Innovative virtual reality system for training in providing first aid in crisis and combat conditions of war using VR/AR technologies

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Abstract

The article considers the concept of developing an intelligent virtual and augmented reality system for teaching first aid in wartime and damage to civilian infrastructure. The proposed VR/AR solution allows you to simulate critical situations, including injuries, mass explosions, burns, and cardiopulmonary resuscitation. Additionally, it offers interactive engagement with victims through the use of modern game engines and VR controllers. The paper presents the functionality of the system, including the simulation of realistic scenarios, gamification of the educational process, automatic assessment of user actions, and integration with the medical triage system (Triage). Additionally, the use of generative AI models (Stable Diffusion, Leonardo.Ai, Trellis3D, Meshy, Sloyd) to create 2D and 3D content is described, which provides rapid visualisation and prototyping of training scenes. The results of the work demonstrate that the introduction of such technologies enables the enhancement of training efficiency for doctors, military personnel, volunteers, and civilians, reduces the level of panic during emergency events, and fosters practical skills in assisting in safe conditions.

Keywords

smart system, artificial Iitelligence, application, virtual reality, augmented reality, first aid, VR/AR simulator, generative artificial intelligence, training systems, war conditions, crisis situations, triage, simulation

1. Introduction

The full-scale war against Ukraine has demonstrated how vulnerable civilian infrastructure can be during massive attacks and how often not only the military, but also civilians are affected. In such conditions, the issue of providing quick and effective first aid becomes especially relevant. A person's life depends on the right actions in the first minutes after an injury, but not all citizens have the basic skills to respond to critical situations. Traditional approaches to first aid training, based on lectures and training with dummies, do not always reflect the realities of combat wounds, explosions, mass casualties, or psychological stress faced by both military and civilians.

The relevance of the topic is primarily due to the war in Ukraine, attacks on civilian infrastructure, and the growing need for mass preparation of the population for the provision of first aid. In turn, there are limitations of traditional methods (lectures, training on mannequins) and the growing prospects of VR/AR technologies in training (realistic modelling, gamification, safe practice of skills). Modern digital technologies create new opportunities to overcome this challenge. In particular, virtual reality (VR) and augmented reality (AR) enable the creation of interactive simulators that recreate realistic emergency conditions. Intelligent VR/AR systems can simulate scenes of destruction in urban environments after shelling, reproduce the emotional reactions of victims (such as panic and shock), and provide users with interactive tasks, including applying a tourniquet to stop bleeding, performing cardiopulmonary resuscitation, or providing assistance in cases of burns.

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A key feature of such systems is the integration of the educational and training process with gamification and algorithms for assessing the effectiveness of actions. Thanks to this, the user receives feedback in real-time: the system fixes errors, offers hints, and allows you to repeat scenarios until they are perfectly executed. The integration of the principles of medical triage (Triage) makes it possible not only to teach basic skills but also to form a strategy for assisting in a situation of mass casualties, which is especially relevant in the realities of wartime.

The target audience of such VR/AR solutions encompasses a wide range of users, including pupils and students enrolled in civil protection courses, volunteers and citizens seeking to prepare for emergencies, as well as military personnel and medical professionals who aim to enhance their skills in simulated combat conditions. The use of such technologies in educational institutions, first aid courses and military training creates prerequisites for the formation of a more resilient society capable of adequately responding to the challenges of war and terrorist attacks.

Thus, an intelligent virtual reality system for providing first aid is not only an educational or technological product, but also a vital component of national security. It aims to prepare the general population for action in crises, reduce panic, and increase the chances of survival for victims. This article discusses the concept of creating such a system, its functionality and prospects for implementation in educational and medical practice.

2. Problem statement

Hostilities, massive attacks on civilian infrastructure, and an increase in the number of civilian casualties are exacerbating the issue of preparing the general public for the provision of first aid. Existing teaching methods (lectures, workshops on mannequins) have a number of limitations: they do not reproduce psychological pressure, complex combat wounds, chaotic conditions of destruction and the need to act in a short period of time. This leads to the fact that even individuals who have completed introductory courses are not always prepared to respond correctly during real crises. Thus, the problem arises of creating an innovative tool that would combine a realistic reproduction of emergency conditions, interactivity, gamification, and a system for evaluating actions. The development of an intelligent VR/AR system for first aid allows for solving this problem, providing a qualitatively new level of training for the population, medical workers, and the military in a safe, yet as realistic as possible environment. The main problems and needs of modern society in Ukraine:

- Insufficient effectiveness of existing educational approaches to prepare civilians and military personnel for actions in crisis conditions.
- Lack of tools that simultaneously simulate stressors, chaotic conditions and multi-scenario emergencies.
- The need to create an interactive system that would ensure:
  i. approximation to real combat conditions;
  ii. systemic training of skills (Triage, CPR, bleeding arrest).

The article aims to substantiate and develop the concept of an intelligent virtual and augmented reality system for teaching first aid in wartime and mitigating damage to civilian infrastructure. The system should provide simulations of realistic scenarios, foster the development of practical skills in crises, and enhance the readiness of both civilians and specialists for an effective response.

The main objectives of the study:

- To analyse modern approaches to first aid training and determine their limitations.
- To develop and describe the concept of a VR/AR simulator (system) of pre-medical care with the integration of intellectual functions, focused on war conditions and crises.
- Describe key learning scenarios and user interaction mechanics.

- Consider the system's functionality, including interactivity, gamification, evaluation of user actions, and the application of Triage principles.
- Demonstrate the role of generative AI models in creating 2D and 3D content for simulations of learning environments.
- Evaluate the potential impact of VR/AR solutions and the benefits of the proposed system on the training of doctors, military, volunteers, and civilians in emergencies.
- To identify and formulate prospects for the practical implementation of such systems in the field of education, medicine and military training.

3. Related works

Recent years have shown a significant increase in the number of works on the use of VR/AR to teach fundamental and advanced first aid skills. The issue of mass training in pre-medical care has become critical in connection with conflict and military events that lead to damage to civilian infrastructure and a large number of wounded. In response, there is a growing interest in VR/AR technologies as tools for large-scale, accessible, and realistic training of the population, volunteers, and medical staff [1]. Various studies highlight this need and form a framework for the application of VR/AR systems in urban scenarios after shelling. Studies [2-3] use RCT, quasi-experiments, and mixed approaches (control experiments, UX analysis, scenario simulations) to measure the effectiveness of VR/AR programs against traditional methods (lectures + mannequins). The results of two extensive reviews and meta-studies suggest that VR/AR often improves CPR/BLS and crisis decision-making skills compared to classical methods [2-3].

Several systematic reviews and RCTs have shown that VR/AR training can improve the quality of resuscitation skills (frequency and depth of compressions, correct sequence of actions) or, at least, is not inferior to standard training, and in some nuances exceeds it (better memorised procedure, greater motivation to repeat training). AR solutions integrated with mannequins provide an additional advantage – the combination of haptic/manikin and AR prompts improves accuracy and self-learning [3-4]. A review and meta-analysis of recent years has shown that VR/AR training for CPR/BLS generally produces effects commensurate with traditional face-to-face training in key parameters (depth and frequency of compressions, overall performance score), with subgroups combining AR with a physical dummy having additional advantages in the accuracy of practical skills [1, 5]. At the same time, the authors note the significant heterogeneity of studies and the need to standardise assessment protocols [1]. Military structures are actively integrating VR to train medical personnel and first-echelon medics. Commercial and project products (SimX, VALORE, etc.) have shown the possibility of large-scale deployment of VR modules for the training of combat medics with realistic scenarios (injuries, mass casualties, evacuation under fire). Public reports and cases confirm that VR allows you to work out complex algorithms in a safe environment with the ability to quickly repeat and collect telemetry for action analysis [6-8]. Studies on pre-medical training indicate the critical need for rapid formation of actions according to algorithms in the face of military defeats and mass incidents; for Ukraine, an additional factor is constant missile attacks on civilian infrastructure and "military-civilian" response scenarios. It should be identified as a key target and audience: pupils/students, citizens/volunteers, military personnel, and medics, with a focus on training first aid skills (tourniquet, bleeding control, CPR) in realistic combat and urban scenes following shelling.

Research in the field of serious games and gamification (especially for tactical rescuers and military medics) shows that the addition of game mechanics (missions, levels, rewards) increases motivation and frequency of repeated training. Adaptive scenarios that change in complexity depending on user outcomes contribute to the personalisation of learning and the better consolidation of skills [9-10]. Modern reviews of VR/AR in medicine mark the transition from static simulators to adaptive, intelligent environments with individualised complexity, telemetry collection, and real-time feedback. In our project, this is specified by the choice of Unreal Engine / Unity engines, target devices (Meta Quest, HTC Vive, HoloLens, mobile AR), as well as the integration of generative AI tools (Stable Diffusion, Leonardo.AI, Trellis3D) to speed up the creation of 2D/3D content and subsequent import into UE5/Unity. Such a stack is consistent with the trend for fast content iteration and scalability to different media.

Work on AR add-ons for physical mannequins (e.g., Holo-BLSD) demonstrates that adding visual AR feedback to the tactile feel of the dummy improves the perception and learning outcomes of students, especially non-professionals. Holo-BLSD has shown high acceptability and usability in pilot studies [5, 11]. At the same time, the absence or weak implementation of haptic feedback leaves limitations for the full development of skills that require force/position control.

The literature [1-11] emphasises the importance of scenario-oriented learning, gamification (missions, achievements, ratings), and formative assessment (step-by-step feedback, error capture, and action analytics) – these approaches increase engagement, speed up skill formation, and facilitate transfer to real practice. In such systems, they should be directly embedded in the functionality, including realistic scenarios of defeats, interaction with tools, automatic assessment, and game mechanics for motivation. The latest breakthrough is the use of generative models to quickly create 2D sketches and 3D objects (textures, meshes, characters) [8, 12-13]. New open models and tools (e.g., Tencent's Hunyuan3D and other image-to-3D/text-to-3D systems) make it possible to reduce the time from prototype to integration into the engine (Unity/UE). It is beneficial for projects that require many variable scenarios (different locations, types of injuries, clothing, and environments). At the same time, the quality of geometry, optimisation for VR, and issues related to licenses/ethics of generative content should be taken into account. Empirical studies of VR medicine demonstrate that transitioning to the context (visual-auditory stressors, time constraints, scene chaos) is crucial for the formation of "muscle memory" and making informed decisions under pressure. It is reflected in the terms of reference, which include building destroyed urban scenes, selecting libraries/assets, setting up collisions, implementing "smooth locomotion", creating a UI for a VR template, and working with Blueprints for interactive functionality (such as a grab system and VR pickup items).

Publications on VR education agree on the need for multi-stage testing, involving subject specialists and target users, as well as formal checks of compliance with medical protocols. In terms of work, this is implemented through alpha sessions with paramedics/military instructors, beta sessions with students/rescuers/volunteers, automated stability tests, and the requirement to certify content to pre-medical standards. Modern intelligent simulators rely on performance metrics (time, correctness of the sequence, and quality of manipulations) and dashboards of individual progress, which allow you to adapt the complexity and personalise the trajectory. The terms of reference should include the collection of errors, feedback, and performance assessment, as well as the requirements for personal data protection (GDPR) and cybersecurity of infrastructure. Literature on edtech/medtech emphasises phased implementation: MVPs → pilots → scaling with related business processes (marketing, partnerships, financial and risk management). The file presents the WBS, budget items (including equipment, licenses, and servers), marketing channels, and risk management, creating a "bridge" from a research prototype to a viable product for educational institutions and defence forces. The systematization of such studies corresponds to the key vector trends of the industry: (i) contextualized simulation for real combat scenarios; (ii) intellectual adaptation of learning and formative assessment; (iii) generative AI to accelerate content production; (iv) multi-stage testing and protocol certification; (v) legal/ethical framework (GDPR) and technical cybersecurity; (vi) project and business scaling circuit (WBS, budget, risks). It aligns with the current roadmap for VR/AR solutions in pre-medical training, specifically focusing on applications in war and hybrid civil-military environments.

The literature [1-13] reveals several significant limitations: the unevenness of the evidence base (various methods and metrics), the insufficiency of long-term studies on the transfer of skills to real events, the issues of haptics and proving the impact on clinical outcomes, as well as the issue of the cost and availability of systems for mass adoption. All these issues are crucial for projects focused on military scenarios and highlight the need for further RCTs, standardisation of metrics, and long-term observational studies. Main developments/products and their features:

- AR dummies / Holo-BLSD – studies showing the superiority of AR and dummies in BLS training [5].
- SimX / VALOR (DoD) – large-scale military projects focused on the integration of VR for mobile and divisional learning; emphasis on realistic combat scenarios and analytics [6].
- Scientific RCTs and scoping reviews have accumulated the evidence base for improving CPR/BLS, pointing to the positive role of VR/AR but emphasising the need for larger randomised trials and long-term measurements [2, 14].

Problems, limitations and open questions [15-24]:

- Transfer of training to real conditions - many studies show improvements in the training session, but to a lesser extent, it has been proven how this affects real events under stress.
- Standardisation of metrics – different jobs use incompatible metrics, making comparisons difficult.
- VR content optimisation – automatically generated 3D objects require optimisation (polygons, collisions, LOD) for smooth operation on VR headsets.
- Legal/ethical issues – licenses for AI content, protection of user data in training platforms, compliance with medical standards.
- Cost and technical accessibility – the cost of equipment and the need for technical support for mass implementation in schools/communities.

Table 1
Comparison of relevant systems/works

System / History	Type	Target audience	Strengths	Weaknesses/ limitations	Evidence base/comments
SimX [6]	Commercial VR platform (multiplayer, cloud)	Doctors, Medical Students, EMS, Military	Scalability, extensive script library, analytics, multi-user, integration with education	Cost, need for facilitator training, partially proprietary content	It is used in clinics and law enforcement agencies, with a strong industrial backup.
Holo-BLSD [5]	AR superstructure over a mannequin	Medical Professionals, Residents	AR and dummy → tactile and visual feedback; good usability in the pilot; Logging actions	Pilot small studies; hardware limitations (HoloLens) and visual quality	The pilot study demonstrates acceptability and feasibility (n≈26).
RCTs / Systematic Reviews [1]	Research works	Labour members, students, cadets	Demonstrate equivalent VR/AR performance compared to traditional training, emphasising the	Heterogeneity of methods; short observation periods; Lack of long-term data	Meta-analyses show that VR/AR is not inferior to face-to-face training; Subgroups with a dummy win.

			role of AR and the mannequin.		
Generative text→3D tools [8, 12]	Technology Tools (AI)	VR/AR Content Developers	Rapid prototyping, large volumes of variable content	The need for refinement, optimisation for VR, license/ethics issues	Technical studies 2024–2025 demonstrate the rapid evolution of the pipeline.
Our project	VR/AR Concept/Prototype with Generative AI Integration	Pupils, students, volunteers, military, and doctors	A combination of scenario realism, triage, gamification, and AI content generation; positive pilot results (P↑).	The need for large-scale testing, certification, and content optimisation for VR platforms	The results of the file showed an increase in the efficiency of P in the scenarios, which correlates with the approaches in the literature.

4. Research methods

Military and defence structures are actively implementing VR simulators for tactical medicine training – industry examples show scalable platforms focused on realistic combat scenarios and action analytics (SimX is a commercial platform for clinical and tactical simulations). Such solutions focus on the possibility of synchronous multi-person training, telemetry collection and adaptive complexity of scenarios [6-8]. These characteristics echo the functionality (multiscenario, triage, action analytics) [6-8]. Several papers have shown [5-11] that AR layers superimposed on a physical mannequin combine the advantages of tactile control and visual feedback. It is essential for skills that require a sense of strength/position (e.g., proper depth of compressions, pressing, tourniquet application). AR solutions for BLS/CPR often demonstrate better self-learning performance in non-medical populations [5, 11]. Modern approaches to medical simulation design include: (1) scenario-oriented learning, (2) gamification as a means of increasing motivation and repetition rate, (3) formative assessment with instant feedback [1]. These elements allow you to increase the retention of knowledge and the "transfer" of skills into practical actions; Many paid and research solutions integrate ratings, missions, and adaptive difficulty algorithms. The project also provides gamification, triage logic, and an integrated metric for evaluating actions [1]. The new generation of text-to-3D and image-to-3D models (for example, robots and tools such as Hunyuan3D, Trellis3D) significantly reduces the time required for creating visual assets. It allows you to quickly generate variable scenarios and characters, which is critical for scaling simulators with a large number of scenarios [8, 12-13]. However, automatic models often require post-processing (LOD, polygon optimisation, texture editing) to work stably in VR engines. It fits well with the practical remarks about pipeline art generation → 3D → integration into UE/Unity. In scientific papers, metrics are typically used, including the percentage of correctly performed steps (P), reaction time (τ), correctness of the sequence, and indicators of the quality of manipulations (for CPR – frequency and depth of compressions) [2-3]. Systematic reviews note positive dynamics in these indicators after VR/AR training, but the quality of evidence varies (different measurement methods, short observation periods, small samples in some studies).

The main areas of research include the analysis of literature and experience, the application of the scenario modelling method, the use of well-known tools for developing VR/AR solutions, and, accordingly, the implementation of development testing. The first stage of the study involves investigating existing VR/AR solutions in medicine and military training. Next, it is necessary to develop crisis VR/AR scenes (city streets after shelling, evacuation of the wounded, burns, and mass casualties) based on Unity/Unreal Engine, Blender/3ds Max tools, and AI generators (Stable Diffusion, Leonardo.Ai, Trellis3D, Meshy, Sloyd). Experimental testing will consist of conducting alpha and beta tests with doctors, students, and volunteers. Let us describe the primary research processes in more detail.

At the first stage, a systematic review of scientific papers and applied solutions in the field of VR/AR technologies for medical and military training was conducted. To compare the effectiveness of traditional and innovative approaches, the integral coefficient was used:

$$E=\frac{\sum_{i=1}^{n} w_i \cdot p_i}{\sum_{i=1}^{n} w_i}, \tag{1}$$

where p_i – is the indicator of the effectiveness of the i method (level of assimilation, learning speed, psychological readiness), w_i – is the weighting factor of importance, E – is the integral assessment of effectiveness.

The development of the VR/AR simulator was carried out through scenario modelling of crises, including injuries, explosions, burns, and mass casualties. A set of states describes each simulation:

$$S=\{s_1, s_2, \ldots, s_m\}, s_j \in \{\text{stable, critical, lethal}\}, \tag{2}$$

where s_j – is the condition of the victim according to the Triage protocol. The transition between states depends on the user's actions and reaction time

$$s_{t+1}=f(s_t, a_t, \tau), \tag{3}$$

where a_t – is the user's action (applying a tourniquet, performing CPR, etc.), τ is the reaction time. To assess the correctness of the implementation of the algorithms of first aid, an integral metric is proposed:

$$Q=\alpha \cdot C+\beta \cdot T+\gamma \cdot R, \tag{4}$$

where C – correctness of actions (binary score 0/1), T – speed of execution (normalised relative to the optimal time), R – sequence of protocol adherence, α, β, γ – weighting factors determined by experts. Generative artificial intelligence models (Stable Diffusion, Trellis3D, Meshy, Sloyd) were used to create the learning environment. The generation process is described as minimising the loss function:

$$L=E_{x \sim p_{data}}[|G(z)-x|^2], \tag{5}$$

where x – is the target image or 3D model, $G(z)$ – is the result of generation based on the text prompt z, .p_{data} – is the distribution of real data. The system underwent alpha testing (with the participation of paramedics and military instructors) and beta testing (with the involvement of students and volunteers). The success rate was evaluated based on the results:

$$P=\frac{N_{correct}}{N_{total}} \cdot 100\%, \tag{6}$$

where $N_{correct}$ – is the number of correctly performed actions, N_{total} – is the total number of necessary steps in the scenario. Thus, the methods used combine quantitative assessment of effectiveness, simulation modelling of crisis scenarios, and a generative approach to creating visual content, which provides a comprehensive study and confirmation of the performance of the VR/AR system in pre-medical care. A detailed analysis of modern approaches to first aid training and their limitations has been carried out.

