Czech University of Life Sciences Prague
Faculty of Economics and Management
Department of Information Technologies

Bachelor Thesis

Artificial Intelligence in Virtual Reality

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

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Informatics

Thesis title

Artificial Intelligence in Virtual Reality

Objectives of thesis

The thesis deals with the topic of utilization of AI in virtual reality applications such as games. The main objective is to analyze and compare selected existing solutions and evaluate the suitability of AI integration in them.
Partial objectives of the thesis are:
- study and analyze available literature and online resources with focus on AI and virtual reality applications
- compare and evaluate existing solutions for AI integration within virtual reality applications
- propose own implementation of AI in virtual reality and discuss its suitability
- formulate conclusions based on the achieved results

Methodology

The methodology of the theoretical part is based on study and analysis of available literature and online resources. The main focus will be on integration of AI technologies and approaches within virtual reality applications. In the practical part, several existing solutions will be analyzed and compared based on selected criteria. Based on the obtained information, a solution utilizing AI will be proposed and discussed. The results of both the theoretical and practical parts will be used to formulate the thesis conclusions.

The proposed extent of the thesis

40-50

Keywords

AI, virtual reality, application development, computer games, automated content generation, human-computer interaction

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Recommended information sources

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Prague on 13. 03. 2024

Declaration

I declare that I have worked on my bachelor thesis titled "Artificial Intelligence in Virtual Reality" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 15.03.2024 _____

Acknowledgement

I would like to thank and to express my heartfelt gratitude to the incredible individuals and support systems that have been an integral part of my thesis journey.

First and foremost, my sincere gratitude goes for my dear friend Kathrin and family and friends, I can never fully express how grateful I am for your unwavering support. Your belief in me and your constant encouragement have been the driving force behind my persistence.

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To the authors whose works formed the building blocks of my research, thank you for paving the way with your innovative ideas and rigorous exploration. Your contributions have been a backbone for the knowledge I've gained. And I am humbled to contribute to the collective endeavor for future research.

With sincere gratitude,
Minjinsor Ganbaatar

Artificial Intelligence in Virtual Reality

Abstract

This thesis is primarily focused on Artificial Intelligence in Virtual Reality and its utilization for future applications. The thesis will focus on analyzing and comparing unprecedented opportunities that AI is giving in Virtual Reality. Which in the realm of technology, leading to innovative advancements across various domains.

This thesis analyzes the dynamics between Artificial Intelligence and Virtual Reality with a primary focus on video games, automated content generation as well as human-computer interaction aiming to assess the viability and potential of this integration.

Keywords: AI, virtual reality, application development, computer games, automated content generation, human-computer interaction

Umělá inteligence ve virtuální realitě

Abstrakt

Tato práce je primárně zaměřena na umělou inteligenci ve virtuální realitě a její využití pro budoucí aplikace. Práce se zaměří na analýzu a srovnání příležitostí, které AI ve virtuální realitě poskytuje. Což v oblasti technologií vede k inovativnímu pokroku v různých oblastech.

Tato práce analyzuje dynamiku mezi umělou inteligencí a virtuální realitou s primárním zaměřením na videohry, automatizované generování obsahu a interakci člověka s počítačem s cílem posoudit proveditelnost a potenciál této integrace.

Klíčová slova: AI, virtuální realita, vývoj aplikací, počítačové hry, automatizované generování obsahu, interakce člověk-počítač

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1 Introduction

In a world where technology is redefining its bounds and extensions on human experience each day, implementing Artificial Intelligence (AI) and Virtual Reality (VR) constitutes a remarkable feat.

As they develop with time they create brand-new experiences in every area from the education field to our day-to-day life of entertainment.

The evolution of AI and VR has unfolded a new outlook of possibilities, propelling their integration beyond mere coexistence into a space where their interaction holds transformative power. By connecting their cognitive capabilities, AI and VR create new pathways of enhanced user experiences.

Therefore, this study embarks on a journey to uncover the dynamics of this relationship and to comprehend the extent to which AI's augmentation can elevate the realms of VR.

This thesis delves into the complex interplay between these two cutting-edge domains, particularly their collaborative potential within applications, notably in the realm of gaming.

During this exploration, the research centres on dissecting existing solutions that merge AI and VR, while also proposing an innovative integration approach tailored to address the unique demands of VR applications. Through the analysis of these solutions, followed by an in-depth discourse on their application, this thesis aims to contribute to the ongoing dialogue of combining AI and VR, emphasizing its transformative potential. Therefore, begin by uncovering the challenges and opportunities that intersect AI and VR. While speculating for a future in which intelligent algorithms and immersive virtual environments harmoniously unite

2 Objectives and Methodology

2.1 Objectives

The thesis deals with the topic of utilization of AI in VR applications such as video games. The main objective is to analyse and compare selected existing solutions and evaluate the suitability of AI integration in them.

Partial objectives of the thesis are:

- Study and analyse available literature and online resources with focus on AI and VR applications.
- Compare and evaluate existing solutions for AI integration within VR applications.
- Propose an own implementation of AI in VR and discuss its suitability.
- Formulate conclusions based on the achieved results.

2.2 Methodology

The methodology of the theoretical part is based on the study and analysis of available literature and online resources. The main focus will be on integration of AI technologies and approaches within VR applications. In the practical part, several existing solutions will be analysed and compared based on selected criteria. Based on the obtained information, a solution utilizing AI will be proposed and discussed. The results of both the theoretical and practical parts will be used to formulate the thesis conclusions.

3 Literature Review

3.1 Artificial Intelligence

In the first half of the 20th century, people around the world started to familiarize themselves with the concept of Artificial intelligence thanks to science-fiction such as the character of Maria from the "Metropolis" movie in early 1927. Since the 1950s we cultivated scientists, mathematicians, and philosophers with the concept of artificial intelligence, now commonly known as AI.

Among them was Alan Turing, a young British computer scientist who made the significant foundation for the future of AI, later known as the Turing test. Turing proposed that since humans use available information and reason to solve problems and make decisions, " why can't machines do the same thing?". This was the idea of his paper "Computing Machinery and Intelligence" from 1950 in which he explored how to build intelligent machines and how to test their intelligence. Five years later the terminology of Artificial intelligence was officially adopted by a group of researchers, including John McCarthy and Marvin Minsky at the Dartmouth Conference (1).

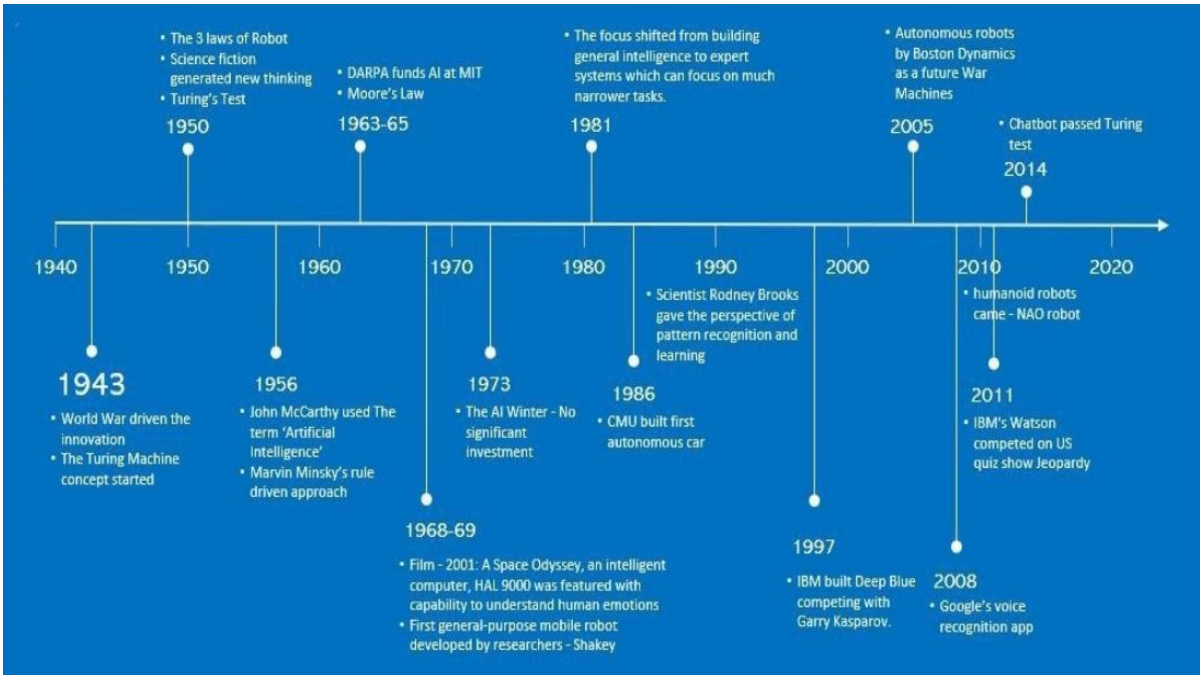

Figure 1 - Timeline of AI development. Source: (24)

However, in the 1950's computers lacked one of the main elements. Where they can execute the commands yet can't store the command.

