology [16,21,76–79] to provide features such as:

AI-powered property search and recommendations: AI algorithms can analyze large amounts of data to provide personalized property recommendations to buyers based on their preferences and search history.

Virtual agents: AI-powered virtual agents can assist buyers in finding properties that match their criteria, answering their questions, and guiding them through the buying process.

Virtual property tours: VR technology can provide immersive virtual tours of properties, allowing buyers to "visit" properties from anywhere in the world and get a sense of the layout, atmosphere, and neighborhood.

Automation of tasks: AI technologies could automate tasks such as property inspections and showings, which reduces time and costs for real estate agents and clients.

Virtual staging: VR technology creates virtual staging of properties, which can help agents showcase properties to potential buyers without needing physical staging.

Personalized service: AI provides personalized and tailored services to clients, such as customized property recommendations and virtual tours based on their preferences and search history.

Predictions and market insights: AI analyzes market data and provides predictions on property prices, rental rates, and other market trends, which can help real estate professionals make more informed decisions.

Real estate app development based on AI and VR technologies [16,80] includes property management, real-time updates on market conditions, and other tools to help real estate professionals and consumers navigate the real estate market. App developers must ensure that the app is user-friendly and easy to navigate and that the AI and VR technologies are accurate and reliable. They should also consider privacy and security concerns and ensure that the app complies with regulations and laws.

Virtual reality is an upcoming technological innovation that has many advantages in the real estate market. Most customers spend time browsing photos from an advertisement. Thanks to the development of technology and virtual reality, customers can walk through all these areas without personally entering them, literally from the comfort of their backyard. For this purpose, many companies have developed interactive 3D virtual real estate presentations, and one of them is the company Maruco Media. Currently, "ordinary" virtual walks on the market are created by gluing photographs on the 360° sphere, thus giving a dome-like impression of space or static panoramas in 360°. Maruco Media offers a recording of virtual walks in the right 3D.

Laser technology measures the precise distance between the walls and obstacles in the space and thus creates a faithful 3D model of that space that can be viewed and explored from all angles (Figure 3).

Figure 3. 3D model of space. [79].

Pandžić et al. [34] state that, with the dollhouse view option, the users can rotate the entire object in all directions as if holding it in the palm of their hand. This comprehensive real-time recording system with interactive 3D and VR experience creates an emotion as if users are really in it. For example, imagine a table in the kitchen—VR technology allows us to see it from various perspectives, and move around it, while other virtual walks show it only as a 2D part of the photo. 3D info tags provide an interactive, informative dimension to a presentation through which visitors can be introduced to specific products and services (Figure 4).

Figure 4. 3D of space. [80].

This way of presenting real estate is an absolute hit, and with quality photo and video material, it has become the main tool for presentation for real estate agencies.

The attractiveness of the sales area is of great importance in consumer psychology, especially today, when online shopping is becoming increasingly popular. A visual presentation of space is the number one priority if we want to attract potential customers,

intrigue them, and only then present the product that needs to be sold. We met with the latest technological solutions and did not have to make a lengthy decision.

An interactive 3D virtual walk can be an excellent marketing tool for open and closed spaces, as space is recorded in vertical and horizontal directions and is available online 24 h a day. Targeted customers are all wider-use spaces, but more precisely, all spaces, facilities, and properties that sellers want to be highlighted and presented to others. When it comes to real estate, sellers must have access to the latest technology in competitive markets.

Matterport in San Francisco is one of several media technology companies offering brokers, real estate agents, and 3-D service providers for interior recording. Matterport connects images to secure the passage that transmits to the cloud service [81,82].

Circle Visions is creating real estate that does not exist yet. People who build their own homes or rearrange their current ones can use virtual reality to understand how the property will look after completion. Users cannot feel the space in the draft, but thanks to virtual reality in real estate, we can open the door of a room, turn on the lights, and get a sense of the measure or feeling of the room.

Digitalization, big data, and data analytics are the main words currently occupying the real estate industry. However, the impact of digitization on future market development cannot be accurately estimated yet.