Table 2
A short list of modern approaches

Name	Advantages	Restriction
Traditional face-to-face lectures and workshops on mannequins	– Simplicity of organisation; basic motor skills (tourniquet, compression) are practised. – The presence of tactile/haptic feedback (dummy).	– Low realism of the context: do not reproduce chaos, sounds, limited visibility and emotional stress characteristic of war scenarios. – Limited variability of scenarios: it is difficult and expensive to simulate many different types of injuries and large-scale incidents. – Dependence on infrastructure and instructors, in wartime, access to training centres/instructors may be limited. – Scaling problems: it isn't easy to train large masses of the population quickly and simultaneously. (The restriction is mentioned in the file as a motivation for VR/AR).
High-fidelity simulation centres with actors and complex stands	– High realism, complex scenarios, role-playing games with actors. – Suitable for professional training (doctors, military).	– High cost of equipment and maintenance. – The need for special sites – restrictions on accessibility during mass attacks or evacuations. – Limited scalability – suitable for a narrow circle of specialists, but not for mass civilian exercises.
E-learning / online courses (videos, interactive modules)	– Easily scalable, available with remote learning. – Possibility of theoretical training at any time.	– Lack of practical, tactile experience – it is challenging to teach motor skills only through video. – Low motivation for repetitions without interactive elements. – They do not reproduce the stressful context of combat conditions.
Serious games and simulators on PC/mobile devices	– Engagement through game mechanics; increase motivation. – Good for learning algorithms, decision-making, and theory.	– Limited motor skills (hand manipulation, pressure force, etc.). – The issue of portability – gamified execution does not always translate into correct physical actions.
VR simulations (whole virtual reality)	– High degree of immersion: visual and audio stressors, limited visibility, timers – bring	– Lack of haptic/tactile feedback: applying a tourniquet, the correct compression force is brutal to feel without a dummy or special equipment.

	the conditions of war closer. – The possibility of multiple repetition and variability of scenarios at low risk. – The ability to integrate analytics and formative feedback (metrics Q, P, etc.). These approaches were key in project, which showed an increase in P.	– Technical requirements (headset, powerful PC) and dependence on power supply/Internet, which can be critical during attacks. – Funds (purchasing headsets for mass training can be expensive). – Cybersecurity and data protection: Telemetry collection requires compliance with policies (GDPR, etc.).
AR systems, in particular AR add-ons over mannequins (a hybrid of tactile and visual feedback).	– Combines the tactile experience of the dummy with visual AR information (hints, internal anatomy, Triage directions). – Allows you to practice motor skills more accurately and add context at the same time.	The need to synchronise equipment (dummy and AR device). – Limited mobility – the dummy is difficult to deploy centrally in large numbers. – The price of AR headsets (e.g., HoloLens) and the complexity of integration. (The effectiveness of AR and the dummy is confirmed in the literature and mentioned in the file as a promising direction.)
Tactical/military training (tactical combat casualty care, training for combat medics)	Focused on the realities of hostilities: evacuation under fire, mass casualties, Triage priorities. – It is used to train doctors and army personnel.	– The need for special scenarios and coaches with experience. – Moral and psychological costs when working out extreme scenarios with actors (stress of participants). – The difficulty of scaling up to the civilian population without adaptation.

Special restrictions in the context of the war:

- Infrastructure vulnerability – access to electricity, internet, and training facilities may be interrupted; solutions must have offline modes or mobile options (e.g., AR on a smartphone).
- The need for mass scale – to train large groups quickly and simultaneously; Traditional methods and high-fidelity centres are not suitable.
- Psychological stress – training sessions should simulate emotional stress, but not traumatise; adaptive difficulty levels are required.
- Personnel and financial constraints – shortage of instructors and money during hostilities.
- Ethical and legal issues – quality and certification of educational content, protection of participants' data.

The blended learning approach combines online theory and VR scenarios with offline practice on mannequins (or AR and mannequin). It reduces the need for physical infrastructure and preserves the tactile experience. Mobile AR solutions consist of developing lightweight AR versions for smartphones that can be run offline and that will give basic visual instructions (important in restricted areas). The integration of gamification and adaptability aims to increase motivation and gradually increase the stress load according to the user's level. AR and Key Skills Haptics allows you to invest in developing budget-friendly haptic solutions or supporting mannequins with AR add-ons for the most critical practical exercises. Content pipeline optimisation enables the use of generative AI (text → 3D) for rapid scripting, accompanied by a post-processing and LOD optimisation step for VR applications. It partially addresses the problem of scenario variability at moderate costs. Standardisation of assessment is based on the introduction of unified metrics (P, Q, τ) to compare the effectiveness of different approaches and qualitative improvements (to assess success). Pilot programs and multi-stage testing are initially conducted with experts → subsequently with target groups → scaled; concurrently, work on certifying content in accordance with the guidelines (Ministry of Health, Red Cross).

Modern approaches have strengths, including tactility (mannequins), realism (simulation centres), scalability (e-learning), and immersion (VR/AR). However, no approach alone satisfies the entire set of requirements that arise in wartime: scale, accessibility, realism of stress, tactile feedback, and infrastructure endurance. The best strategy is a combined approach:

$$VR/AR\left(for\ context \wedge decision-making\ training\right)$$
$$+mannequin/haptics\left(for\ motor\ skills\right)$$
$$+mobile\ solutions\left(for\ accessibility\right)+generative\ AI\left(f \vee rapid\ scenario\ building\right).$$

It corresponds to both the project concept and the data obtained in testing (an increase in P in the VR/AR group). Practical training in pre-medical care during wartime requires an integrated approach that considers not only the development of basic skills but also psychological stress, logistics, and the availability of technology. Today, there are several primary methods: traditional training on mannequins, simulation centres, e-learning, serious games, VR/AR systems, and their combinations. Traditional training provides the development of motor skills, but is limited in the variability of scenarios and does not replicate the real context of stressful conditions. Simulation centres featuring actors and high-fidelity equipment enable you to achieve a high level of realism, but they remain expensive and limited in scale. Online courses and mobile applications have advantages in accessibility, but do not provide practical skills. Serious games show potential in learning algorithms and increasing motivation, but their impact on motor development remains limited. VR simulations enable you to recreate complex combat scenarios, create immersive conditions, and generate an emotional load, which is crucial for adapting to real-world events. Meta-analyses indicate that VR/AR training often surpasses the effectiveness of traditional methods in developing basic life support skills. At the same time, VR does not provide proper tactile feedback, which reduces the quality of practising critical actions such as chest compressions or tourniquet applications. AR systems, in particular those that superimpose additional layers of information on physical mannequins, partially solve this problem. In wartime, the limitations of these approaches are intensifying: power and internet outages, a shortage of instructors, high stress, and the need for rapid mass training of the civilian population. As the results of experimental studies demonstrate, the hybrid model (utilising VR for immersion and scenarios, as well as AR/dummy for practical skills) is optimal for scalable and effective training. Thus, no single approach is sufficient to solve the entire range of training tasks in wartime. The most promising direction is the integration of VR, AR, and physical mannequins into a single system with elements of gamification and generative content, enabling the quick creation of scenarios. Checklist of technical requirements for the implementation of a hybrid program (VR, AR and mannequin):

1. VR infrastructure:
    a. Headsets (Meta Quest 2/3 or similar) with offline mode.
    b. Scenarios with generative 3D content (Meshy, Sloyd, Hunyuan3D).
    c. Offline mode of operation for conditions of power/network outages.
2. AR components:
    a. AR glasses or a smartphone with ARKit/ARCore.
    b. Interactive prompts (colour triage, annotations on the mannequin).

    c. Synchronisation with the dummy (BLE/pressure sensors).
3. Mannequins:
    a. CPR dummy with compression depth sensors.
    b. Arm/limb dummy for applying a tourniquet.
    c. Ability to integrate with an AR module.
4. Software:
    a. Modular architecture (VR scenes, AR layers, and analytics).
    b. Telemetry collection system (metrics P, Q, τ).
    c. Adaptive difficulty level and gamification.
5. Infrastructure and Security:
    a. Secure data storage, GDPR compliance.
    b. Possibility of local server deployment.

Scaling for schools, hospitals, and mobile trainings.

Table 3
The "threshold of influence" of technologies in pre-medical care education

Technology	Strengths	Main problems/limitations	Type of tasks where the most effective
Lectures and mannequins	Tactile skills, simplicity	Low realism, few scenarios	Basic motor skills
Simulation centers	Realism, role-playing games	High cost, low scalability	Professional medical training
E-learning / mobile courses	Scalability, availability	Lack of practice, low motivation	Theoretical training
Serious games	Motivation, working out algorithms	Limited transference to physical skills	Algorithmic solutions
VR	Realistic scenarios, stress modelling	Lack of haptics, technical requirements	Solutions under stress
AR and mannequin	Tactility and visual support	Cost, complexity of integration	Motor training
Hybrid (VR/AR, mannequin)	Comprehensiveness, adaptability, scalability	Need for coordination of equipment and funds	Mass training in the realities of war

Figure 1 clearly illustrates the strengths and weaknesses of each E-learning technology (high scalability, low realism), simulation centres (maximum realism, but minimal scalability), and the VR/AR and mannequin hybrid (optimal balance of both characteristics). Modern challenges related to the war and massive attacks on civilian infrastructure necessitate rapid and scalable training in pre-medical care among civilians and paramedics. Traditional approaches (dummies, simulation centres) are limited by accessibility, scalability, and the ability to recreate a realistic combat environment. Therefore, there is a need to create an integrated VR/AR simulator that combines immersion in a stressful environment with practical practice of critical skills.

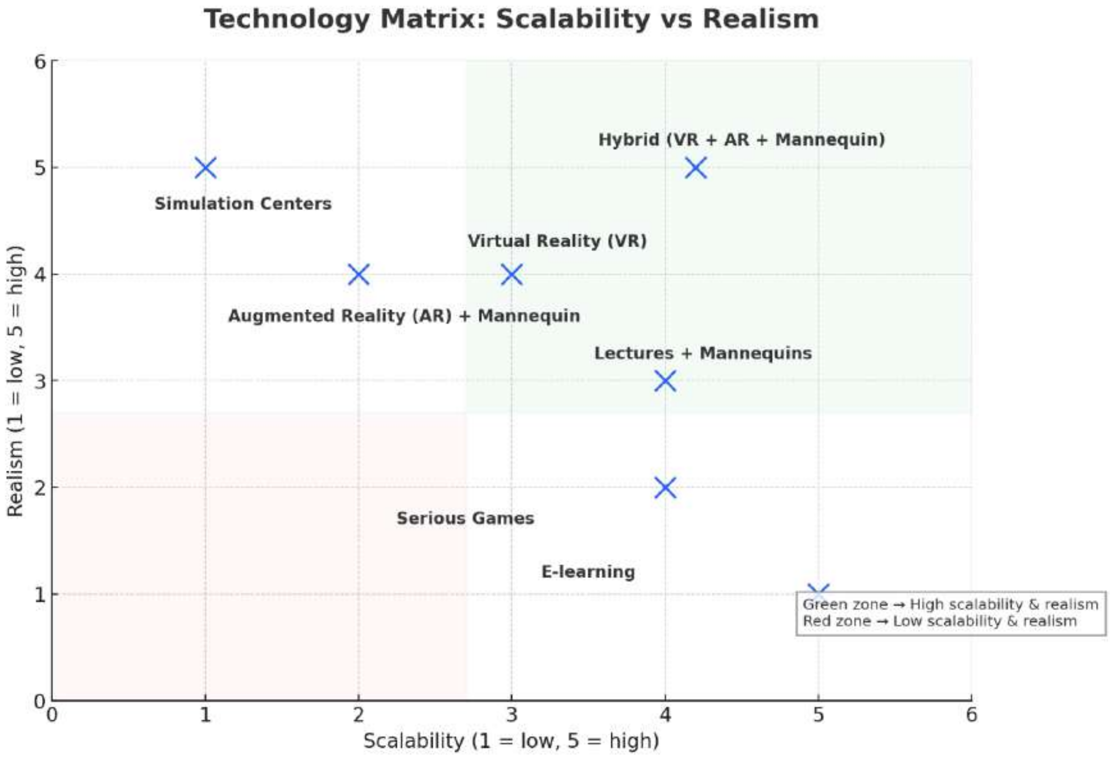

Figure 1: Infographics in the form of a matrix "Scalability vs Realism"

The main components of the concept:

1. Virtual reality (VR) for immersion in context:
   a. Reproduction of realistic war scenarios: a street after a missile strike, shelling of residential areas, mass destruction.
   b. An emotionally and stressful environment (sounds of explosions, smoke, and chaos), which fosters psychological stability and brings training closer to real-world conditions.
   c. A triage system (green, yellow, red) that requires the user to make decisions in a short amount of time.
   d. Generative AI content for the variability of scenarios (different types of injuries, number of victims, civilian/military injuries).
2. Augmented reality (AR) for practical skills:
   a. Use of AR add-ons on physical mannequins: the user sees visual cues (the placement of the tourniquet, indicators of vital functions, and anatomical landmarks).
   b. AR mode on a smartphone or headset (such as HoloLens or Meta Quest Pro) allows you to train in mobile conditions, even without a full-fledged VR room.
   c. Support for a "hybrid dummy": a CPR dummy for practising compressions and a limb for applying a tourniquet with AR visualisation of bleeding.
3. Intelligent Assessment and Analytics System**:**
   a. Automatically recorded metrics of success (P), quality of execution (Q) and reaction time (τ).
   b. Adaptive Difficulty Level: The system increases the intensity of the scenarios as the user's results improve.
   c. Real-time feedback (choosing the wrong algorithm, reacting too slowly, or an error in applying the tourniquet).
4. Mobility and scalability:

a. Support for both stationary VR centres (for group training) and mobile AR versions (for smartphones and tablets).
b. Offline mode of operation for areas with Internet and power outages.
c. Possibility of use in schools, universities, medical institutions, as well as in military units.

5. Gamification and Scenario Learning:
   a. A point system that motivates you to re-pass.
   b. Branched scenarios: incorrect actions lead to a complication of the situation (deterioration of the condition of the wounded).
   c. Multiplayer mode (teamwork of paramedics, evacuation, and distribution of roles).

Expected advantages of the concept:

- Realistic simulation of combat conditions is not available in traditional methods.
- Scalability and accessibility: from VR rooms to mobile AR solutions.
- Combination of motor skills and cognitive skills: VR for algorithms, AR and dummy for tactile actions.
- Improving learning effectiveness, in particular, the study's results indicate an increase in the P success rate by ≈30% approximately when using VR/AR compared to traditional learning.

Thus, the concept of a VR/AR simulator of first aid is a hybrid learning ecosystem that allows you to quickly, efficiently, and massively teach civilians and the military basic life-saving skills in extreme conditions of war and emergencies.

5. Experiments

5.1. Canvas of the business model according to O. Osterwalder

The developed business model is based on the concept outlined by O. Osterwalder, which allows for a comprehensive reflection of the logic behind creating, promoting, and consuming the value of an innovative VR/AR product for pre-medical care training. The target audience of the project includes three main groups of users: representatives of the educational environment, civil society and professional services. The first group includes high school students, medical university and college students, and teachers who seek to introduce interactive technologies into the learning process. The second group is represented by citizens who want to master first aid skills and volunteers working in risk areas. The third group comprises military personnel, medical personnel, and tactical medicine instructors who aim to refine their practical skills in emergency situations.

The value proposition of the product is to create a safe, accessible and realistic environment for training actions in critical situations. The use of virtual and augmented reality technologies provides the ability to simulate scenarios of wounds, bleeding, burns, explosions and heart attacks with the reproduction of psychological reactions of victims. In the VR environment, the user interacts directly with the training objects, whereas the AR version allows training with lifelike mannequins or people, superimposing virtual injuries on physical objects. Gamification elements, such as difficulty levels, achievements, and competitive modes, help increase motivation, while the automatic assessment and feedback system provides real-time error correction.

The key factor in the successful functioning of the business model is an effective system of communication with potential users. A combination of online and offline channels is provided: the official website and marketplaces (Steam, Oculus Store, Google Play, Apple App Store) provide product distribution and the ability to purchase or subscribe; cooperation with educational institutions, military academies, the Ministry of Health, the Red Cross and public organizations contributes to the integration of the VR/AR simulator into academic programs. The active use of social networks and specialised media platforms (YouTube, TikTok, Instagram, LinkedIn) allows you to expand your audience reach. At the same time, demonstrations at medical forums and thematic exhibitions help build trust among professional users.

Interaction with clients involves several levels of engagement, including individual training at your own pace, group classes for educational and military institutions, as well as corporate solutions for medical centres. User support is implemented through a chatbot, an FAQ system, a forum, and a specialised Discord server. To increase engagement, various motivation mechanisms are being implemented, including ratings, achievements, thematic challenges, and loyalty programs. Additionally, users can provide feedback and suggestions for improving simulations, participate in beta testing, and access new scenarios through a subscription system.

The financial model encompasses a combination of several revenue streams, including the sale of a licensed version of the product, a monthly or annual subscription model, corporate licenses for educational and medical institutions, as well as grant and state funding within the context of medical education development programs. Additional sources of income can be affiliate programs with medical device manufacturers and branded training courses.

Human, technical, informational and financial resources are needed to implement the project. The team consists of developers of VR/AR environments, 3D designers, medical consultants, game designers, UX/UI designers, and marketing specialists. The technical base includes Unity or Unreal Engine 5 platforms, 3D modelling programs (Blender, 3ds Max, ZBrush), VR/AR equipment, as well as cloud services such as AWS, Google Cloud, or Azure for data storage. Information resources are developed based on official protocols for pre-medical care, the practical experience of doctors, and the results of scientific research on the effectiveness of VR/AR technologies in education.

Key activities include creating a minimum viable product (MVP), conducting market research, identifying user needs, testing prototypes, obtaining certification according to educational and medical standards, marketing, and scaling the product. At the testing stage, it is planned to involve medical specialists, military personnel and volunteers to assess the quality of simulations and provide professional feedback. The project's partner ecosystem includes medical organizations (Ministry of Health, Red Cross), educational institutions (medical universities, colleges, military lyceums), military and rescue services (Ministry of Defense, State Emergency Service), as well as technology partners – developers of VR/AR equipment and platforms (Meta, HTC, Valve, Unity, Unreal Engine) and companies specializing in generating 3D content using artificial intelligence.