Moreover, one of the setbacks in the early stages of developing AI where financial issues - leasing a computer could cost up to $200,000 a month. Therefore, its development was put on hold for the next 20 years (2).

Almost a century later, this field of computer science developed its own branches: machine learning where computers learn from data, natural language processing, which is understanding and generating human language, robotics which creates machines that can move and react to sensory input, and computer vision which is enabling machines to see and interpret visual information.

3.1.1 Introduction of AI

Artificial Intelligence is divided into 3 categories based on their capabilities and functionality.

1. Narrow or Weak AI is made for one or limited tasks. It operates in pre-set rules and does not have the capabilities to understand outside of its designed function(3). Due to its practicality it is widely used in the real world. For example: AI for chess may beat the grandmasters, but cannot perform other tasks than what it was designed to.
2. Strong AI operates similar to humans due to its ability to use intelligence in any given problem (5). This insinuates that the AI can perform on a complex and abstracts level by understanding and generalizing the context. For example: hotel robots that can work in different jobs as chef or receptionist, etc.
3. Artificial Superintelligence is speculated to surpass human intelligence and its capability. It includes decision making, rationalizing, and understanding emotions.

In its current state, AI is branched into the following subfields:

- Natural Language Processing (NLP): NLP provide machines to comprehend, interpret, and generate human language (4). Influential works including "Speech and Language Processing" by Dan Jurafsky and James H. Martin, along with "Natural Language Processing with Python" by Steven Bird and Ewan Klein delve into the intricacies of NLP. In recent years NLP is increasingly used by new platforms such as ChatGPT, Bard, BingAI, etc.

- Computer Vision: Enabling machines to solve and process visual data, computer vision facilitates tasks like image and video recognition. "Computer Vision: Algorithms and Applications" by Richard Szeliski offers a comprehensive view of this field.

- Machine Learning: This subfield revolves around the development of algorithms enabling computers to learn patterns from data. Techniques comprehend supervised learning, unsupervised learning, and reinforcement learning. For example, sources such as "Pattern Recognition and Machine Learning" by Christopher M. Bishop and "Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow" by Aurélien Géron will give significant insights.

- Robotics: The mixture of AI and mechanical engineering yields robotics, encompassing the design, construction, and operation of robots. "Introduction to Autonomous Robots" by Nikolaus Correll, Bradley Hayes, et al. shows insights into the intersection of robotics and AI.

- Neural Network is a computing system that is a branch of machine learning which focuses on simulating human brains to mimic their process of information. Fundamentally a neural network is a complex web inspired by our brain's architecture, working to decipher and understand information in a way that mirrors human thought processes. It is made of units called neurons, each linked to others, sharing data and insights. By sifting through layers of data, these networks tweak their internal connections to improve in predicting outcomes, recognizing images, understanding spoken words, and making decisions. This

adaptability allows them to master tasks without being directly programmed for each one, showcasing their ability to learn and grow smarter over time. (5)

- Deep Learning: An offshoot of machine learning, deep learning employs artificial neural networks to model and solve intricate problems. A major insight in this domain is "Deep Learning" by Ian Goodfellow, Yoshua Bengio, and Aaron Courville

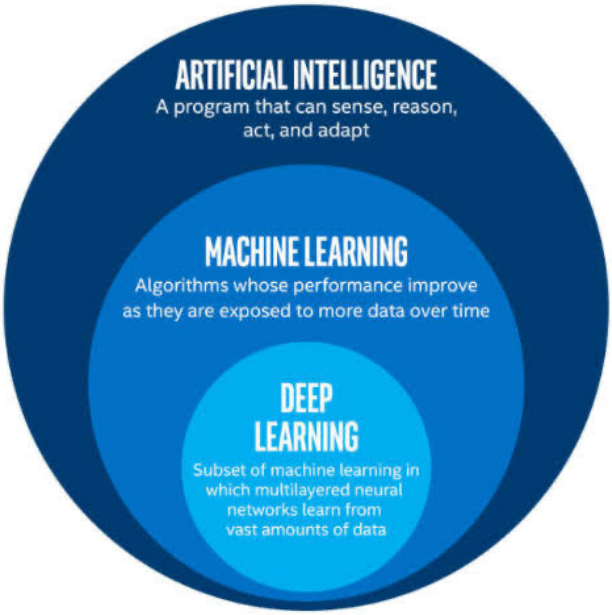

Figure 2 - Hierarchy of AI, Machine Learning, and Deep Learning. Source: (25)

3.1.2 Hardware and Software

AI development hardware is dependent on the nature of the task, the size of dataset, and the complexity of the model.

Processor (CPU): AI development is a computationally intensive task and a powerful processor significantly lowers deep-learning model training time. Depending on business tasks or personal development, modern CPUs with many cores and high speeds are often recommended for AI development. When it comes to CPUs for business or development use, the CPU choice is often down to selecting based on core count and clock speed. For example, Nvidia graphic cards that have tensor cores which are specifically made for AI, the Intel Core i7 to i9, AMD Ryzen 7 to 9 are more than adequate for the small business, backoffice or development/coding. Intel Xeon W and AMD Threadripper Pro (TR Pro) is appropriate for more specialized business needs or an acute development project.

Graphics Processing Unit (GPU): GPUs are heavily used for deep learning training, as these models often consist of thousands of matrix operations that can all be performed in parallel. The most popular choice for deep learning workloads are Nvidia GPUs; a high-end systems might offer the Nvidia GeForce RTX 30 series or the Nvidia Titan RTX.

RAM: AI servers usually load up with 128 to 512GB of DRAM, and HBM (high-bandwidth memory) modules, which are faster than traditional memory types, are common on high-end GPUs.

Table 1 - Processor Comparison for AI Workloads. Source: author

Feature / Processor	Intel Core i7	Intel Core i9	AMD Ryzen 7	AMD Ryzen 9	Intel Xeon W	AMD Threadripper Pro
Core Count	Up to 8 Cores	Up to 18 Cores	Up to 8 Cores	Up to 16 Cores	Up to 28 Cores	Up to 64 Cores
Thread Count	Up to 16 Threads	Up to 36 Threads	Up to 16 Threads	Up to 32 Threads	Up to 56 Threads	Up to 128 Threads
Performance in AI	Good for basic ML tasks	Better for complex ML tasks	Good for basic ML tasks	Better for complex ML tasks	Excellent for high-end ML/DL	Exceptional for large-scale ML/DL
Parallel Processing	Moderate	High	Moderate	High	Very High	Highest
Memory Capacity	Up to 128GB	Up to 256GB	Up to 128GB	Up to 256GB	Up to 1TB+ (supports ECC RAM)	Up to 2TB+ (supports ECC RAM)
Price for AI Applications	Moderate	High	Moderate	High	Higher (due to ECC RAM support)	Highest (professional-grade)
Target AI Use Cases	Entry-level AI/ML tasks	Advanced AI/ML tasks	Entry-level AI/ML tasks	Advanced AI/ML tasks	Professional AI/ML workloads	Large-scale, intensive AI/ML projects
Integrated Graphics	Yes (most models)	Yes (most models)	No	No	No (typically)	No

Table 2 - Processor Comparison of NVIDIA. Source: author

Feature/Processor	NVIDIA A100	NVIDIA V100
Core Count	6912 CUDA Cores	5120 CUDA Cores
Performance in AI	Best for large-scale ML/DL	Excellent for high-end ML/DL
Parallel Processing	Highest	Very High
Memory Capacity	40GB HBM2	16GB/32GB HBM2
Price for AI Applications	Highest	Very High
Target AI Use Cases	Large-scale, intensive AI/ML projects	High-end AI/ML projects
Integrated Graphics	N/A	N/A

Network: AI systems are often clustered to scale performance. Therefore, expect multiple 10Gbps or higher Ethernet interfaces at a minimum; some also add InfiniBand or dedicated GPU (NVLink) interfaces for intracluster communication.