Artificial intelligence requires the possibility of revolutionizing and modernizing the real estate sector. AI tools are software solutions programmed for learning and optimization. AI tools are used to advance and accelerate labor-intensive processes. Therefore, many steps taken by stakeholders, such as sellers, real estate agents, property managers, and investors in the real estate industry, can be more effective. This also leads to potential savings in the cost of real estate transactions. With the emergence of artificial intelligence [53,83,84] in the real estate industry, technical solutions will become increasingly important, and human labor's importance will change. In the future, artificial intelligence in real estate will specifically automate the management of objects, i.e., administration and support of real estate objects. Artificial intelligence also helps the real estate industry's organization and assessment of big data.

Artificial intelligence services [83] make transactions with less manual input, speed up due diligence methods, and make the entire process more efficient. AI tools support sifting through big data and checking the documents, opportunities, and risks associated with a business. AI tools allow the broker additional time to advise and confer with the consumer. Customers can use AI chatbots [84] to analyze relevant facts from different data sources. Virtual communication partners consider the property's value and find a suitable property.

A large and varied amount of data can easily be stored with the help of artificial intelligence in the correct order or relationships. On the other hand, AI can help index information to the most important aspects or compress it into a summary. In the framework of transactions, AI is currently rarely used. The current status of AI is shown well in legal matters. Before the transaction, many contracts must be examined and summarized. Nevertheless, examining all contracts in the short term is impossible, especially with more extensive portfolios. AI significantly increases the efficiency and speed of data transfer, which is particularly relevant in the current environment with many documents.

3.2. Advantages and Disadvantages of VR and AI in Real Estate

The analysis of the advantages and disadvantages of virtual reality and artificial intelligence in real estate is shown in Table 1.

Implementing VR and AI technologies in the real estate industry provides many benefits, including increased efficiency, cost savings, and improved client services. It can make buying or renting a property more interactive and engaging and give buyers the ability to visualize a property before seeing it in person.

Table 1. Advantages and Disadvantages of VR and AI in Real Estate.

Technology	pros	cons
AI technology	One significant benefit of using Artificial Intelligence (AI) technology in the real estate industry is improved efficiency and automation of various tasks. For example, AI can analyze large amounts of data and make predictions about market trends and property values, which can help real estate specialists make better-informed decisions. AI can automate tasks such as property inspections and showings, saving time and reducing costs for real estate agents and clients. Another advantage of using AI in real estate is the ability to provide personalized and tailored services to clients. For example, AI can analyze clients' preferences and search history to provide them with a customized list of properties that match their criteria to save clients time and effort in their search for a new property. AI can also increase access to real estate information and services for people who may have previously been excluded from the market. This is particularly true for people with disabilities, elderly people, and people living in remote or underserved areas. AI-enabled virtual tours, chatbots, and other technologies can help these groups access property information and communicate with real estate agents. Using AI technology in the real estate industry can provide many benefits, including increased efficiency, cost savings, and improved client services.	One potential drawback of using Artificial Intelligence (AI) technology in the real estate industry is the potential for errors and inaccuracies in the data used to train the AI systems. If the data used to train the AI is inaccurate or biased, the predictions and decisions made by the AI system may also be inaccurate or biased. This can lead to incorrect valuations or property recommendations, leading to poor investment decisions and financial losses for buyers and sellers. Another disadvantage of AI technology in real estate is the potential for job loss for real estate agents and other industry professionals. As AI becomes increasingly capable of performing tasks that were previously done by humans, such as property inspections and showings, there is a risk that some jobs may become obsolete. AI technology could be used to make real estate decisions that are not in the consumers' interest, such as using data to discriminate against certain groups of people in the housing market. This could lead to a lack of access to certain properties or neighborhoods for certain groups, perpetuating existing inequalities. AI technology can also raise privacy concerns. As AI systems collect and analyze data on buyers, sellers and properties, there is a risk that this data could be used for nefarious purposes. While AI technology can improve efficiency and decision-making in the real estate industry, it is essential to be aware of and address these potential drawbacks. It is crucial to ensure that the data used to train AI is accurate and unbiased and that the technology is used ethically and responsibly to protect the best interests of consumers.
VR technology	One significant benefit of using virtual reality technology in the real estate industry is the ability to provide immersive and interactive property tours to potential buyers. VR technology allows buyers to experience properties as if they were physically present, which can help them make more informed decisions about whether a property is a right fit for them. VR technology can create virtual walkthroughs of properties under construction, giving buyers a sense of what the finished product will look like. Another advantage of using VR in real estate is reducing costs and increasing efficiency. For example, VR technology can create virtual tours of properties, saving real estate agents time and money on travel expenses. VR technology can be used to create virtual staging of properties, which can help agents showcase properties to potential buyers without needing physical staging. VR technology can also increase accessibility to the real estate market for people with disabilities, older adults, and people living in remote or underserved areas. VR technology makes it easier for these groups to access information about properties and communicate with real estate agents by providing virtual tours and virtual walkthroughs of properties.	One potential drawback of using virtual reality technology in the real estate industry is the cost of equipment and software. VR equipment is expensive and may not be accessible to all real estate agents or consumers. Furthermore, developing and maintaining VR software and content can be expensive. Another disadvantage of using VR in real estate is that it can be challenging to depict properties accurately in virtual reality. For example, virtual tours may not fully capture a property's scale, layout, or atmosphere, leading to disappointment when a buyer sees the property in person. The technology itself may not be advanced enough to accurately depict properties, especially if those are older or have unique characteristics. VR technology in the real estate industry decreases human interaction and buying personalization. As more and more buyers rely on virtual tours and other VR experiences, they may have less contact with real estate agents and other professionals, making it harder for them to get the information and guidance they need. VR technology may not be able to account for certain variables such as light, weather, or time of day that can affect how a property looks or feels. While VR technology can improve the buying experience in the real estate industry, since VR is in its early stages, people are still discovering the proper technique. One of the disadvantages of the real estate markets is that customers may have difficulty finding a real estate agent or broker using this technology, especially if they do not live in a large metropolitan area. Most brokerage firms continue using 2-D photographs and video marketing videos. Furthermore, companies using virtual reality are, in most cases, marketing perennial ownership.