The cost structure encompasses the expenses associated with developing training scenarios and medical expertise, remuneration for the development team, purchasing software licenses and VR/AR equipment, providing server infrastructure, marketing, administrative costs, and certification. A vital budget item is also the promotion of the product through participation in exhibitions, the creation of advertising materials and collaborations with medical and technology bloggers. Thus, the presented business model demonstrates an integrated approach to creating an educational VR/AR product that combines technological innovation, pedagogical efficiency, and social significance. Its implementation will contribute to increasing the level of training for the population, doctors, and military personnel in emergencies, as well as the development of the domestic segment of XR technology use in the field of medical education.

5.2. Structure/stages of implementation of the MVP VR/AR-simulator of first aid

The development of a minimum viable product (MVP) for a VR/AR simulator of pre-medical care involves a comprehensive, phased implementation that encompasses research, design, technical development, testing, marketing, scaling, and project management. This sequence corresponds to the classic Work Breakdown Structure (WBS) structure and is designed to ensure controllability, efficiency, and high quality of the final result.

At the initial stage, which includes research and planning, an in-depth analysis of the VR/AR education market is carried out. Particular attention is paid to the study of modern trends in simulation training, the analysis of competitive solutions, their strengths and weaknesses, as well as the assessment of potential demand among educational and military institutions. The barriers to the introduction of VR/AR technologies into educational processes, the pace of their adoption, and their effectiveness in training pre-medical care specialists are investigated. At the same time, an analysis of the target audience's needs is conducted, involving interviews with paramedics, instructors, military medics, and emergency services specialists. Based on the data obtained, a list of critical skills and scenarios that need to be implemented in a VR/AR environment is formed, including bleeding control, cardiopulmonary resuscitation, and evacuation of victims.

Next, the terms of reference of the product are determined. The optimal technology stack is chosen, including Unity or Unreal Engine platforms, as well as target devices – Meta Quest, HTC Vive, HoloLens and mobile devices with AR support. An assessment of the budget and the need for specialists of various profiles (developers, 3D designers, UX/UI specialists, medical consultants, testers) is carried out, as well as possible sources of funding are analysed, including grants, investments, and crowdfunding campaigns. The result of the stage is a prepared package of documentation, including a technical description, implementation schedule, risk management plan, and presentation materials for partners and investors.

The second stage involves the direct development of an MVP. At this stage, realistic three-dimensional models of the environment are created, particularly of urban locations after extraordinary events – such as explosions or shelling – with a detailed reproduction of objects, including first aid kits, stretchers, medical equipment, and transportation and equipment. Characters are developed, including paramedics and those with various types of injuries, reflecting a wide range of real-world scenarios. Particular attention is paid to VR/AR interaction, where motion control systems are configured through controllers or gloves. The mechanics of viewing the victim, interaction with objects, and tactile feedback are implemented through the vibration of controllers.

The software component includes the creation of scenarios of varying complexity – ranging from mild to critical conditions - as well as the logic for assessing the correctness of the user's actions in accordance with first aid protocols. There is a virtual instructor with voice prompts, the ability to repeat workouts and view mistakes. In the visual and auditory aspects, a dynamic sound environment (heartbeats, screams, explosions, ambient noise), the effects of destruction, smoke, blood and facial expressions of the characters are realised. At the end of the stage, the simulator is optimised for various devices – including VR headsets, mobile devices, and PCs – to ensure a balance between rendering quality and performance.

The third stage focuses on testing and improving the system. First, the team conducts internal functional testing to identify technical errors and verify the performance of the mechanics. After that, alpha testing takes place with the involvement of specialists, including paramedics, military instructors, and representatives of emergency services. Their feedback enables you to assess the level of realism in the simulation, the logic of the educational process, and potential shortcomings. Next, beta testing is organised among students, volunteers, and rescuers, which allows you to evaluate the intuitiveness of the interface, the effectiveness of the training, and the level of user immersion. To increase stability, automated tests and unit testing of critical algorithms are being implemented. Based on the results, bugs are eliminated, object physics, animations, graphics and interface are improved.

The fourth stage concerns marketing and promotion. The launch of the official website and social network pages allows you to present the product, post educational content, video reviews, and publications about VR/AR training. Targeted advertising and SEO optimisation help to expand audience reach. An important area is cooperation with educational institutions, military academies, and medical organisations, which are provided with test access and preferential conditions. Demonstrating the product at exhibitions, conferences, and forums helps establish contacts with potential partners, while collaborations with medical bloggers and experts build trust among the general public.

The fifth stage involves scaling and developing partnerships. The product is integrated into the educational programs of universities and colleges, and specialised training courses and methodological materials are created for teachers. It is planned to introduce online training with certification and a system for testing results. Further expansion of the functionality includes the addition of new scenarios, such as traffic accidents, fires, natural disasters, and terrorist acts. To increase international competitiveness, product localisation, content translation into multiple languages, and adaptation of cultural characteristics in training are carried out.

The final stage – project management – involves the systematic control of task implementation, legal support, financial monitoring, and personnel management. Agile management methodologies (Agile, Scrum, Waterfall) are used to increase the effectiveness of teamwork. Reports, analytical reviews and strategic meetings are held regularly. Registration of intellectual property, compliance with international safety standards and medical certification are ensured. Much attention is paid to team building – creating an organisational structure, establishing effective communication, implementing a motivational system, and providing professional training. Financial management encompasses budget control, cost analysis, and cost adjustments in response to project changes. In addition, risk management is carried out, ranging from technical to legal aspects, with the development of response plans and mechanisms for minimising risks. Thus, the presented structure of the WBS provides a systematic approach to implementing the MVP VR/AR simulator for pre-medical care, combining technical, educational, medical, and organisational components. This model enables us to gradually develop a high-quality, scientifically based product with a high potential for implementation in the field of first aid training, both in Ukraine and internationally.

5.3. Concept and structure of the project

The primary objective of the project is to develop an interactive educational environment that fosters the acquisition of practical skills in pre-medical care during emergencies, particularly in conflict situations. The project aims to teach users how to respond quickly, accurately, and consistently in critical situations where the preservation of life depends on the accuracy of their actions. One of the key tasks is to develop a system that combines virtual (VR) and augmented reality (AR) technologies with gamification approaches to learning. This format enables you to enhance user engagement, create a safe yet psychologically realistic training environment, and ensure the effective assimilation of knowledge through practice. In the context of modern challenges caused by the war, digital modelling of situations involving assistance to victims is becoming a tool not only for education but also for preparing the population for real crisis conditions. The project is designed for a broad audience of users, encompassing educational, civil, and professional fields. For pupils and students, the VR/AR simulator can be used during medical training or life safety classes, creating an opportunity to consolidate theoretical knowledge through simulation experience. Citizens and volunteers get the chance to train in first aid on their own, working out the algorithms of actions in situations of mass destruction or natural disasters. For military personnel and medical specialists, the project acts as a platform for realistic simulations of combat injuries, actions in stressful conditions, and teamwork coordination. Thus, the product serves both educational and social functions, contributing to an increase in the level of public preparedness for actions in extraordinary circumstances.

The software product implements complex functionality aimed at replicating the full cycle of first aid training, from familiarisation with the theoretical foundations to the assessment of the user's practical actions. The basic components of the system include simulation of critical situations (injuries, explosions, collapses, and missile strikes), interactive training scenarios, and a module for assessing the effectiveness of actions. In a VR environment, users can perform typical procedures, such as applying a tourniquet, stopping bleeding, performing cardiopulmonary resuscitation, dressing wounds, and transporting victims. VR/AR technologies enable realistic interaction with medical instruments and training mannequins, and also allow for capturing every user action. The system automatically analyses the correctness and sequence of actions, response time, and also provides individual feedback. Gamification mechanics – difficulty levels, missions, rewards, ratings – increase motivation to learn and contribute to the consolidation of skills.

The visual style of the VR/AR environment is determined depending on the learning goals and technical limitations of the platform. In creating the most realistic scenario, highly detailed graphics with physically correct lighting and textures are used, which enhances the user's emotional engagement and the reliability of the simulations. For mobile devices and educational institutions with limited technical resources, it is advisable to use stylised graphics, such as Low Poly or Stylised, which provide an optimal balance between performance and visual quality.

The technical architecture of the project is based on the use of modern game engines, such as Unity or Unreal Engine 5, which provide full support for VR/AR technologies. The software part is optimised for VR headsets (Meta Quest, HTC Vive, Valve Index) and mobile devices with AR support. Modelling of three-dimensional objects is carried out in Blender and 3ds Max environments, and artificial intelligence tools are utilised to generate additional models and textures, including Stable Diffusion, Leonardo.Ai, and Trellis3D. This approach enables you to reduce content development time, provide a variety of visual elements, and increase the photorealism of educational scenes. The main simulation scene recreates the urban environment after a missile strike or explosion (Fig. 2). The location is located in typical Ukrainian urban conditions (for example, on Lviv Street), where the player sees destroyed buildings, damaged cars, smoke, fires, and debris. In such realistic circumstances, the user assumes the role of a paramedic who must assess the situation quickly, prioritise assistance, and save the victims. The scene includes three levels of severity of the victims according to the Triage system: critical, moderate and mild. For example, an unconscious child needs cardiopulmonary resuscitation, his mother has severe bleeding from his arm, and another victim has burns to the upper body. The player must consistently perform actions guided by the algorithms of first aid. In VR mode, interaction occurs in the first person: the user sees themselves in a paramedic's uniform, has the opportunity to open a medical backpack, use tourniquets, bandages, scissors, and dressings. The hint system helps to navigate the correct sequence of actions, and the time limit creates the effect of realistic stress. In AR mode, the user can perform the same actions on physical mannequins or training partners, with a virtual reconstruction of wounds and injuries superimposed on top. To enhance the educational value, the project features a system of scenarios and training modules, comprising a theoretical component, practical development, and final testing. Additionally, there is a multiplayer mode that allows you to train team interaction.

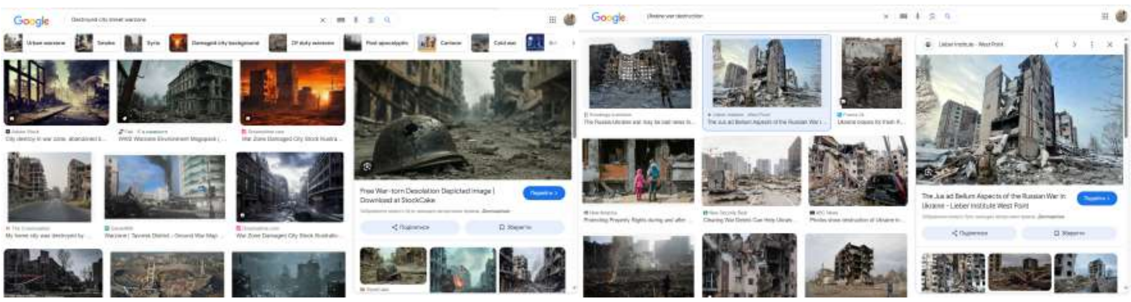

Figure 2: Search for the concept of the project.

The audiovisual component plays a crucial role in creating the illusion of presence. The realistic sounds of explosions, sirens, footsteps and screams of victims are complemented by voice prompts that simulate communication with an ambulance dispatcher. The user interface (UX/UI) is built on the principles of intuitive interaction: the main menu allows you to choose a scenario, difficulty level, and view educational materials. During the simulation process, AR prompts provide contextual instructions, such as: "Place the tourniquet above the wound." Artificial intelligence (AI) within the system is used to dynamically generate scenarios, adapt complexity to the user's level, and simulate the behaviour of victims who may change their state, lose consciousness, or exhibit signs of panic. It makes each workout unique and increases the realism of the learning experience. Thus, the proposed VR/AR project constitutes an innovative educational platform that combines technological, psychological, and pedagogical aspects of preparing the population for the provision of pre-medical care in war and emergencies.

5.4. Using Artificial Intelligence to Visualise Ideas and Concepts

Artificial intelligence (AI. *Artificial Intelligence (AI)* plays a key role in modern approaches to visual content creation. Thanks to machine learning algorithms and deep neural networks, the process of developing concept art, 3D modelling, and artistic visualisation is greatly simplified. AI systems can generate illustrations, stylised images, and even full-fledged three-dimensional models based solely on text descriptions (known as *prompt-based generation*). The main uses of AI for visualisation include:

- Generation of 2D images by text prompts – DALL·services E, MidJourney, Stable Diffusion, and Leonardo.Ai allow you to create artistic images of any style.
- Converting sketches into detailed illustrations (Deep Dream Generator, Artbreeder).
- Create 3D models based on 2D images or text descriptions (Trellis3D, Meshy, Sloyd, Hunyuan3D).
- Automatic texturing and rendering (NVIDIA GANverse3D, AI Render).

Thus, the application of AI enables artists, designers, and developers to significantly reduce the time it takes to create visual concepts and improve the quality of results by iteratively improving the generated images.

Generative AI is a subfield of AI that focuses on creating new content, including images, texts, music, and videos. Generative models not only analyse data but also reproduce new, unique artefacts, imitating the style or structure of the original dataset. Generative AI's typical use cases are for images (DALL· E, MidJourney, Stable Diffusion), music (OpenAI Jukebox, AIVA, Soundraw_, texts (GPT (ChatGPT), Bard, Claude) and video (Runway Gen-2, Pika Labs).

- Diffusion Models – used in Stable Diffusion and DALL· E 3. The principle of operation is to gradually "cleanse" the noise image until a clear structure is obtained. They are characterised by high detail and controllability of the process.
- Generative adversarial neural networks (GANs) are implemented in StyleGAN and NVIDIA GauGAN. One network (the generator) creates content, while the other (the discriminator) evaluates its quality, ensuring a gradual improvement in the result.
- Transformers are architectures that use the attention mechanism to process sequences of data. In DALL·E models E3, Imagen, and Parti Transformers analyse text descriptions, converting them into vector representations that control the generation process.

Table 4
Generative Artificial Intelligence Models

Algorithm	Short description	Examples of AI services	Advantages	Disadvantages
Diffusion Models	Gradual "cleaning" of noise to a clear image	*Stable Diffusion*, *DALL· E 3*	High detail, stability, and controllability	High computing costs

GAN (Generative Adversarial Networks)	Two neural networks compete with each other (the generator and discriminator)	*StyleGAN, GauGAN*	Realistic textures, artistic expressiveness	Less controlled process, unstable learning
Transformers	Encoding text into a vector space to control generation	*DALL· E 3, Imagen, Parti*	High quality, precise semantics control	Require large amounts of data and resources

A prompt is a text description or instruction that the user enters into a generative model to achieve the desired result. In the context of image generation, the prompt determines the style, colour palette, level of detail, and other characteristics of future graphics. The quality of the final result directly depends on the accuracy and detail of the product. For example, wording that is too general leads to fuzzy or random results. As an illustration:

- Ineffective prom: "The city after the war" is too general a description, lacking specific details of the scene.
- Effective prompt: "The city was destroyed after a missile attack, cars were burning, and smoke was everywhere. A paramedic in a red uniform helps the wounded. Realistic style, cinematic lighting, high detail" – the project includes key elements of the scene, characters and artistic style.

Generative models analyse the prompt, encode it into a vector space, and use it as a guide for building visual content. For automated or simplified creation of projects, specialised generative models and algorithms are used:

- GPT (Generative Pre-trained Transformer) is a text-based AI model that helps generate complex and detailed images, videos, or music.
- The Stable Diffusion Prompt Guide is a set of recommendations and tags that allow you to improve the results for generative models.
- The MidJourney Prompt Generator is an algorithm adapted for creating structured prompts optimised for generating stylised images in MidJourney.

Benchmarking tools for generating outputs demonstrate different approaches to the convenience, flexibility, and accuracy of results.

Table 5
Tools and algorithms for creating projects

Tool	Features	Advantages	Disadvantages
Promptomania	Visual Motion Builder for AI	Intuitive interface, support for different models	Limited functionality for complex queries
ChatGPT	Automatic formation of detailed products	Flexibility, adaptation to different models	Sometimes generates too generic prompts
PromptHero	Catalogue of popular promotions	An extensive database of examples, filtering	Some premium promotions are paid

To create *low-poly* scenes focused on stylised game levels, the prom must accurately reflect the composition, key elements, and art style. Conceptually, the prom is designed to provide simplified geometry, a bright palette, and stylised lighting. Example of prompts for a low-poly scene:

- «Low-poly city street after a missile strike, with destroyed buildings, rubble, smoke, and damaged vehicles. A paramedic in a red uniform is helping injured civilians. Simplified polygonal style, bright colours, clean edges, stylised lighting.»
- «Low-poly warzone city, broken roads, ruined buildings, burning vehicles, first responders aiding wounded people. Stylised 3D environment, cinematic lighting, dramatic atmosphere.»

Characters:

- «A male and female paramedic standing side by side in bright red uniforms with reflective stripes, wearing blue latex gloves. Each carries a medical bag with emergency supplies. They are scanning the area, ready to assist. Stylised low-poly aesthetic, cinematic lighting, sharp edges, and vibrant contrast.»
- «A wounded mother standing with a bleeding arm, holding her 7-year-old daughter. The scene depicts a post-apocalyptic warzone with smoke, rubble, and emergency responders in the distance. Stylised low-poly aesthetic, dramatic lighting, strong emotional tension.»

Thus, the products enable you to provide accurate, artistic, and technical specifications of low-poly scenes for VR/AR simulations. For the practical implementation of 2D and 3D concepts, various generative tools are used, differing in the level of control, detail and functionality. The primary free services include:

Table 6
Comparison of Popular AI Image Generation Tools

Tool	Features	Advantages	Disadvantages	Free Plan
Leonardo.Ai	Generate high-quality images with style customisation	High detail, supports low-poly style	Limited number of generations	10 generations/day
DALL· E (ChatGPT)	Realistic images from text descriptions	Easy to use, integration with ChatGPT	Limited number of styles	3–5 generations/day
KREA	AI generator with built-in styles	Free plan, stylish images	Less detail	15 generations/day
Adobe Firefly	Adobe Professional Tool	High quality, integration with Photoshop	Registration required	Free plan, watermarks
Cabina.Ai	Photo, text, video and audio generation	Multimodal content support, simple interface	Limited functionality in the free version	5 generations/day

The services enable you to quickly obtain concept art and 2D images for further use in VR/AR environments. However, the limitations of free plans and the detailing of individual tools highlight the need for a combination of different platforms to achieve an integrated approach.

5.5. Generation of low-poly and realistic scenes for VR/AR pre-medical simulator

The practical implementation of a VR/AR first aid simulator involves creating two main types of scenes: realistic and low-poly. Each approach has specific requirements for graphics, optimisation and interactivity, ensuring the training efficiency and technical stability of the simulator. Realistic scenes are designed to maximise user immersion in combat conditions and critical medical situations. The primary goal is to provide a sense of presence and practice skills in a setting that closely approximates real-world conditions. To create such scenes, generative AI models were used to obtain concept art and reference images with high detail, as well as traditional 3D tools for modelling and texturing:

- 3D modelling based on Blender and 3ds Max for building environments and objects, including destroyed buildings, damaged cars, and infrastructure elements.
- AI texture and detail generation based on Stable Diffusion and Leonardo.Ai to create textures, affected character details, and environmental effects such as smoke, fire, and debris.
- Interactive elements, i.e. VR/AR interaction settings, including physical properties of objects, tactile feedback, and interactive mannequins for practising medical procedures.

The realistic style ensures the accurate transmission of injuries, realistic victim behaviour, and critical scenarios (tourniquet application, cardiopulmonary resuscitation, evacuation), allowing you to develop skills for rapid response and correct actions in combat conditions.