Storage: AI development depends on plenty of storage space for your dataset, your model and training results that need to be saved at least every epoch. Most AI systems tend to use local NVMe drives; the lower latency trumps the high bandwidth that SATA SSDs can offer. For NVMe SSDs you should expect a base of 500GB, as the more, the faster are write and read speeds.

Display: A high resolution display with good color accuracy could help with visualizing not just the data, but training results.

Operating System: Most AI development tools and frameworks support Linux, and many AI developers prefer using Linux for its performance and flexibility. Windows and macOS are also supported by many AI development tools.

Cost Considerations: The cost of development for AI has significantly dropped in the last few decades compared to how it used to be in 1950 where leasing a computer for AI costed up to $200,000 per month (2). In contrast the Tesla V100 GPU, commonly used for training AI models, currently costs around $14,000 (6). The hardware requirements for AI development can be quite demanding, and costly. Moreover, its affordability is expected to increase as the technology evolves, making AI more accessible over time.

Software:

The primary frameworks used in machine learning include TensorFlow, PyTorch, and Keras. These are extensively employed for developing and refining machine learning models, providing a wide range of resources and libraries to facilitate the procedure.

Python has emerged as the primary language for AI development due to its simplicity and wide range of accessible libraries. Other significant languages for AI include R, known for its prowess in statistical analysis; Java esteemed for its portability; and C++ valued for its performance.

For interactive coding, training, and testing of AI models, platforms such as Jupyter Notebooks and Google Colab provide user-friendly interfaces that are well-suited for working with intricate algorithms.

3.1.3 Usage of AI

In the current world, AI usage is embroidered on our fingertips, we are using it on our smartphones, in industries such as healthcare, finance, automotive, electronics, and business etc. Due to its efficiency and accuracy, a lot of companies are looking forward to utilizing its power to improve their services. From the table 2 below you can see how much influence AI is having for the enterprise.

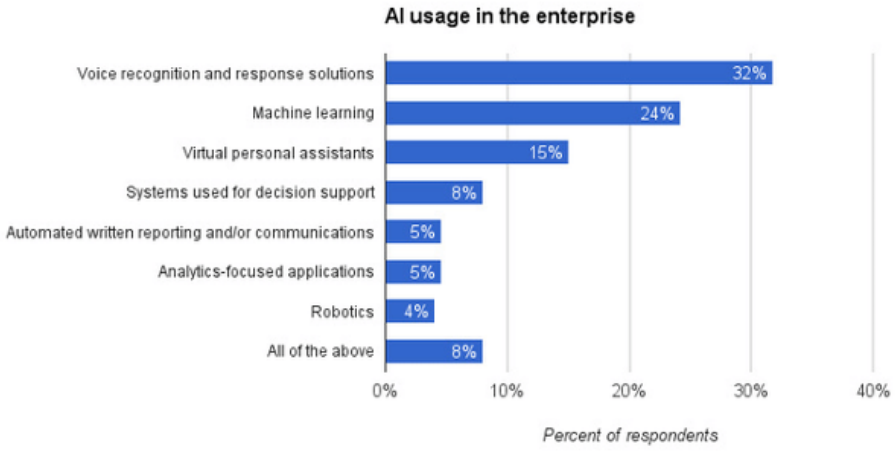

Figure 3 - Usage of AI Technology in enterprise. Source: (29)

One of the biggest companies in the US, Amazon, uses applications for machine learning to develop its digital voice assistant, Alexa. Telling you the day's weather forecast is just one of the more than 70,000 skills Alexa can do.

The way the company reached this extraordinary amount of skills in such a short time and can even continue to increase this number is achieved by Amazon giving free access to Alexa Voice Service that developers can keep building skills to augment the system.

Amazon also uses artificial intelligence to offer a new convenience store concept called Amazon Go(7). Unlike other stores, there is no checkout point. The stores have a tracking system via AI technology that tracks what items you pick up and then automatically charges you for those items through the Amazon Go app. Hence there is no checkout point, customers bring their bags to fill up with items, while cameras are watching their every move to identify every item they put in their bag to ultimately charge it.

AI in Gaming:

Artificial intelligence is increasingly used to create gaming environments that are more flexible and life-like. This causes an improvement of visual aesthetics and the overall gaming experience. It has also started to create alternative dynamic and responsive non-player characters that provide a greater immersion and a more challenging gameplay experience. Additionally, further advancements in AI technologies will soon enable gamers to experience lifelike non-player character (NPC)behaviors, dynamic game worlds, intelligent enemy AI, procedural content generation, and other capabilities (8). Also, AI can be used to detect and address potential issues such as cheating in which case it can enforce the rules or rebalance games in favor of players who fall behind for a more fair gaming experience.

Artificial intelligence lessens the predictability of the actions of non-player characters (NPC), and permits them to display greater intelligence than before. Likewise, it can generate carious different NPCs in a split second for the game - you can see the example of generated NPCs in Fig. 3. This adds an element of complexity to gaming, creating an experience that's richer and better immersiveness. AI algorithms can also generate game content in real-time according to the gamer's actions, which allows a more varied and exciting gaming experience (8).

Figure 4 - AI generated NPCs for video game. Source: (26)

3.2 Virtual Reality

3.2.1 Introduction to Virtual reality

The development of Virtual Reality (VR) has a story that consists of both technological and creative revolutions. Its origins can be traced back to the emergence of simulation and computer graphics during the 1960s (9). For example, Morton Heiligs Sensorama aimed to create a full sensory experience while Ivan Sutherland‘s „The Sword of Damocles“ can be seen as one of the earliest examples of a VR head mounted display system. These initial forays laid the groundwork for a field in human-computer interaction.

In the 1980s Jaron Lanier coined the term "Virtual Reality"; a phrase that encapsulates the idea of a computer-generated environment that makes the user feel like they are experiencing it first hand. Laniers work, discussed in his paper "An Odyssey in the Real", Scientific American, 1992, represented a pivotal moment in the evolution of VR turning the field from one of just creating these environments, to making them interactive and immersive (10).

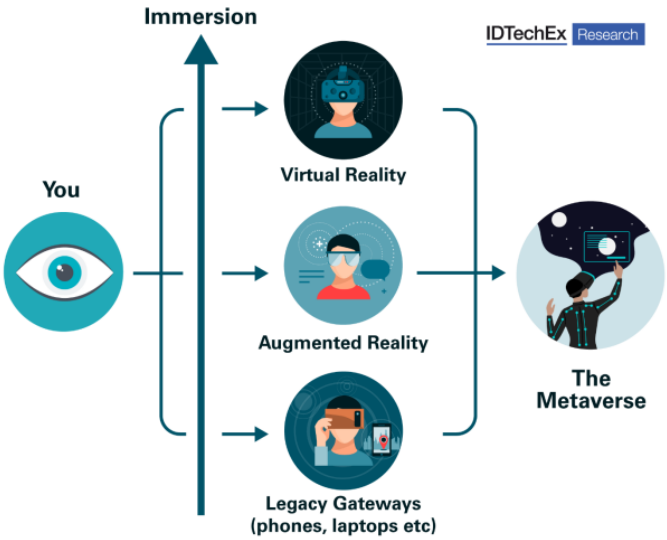

Figure 5 - Spectrum of Digital Realities. Source: (27)

The evolution of the VR experience spans several distinct phases. Early pioneering efforts, such as Sutherlands "Ultimate Display" modelled a world that seamlessly merges the virtual and the real.

What is followed was the arrival of consumer focused devices in the 2010s such as the Oculus Rift together with HTC Vive which brought the world of VR to life and making it more: immersive, available. The technology was no longer confined to just certain domains but could be used in areas such as entertainment, education and professional training.

Regarding VR/AR technology Apple unveils a $3499 mixed reality headset this year, the Apple Vision Pro with two micro-OLED displays. The design is similar to ski goggles and it features an external battery pack, visionOS, support for iPhone and iPad apps, and various activities, including work and gaming, and content consumption. The Vision Pro comes with 12 cameras and five sensors that recognize hand gestures and map its environment. It launched in February 2024 and is U.S.-only at first (11).