3.3. Cybersecurity in the Real Estate Industry

Cybersecurity in the real estate industry is a growing concern as the industry becomes increasingly digitized [85,86]. Real estate companies handle sensitive personal and financial information, such as property ownership records, mortgage applications, and closing documents, which can make them a target for cybercriminals.

One major threat to cybersecurity in the real estate industry is data breaches, in which hackers gain unauthorized access to sensitive information. Data breaches lead to the theft of personal and financial information, which is used for identity theft and financial fraud. Data breaches can also result in damage to the company's reputation and loss of trust from customers. Another cybersecurity concern in the real estate industry is the rise of phishing scams, in which criminals pose as legitimate real estate companies or agents to gain access to sensitive information. These scams can take the form of fake websites, emails, or social media messages, leading to the loss of personal and financial information.

Real estate companies can protect themselves and their customers from cyber threats by implementing strong cybersecurity policies and procedures (including regular security updates and backups, employee training, encryption, and other security technologies to protect sensitive information). Incident response plans are also vital in the case of cyber-attacks (including identifying the cause of the attack, containing the incident, eradicating the attack, and recovering the systems).

Cybersecurity is a critical issue in the real estate industry, as the industry's reliance on technology and sensitive personal and financial information make it a target for cybercriminals. By taking proactive measures to protect against cyber threats, real estate companies can help ensure the safety and security of their customers' information.

Cyber risks are also increasing in the context of ongoing digitization. Integrated building management systems control the fully networked building services. Real estate is becoming more and more cyber-physical systems. In this development, the facility management company, the owner, the tenants, the service companies, and the administration are integrated into the system. Networking home automation-related information via corresponding interfaces creates a "cyber real estate".

There are risks associated with this, including:

- Technical failure: possible system failure affecting other systems;
- Criminal attacks: hacking and sabotage by unauthorized entry into the systems;
- Privacy issues: the stored data can be stolen or lost.

The risks mentioned must be respected during ongoing operations and always be considered during real estate management. Without the appropriate precautions, the property may be expected to lose value.

However, according to Ćirić [87], the impact of AI and VR in the business provides many benefits, of which the most obvious are the following:

- No expensive real estate, no arrangement of a shop window;
- Minimum sales personnel are required;
- There is a possibility of selling to customers in any geographical area;
- Instant communication is enabled;
- An interactive multimedia catalog is presented that can provide as much information as the customer wants (without expensive classic catalogs and postal costs);
- Adjustments for changes in sales prices and inventory levels can be made very quickly;
- Great adaptability to customer requirements;
- Virtual reality technology allows a free 360° panoramic view of an object from anywhere and creates a depth perception with 3D images, which cannot be achieved with a simple website;
- Saves time, saves effort, saves file folders—the professional interior visualization;
- An interior visualization enhances users' real estate presentation convincingly.