Low-poly scenes feature simplified geometry and stylised graphics, enabling high performance on mobile devices and mid-range VR headsets. The primary objectives of the low-poly approach are to optimise performance, preserve key learning elements, and maintain a stylised visual design. To generate low-poly scenes, combinations of projects for generative AI models and classic 3D modelling were used:

- Advances in generative AI, in particular, include textual descriptions of key scenes and characters, with an emphasis on lightweight geometry, vivid colours, and simplified lighting. For example, a prom for a low-poly scene might look like this: "Low-poly warzone city, broken roads, ruined buildings, burning vehicles, first responders aiding wounded people. Stylised 3D environment, cinematic lighting, dramatic atmosphere."
- Character modelling based on Blender or 3ds Max to create low-poly models of paramedics, casualties, and medical instruments.
- AI support based on Leonardo.Ai and Trellis3D to generate textures and additional details of the environment that increase the aesthetic quality of the scene without significantly increasing the computational load.

Low-poly scenes offer stable performance across devices, enabling you to incorporate multiplayer scenarios and repetitive workouts without compromising FPS or interaction quality. After generating realistic and low-poly scenes, they are integrated into the VR/AR environment. The main stages include:

- Performance optimisation – a balance between graphics quality and rendering speed for VR headsets (Meta Quest, HTC Vive) and mobile devices (AR version).
- Interaction programming – setting up manipulations with objects, using medical instruments, assessing the effectiveness of user actions using the Triage system.

- Implementation of tactile and sound feedback – the realisation of the feeling of touching objects and simulation of environmental sounds (explosions, screams, heartbeat).
- Training scenarios – the inclusion of different levels of difficulty and event options that allow you to train both basic and critical medical skills.

The use of generative AI to create concept art and low-poly scenes can significantly reduce development time and increase design flexibility (Fig. 3-8). The combination of realistic and stylised scenes provides comprehensive training for users, ranging from immersion in combat conditions to training on simplified yet functional models (Fig. 9-13). This approach enables you to combine educational efficiency, high-level immersion, and technical optimisation, which is crucial for creating a VR/AR first aid simulator suitable for a wide range of users – from students and volunteers to military personnel and healthcare professionals.

Figure 3: DALL· Based Concepts E (ChatGPT)

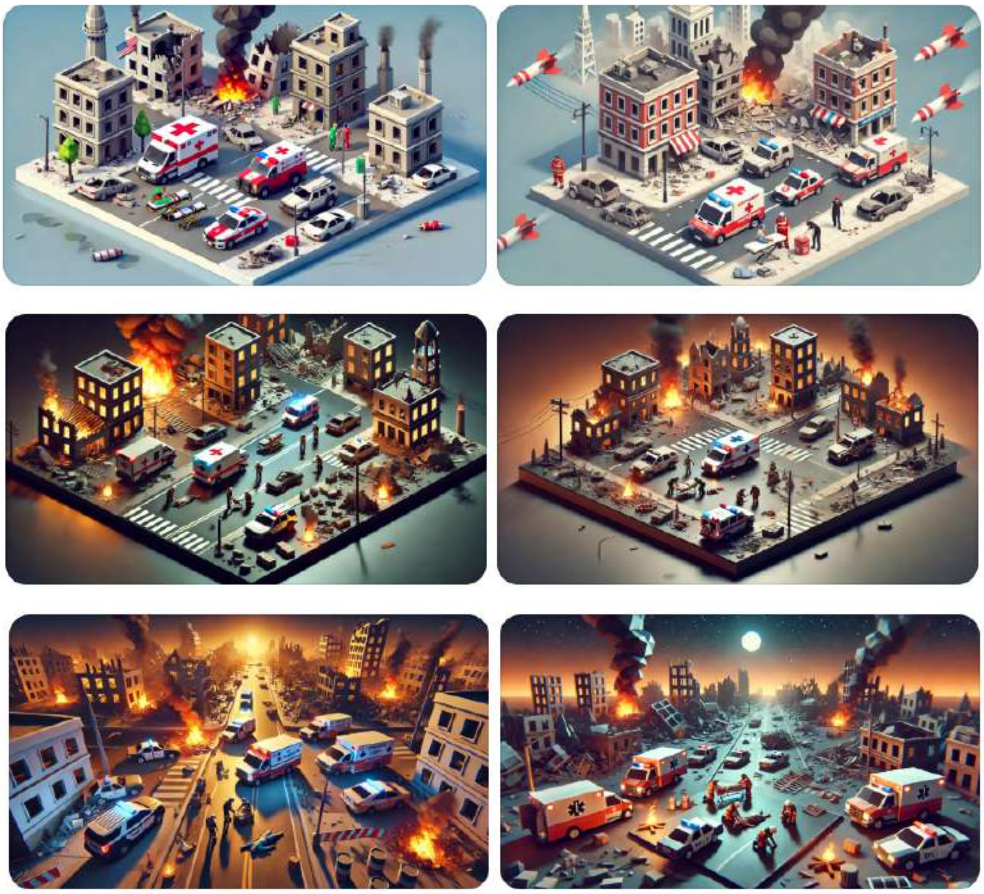

Figure 4: DALL· Based Concepts E

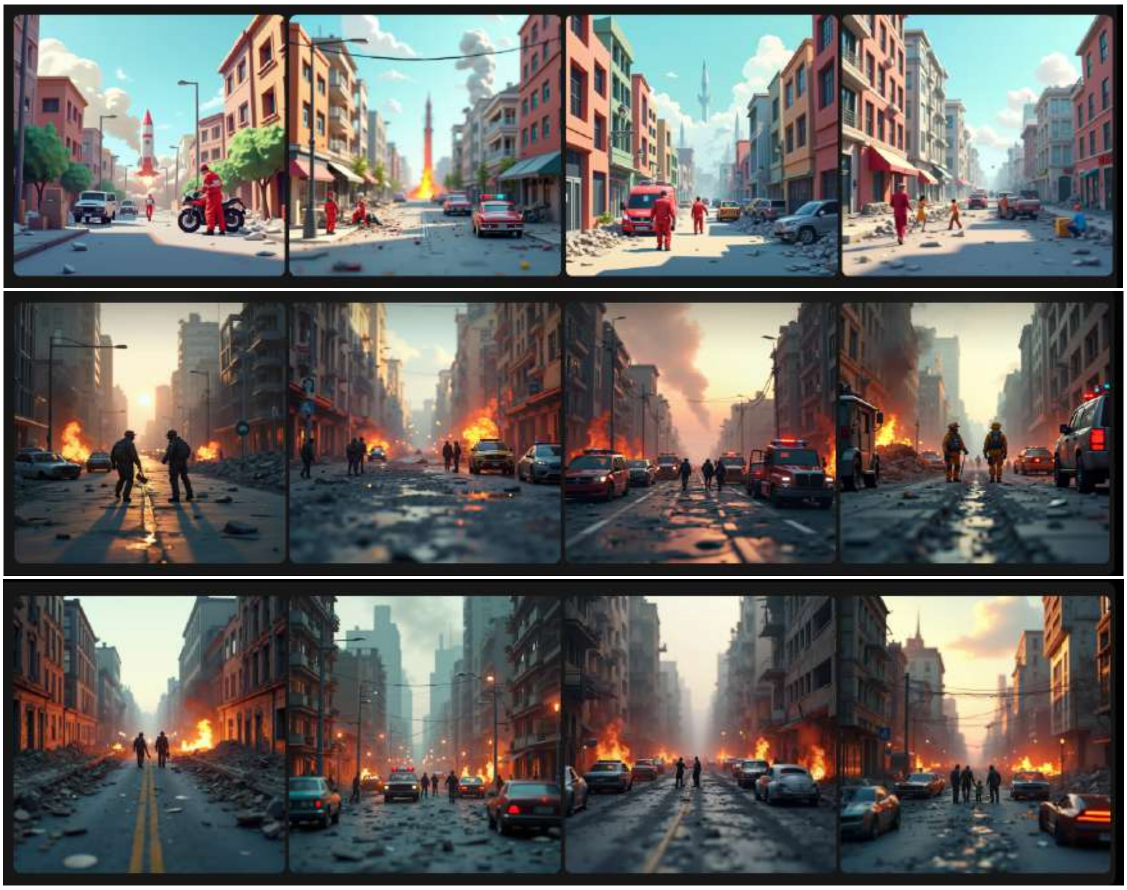

Figure 5: KREA-based concepts

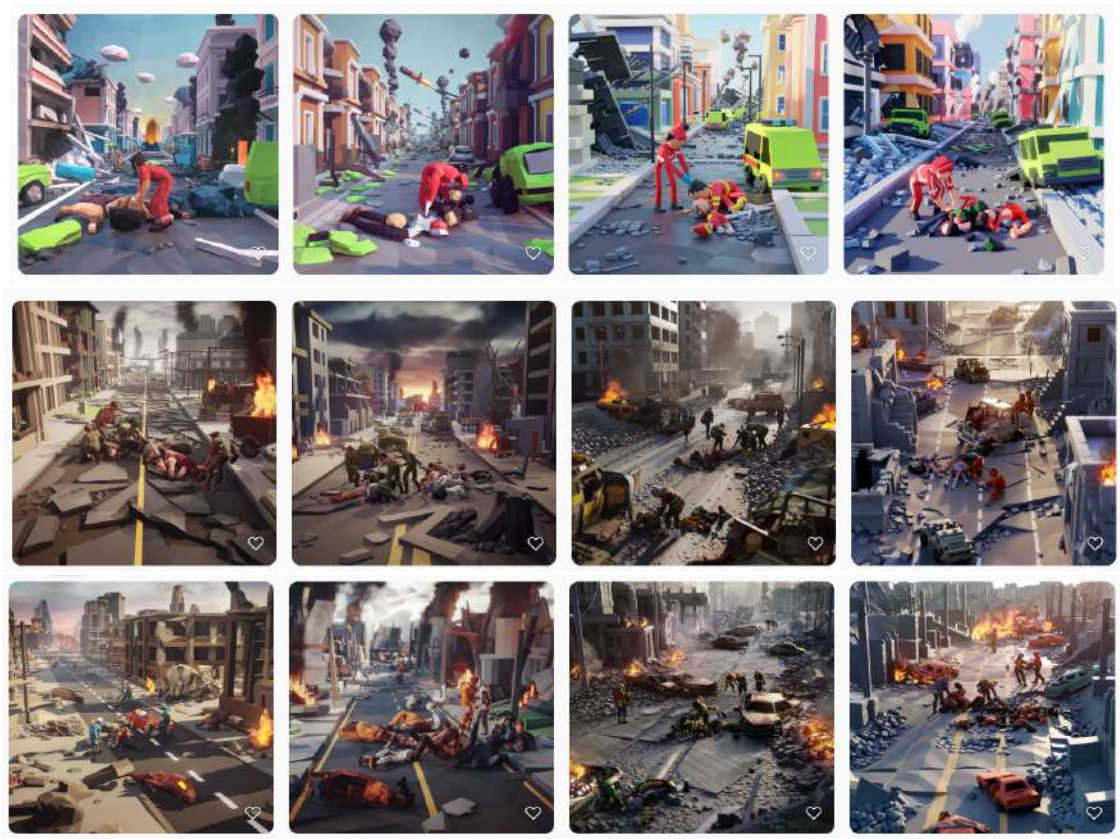

Figure 6: Ideogram-based concepts

Figure 7: Concepts based on Cabina.Ai (Leonardo.Ai)

Figure 8: Concepts based on Cabina.Ai (Flux)

Figure 9: DALL-based characters· E

Figure 10: Characters based on Cabina.Ai (Leonardo.Ai)

Figure 11: KREA-based characters

Figure 12: Characters based on Ideogram

Figure 13: Characters based on Cabina.Ai (Flux)

5.6. Testing and evaluation of the effectiveness of a VR/AR simulator for first aid

VR/AR testing of the first aid simulator aims to evaluate its functionality, training effectiveness, and user experience. The testing process comprises several stages: internal testing by the development team, alpha and beta testing involving specialists and volunteers, as well as automated system stability checks. At the initial stage of testing, a functional assessment of the simulator's basic mechanics was conducted. The primary focus was on verifying the operation of the Triage system, VR/AR interaction with objects, the accuracy of the physics models, and the replication of medical care scenarios. Testing made it possible to identify critical bugs in character control and optimise performance for various devices. Alpha testing was conducted with the participation of specialists, including paramedics, military instructors, and representatives from emergency services. The main criteria were the realism of the victims' behaviour, the logic of the training scenarios, and ease of use. Beta testing with volunteers and students allowed us to evaluate the effectiveness of learning, the intuitiveness of the interface, and the level of immersion. Collecting feedback and analysing it helped adjust the complexity of the scenarios, add hints for beginners, and optimise the balance between learning effectiveness and interactivity. Automated tests were implemented to verify the stability of the VR/AR environment, including unit tests of critical algorithms and control programs for checking the rendering and physics of objects. Automation allows you to quickly detect regressions and maintain high quality of the simulator in the long run. The following indicators evaluated the effectiveness of the simulator: the speed of the user's reaction, the correctness of the procedures, the ability to re-complete scenarios and improve skills over time. The combined use of realistic and low-poly scenes provides comprehensive training, where realistic scenes build response skills, and stylised low-poly scenes maintain a high level of practice on different devices without sacrificing performance.

To generate high-quality images based on text messages, the VR/AR simulator uses diffusion models integrated into Stable Diffusion. The main models and their functions are presented in Table 7. The use of these models enables you to obtain high-quality concept art for both realistic and low-poly scenes, while providing detailed composition control and the ability to quickly edit individual elements of the scene.

Table 7
Using Diffusion Models for Image Generation

Model	Principle of operation	Features
Latent Diffusion Models (LDM)	Converts a text prompt to a vector space and generates an image	Optimised for desktop PCs
Text-to-Image Diffusion	Generating an image from a text description	Support for a wide range of styles
ControlNet	Allows you to set the structure and shape of the image	Improves composition control
Inpainting Diffusion	Allows you to restore or complete parts of images	Used for retouching or correcting defects

To simplify the process of image generation without installing on-premises software environments, there are online platforms that provide access to Stable Diffusion. The leading platforms and their characteristics are presented in Table 8. Such platforms enable you to integrate generative AI into the development of a VR/AR simulator, providing quick access to concept art, textures, and references for 3D models.

Table 8
Leading platforms and their characteristics

Platform	Plan	Features	Generation limit
Clipdrop (by Stability AI)	Free	Simple interface, support inpainting	3-5 generations per day
Mage.Space	Free	Real-time image generation	10 generations per day
Leonardo.Ai	Shareware	High-quality images, different styles	10 generations per day
DreamStudio	Paid	Support advanced inpainting, API	100 credits upon registration
Hugging Face Spaces	Free	Many models to choose from	No limits, but slow speed

Images of the main characters are generated using Stable Diffusion, which applies model adaptation to specific styles (Fig. 14-16). There is a problem that this character, when downloaded to a local computer, generates Stable Diffusion with its back, so it is used by the online version of this neural network (Fig. 17).

Figure 14: Paramedics

Figure 15: A man with burns

Figure 16: Mother with child

Figure 17: Man with burns

5.7. Practical implementation of 3D content generation for VR/AR simulator

Modern generative AI tools allow you to quickly create 3D models for VR/AR simulators using text descriptions or 2D images. Below are the top five free services:

Table 9
Top Best Free AI Tools for 3D Content Generation

Tool Name	Key Features	Supported formats	Advantages	Disadvantages
Trellis3D (Fig. 18)	Generation of 3D models from text or images, support for Mesh, NeRF, Gaussians	OBJ, GLB, USD	High detail, support for various formats, free access	Limited documentation

Meshy (Fig. 19-21)	Generating 3D objects from prompts or images	OBJ, FBX	Intuitive interface, fast generation	Limit on free generations
Sloyd	Parametric 3D modelling with AI	OBJ, GLB	Easy to change model parameters, user-friendly interface	Less control over parts
Tripo (Fig. 22-23)	Generation of 3D models based on text queries	GLB, FBX	Flexible model editing, fast generation	Online access required
Masterpiece X	VR editing and generation of 3D models	OBJ, FBX, GLB	Support for collaboration, integration with VR	Limited Free Plan

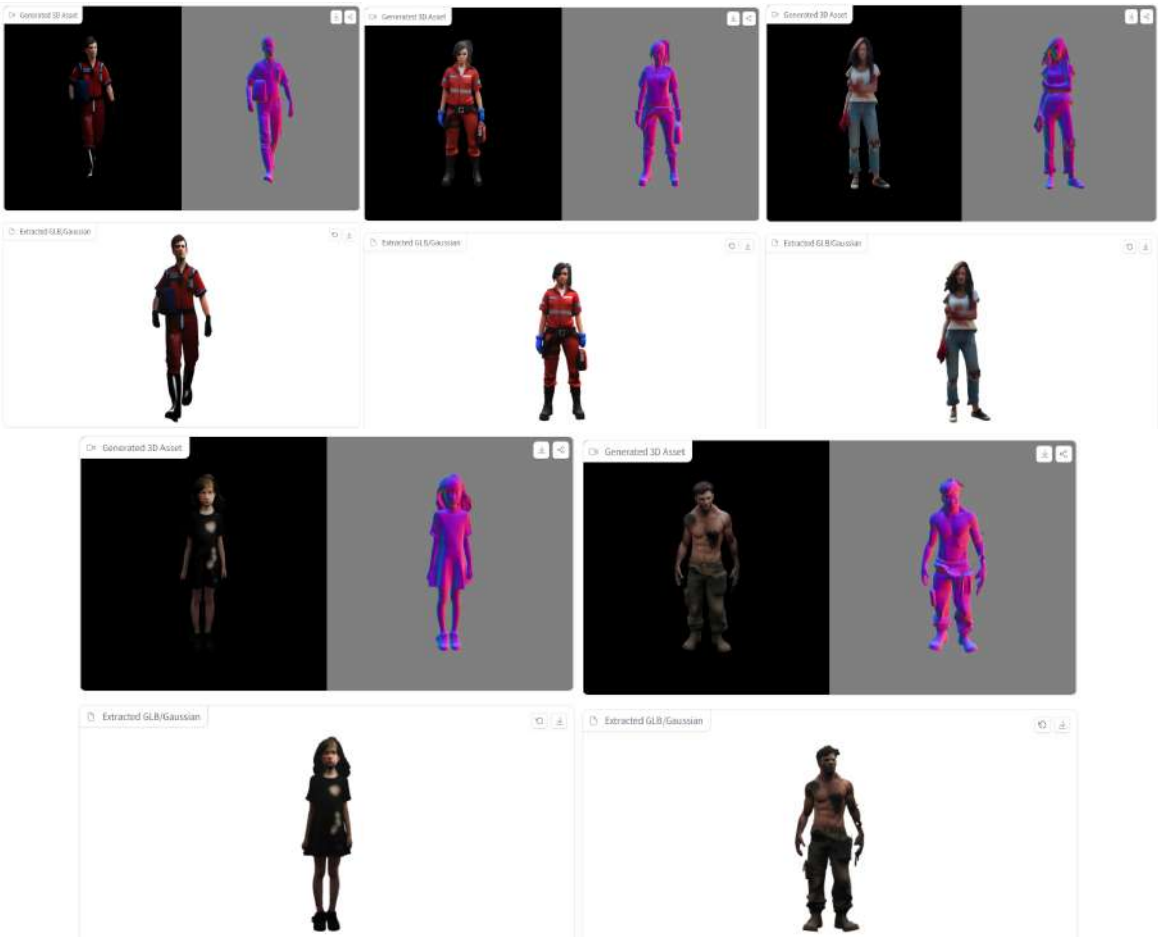

Figure 18: Examples of generating 3D models based on Trellis

Figure 19: Examples of generating 3D models of Buildings based on Mersy

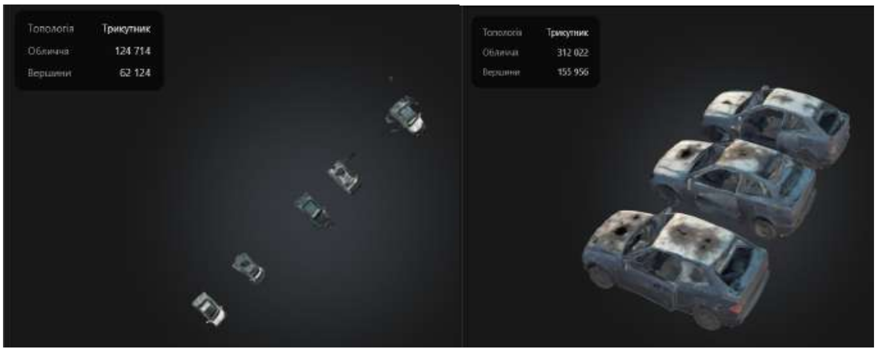

Figure 20: Examples of 3D Model Generation of Mersy-based machines

Figure 21: Examples of generation of 3D models of Characters based on Mersy

Figure 22: Examples of generating 3D models of Tripo-based buildings

Figure 23: Examples of generating 3D models of Characters based on Tripo

To demonstrate the practical implementation, a collection of 3D models has been created and is located on Google Drive (https://drive.google.com/drive/folders/1OPnl--VDgQ0hSJx46E6X7CjOssAuRrhO?usp=sharing) in the "3D models" folder. The collection contains models created with Trellis3D, Meshy and Tripo. Among them are buildings, vehicles and characters for use in VR/AR simulators. OBJ (a universal format for sharing 3D models), FBX (widely used in game development and animation), and GLB/GLTF (optimal for web applications and VR/AR scenes, providing compact scene saving along with textures). Modern research and development in the field of generative AI allows you to create 3D models using open models with support for text descriptions and 2D references. The main open source models are presented:

Table 10
Open-source generative models for creating 3D models

Model	Developer	Key Features
Hunyuan3D (Fig. 24)	Tencent	Generates 3D models from 2D images, uses DiT (Diffusion Transformer) for shape and Paint for textures
Trellis3D	Microsoft	Supports various 3D formats such as Radiance Fields, 3D Gaussians, and meshes
Meshy	Meshy.ai	Creates 3D models based on text descriptions and references
Rodin	Microsoft AI	Generates realistic 3D avatars from photos
DreamFusion	Google Research	Uses NeRF (Neural Radiance Fields) to create 3D objects from text descriptions

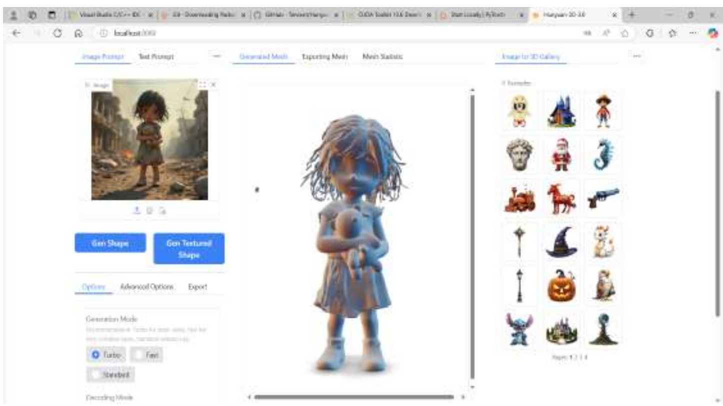

Figure 24: Examples of generating 3D models of Characters based on Hunyuan3D

The use of these models enables the creation of a diverse range of objects for VR/AR simulators, offering a high level of detail, flexibility in settings, and support for multiple formats for seamless integration into various platforms.

5.8. Working with VR First Aid in Unreal Engine. VR Template script. OpenXR

The topic is relevant and socially significant. It also has practical value for the training of military personnel, rescue workers, students in medical and technical specialities, volunteers, high school students, and anyone who wishes to learn. The use of VR makes it possible to simulate real emergencies without risk to life. It makes it possible to train critical first aid skills, reduce panic levels during emergencies and memorise the sequence of actions in crisis scenarios. The project in Fig. 25 allows you to combine the development of a virtual scene (3D modelling), the implementation of interaction and action selection scenarios, the creation of a UI/UX feedback interface, and the optimisation of the VR experience for the player using (Triage systems, timers, interactive prompts, etc.).

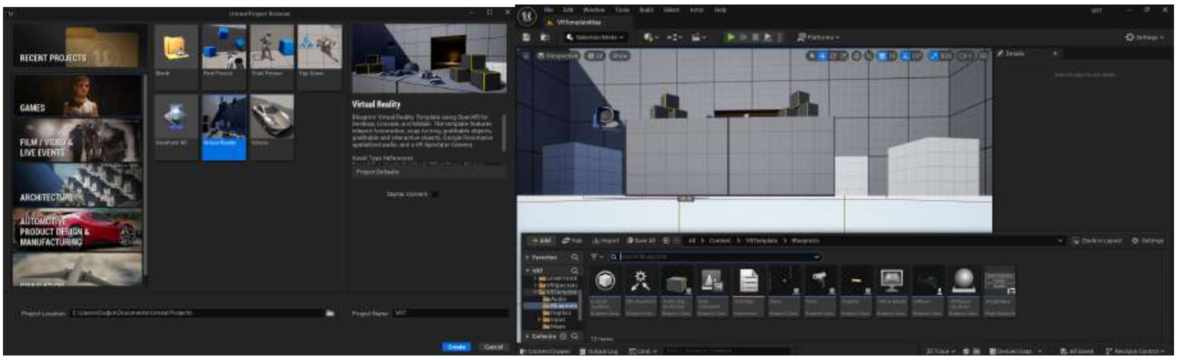

Figure 25: Unreal Engine 5 Launch and VR Template

Table 11
Virtual Stage Classes

Class Name	Type	Appointment
VRPawn	Blueprint Class	Virtual player character. Contains logic for control, teleportation, and object capture
BPI_PawnAnim	Interface	VRPawn animation interface. Provides interaction with animated events
VRGameMode	Blueprint Class	Defines the rules of the game, including which Pawn is used, the Game State, and the HUD, among others.
VRSpectator	Blueprint Class	Displaying the scene on the monitor (from the player's side). Not used in mobile VR
B_Asset Guideline	Blueprint Class	A service template for designing or checking the structure of scenes
VRTeleportVisualizer	Blueprint Class	Responsible for visualising the teleport arc and target points
WidgetMenu	Widget Blueprint	User interface in VR. May contain buttons, indicators, hints

Menu	Blueprint Class	Controls the invocation and display of `the WidgetMenu` via VR Motion Controller
GrabType	Enumeration	Types of grab interactions (for example: manual, automatic, pinching)
Grab Component	Blueprint Class	A component that provides the ability to interact with objects (grab/drop)
Grabbable_SmallCube	Blueprint Class	An example of an object that can be captured. Serves as a template for creating VR items
Pistol	Blueprint Class	Test object for checking grab and shooting (can be redesigned)
Projectile	Blueprint Class	Object for shooting/flying. Demonstration of physics or alternative interactions

Although the VR template is focused on the use of a helmet, it is possible to perform partial testing without one: simulating the scene, manually moving the camera, and testing Grab objects. In the first method, the camera is not tied to VR, but you can observe how objects behave (such as gravity and collision). Even without a VR helmet, you can see physics in action: thrown objects bounce, and gravity is evident. If an object has a Grab component and physics enabled, its reaction is visible in the simulation. The next step is to simulate the situation on a street in a Ukrainian city after a missile attack, where the player, in the role of a paramedic, must assist victims according to the Triage algorithm, using VR tools (Fig. 26).

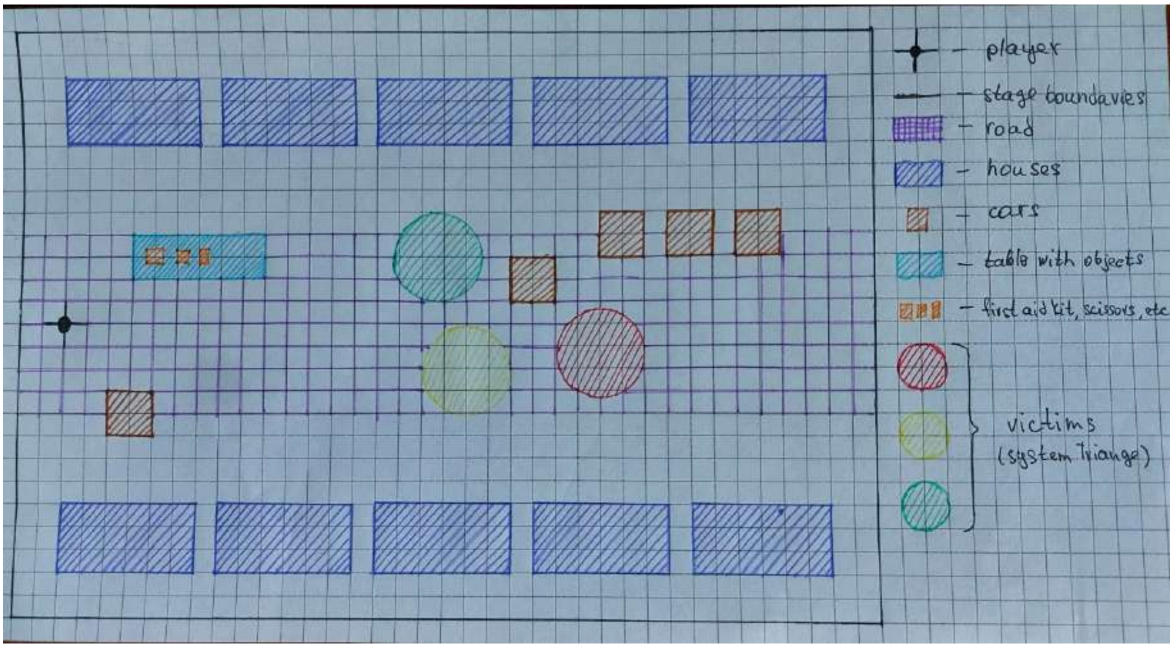

Figure 26: Sketch of the scene

Particular attention is paid to prototyping the VR scene for simulating the provision of first aid. In the process, the logic of the player's interaction with items through the grab system was implemented, and his own VR pickup items were created. The structure of the environment was built from simple geometric shapes (Fig. 27-30).

Table 12
VR content of the project under development

Category	Description
3D Models & Animation	- Victims with basic posture and/or animation (breathing, panic); - Medical backpack, tourniquets, bandages, scissors, etc.; - Broken cars, debris, damaged buildings; - Destruction scene: objects with smoke and fire animation
Light and shadows	- The primary source is Directional Light (imitation of the sun); - Skylight and atmospheric fog for depth; - Dynamic shadows from cars, wrecks, characters
Environment	- A broken street with ruins and debris; - Textures of damaged asphalt, smoke, and fire
Physics	- Physics for characters and objects that can be interacted with; - Realistic gravity; - Collisions of buildings, machines, debris
Spatial sound	- Sirens, explosions in the distance, screams; - Realistic sound positioning via Sound Cue
Menu and HUD (interface)	- VR HUD with a timer and hints ("Apply a tourniquet", "Start CPR"); - Mode selection menu (training/simulation/evaluation) ; - Evaluation of the result upon completion (correctness of actions, time, sequence)

Table 13
VR interactions of the project under development

Category	Description
Selection / Indication	- Pointing objects via VR Motion Controller (laser pointer) - Selection of the victim by pointing the beam (Line Trace) and confirming the action (button or grab); - AR tags above characters – colour according to Triage
Navigation	- Teleportation within the range via NavMeshBoundVolume; - Direction selection – movement of the joystick or direction of the controller; - Restricted areas (red outline) – teleporting there is not possible
Manipulation (grabbing)	- Grabbing items through GrabComponent; - Pressing the Grip Button – activates the grip; - Use of objects: body overlay, Drop (release)
Menu	- The menu is pinned to the hand or appears in front of the player - Menu created via Widget Blueprint (UMG) - The Menu button on the controller opens the VR HUD: ▫ Mode selection (training/simulation/evaluation); ▫ Timer output, stress/time indicator; ▫ Built-in prompts ("Examine the victim", "Start CPR")

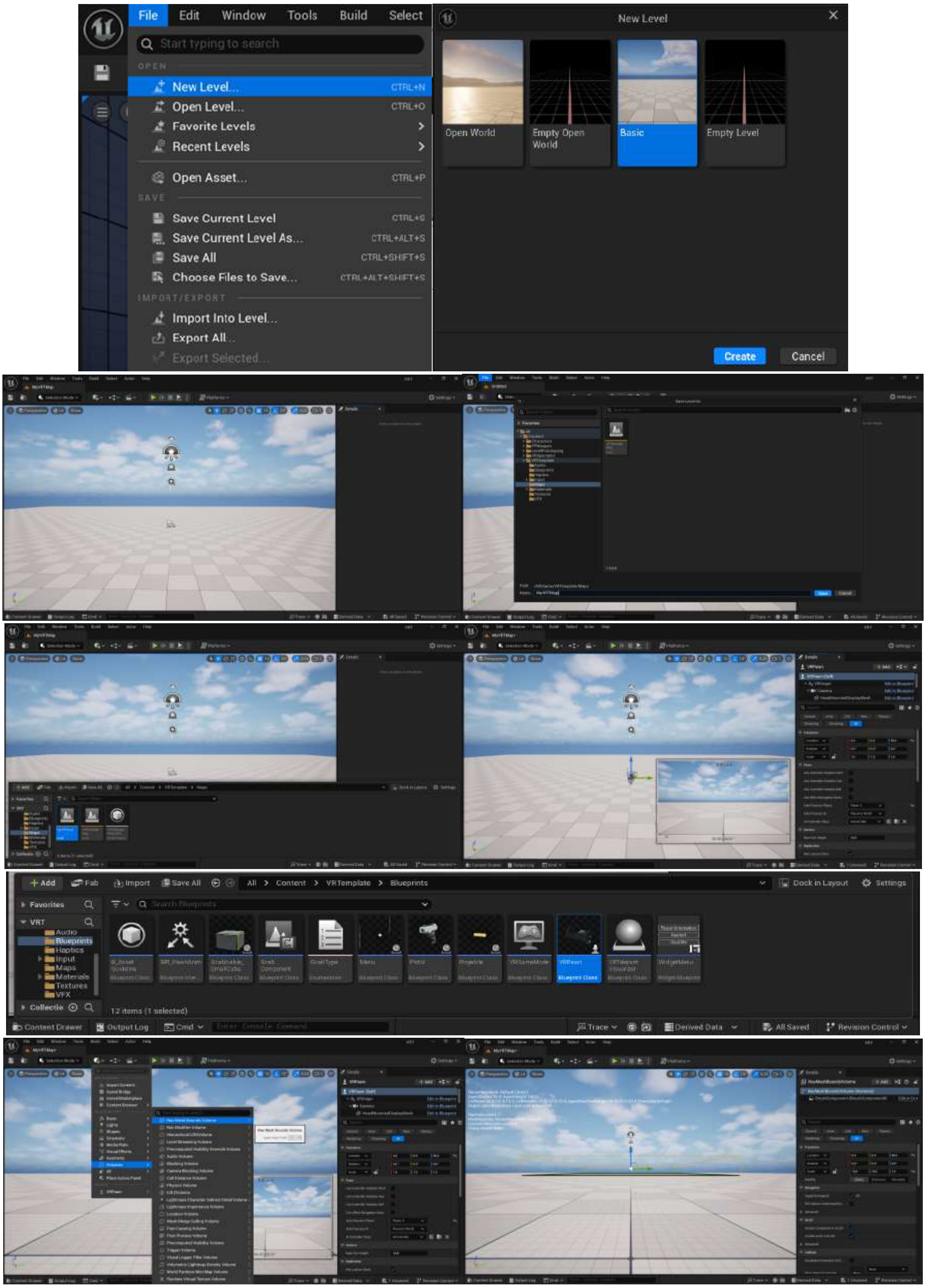

Figure 27: Setting the scene

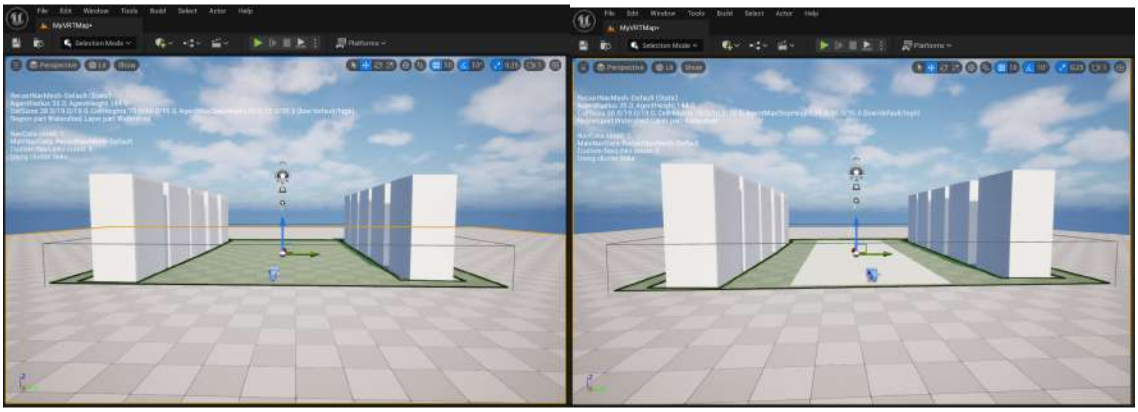

Figure 28: Choosing the location of houses and roads

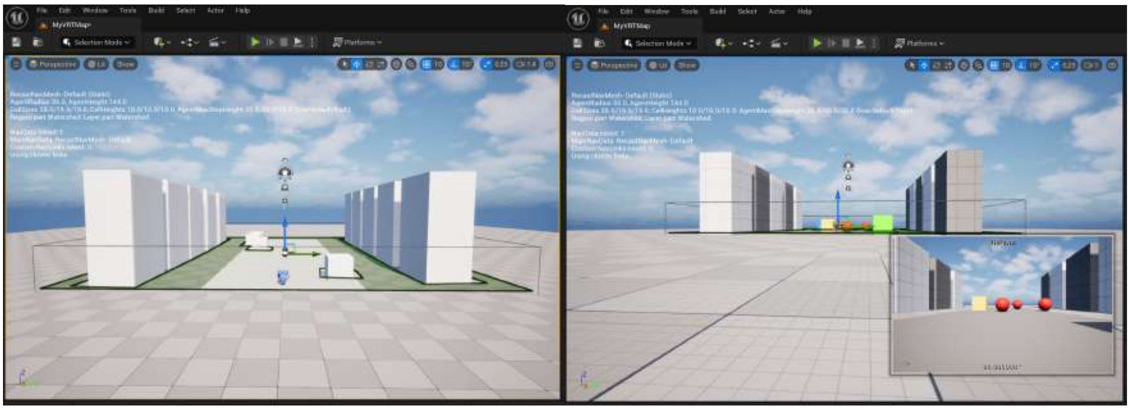

Figure 29: Choosing the location of cars and victims

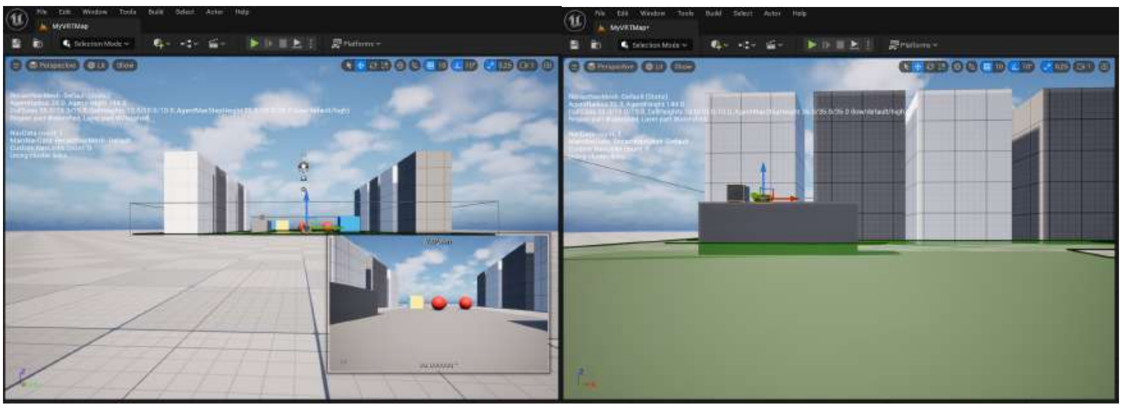

Figure 30: Prototyping a VR scene for a simulation of first aid

5.9. Migration of Unreal Engine content to the virtual reality scene in Unreal Engine. Collision settings for UE objects. Smooth Locomotion

VR of first aid (in conditions of a rocket hitting a house on a residential street). This topic is highly relevant to modern conditions, allowing not only the simulation of an environment after shelling, but also the development of the user's practical skills in disaster conditions. The goal of the VR project is to create a realistic environment of a damaged city street. To search for content, the Fab marketplace was used, where it is possible to import assets to Unreal Engine for free (Fig. 31-32). In parallel with free solutions, paid content in the Unreal Engine Marketplace was explored, which could significantly improve the quality of scene and save time on creating from scratch (Fig. 33-34). The Poly.pizza platform is a simple service offering free, low-poly models (Fig. 35). The

Sketchfab platform is a well-known service that contains thousands of free models with textures (Fig. 36).