3.2.2 Hardware and Software

Most VR systems are based on headsets that are strapped to your eyes, much like ski goggles, that offer visual immersion; some also include additional sensory inputs, such as audio and/or haptic feedback.

VR Headsets: These are the most recognizable devices. They consist of either a console, a PC, or a mobile device which is attached to a HMD (Head Mounted Display). For example, the HTC Vive. Budget mobile HMDs are also available for as little as $100 (e.g. Samsung Gear VR) (12).

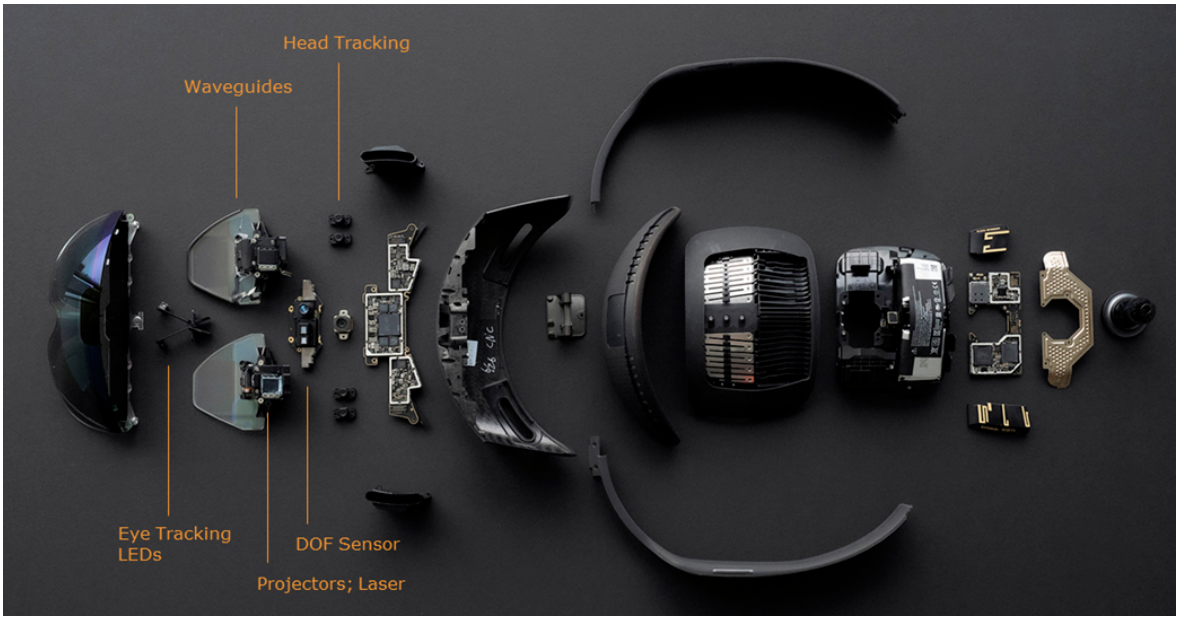

Figure 6 - VR headset Hardware component. Source (28)

Motion Tracking Hardware: These are the sensors with which you'll be able to lean into a table to draw or look around a corner in VR. Controller input: Most HMDs have access to a range of devices such as Leap motion controller or Microsoft's HolopairsControllers, gloves, and treadmills. This is not necessary for all VR experiences, however, it may be considered a desirable for certain individuals.

Input Devices for VR: Most HMDs have a range of input devices known as a controllers. Some will use a glove or the Razer Hydra motion controller. The technology is improving however, the VR set up including input devices hasn't changed since 1980s.

Powerful computers: Many VR experiences will work on high-end gaming computers costing 1000 $ or more. Smaller, lower-cost computers may work, but they could have difficulty operating more in-depth experiences.

Software: There are myriad ways to develop VR. However most known software are Unity Virtual Reality Engine and Blender 3D Computer Graphics Software Toolset.

Unity Virtual Reality Engine: Unity is best known for its expertise in game development. However, Unity expertise extends beyond game development, such as assisting you in many other VR solutions for numerous other sectors, for instance, media, automotive engineering, transport and manufacturing together with entertainment to give just some examples. It can also be paired with every major VR platform out there, namely Oculus Go, Oculus Rift, HTC Vive, HTC Vive Pro, PlayStation VR, Google Daydream or Lenovo Mirage and so forth. Also, it has a powerful portal where visitors can access different types of VR development courses(13).

Blender 3D Computer Graphics Software Toolset: Blender has been a name to be reckoned with in the 3D model and animation industry ever since its inception in mid 90s. Due to it is free and open-source software employed to build 3D printed models and VR games (14).

It has of its in-built rendering tool which offers stunning features such as VR rendering, modelling, animation, rigging, sculpting, and simulation processes. It also offers a fully compatible with a host of systems, including Linux, DragonFly BSD, macOS, Windows, Android, OpenBSD, NetBSD, FreeBSD, and Haiku.

3.3 Augmented Reality

Augmented Reality, as we define it here, is any real-time, direct or indirect view of a physical environment that has been digitally enhanced–or augmented either indirectly (through the use of computers with live video input) or directly (through a headset).

Augmented reality (AR) has become a powerful technique for overlaying virtual elements onto the physical environment and enhancing how we perceive or respond to it (15).

Augmented reality is three-dimensional and interactive. It merges real objects of light and shadow with virtual ones, offering both worlds together in richly textured space. Augmented Reality is a new medium merging the physical and digital realms with installations. This medium opens up new possibilities that have never been available before.

It’s control is continuous or automatic affording great authority over one's point of view throughout all stages in interaction with content. Unlike VR, which creates an immersive virtual environment around the user, AR overlays digital content onto the user's immediate surroundings in real time. Such an effect can be achieved via smartphone, tablet or AR

glasses. AR is used in fields ranging from games and education to navigation and retail services, providing a mixed experience of the virtual and physical space (16).

Using cognitive methods and AR technologies have transformed photographs into immersive tools that give further understanding on a variety of subjects. It is widely used by organizations to visually represent complex information (17). Many enterprises has started to turn to AR apps for better engagement of users. This is reflected in the way how industries provide us with visually compelling and innovative presentations of digital content through many kinds AR techniques, as shown in Fig. 7.

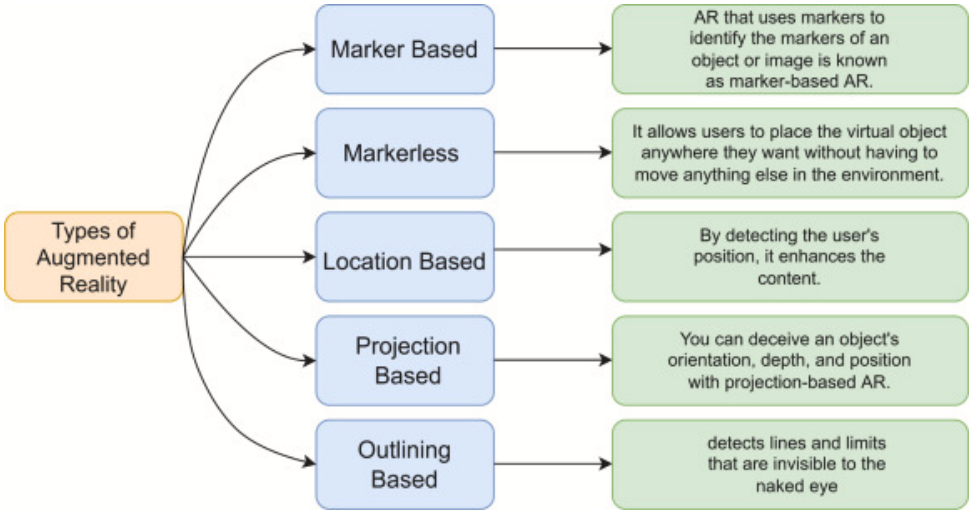

Figure 7 - Different types of Augmented Reality applications. Source: (17).

The Czech Republic's Signal Festival in Prague recently incorporated (AR) technologies into their event—providing unique art experience opportunities never seen in a Central European country before. This innovative approach was first seen in 2021 as part of the festival's ninth-year edition and has been continued since its initial introduction. The festival features a variety of AR art installations on display through a specially developed mobile app.