Against the background of the described advantages, it is a justified question why the use of AI and VR in the real estate industry remains low and still awaits a real breakthrough.

The first reason is related to the highly fragmented market. Many start-ups that develop AI solutions only do so for a specific niche. Many solutions are missing. Also, the range of AI solutions especially for the real estate industry is still limited, and often quite error-prone. A second reason for the reserved use lies in data security. Where sensitive business data is processed by artificial intelligence, the security of the data is of particular importance. Most artificial intelligence programs are roughly integrated into two ways: via a public cloud or by installing it on their server. Although the second version appears intuitively as the better option, it is associated with significantly higher costs.

4. Conclusions

Artificial intelligence and virtual reality are fundamental innovations that change and improve our economy and lives.

Over time, the user has adapted virtual reality to himself and his needs. The main advantage of the virtual environment is that the room can be found in an environment that would otherwise be inaccessible due to price, security, or perceived limitations.

Real estate app development based on AI and VR technologies can provide a range of benefits for both real estate professionals and consumers.

AI-powered real estate apps predict market trends, property values, and other factors to help real estate experts make decisions. AI automates property inspections and showings, saving time and reducing costs for real estate agents and clients.

VR-powered real estate apps can provide potential buyers with an immersive and interactive property tour experience. VR technology allows buyers to experience properties as if they were physically present, which can help them make more informed decisions about whether a property is a right fit for them. AI/VR technology is used to create virtual walkthroughs of properties under construction, allowing buyers to get a sense of what the finished product will look like. A real estate app that combines AI and VR technologies provides an even more enhanced experience. For example, an AI-powered virtual agent could assist buyers in finding properties that match their criteria, while a VR-powered virtual tour can provide an immersive experience of the property.

In addition to these features, real estate app development based on AI/VR technologies can include property search and comparison, property management, and real-time updates on market conditions.

Real estate app development based on AI and VR technologies improves efficiency, cost savings, and enhances buying experiences. The app developer should consider privacy and security concerns, as well as provide a seamless user experience.

Today, it is possible to manage many interactive computer environments and simulations that combine different senses to create a faithful illusion of reality. The technology enables the imitation of stereoscopic vision and manipulation of video, audio, and scent effects. Today, virtual reality allows us to go from home through the Internet to the most famous world museums or to walk the streets of all the world's leading cities. We conclude that the main challenges for the real estate sector are to program systems with automatic reading support and data estimation. Artificial tools can estimate real estate agreements and further independent documents. Developing reliable solutions with automatic learning ability and using them in practice need vastly qualified experts. Apart from the functionality, the users need to also pay attention to data security and comply with legal conditions. Virtual tools cannot replace decision making. Decision making is the most difficult human task. For this purpose, the real estate segment involves an effective collaboration of artificial intelligence and human decision-making competence.

Future work. Artificial intelligence and virtual reality play an important role in real estate. In the future, work based on this survey will investigate the decision-making methods in real estate development. The future of artificial intelligence and virtual reality in real estate looks promising, with many opportunities for further research and development in this area. AI is expected to play an even more significant role in the real estate industry, with more advanced algorithms and data used to provide more accurate and detailed insights

into property values, market trends, and customer preferences. AI-powered systems will continue to automate and streamline various aspects of the buying and selling process, such as property evaluation and negotiations, making the process more efficient for customers and real estate professionals. AI-powered virtual assistants and chatbots will continue to evolve and become more sophisticated, providing customers with more personalized and responsive service. VR is expected to become more immersive and responsive, allowing customers to experience properties more realistically and interactively. In the future, VR technology is expected to enable the creation of virtual open houses, with the ability to interact with other virtual visitors and real estate agents. VR is used for creating virtual staging of empty properties, making it possible for potential buyers to visualize how the space could look with furniture and other elements. The combination of AI and VR brings many benefits to the real estate industry, such as the ability to provide virtual tours that can be tailored to the specific preferences and needs of individual customers and the ability to analyze customer behavior and preferences during the virtual tours to provide more accurate recommendations and insights. The future of AI and VR in real estate is one of continued innovation and experimentation, with the potential to significantly enhance the customer experience and streamline operations for real estate professionals.

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