Table 14
List of keywords used for content search

Target	Search queries
Ruined Street	destroyed street, war zone street, post-apocalyptic street
Destroyed houses	damaged building, destroyed house, ruined building
Destroyed machines	wrecked car, damaged car, burnt vehicle, crashed car
Ambulance	ambulance, emergency vehicle, hospital van, paramedic car
Kit	first aid kit, medical bag, ifak, emergency box
Medical instruments	medical scissors, tourniquet, emergency tools, bandage
Road	asphalt texture, road material, pavement PBR texture
Sky	HDRI sky, sky background, skybox, realistic sky
Wreckage	rubble, concrete debris, destruction pieces, broken wall
Smoke	smoke VFX, dust particles, fire smoke, explosion debris

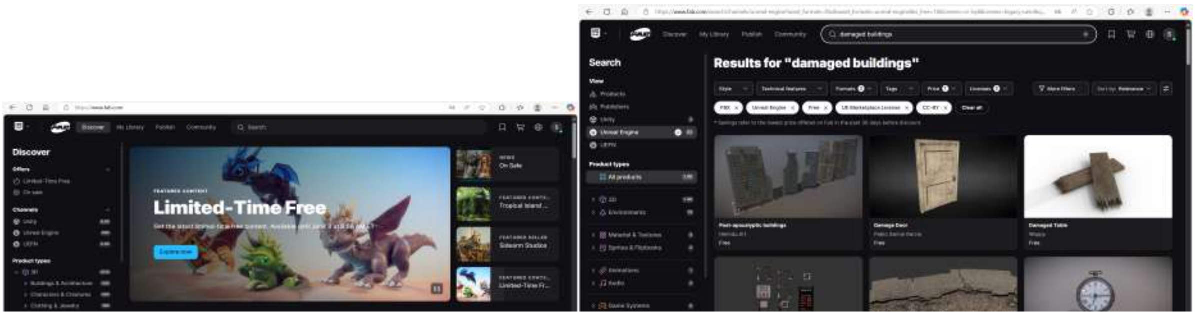

Figure 31: Fab Marketplace

Figure 32: Fab URLs: https://www.fab.com/listings/0e895257-8bb6-4fbf-899c-4a4a0288c2d5, https://www.fab.com/listings/6870c563-f3c8-4f19-805b-f4ba9b536559, https://www.fab.com/listings/ed5f6c30-a0b4-48a7-bb12-c7105f412e55

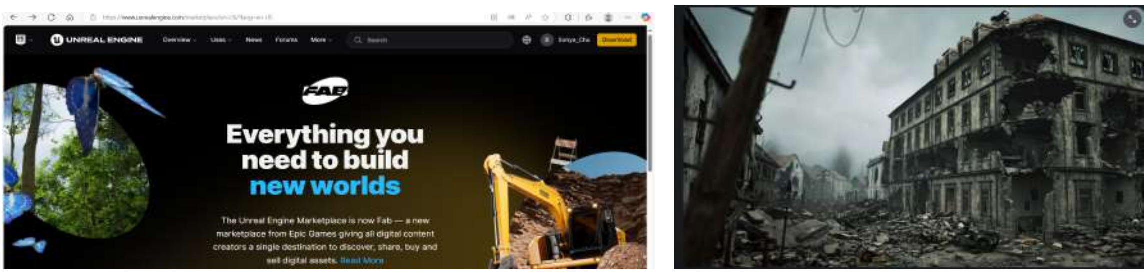

Figure 33: Unreal Engine Marketplace and URL: https://www.unrealengine.com/marketplace/en-US/product/ww2-warzone-environment-megapack

Figure 34: Unreal Engine Marketplace URLs: https://www.unrealengine.com/marketplace/en-US/product/ambulance-drivable, https://www.unrealengine.com/marketplace/first-aid-set

Figure 35: Choosing a building model (https://poly.pizza/m/7zyZfQrt3ZP), a road (https://poly.pizza/m/e3QRTZLNQU5) and an ambulance (https://poly.pizza/m/8NOFImgkI5N) on the poly.pizza platform

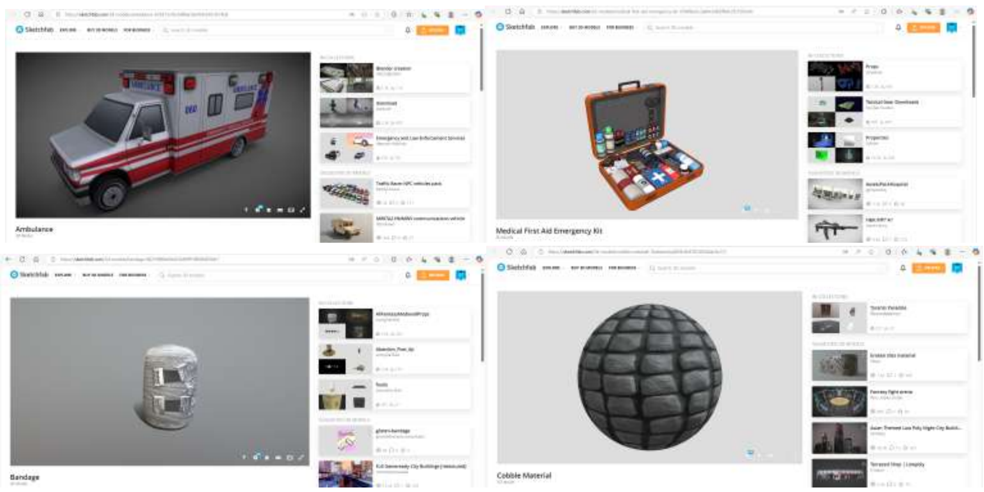

Figure 36: Choosing a model of an ambulance (https://sketchfab.com/3d-models/ambulance-b78313c16c9d46a7a67643245cf278d2), first aid kit (https://sketchfab.com/3d-models/medical-first-aid-emergency-kit-d588fee3c3a94c0d82884c2fc1505e9c), bandage (https://sketchfab.com/3d-models/bandage-86276f80e946430d9fff7d905bf056b1) and cobbie material (https://sketchfab.com/3d-models/cobble-material-1bebeecbcd204c8c87f230542ab3a121) on the Sketchfab platform.

To create a scene as realistic as possible for the VR project "First aid after a missile strike on a residential street", a search was conducted for free 3D content on leading platforms for 3D models. The main selection criteria were:

- the ability to download models for free;
- availability of formats compatible with Unreal Engine (mainly .fbx, .obj);
- compliance with the project theme: destroyed buildings, debris, medical instruments, smoke, transport, etc.;
- adaptation of models for VR scenes (low/medium polygonality, PBR textures, presence of regular/reflection maps, etc.).

The CGTrader platform is a professional resource with paid and free models, including scanned objects (Fig. 38).

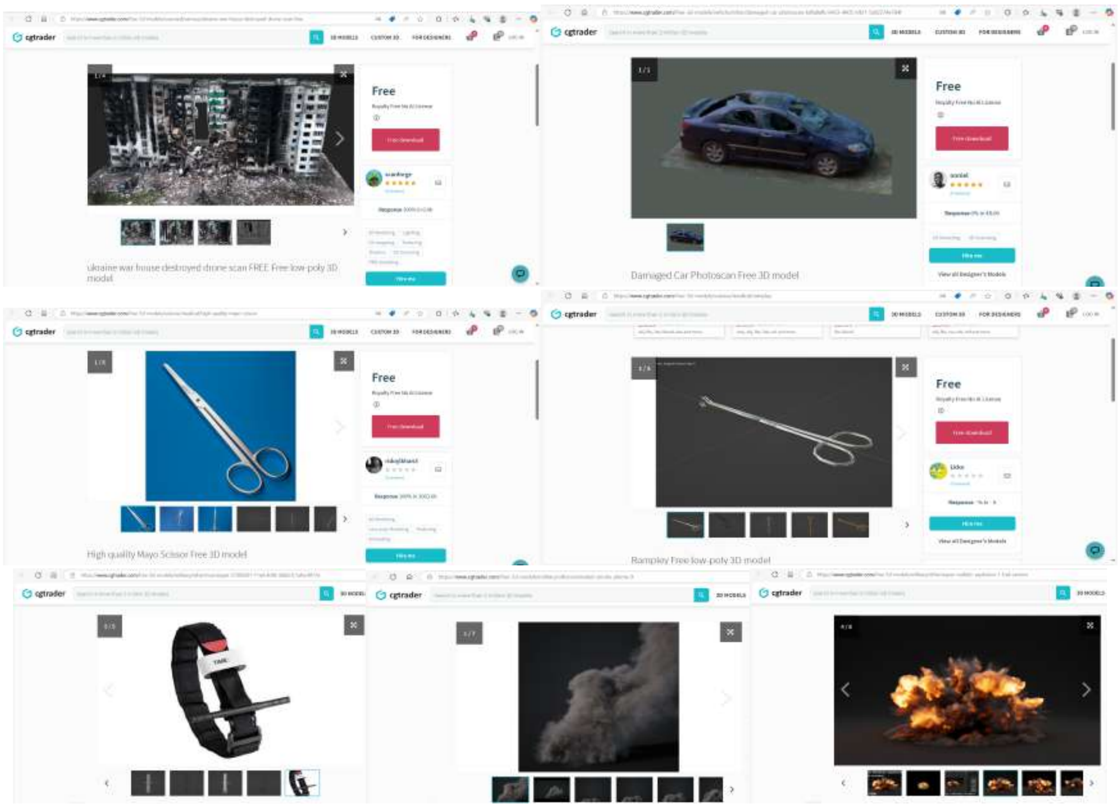

Figure 37: Choosing a model of a destroyed building (https://www.cgtrader.com/free-3d-models/scanned/various/ukraine-war-house-destroyed-drone-scan-free), car (https://www.cgtrader.com/free-3d-models/vehicle/other/damaged-car-photoscan-6dfa8efb-6433-4905-b921-5a82274e784f), medical bottoms (https://www.cgtrader.com/free-3d-models/science/medical/high-quality-mayo-scissor), rampley (https://www.cgtrader.com/free-3d-models/science/medical/rampley), tourniquet (https://www.cgtrader.com/free-3d-models/military/other/tourniquet-57005691-11a4-4c98-9d0d-fc1afac4917e), clouds of smoke (https://www.cgtrader.com/free-3d-models/military/other/animated-smoke-plume-9) and explosion (https://www.cgtrader.com/free-3d-models/military/other/super-realistic-explosion-1-trial-version) on the CGTrader platform

PolyHaven platform - free PBR content: HDRI sky, materials, models (Fig. 38).

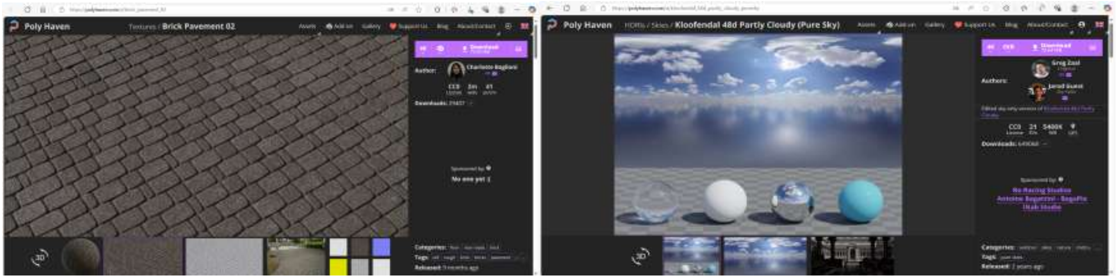

Figure 38: Choosing a Road Paving Model (https://polyhaven.com/a/brick_pavement_02) and Sky (https://polyhaven.com/a/kloofendal_48d_partly_cloudy_puresky) on the PolyHaven Platform

An analysis of the available content on the TurboSquid and Free3D platforms was conducted, revealing that most models are either paid or lack a relevant topic. Normal free VR content for the scene was not found. BlenderKit is a plugin for Blender (Fig. 39) that enables the import of free 3D assets. Some models are suitable for export to UE (via .fbx).

Figure 39: Choosing a model of an ambulance (https://www.blenderkit.com/asset-gallery-detail/367c0def-0dec-4089-852e-9a28c1f0d31a/), first aid kit (https://www.blenderkit.com/asset-gallery-detail/1e2a0959-4774-454b-9a43-f7d30e1d6671/) and medical scissors (https://www.blenderkit.com/asset-gallery-detail/8d7be629-be25-41d7-bae4-2c668908d35a/) on the Blender platform.

3D Warehouse (SketchUp) – models in Fig. 40 in .skp format (can be converted to .fbx via Blender or SketchUp).

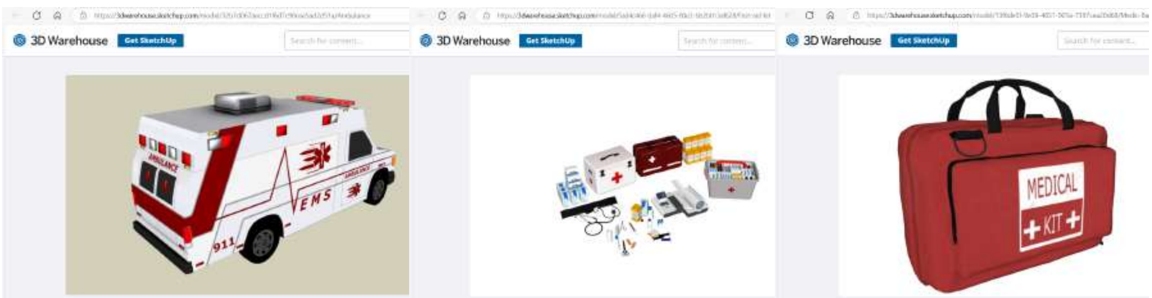

Figure 40: Choosing a model of an ambulance (https://3dwarehouse.sketchup.com/model/32b7d067aeccd1f6d7c90cee5ad2d51a/Ambulance), first aid kit (https://3dwarehouse.sketchup.com/model/5ad4c466-daf4-4605-80e3-bb2b013af628/First-aid-kit) and medical bag (https://3dwarehouse.sketchup.com/model/13f6de5f-9e38-4651-901a-7397cea20d68/Medic-Bag) on the 3D Warehouse platform

The search made it possible to form a full-fledged library of objects for creating a VR scene on the topic of first aid:

- destroyed objects of the city;
- realistic textures of surfaces and sky;
- vehicles (including ambulances);
- first-aid kits, tourniquets, dressings;
- effects of smoke and explosions.

Content from the Sketchfab, CGTrader, and Poly.pizza platforms is the most suitable for Unreal Engine without additional processing. Additional resources, such as BlenderKit and 3D Warehouse, expand the possibilities for VR-adapted models.

Paid models that would significantly improve the implementation of the VR project scene on the topic "First aid after a missile attack". They are of high quality, optimised for Unreal Engine, often contain PBR textures, LOD levels, animations, or manageability (e.g. transport):

1. WW2 Warzone Environment Megapack includes: dozens of buildings, debris, barricades, sandbags, smoke and fire effects. Why it is essential: allows you to quickly create a cohesive scene with a high level of destruction. Suitable for visualising the street after a missile strike.

2. Ambulance (Drivable) includes: a realistic ambulance with interior, handling, and door opening. Why it matters: a key element of the first aid scene. Allows interactive interaction (boarding, loading victims).

3. First Aid Set includes: first aid kits, bandages, tourniquets, scissors, syringes, etc.

Why it matters: used to simulate the user's actions in a VR scene – applying bandages, stopping bleeding, etc. General benefits of using paid models

- Time saved (no need to create everything from scratch)
- Professional optimisation for VR (low-poly options + LOD)
- Support for animations/collisions/settings for UE
- Realism and immersive VR

Unreal Engine supports importing third-party 3D models in various formats, including .fbx, .obj, .glb, and .gltf (Fig. 41). The FBX format is the most widely used because it stores geometry, animations, skeletons (for skinning), materials, and basic texture information. Instructions on how to import 3D models:

1. Download the model from the resource.

2. Make sure it is in the correct format. If it is in another format (e.g., .blend or .skp), convert it to .fbx using Blender.