Using the Signal Festival app designed for AR core-phones, people can experience a part of the festival within Prague's district of Karlín. By scanning a specific location's Signal marker, virtual art pieces fitted to their environment will appear on the screen. This innovative setup brings together real and virtual art experiences in one application that allows sculptures and artworks to be present in an app (21).

3.4 AI and VR based applications in real life

At the present time, Meta and Apple Vision Pro is peak of the intersection between Artificial Intelligence and Virtual Reality. It emphasizes a significant milestone in the integration of advanced technologies within the academic and technological spheres.

3.4.1 Apple Vision Pro

Integrating both augmented reality (AR) and virtual reality (VR), the Apple Vision Pro creates numerous opportunities for applying artificial intelligence (AI) in different sectors (11).

In entertainment markets, the Vision Pro has the potential to change gaming and movies. VR gaming experiences presumed to be personalized for individual players by AI. As for movies, this technology would enable interactive stories that viewers helped to shape--perhaps by influencing which direction the plot took. Additionally, communication in live time, for example facetime user's making brand new reality by both mixing digital and real now it's known as mixed reality.

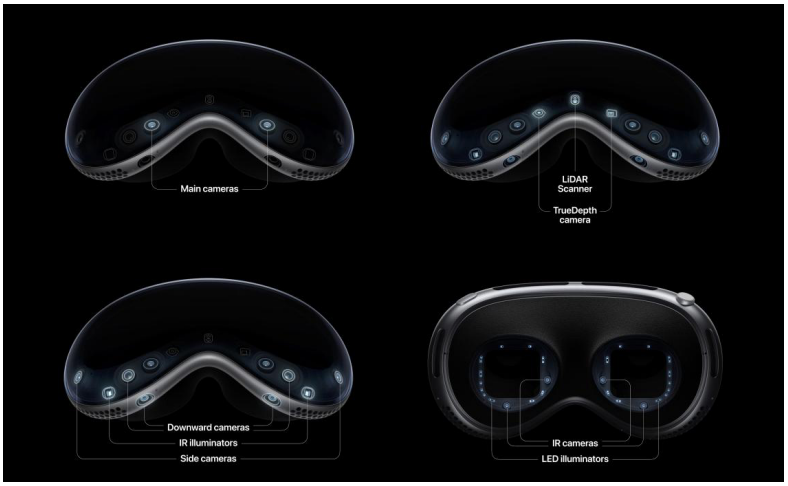

Figure 8 - Apple Vision Pro Headset Sensor Layout. Source: (11)

According to the manufacturer, Vision Pro is promising to blend seamlessly the digital world with the user's real world. For example, the user is not limited by the display, Therefore, they can turn their current space into any panoramic scene. Only using their fingertip.

The Vision Pro also opens up new possibilities for virtual social interaction. Due to its combination of VR and AR. Apple using deep learning to create seamless user experience which user's can intuitively navigate through with the device.

Aimed specifically at supporting these new functions is the device's hardware, including a new R1 processor. Among others, the R1 processor is designed to optimize spatial computing functions inherent in a seamless mixed reality experience. Technologies such as foveated rendering improve visual quality and and performance by focusing primarily on whatever area the user is looking at, as well as conserving battery life (11).

According to the experts, AI with VR in the the Apple Vision Pro has potential to change professional training, entertainment, education and social interaction. Its hardware exists to support a full spectrum of richly interactive experiences--a new way for people to be with digital content and each other. And as its use spreads farther, so too is its potential to lead in many areas.

3.4.2 Meta

The virtual reality headset from Meta is a leap forward in combining digital technology with human experience, a retrenchment towards the full realization of an immersive virtual environment. This piece of equipment boasts an integrated artificial intelligence (AI), supporting not only high resolution displays for incredible clarity but also a whole range of AI applications that are used to enrich user interactions and environments. Making use of AI to adapt to human actions and preferences, these adaptive environments powered by the latest tool in artificial intelligence take users through virtual spaces as easily and naturally as if they were real world ones.

With a leading advanced systems for AI-powered tracking and reception, the headset follows every subtle motion made by the wearer and translates these actions into the virtual world with precision. By using AI to process these high levels of information, this advanced action creates a seamless union between user and digital environment. With AI as an added element, immersion is more acute. According to the manufacture, users would be able to pick up inanimate objects with their hands, as AI algorithms predict and correct their intentions; or, look around to find a vivid virtual world popping into view in response to everyone else 's dynamic interests.

Equally sophisticated is the surround sound experience, with AI-driven spatial audio that matches the depth and spaciousness of the field vision. This AI-helped sound immersion is an essential part of turning the virtual space, so carefully displayed from afar by an LCD or OLED screen, into a living world. The headset's performance in providing AI-enhanced immersive experiences is made even smoother by Wi-Fi 6E, which helps reduce delays to the point where an essential feeling of instant response and presence is preserved.

Usability, again improved by AI, is another key factor. The headset's long battery life, made possible by efficient AI power management, means that users can go on and on with their adventures, game playing or attending virtual meetings as much as they want without having to worry about recharging their hardware.

Above all, Meta's VR with AI headsets raises the bar for design by becoming a vehicle to digital domains where the real and virtual blur together. It embodies a major step forward in digital interfacing, promising more science and entertainment pleasures that truly touch the heart.

Meta presents a future where the physical and digital combine; through the power of superior display technology, exact AI tracking, lifelike sound and other features such as modern connectivity and battery life, people should be able to have immersive experiences effectively merging with model human ones (22).

3.4.3 Artificial Intelligence in Virtual Reality other areas:

- Health Care Education and Simulation: With virtual reality enhanced by artificial intelligence, medical training has advanced like never before. This form of high-fidelity simulation provides a space for medical students and professionals to practice complex operations in peace. AI offers real-time guidance and feedback, assuring technique precision and procedural correctness. "Precision OS" is a case in point: this platform is at the forefront of educational reform-helping out healthcare workers, and by extension benefiting the patient.

- Architectural Visualization and Design: Combining VR with AI has become a crucial tool for architects and designers. With it, two-dimensional blueprints are converted into three-dimensional virtual reality, where you can walk into the room

and see for yourself both what that looks like on paper and how it works in real life. This promotes thorough examination and evaluation of architectural designs and enhances communication between architects, clients, and various participants. Tools like "IrisVR" are crucial to the collaborative architectural designing process.

- Education and Training: Incorporating AI into VR has given a fresh lease of life to educational methods. Students now have performances without boundaries to enjoy as they learn interactive and experience-oriented. By typing "Proteus," students can enter a computer and take in the sights or sounds of events long past. They can wander through Chinese gardens come to West End theatres, right at home on the couch. Adaptive AI algorithms can be tailored to different learning styles, bringing more personal care for your educational experiences than ever before. "Engage," in transcending territory by banding together students and teachers from all over the world with its interactive virtual classroom Alliance.

- Automotive and Manufacturing Simulation: The fusion of AI and VR is transforming techniques and refining safety standards in the automotive and manufacturing industries. AI-driven simulations become virtual grounds for vehicle design and manufacturing process, ensuring that potential issues are spotted by engineers early on in their season and corrected--all the way down through preconception rather than at prototype expense. This kind of integration, which is being demonstrated by "Esi IC.IDO," webinar demonstrated to show innovative enterprise VR for engineering represents a revolutionary leap in industrial innovation and efficiency.

- Distributing information Technologies and Innovations in Virtual Reality: Artificial intelligence combined with perfected optics is giving birth to more vivid three-dimensional displays at Stanford University.

Their work aims to overcome the deficiencies of current VR- and AR technologies--so often just 2D projections--by generating holographic images beautiful to the eye. Recent publications show substantial advances in display quality for holography, with a broad spectrum of applications across such diverse spheres as gaming and medicine.

4 Practical Part

AI is growing and building so far unimaginable possibilities. One of the main parts of implementing itself is video games. This chapter will consist of two parts. The first part will showcase the analyzation of two video games “Death Stranding” and “Ghost of Tsushima” – with the purpose to compare each of their AI implementation. Afterwards the chapter will cover which game is suitable for adaption into VR.

4.1 The use of AI in “Death Stranding”

“Death Stranding” is a video game developed by Kojima productions. The genre of the game is action, adventure and open world. It runs on either Microsoft windows or Playstation4 as platform. The background of the story follows Sam Porter Bridges (the player’s character) as he goes through a post-apocalyptic world, delivering essential supplies while confronting supernatural creatures.