3. In Content Browser Unreal Engine, create a new folder.

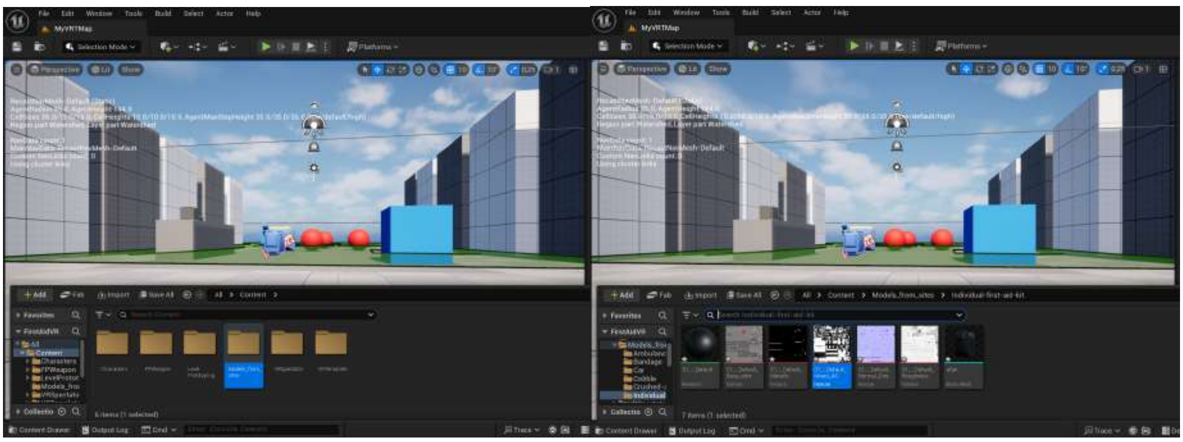

Figure 41: Project in Unreal Engine

4. RMB in the → Import to ..., select the file and leave such options as Import Mesh, Import Textures and Import Materials in the dialogue box. After importing, objects are created, including Static Mesh, Material, and Textures (such as Base Colour, Normal, Roughness, etc.).

5. Setting up texture maps (PBR) in Fig. 42:

- Create a new Material or open the one you created during import.
- Drag and drop each texture into the Graph of the Material editor.
- Connect accordingly:
- Click Apply to save the changes.

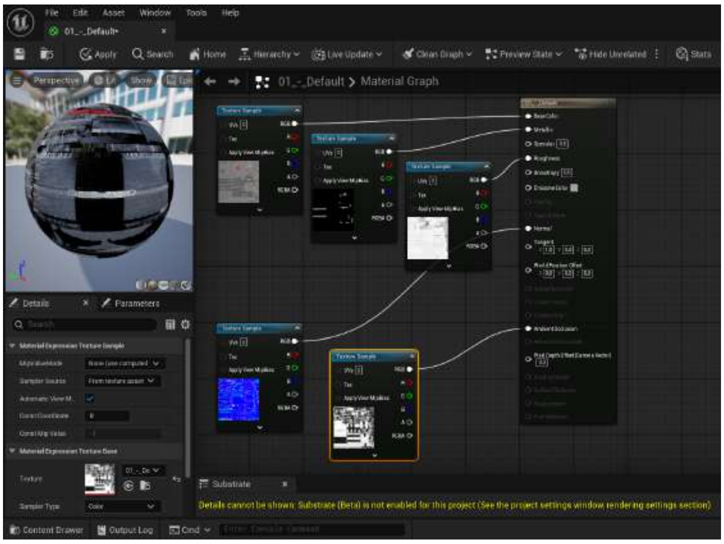

Figure 42: Setting Texture Maps (PBR)

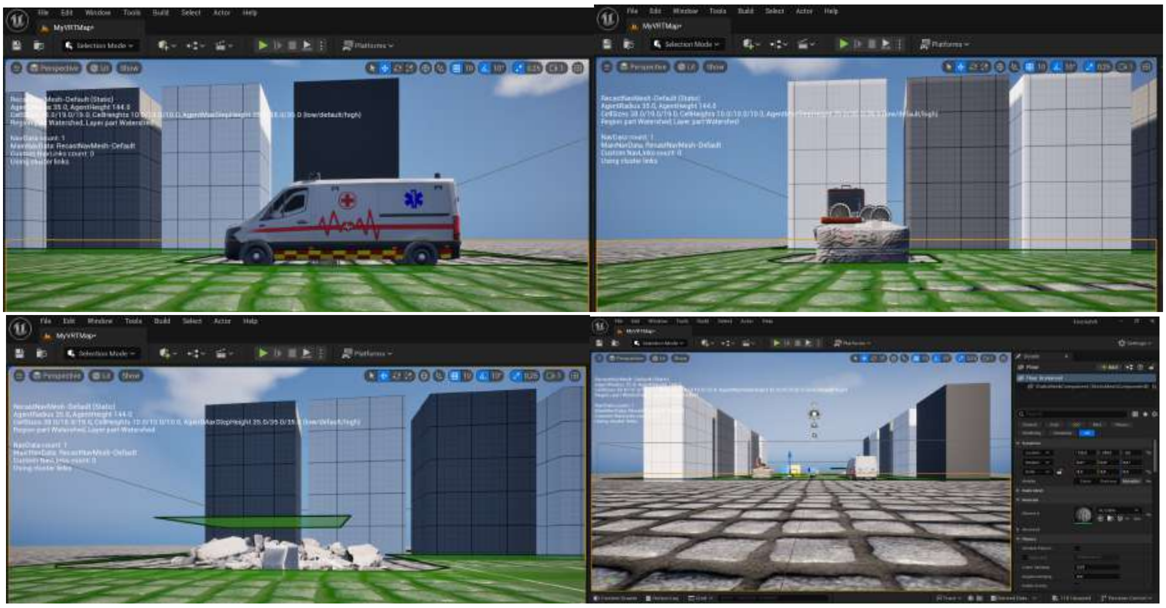

Figure 43: The process of working on a project with models

6. After successfully importing the models, they can be used on the stage:

- Drag and drop from Content Browser.
- Zoom, rotate, change position.
- Assign a collision so that the VR character does not pass through the model.

- Apply NavMesh if the object is to be used as a constraint for movement.

During the execution of this task, the following was performed (Fig. 43):
- Import 3D models.
- Manually configured PBR textures (where required) in the Material Editor.
- Added models to the scene, including: ambulance, first aid kits, tourniquet, scissors, debris.
- Models are scaled according to the scene.
- The display of textures, the level of detail and the correctness of lighting have been checked.

6. Results

In modern 3D modelling, generative neural networks (also known as Generative AI) significantly simplify the creation of complex or rare objects that are difficult to find on standard marketplaces or to create manually. It is especially true for highly specialised VR scenes, such as:

- Simulations of medical emergencies;
- Damaged buildings and vehicles;
- Human models with characteristic wounds or postures.

Generative models enable you to minimise the lack of unique props, automate part of the 3D production process, and adapt the scene to individual scenarios.

As part of this task, generative neural networks were used:

1. Mersy – to generate damaged environments: destroyed houses and damaged cars

2. Tripo – to create the environment and human models of the victims: at home, a child in an unconscious state (CPR), a mother with bleeding from the arm (applying a tourniquet) and a man with burns on the body (processing burns).

Importing the generated models to the UE (Fig. 44):

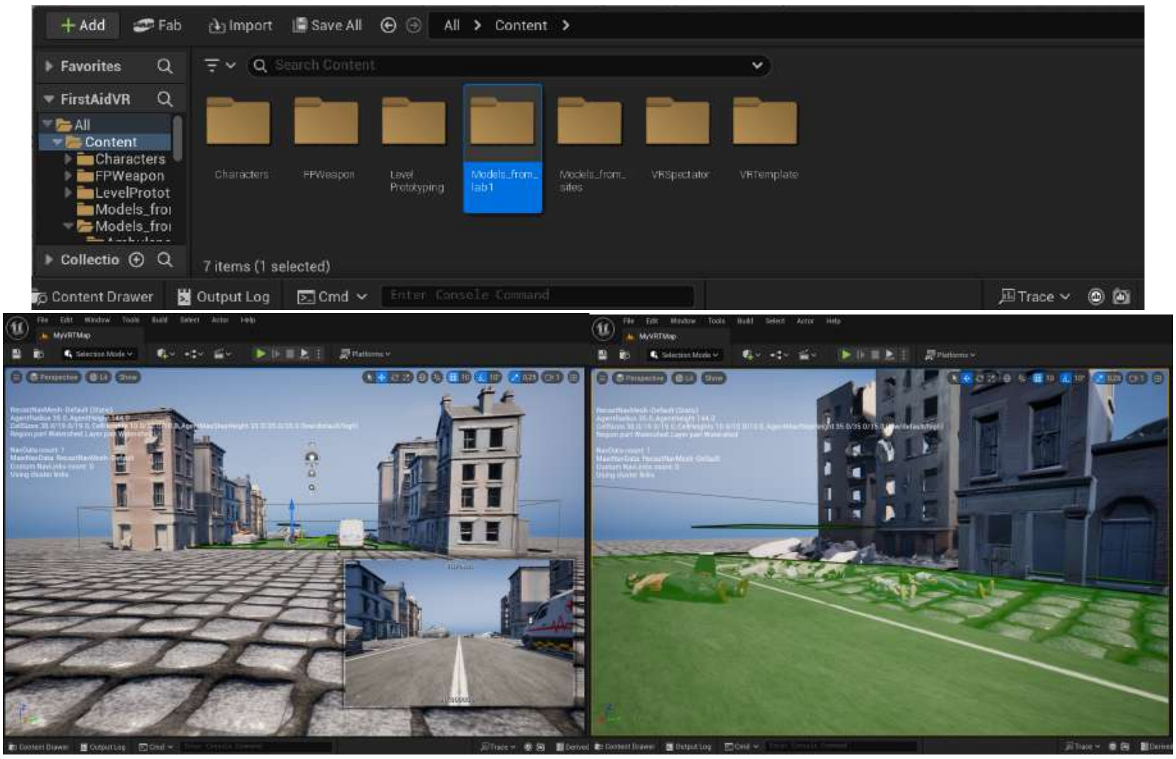

Figure 44: Scene with imported 3D content and the location of the missile/mine impact with victims

1. Export from Tripo/Mersy in .fbx or obj format.
2. Convert to .fbx via Blender if necessary.
3. A new folder has been created in the Unreal Engine project.
4. Import to ... .
5. Check the Import Mesh, Import Textures, and Import Materials checkboxes.
6. All models have been successfully imported:

Generative neural networks made it possible to significantly expand the library of 3D assets and give the scene individuality and believability, in particular:

- Realistic simulation of the consequences of shelling.
- Simulation of critical conditions of people for training in first aid.

The models proved suitable for VR scenes, and their ease of generation allowed for quick adaptation to training scenarios.

Collision in Unreal Engine is a system that defines the physical boundaries of a 3D object. It is used to handle collisions with other objects or a character. For example, due to a collision, the player cannot pass through walls, and objects do not pass through each other. In the case of a Static Mesh (static 3D model), the collision can be of two types:

1. Simple Collision (simplified) – usually consists of geometrically simple shapes (Box, Sphere, Capsule), fast and efficient.
2. Complex Collision – uses the geometry of the model itself for collisions. It is more accurate, but less optimised, especially for VR.

How do I create a collision for imported models?

After importing a 3D model into Unreal Engine, you need to check or create a collision manually:

1. Open Static Mesh Editor (double click on the model).
2. In the top menu, click Collision > Add and select the desired type:

- Add Box Collision
- Add Sphere Collision
- Add Capsule Collision
- Add Convex Decomposition

3. In the right Details panel, you can edit the parameters:

- Collision Type (Collision Preset)
- Use Complex as Simple, or Simple only)
- Convex Decomposition Settings: Number of Shells, Accuracy.

4. Click Apply → Save to save the result.

By default, when importing, the model may not have a collision or may have an incorrect one, so it is essential to check each object manually.

In virtual reality, collision is critical to user comfort:

- The player must not pass through walls.
- It is essential to ensure a smooth collision with objects, avoiding "sticking".
- Objects must properly interact with teleportation via NavMesh.

For imported models, a collision was implemented, as shown in the screenshots below (Fig. 45).

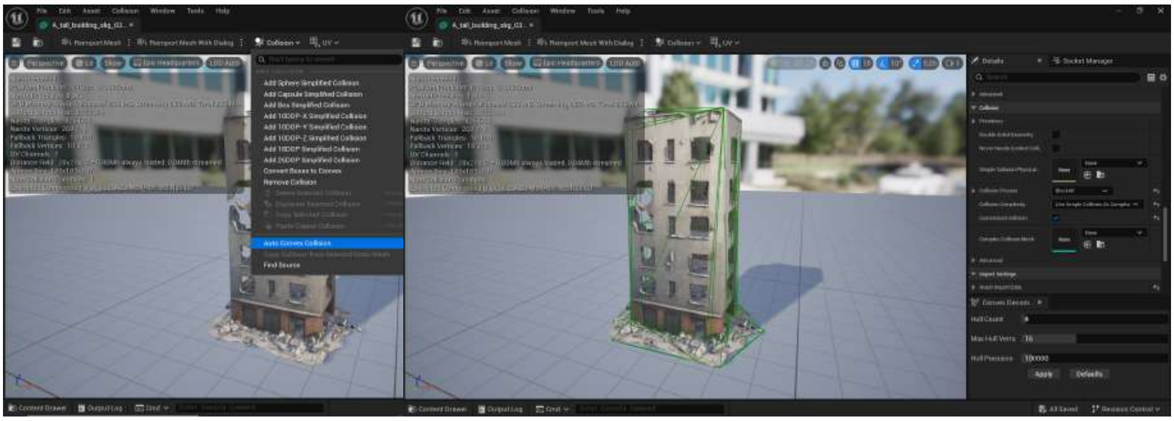

Figure 45: Implementation of collisions for a building object

Smooth Locomotion is a method of moving in VR space that allows users to move smoothly, without teleportation, using analogue controller sticks or keys. This type of navigation allows:

- achieve a more natural movement (similar to traditional first-person games),
- create a deeper immersion in the VR scene,
- provide complete freedom of movement in the virtual world.

However, it should be borne in mind that with improper implementation or too sudden movements, symptoms of VR sickness (dizziness, disorientation) may occur. Therefore, it is essential to implement this feature with consideration for the user's comfort.

According to the guidelines and video instructions, the implementation of Smooth Locomotion in a VR template includes the following steps:

1. Disabling Teleportation: open the character Blueprint (VRPawn or BP_VRCharacter); find and disconnect teleportation nodes; disable SnapTurn if rotation is used.

2. In the Input > Action Mappings, add new actions and assign them the corresponding axes (for example, X/Y from the controller joints).

3. Blueprint Logic: Create Variable and Create events for movement.

4. Class Settings ⟶ set Parent Class as Character and change Auto Possess Player to Player 0.

At the first stage, Smooth Locomotion was implemented according to the video available at: https://www.youtube.com/watch?v=GlctYwY-m2w. Teleportation was enabled, and the 'Teleport' nodes were removed. New Input Actions for movement and rotation were created. The corresponding Blueprint logic was implemented using Add Movement Input, Get Forward Vector and Multiply. However, after starting the project, the character was unable to move, as the movement did not work at all. After that, teleportation was added (previously disabled nodes were activated) and used an alternative technique from the video: https://www.youtube.com/watch?v=VHqtp_R37DU. Result - the character began to move smoothly with the help of the left stick, without breaking control. Teleportation also works, serving as a backup option for movement and providing a comfortable user experience. The scene uses NavMeshBoundsVolume, which allows you to select zones for teleportation (Fig. 46-50). During the work, a topical social theme was chosen – the scene of first aid after a missile strike in a residential area, which made it possible to build a practically significant VR space with educational potential. A library of 3D assets from free and paid sources, including Fab, Sketchfab, and CGTrader, was selected, and generative neural networks (Tripo, Mersy) were used to create unique models of victims and destruction. Implemented:

- Content migrationfrom previous projects using Asset Actions > Migrate function.
- Import 3D models with subsequent adjustment of PBR textures in Material Editor.
- Implementation of physical collisions for imported models.

- Smooth Locomotion – smooth movement using the controller joints, implemented according to the video instructions.

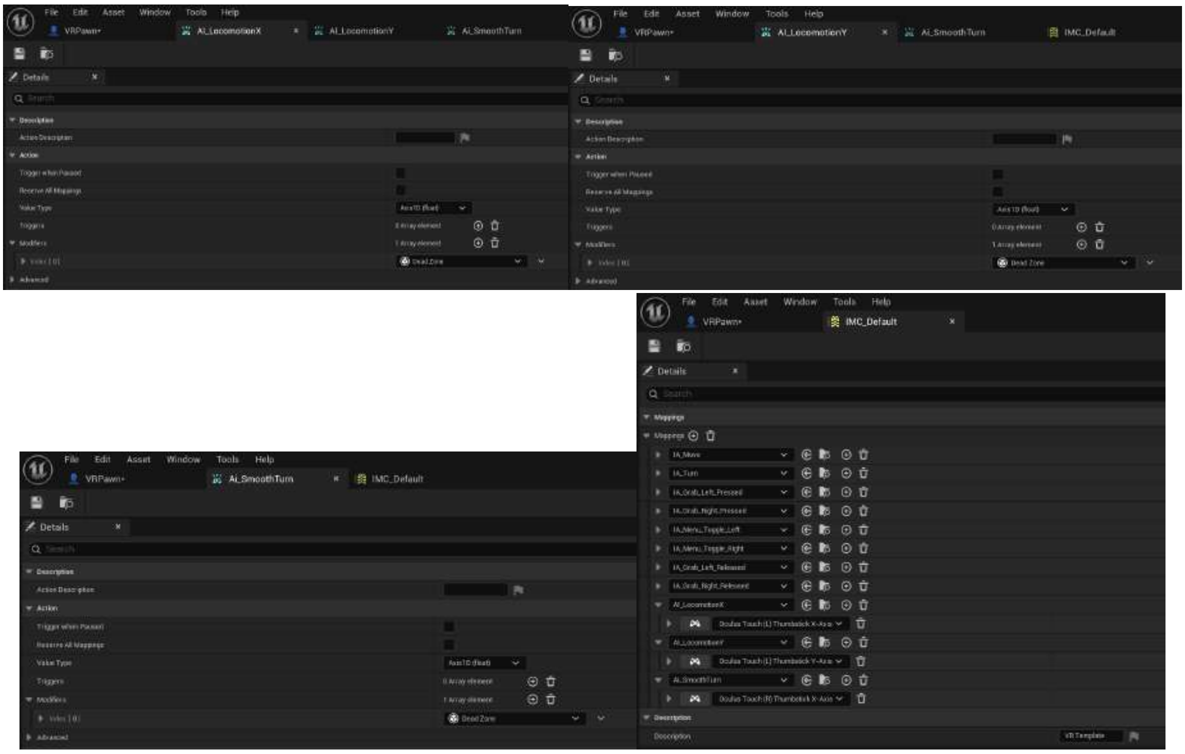

Figure 46: Teleportation Settings

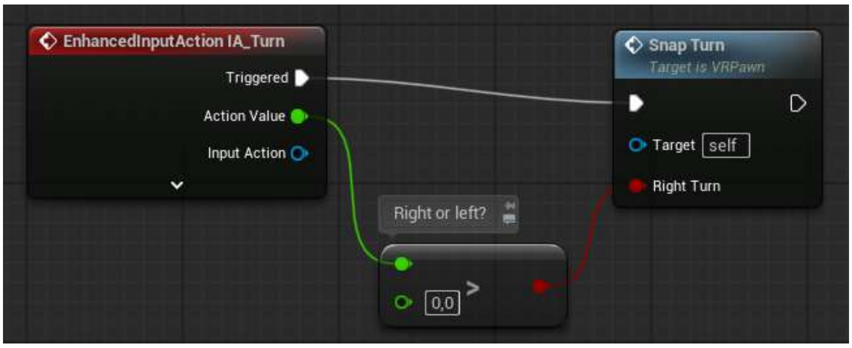

Figure 47: Snap Turn implementation scheme in a VR environment

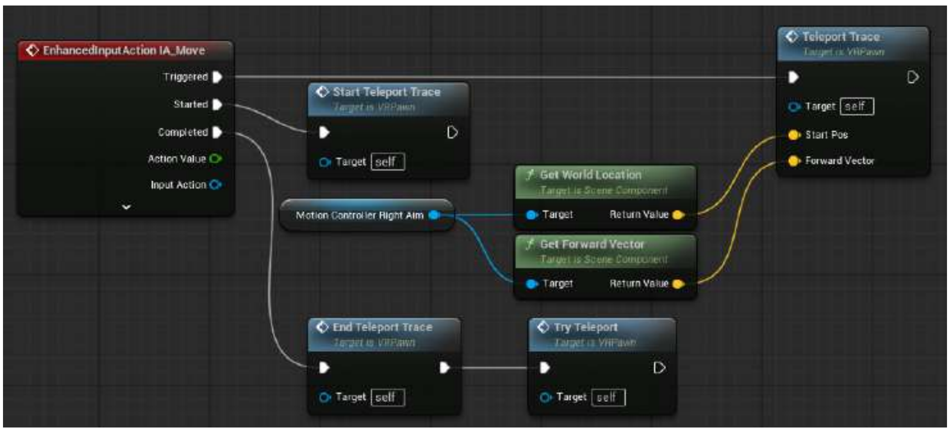

Figure 48: Scheme of implementation of the teleportation system (Teleport) in the VR environment