In “Death Stranding” video game players experience the environment of post apocalypse where nature and weather are in destructed state. In this state of environment, the non-player characters (NPC) and in-game creatures navigate realistically, responding to the nuance of the landscape while ensuring the immersive player experience. This is where the neural networks come into play. The development team employed artificial intelligence extensively throughout the game’s creation, a topic comprehensively explored in various discussions, notably at the Game Developers Conference (GDC). The lead AI developer, Eric Johnson, provided insights into the multifaceted use of AI technologies in the game’s development (18). These technologies were integral in shaping terrain, NPC design philosophy, character movements, and other critical aspects of the game’s AI infrastructure.

This section will focus specifically on the most contentious aspect of AI utilization in “Death Stranding”: the design of NPCs (Non-Player Characters) through neural networks. Neural networks, a subset of artificial intelligence inspired by the human brain's structure and function, were leveraged to imbue NPCs with behaviors and decision-making processes that mimic real human responses.

Hideo Kojima, the game’s creator, explained how NPC’s fate can be affected by players: For example, a player will meet an old man who is a NPC sick in the underground and in need of medicine. In the beginning of the story the player must deliver to the old man (NPC) medicine.

This quest is unavoidable and starts as a mandatory task. After successfully delivering the medicine for the first time, the player will have the choice: keep on bringing him the medicines and other necessities and listen to the past stories from the NPC to create a bond.

Impact of choices: Here comes the AI driven narrative into play. The user's constant forward movement and potential of neglecting the NPC will cause a dire consequence. If the player has forgotten about the NPC throughout the game and did not go back to give the medicines, the NPC can die out of neglect. This dynamic story telling is one of the key features of the Narrative AI. Based on the choices the user made, the Narrative AI will adjust the NPC condition of health state - the more users interreact with the NPC, the more their condition improves. Moreover, this AI driven behaviour encourages the users to have an emotional engagement with the NPC. The players can get affected by the emotional impact of the NPC's fate, because the choice is on their hand.

AI Aspects:

"Death Stranding" uses Neural Network AI technique and Dynamic Data Processing for its narrative. Neural Network AI technique is crucial for modelling behaviour of the NPC. This network processes the vast majority data and repetitive patterns to adapt NPC responses as a realistic interaction, because it's inspired by the structure of the human brain.

Neural network: In the game neural network is utilized by three areas: behaviour modelling, pattern recognition and adaptive responses. In behaviour modelling, neural networks are designed to create the personas of NPCs. By collecting a wide range of potential NPC actions, reactions, and interactions, it will train the neural newtwork to enlarge it's dataset.

Moreover, one of the other key strengths of neural networks is the ability to recognize patterns to understand and interpret player actions, environmental cues, and NPC conditions.

This allows adaptive responses, based on the ability to adapt on learned patterns. Neural Networks enable the NPCs to provide various responses in game, whether its responding to the player's decisions while navigating complex terrain or responding to the changing

dynamics of that game world. In the end, by leveraging neural networks, the game achieves total realism enhancement.

Dynamic Data Processing: in “Death Stranding” dynamic data processing is critical aspect of the AI system. It ensures that the game is responsive and adaptable by involving the continues process of in-game data in real-time. The AI system will constantly monitor and process the player’s action, including movements and interactions to the choices the player made during the game. Dynamic data processing also involves monitoring and tracking the conditions of NPCs. For instance, from the previous case example, AI keeps tab on the health of characters, locations, and their interactions with the user. Moreover, it also assesses the game world state which means the environmental condition, terrain complexity, and the supernatural entities. In the end dynamic data processing ensures the game world feels alive and responsive by continuous immediacy.

Based on the analyses, few potential challenges can occur. In order to train the neural network it is necessary to have a substantial amount of data. Developers need to curate a diverse dataset to ensure the NPCs reaction. Therefore, it demands to craft engaging scenarios that respond to the player’s choices, which makes the developers to count on a wide range of player decisions and their consequences. Which brings us to the next point, where it requires computational resources. Developers need access to high-performance hardware to handle the AI workload. For training phase, the least amount of GPU memory will require 24GB to up to 40GB of VRAM or more.

In summary, in the game world of “Death Stranding” neural network ensures the realistic behaviour of NPCs, while dynamic data processing enables that the NPC’s responses are formed by real-time data.

4.2 AI Usage in Ghost of Tsushima

Developed by Sucker Punch Productions and published by Sony Interactive Entertainment, "Ghost of Tsushima" tells the tale of Tsushima under the very first Mongol invasion against Japan. It is available on both PlayStation 5 and PlayStation 4. The players play as a Jin Sakai, a samurai who is assigned to defend Tsushima Island.

AI aspect:

While the specific AI technology used in "Ghost of Tsushima" is still kept under wraps, experts in the field assume that a rule-based AI acts as an arranger and guide for the behaviour and decision-making of non-player characters (NPCs). Such a system would, by its nature, bring some level of predictability and consistency to a gameplay experience. The NPCs can be expected to travel predetermined paths and interact with players in fixed ways according to owing protocols.

A rule-based system for making decisions for non-player characters, or NPCs, is a program which decides on the behavior of characters under a given set of rules. If a certain condition is met within the game world, the rules will afterwards determine how an NPC should react to that stimulus.

This is how it generally operates in video games:

- Judge-game developers make a series of “if-then” statements which control NPC behaviour with predefined rules. For example, “If the player is found and within range then the enemy NPC will attack.”
- Trigger conditions: The AI checks constantly for specific conditions or triggers like a player entering a certain area or performing certain actions.
- Action: Once a condition is satisfied, the matching rule will be implemented. This means that the NPC will take actions such as chasing after the player, going into an alert state or providing assistance.
- Persistence: By following this philosophy NPCs become predictable and stable in their behaviour, for their behaviour is already determined and is not changed with each game play-through.
- Rule-based AI also enables the reliable and steady game behaviour designers are aiming for. This is especially useful, for example, in puzzle games or

strategic ones where programmers need players to figure out their moves to move forward because of the predictability of NPC behaviour.

However, with a rule-based AI system potential limitations become apparent in certain NPC behaviours, most notably in their sensory perception and memory. NPCs may show a forgetfulness about interactions with players, ignoring all but regular behaviours when the player resumes his position--quite unlike the sensitive and ever-changing responses people make. For example stealth mechanics for stealth mission – which allows players to maneuver various scenarios without being noticed or to silently destroy enemies without causing alarm.

The NPC's response to memory is so short term that it is as if they have no memory at all. Once the player goes into hiding, after only a short period of concealment, NPCs seem to forget him and return to their routines. This behavior could be considered a deviation from realistic responses. Moreover, there are times when NPCs fail to notice the player in plain sight, examining opportunities for improvement in AI design. In summary, "Ghost of Tsushima" is a classic example of rule-based AI in the design of computer games.

4.2.1 Comparison

In the comparative analysis segment of the study, a comprehensive investigation was undertaken for both games, „Death Stranding" and „Ghost of Tsushima", from a technical standpoint as well as through the lens of player experiences, with a particular focus on the dynamics of interaction between non-player characters (NPCs) and human participants.

From a technical perspective, the artificial intelligence (AI) capabilities in the two games exhibit notable disparities, potentially attributable to differences in budget and production costs. "Ghost of Tsushima" has publicly disclosed its production budget at approximately $60 million (23), a figure that is relatively modest when compared to the typical range of $90 million to $180 million for similar high form game classifications of AAA titles . This variance in financial resources may have influenced the depth and complexity of AI interactions within each game. resulting player-NPC interactions.

"Death Stranding" has been open about its initial AI development, sharing insights at the Game Developers Conference (GDC), recognized as a premier educational resource for the gaming industry. In contrast, "Ghost of Tsushima" has not made similar disclosures

regarding its AI development process. At GDC, the AI developers for "Death Stranding" discussed the intricacies of crafting the game's terrain and NPC behaviours, highlighting how certain NPCs' fates are directly impacted by player actions. This was further elaborated during a promotional event in Moscow, where it was revealed that the game employs a variety of AI techniques to enhance different aspects of gameplay (19).

The financial investment in "Death Stranding" appears to have facilitated a more elaborate exploration of AI technologies, as evidenced by the detailed presentations given by its developers at industry events.

Adaptability and Realism:

„Death Stranding" offers high adaptability and can generate more realistic and nuanced behaviours due to the neural networks. However, they require extensive training with high datasets and computational resources. In contrast „Ghost of Tsushima" provides consistency and is easier to control and predict due to the rule-based system, which can be advantageous for game balancing but might lack the depth and adaptability of neural networks.

Development Complexity & Resources:

Neural networks involve a complex development process, requiring substantial data for training and fine-tuning to function as it is intended. Rule-based systems are generally simpler to develop and require less computational power but might not offer the same level of adaptability of NPCs and experience.

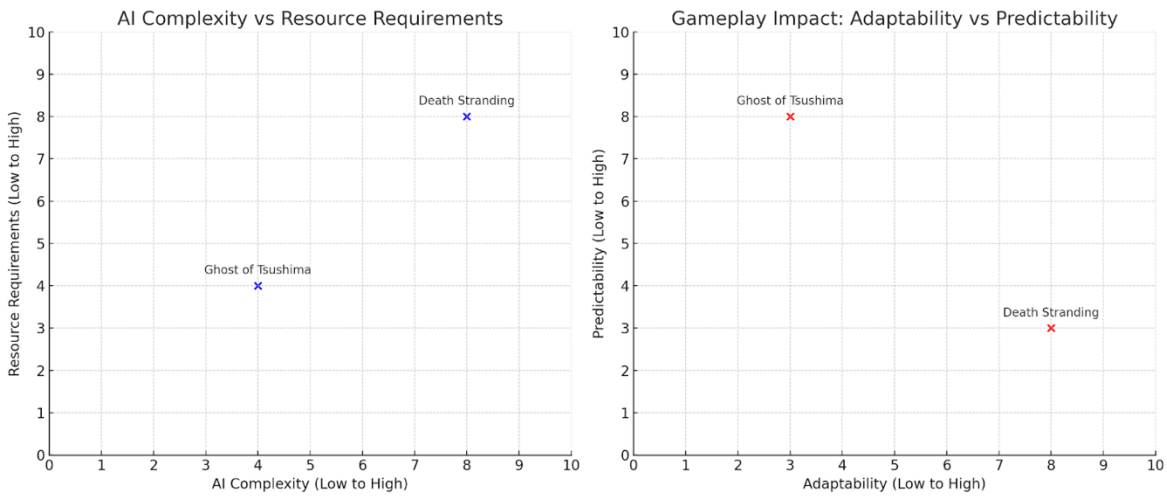

Figure 9 - Comparative Analysis of AI Complexity Versus Resource Requirements in 'Death Stranding' and 'Ghost of Tsushima

Gameplay Impact:

In "Death Stranding," the use of neural networks enhanced the realism of NPC interactions with complex environments, potentially leading to a more immersive player experience. While in "Ghost of Tsushima," the use of rule-based AI ensures predictable and balanced combat encounters, contributing to a fair and enjoyable gameplay experience.

4.3 Implementation of Virtual Reality

The exploration of transforming "Death Stranding" and "Ghost of Tsushima" into virtual reality (VR) experiences presents a multifaceted challenge. This analysis delineates four critical criteria essential for successful adaptation to VR: immersion, gameplay mechanics, narrative and pacing as well as technical considerations, alongside AI and NPC interactions. Each aspect will be scrutinized to determine the feasibility and suitability of these games for VR adaptation.

Immersion

VR demands an immersive experience that captivates the user. Games with a profound atmospheric essence, intricate environments, and a penchant for exploration are prime candidates for VR adaptation.

In its first stage of development, "Death Stranding" undertook location scouting in Iceland in 2016, which later resulted in the game's portrayal of mountainous and riverine landscapes. On the other hand, "Ghost of Tsushima" takes inspiration from the historical Mongol invasion of Japan in 1274, with the game embroiled in rich historical contexts and vivid natural scenery.

Gameplay Mechanics

The adaptability of a game's mechanics to leverage VR's capabilities—emphasizing naturalistic movements and interactions—is paramount. Games predicated on rapid action sequences or complex control systems may confront adaptation barriers, potentially exacerbating VR-induced motion sickness due to the inherent limitations of VR control mechanisms. Therefore, developers should mainly focus on graphic adaptability to reduce each games potential motion sickness. For this case Ghost of Tsushima is a high risk of creating motion sickness due to it’s heavy combat style of game.

Narrative and Pacing

VR experiences are enriched by compelling narratives and deliberate pacing, which anchor the player within the virtual milieu without engendering sensory overload. "Death Stranding" tells the story of a person's discovery and feelings of growing sentiments such as survival and sacrifice caused by changes in society. While "Ghost of Tsushima" narrates the story of Jin Sakai, a samurai entering into a tortuous journey against invasion by Mongols, dealing with themes such as honour, sacrifice, the confrontation between tradition and adaptability.

Technical Considerations and AI Interactions

The integrity of game performance, specifically frame rate consistency and responsive player-NPC interactions, is critical in VR to circumvent motion sickness and preserve immersion. "Death Stranding," with its sophisticated AI and performance benchmarks, might have a slight edge in terms of technical readiness for VR adaptation which is not suitable. Unless the game change their AI type into more narrow it will require an immersive financial investment to keep up with its current video game. In contrast, „Ghost

of Tsushima“ and its simple rule-based AI agents it's more manageable to transition into VR.

Evaluating these criteria, despite the potential for motion sickness, "Ghost of Tsushima" emerges as the more viable candidate for VR adaptation. Its simpler AI, coupled with the game's historical and cultural depth, offers a foundation for an immersive VR experience. The transition of "Ghost of Tsushima" to VR not only aligns with technical feasibility but also promises an enriching experience rooted in historical authenticity and narrative depth.

4.4 Game proposal

In this part, I propose the conceptual framework for VR video game, integrating AI techniques from the insights from the above analysis.

4.4.1 Core concepts and goals

“Shadows of the Shattered World” is a proposed VR action-adventure game that transports players to a post-apocalyptic world where humanity’s remnants grasp at the echoes of their once-mighty civilizations. Drawn from the inspiration of exploration and connection in games like “Ghost of Tsushima” and “Death Stranding,” the game tasks the player with journeying through a world that has been ravaged as they work to rebuild society, re-establishing connections between isolated communities and witnessing, first-hand, their very environment — and the people in it — shift to become an extension of their every action and choice.

Setting and Story:

Set in a world that has been destroyed by a cataclysmic event, “Shadows of the Shattered World” establishes an unusual twist on the typical post-apocalypse universe: mix of ancient Eastern cultures and advanced technology, creating dangerous terrain.

Players adopt the role of a lone wanderer, who stumbles upon an ancient artifact allowing them to commune with the “Echoes of the Past”: the spiritual remnants of the world’s history and its peoples. Their journey will carry them through the crumbling remnants of great cities, to lush countryside overgrown with time, and treacherous technological wastelands in an effort to rebuild the lost connections of the world around them, retracing the footsteps of its downfall, discovering the role of the artifact that they’ve

found and learning how it’s the key to stopping another, even more catastrophic cataclysm in the future.

Exploration: Players will find themselves journeying through a massive, interconnected world, discovering hidden locations, ancient ruins and communities clinging to life between the two. The VR format promises an unprecedented level of immersion, allowing players to explore their landscape as if they were truly there: climbing ruins, traversing paths hair-thin through ravines and riding steeds across the countryside. Each environment has its own unique ecosystem, and a rich backstory along with its history and culture.

Combat: Combat fuses traditional martial arts with the strategic implementation of an alien artifact, giving you access to its powers to manipulate the environment, summon battle-assist echos, and other unique abilities. In VR, combat feels powerful and keeps your movements in play using intuitive motion controls to advocate precision and strategy.

Environmental Interaction: Restore ancient structures, clear obstructions and cultivate land to rebuild and sustain the communities in and around these environments. Your environmental actions do nott just change the physical world, but have a narrative impact as well, changing what is possible in terms of both the game world and your relationships with its NPCs.

VR Enhancements: Realistic combat and environmental interaction using VR physics, detailed haptic feedback, and voice recognition for virtual conversations with the NPCs in the world combine to give you a truly immersive experience where the line between you and the avatar you play begins to blur.

Shadows of the Shattered World is a game that combines exploration, combat, and community-building in a unique and vibrant VR world. It asks you not just to play within its world, but to live in it, as you uncover its secrets and history, and leave an indelible mark of your own.

4.4.2 Parts where human required:

Main Characters and Key NPCs:

Design the main characters and other key NPCs, including their backstories, personalities and the actual story arcs to make sure they are deep and engaging. Because, humans are better at creating nuanced, emotionally resonant characters and storylines which are essential for the player's deep connection to the game.

Write the original storyline and main quests:

Writing the actual central narrative and main quests to make a coherent storyline that is both compelling and keeps the flow steady with plot twists and character development. Complex storytelling requires a level of creativity and unpredictability that AI currently cannot provide.

Artistry:

Establish the game’s visual style, thematic elements, and core mechanics to maintain a unique and consistent player experience. A cohesive artistic vision and design philosophy are crucial for a game’s identity, which requires human intuition and creativity.

Compose the musical score and design the sound effects to evoke the right emotions and build the game’s atmosphere. Music and sound design require a nuanced understanding of human emotion and context, which AI cannot fully replicate.

Voice Acting:

Perform and record dialogues for main characters and important NPCs to provide authentic emotional performances. Human actors can convey the subtleties of emotion, tone, and inflection that bring characters to life.

4.4.3 Part which inclines AI usage:

Side Quests and Procedural Narratives:

AI will generate a broad array of side quests to immerse the player further in the game world. Procedural narrative generation gives you endless play through a unique story and the opportunity for character? development, and conclusion.

Why AI: Based on the previous example game “Death stranding”, AI can create a large number of quests quickly and make sure they are logically coherent, changing based on a player’s actions. Using neuronal networks would hence give human designers more time back. while adapting and creating the vision of developers.

Generating the terrain:

Building expansive, varied landscapes with procedural generation, while creating rules that keep the game's overall aesthetic and function intact.

Why AI: Similar to the previous reason, procedural generation can make unique, huge environments super-fast time vice. It would take humans way longer to craft that data-level of detail.

Generating NPCs:

Randomize the appearance, attributes and behaviour of unimportant NPCs everywhere to fill out the world and keep you from constantly bumping into carbon copies.

Why AI: Making enough good variations for an immersive population would be extremely resource and time intensive to do by hand. For this game proposal you can see the auto generated NPCs in below Fig. 9.

Figure 10 - Example of AI genereated NPCs for the game of Shadows of the Shattered World. Source:author generated by ChatGPT

Creating enemies based on rules:

Use rule-based AI to have enemies behave and react in a predictable way, which is matched to different challenge levels in various different combat rules.

Why AI: These rule-based systems are good at always providing a consistent level of challenge, making for tactical combat that is satisfying to overcome.

4.4.4 Hybrid approach:

AI-Assisted Design can suggest design elements or optimizations that humans can refine and integrate into the game. This approach leverages the efficiency of AI while retaining human creative control for quality and artistic integrity.

AI algorithms can adjust game difficulty based on the player's skill level, while humans set the parameters and ensure fairness.

AI can dynamically create a personalized experience, while humans ensure it aligns with the intended game design.

In conclusion, AI can greatly enhance the efficiency both in source, time, and scope of game development, especially for tasks that involve generation and variation at scale. However, human input is crucial for creative direction, narrative construction, and emotional resonance, ensuring that the game delivers.

5 Results and Discussion

5.1 Comparative analysis of video games

The comparative analysis of "Death Stranding" and "Ghost of Tsushima" revealed significant differences in AI implementation that are reflective of the unique narrative and gameplay objectives of each game.

"Death Stranding" incorporated Neural Network AI alongside Dynamic Data Processing, which allowed for an extremely responsive in-game environment capable of providing the player with a realistic reaction from the NPCs as a result of the complex and multi-faceted nature of the landscape and the player choices within.

The dynamic nature of this AI-driven narrative allowed for a story of emotionally engaging interactive experiences where the player had weighty impacts on the outcomes of the NPCs.

“Ghost of Tsushima” embodied a rule-based AI system which provided an effective mechanism of maintaining control over the NPC population of the game world in a predictable and computationally efficient way. Despite this, it did face deficiencies in NPC perception and memory which did result in some encounters that were not a realistic representation of the area and could benefit from improvement

5.1.1 Challenges

Several game development challenges were brought to light through this analysis, some of these challenges include:

Computational Resources: Training Neural Networks require datasets of sufficient diversity to truly encapsulate the range of potential behaviours exhibited by the players of the game. This proves to be an immensely challenging task for developers and demands the hardware resources.

Predictability from NPCs: The rule-based AI notably encounters predictability of its NPC characters due to its short-term memory.

5.1.2 Adaptability and Realism

Death Stranding" offers high adaptability and realism in NPC behaviours due to neural networks. This comes at the cost of extensive data requirements and significant computational resources.

Rule-based systems like the one in "Ghost of Tsushima" benefit from the predictability and ease of control, though they lack the depth that neural networks offer.

5.1.3 Methodology for VR implementation

Considering its level of immersion, gameplay mechanics, narrative, pacing, and technical considerations, “Ghost of Tsushima” would appear to be highly suited for successful VR translation. The game's AI is less technically complex, and the game's rich historical setting should pose fewer technical hurdles, leading to a highly immersive and culturally profound VR experience.

5.2 Proposed VR game framework – “Shadow of the Shattered World”

A proposed VR game that integrates a creative implementation of AI techniques. The game has the potential for exploring, combat, and community-building within a captivating post-apocalyptic world.

- Human-Centric Design Elements where they will be the crucial to craft fully believable and emotionally engaging character arcs, original dramatic storylines, and deeply evocative artwork, music, and voice acting will be essential for the game's stunning emotional resonance.
- AI-Driven Game Development where throughout the process of game development, AI will be deployed to significantly generate side quests, terrains, and side NPC characteristics, as well as to build the rule-based behaviours of enemies within this framework.
- Hybrid Approaches is where combination of human and AI that will make creative AI design suggestions, difficulty scaling options, and creating deeply personalized player stories.

In conclusion, AI can significantly contribute to enhancing the scope and efficiency both areas such as source and time. By allowing for increased artistry while offering the game development team to sustainably create games that fully manifest their creative vision. Furthermore, the vision is to demonstrate that AI models will be able to significantly enhance high-level design thinking in collaboration with humans in a way which that can take us to a highly compelling and transformative VR playing space for today's games.

6 Conclusion

This thesis explored the intricate interplay of Artificial Intelligence (AI) with Virtual Reality (VR), outlining the game-changing impact. It found that AI has the potential of enriching a better immersive and interactive environment for VR by researching deeply into the role AI plays in the gaming "Death Stranding" and "Ghost of Tsushima". Based on the research, author proposed a VR game "Shadows of the Shattered World". This work has carefully unpacked the critical role of AI in fostering more engaging, reactive, and emotionally resonant VR experiences.

The thesis analysis presented here have unveiled the countless of ways AI can be sensibly and effectively folded into VR, showcasing different forms and shapes AI can take on in virtual settings. "Death Stranding" takes advantage of cutting-edge neural network to unfold a world where every player action makes a dent in the storytelling and gameplay, making a seamless servicing of AI. On the other hand, "Ghost of Tsushima" forges a more traditional, rule-based AI approach to ensure a more consistent and well-bounded gaming experience. Moreover, due to its simple component, AI in the case of „Ghost of Tsushima" can adapt smooth transition and benefit greatly from the immersive VR brings.

The conceptual design of "Shadows of the Shattered World" builds on all of these findings to lay out a feasible blueprint for a more novel VR experience where developers recognize AI's potential to transform the player's interaction within the virtual world. By using hybrid approach for the game development, the environmental interaction, adaptive narratives, and procedural content generation will be effectively efficient. This work illustrates how AI can take VR from mere simulations to interactive experiences rivalling real-world interplay.

Ultimately, the journey of AI within VR is a story of innovation and discovery that has only just began. This pages have spanned the full trajectory from theoretical foundations to practical application, from an in-depth look at the state of existing technology to an exercise in dreaming of what the future may hold. Through the journey, one thing becomes abundantly clear: the intersection of AI and VR is set to fundamentally change not just the way we interact with digital environments, but our experiences as humans. As we prepare

to experience on these new virtual horizons, let this be both a guide for what we have discovered, and a pointer to the countless unknowns waiting to be filled.

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8 List of figures, tables

8.1 List of figures

8.2 List of tables