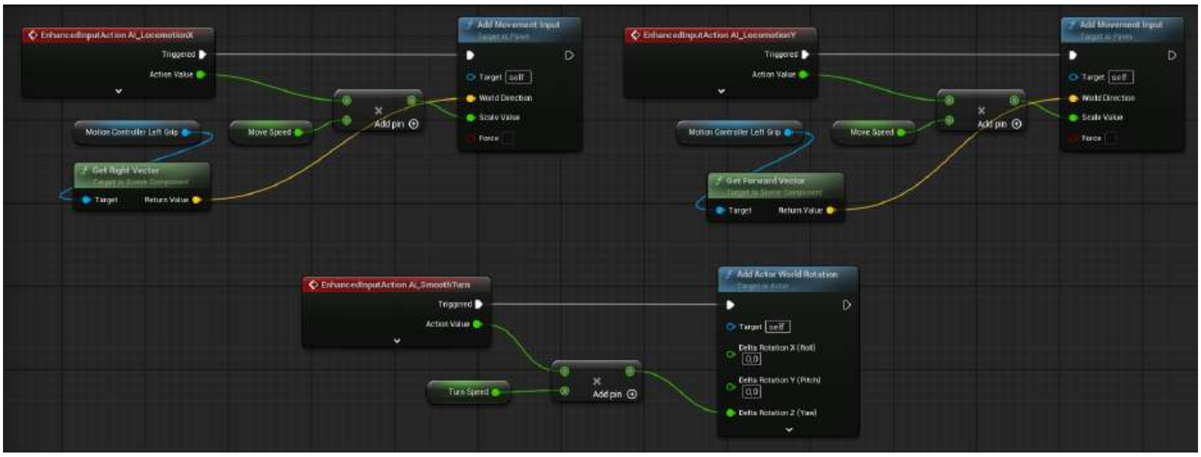

Figure 49: Scheme for implementing Smooth Locomotion in a VR environment

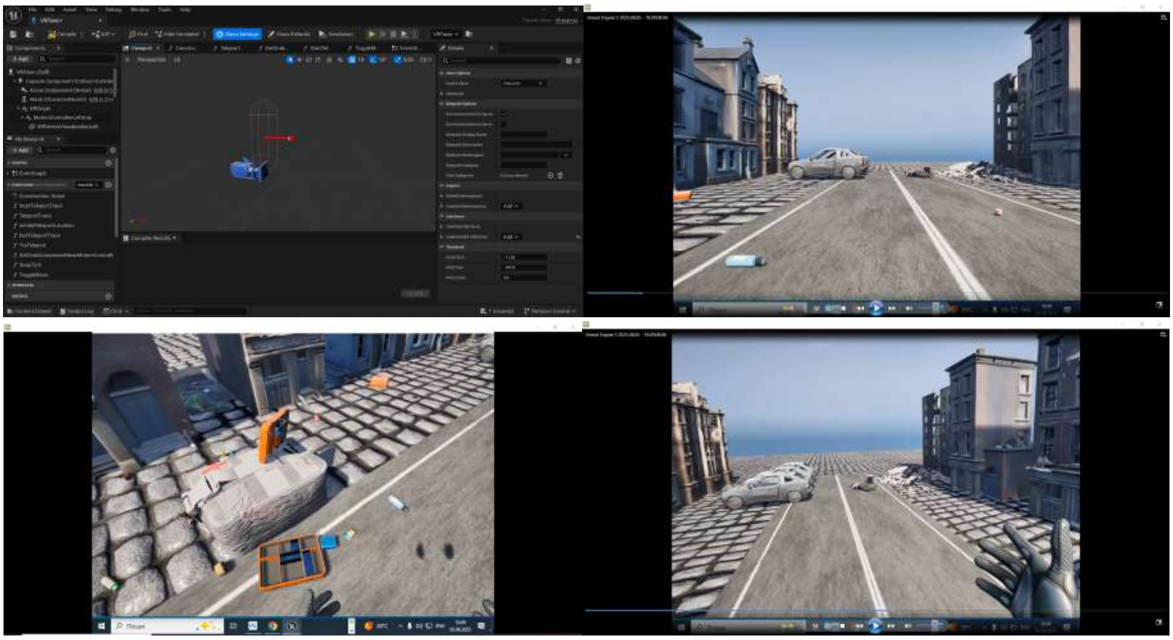

Figure 50: Screenshots from Testing

Particular attention is paid to ensuring the convenience of movement in the VR environment, which is critical for preventing virtual disorientation. An attempt was made to implement movement without teleportation, but a combined approach with teleportation enabled and smooth motion activated proved effective.

The purpose of creating the User Interfaces menu in VR Template is to provide the user with the ability to quickly access auxiliary information, settings, and end the session. The menu is implemented as a UMG menu, part of the virtual reality template, and modified to meet the project's needs (Fig. 51-52).

1. Familiarisation with the UMG template menu. The output menu is located at the path: Content > VRTemplate > Blueprints > WidgetMenu. The project opened the Widget Blueprint of the standard menu, using the Unreal Motion Graphics (UMG) system.

2. The menu has been modified as follows - the basic design of the template menu has been preserved, and two new buttons have been added: Instructions and Settings.

3. Adding the Instructions button. In the Designer section, the InstructionsButton has been added to the vertical block. A Text_Instruction text element is bound to the button, which displays the text of the instructions. The Graph implements logic – when you click on the Instructions button, a message with instructions for the player appears on the screen.

4. Adding the Settings button. Similarly, the SettingsButton was added. An OnClicked event is configured in the Graph that displays the message: The settings menu will be implemented soon.

5. Embedding a modified menu in a VR scene. The menu is connected to the Blueprint Menu, which is responsible for the interaction of the controllers with the UI. It has been verified that when the user presses the menu button on the VR controller, the menu appears in front of them. The menu is not permanently active in the scene; it is called up when necessary by pressing a button. The menu is positioned in front of the player in a convenient field of view, oriented relative to his position.

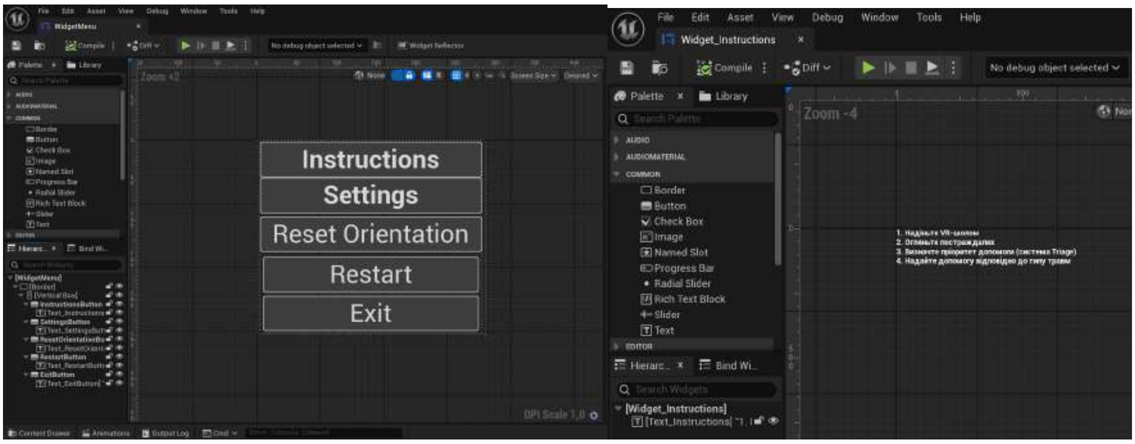

Figure 51: Modified standard VR menu

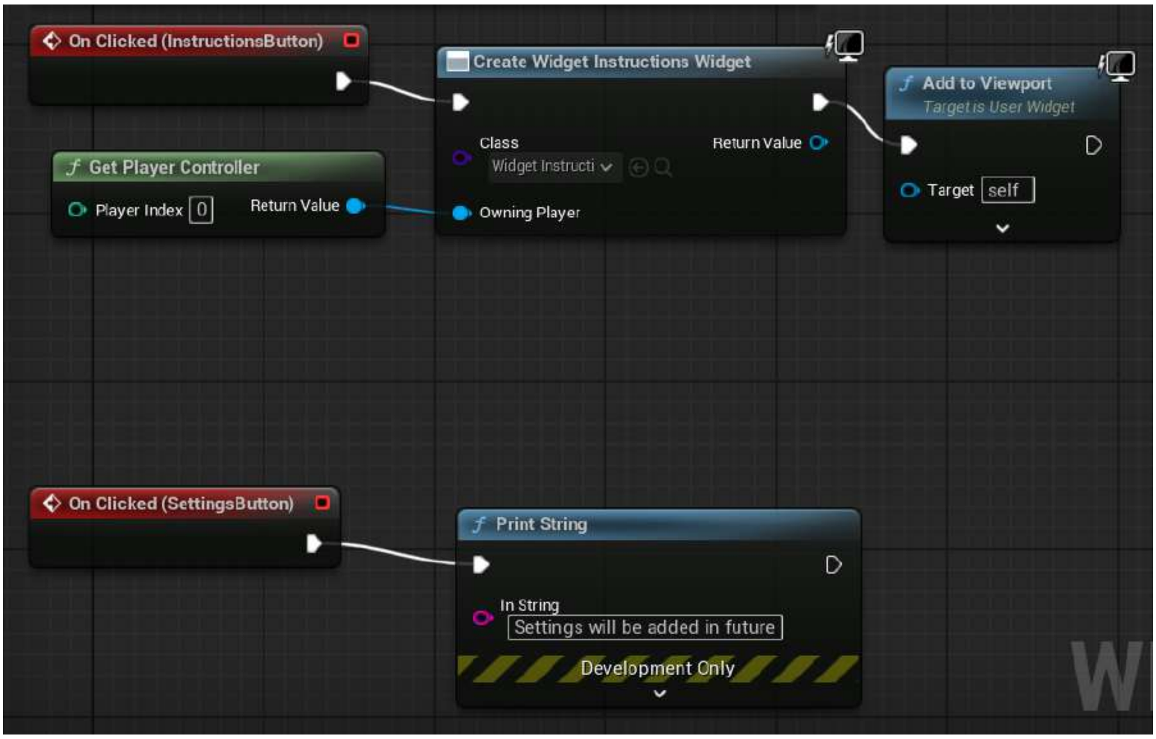

Figure 52: Scheme for the implementation of the "Instructions" and "Settings" buttons of the modified standard VR menu

Video is used as educational content for the user (instructions), and audio adds atmosphere and enhances the effect of presence, reacting to events in the scene (Fig. 53-55).

1. Audio content – two sound effects are implemented:

1.1 Alarm siren. The file has been imported into the project. Added Audio Actor at the scene level. The following parameters are set: Auto Activate (true) and Looping (true). This sound is activated automatically when the simulation starts and repeats continuously, simulating air raid conditions.

1.2 Missile hits. The file has been imported into the project. Added Audio Actor configured to activate with a delay. The sound of the hit is not repeated, but sounds once - creating a dramatic effect.

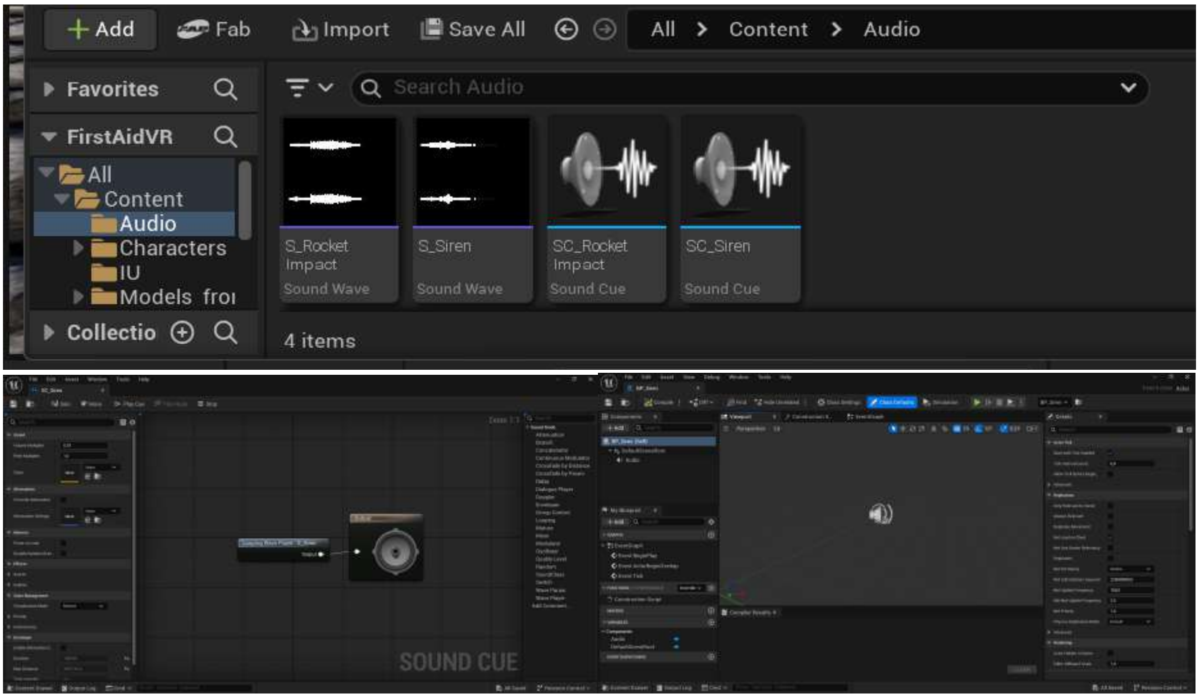

Figure 53: Scheme for the implementation of starting the siren sound

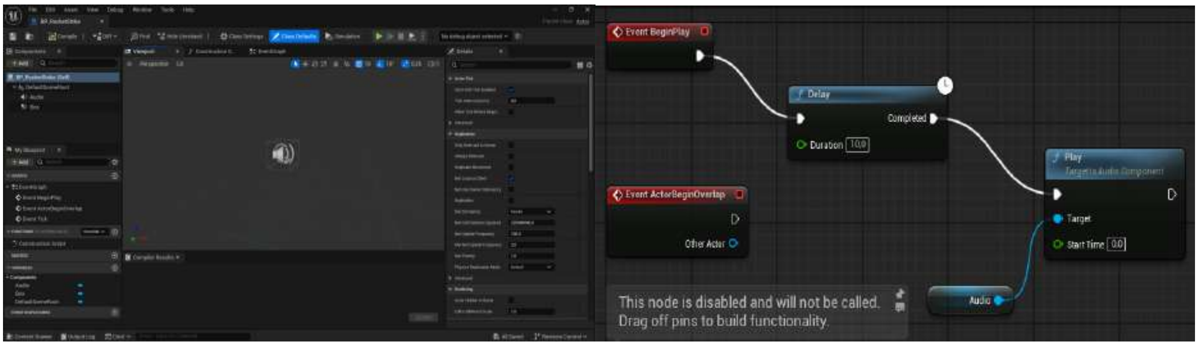

Figure 54: Scheme for the implementation of the launch of the sound of a rocket/mine explosion

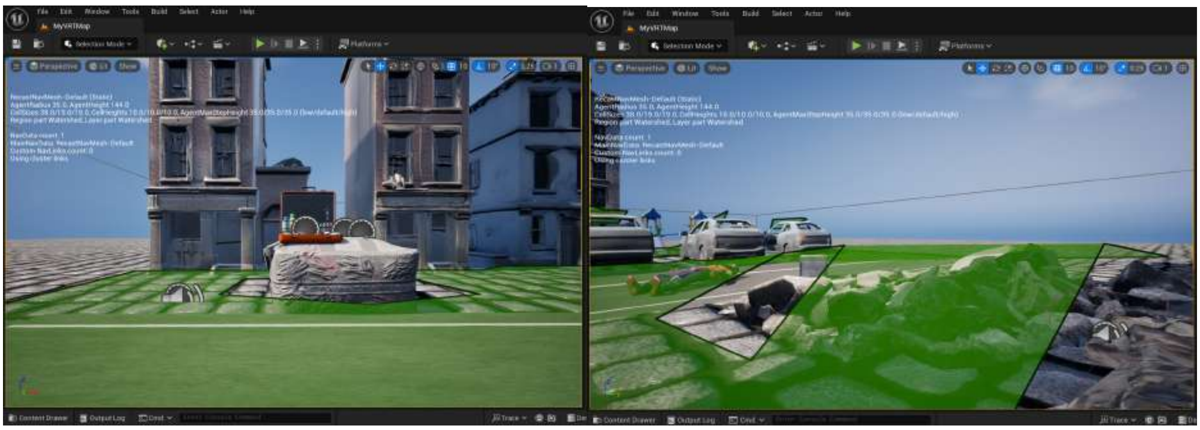

Figure 55: Illustration of the activation of the siren sound (left) and the explosion sound (right)

2. Video content. 5 educational videos have been added to the VR scene (Fig. 56-57):

Table 15
Video content for the project

Video Title	Content
Triage	Victim sorting system into four categories
CPR	CPR for children from 1 to 12 years old
Bleed Stop	Stopping bleeding with a tourniquet
Burn	Processing burns
Panic	Panic Attack Assistance

2.1 Import media files. Video files in .mp4 format have been imported into the project.

2.2 Implementation of the menu for video selection. Five new buttons have been added to the Widget Blueprint menu: Button_Triage, Button_CPR, Button_Bleed, Button_Burns, and Button_Panic. In the Graph tab, OnClicked event handling has been added to each button, which activates the corresponding Media Player:

2.3 Video display in the scene. The stage features a Static Mesh Plane to which footage from the video is applied. The video is displayed as a "screen" within the training site area. It significantly enhances the interactivity and information content of the VR environment, enabling the user not only to act but also to learn in real-time.

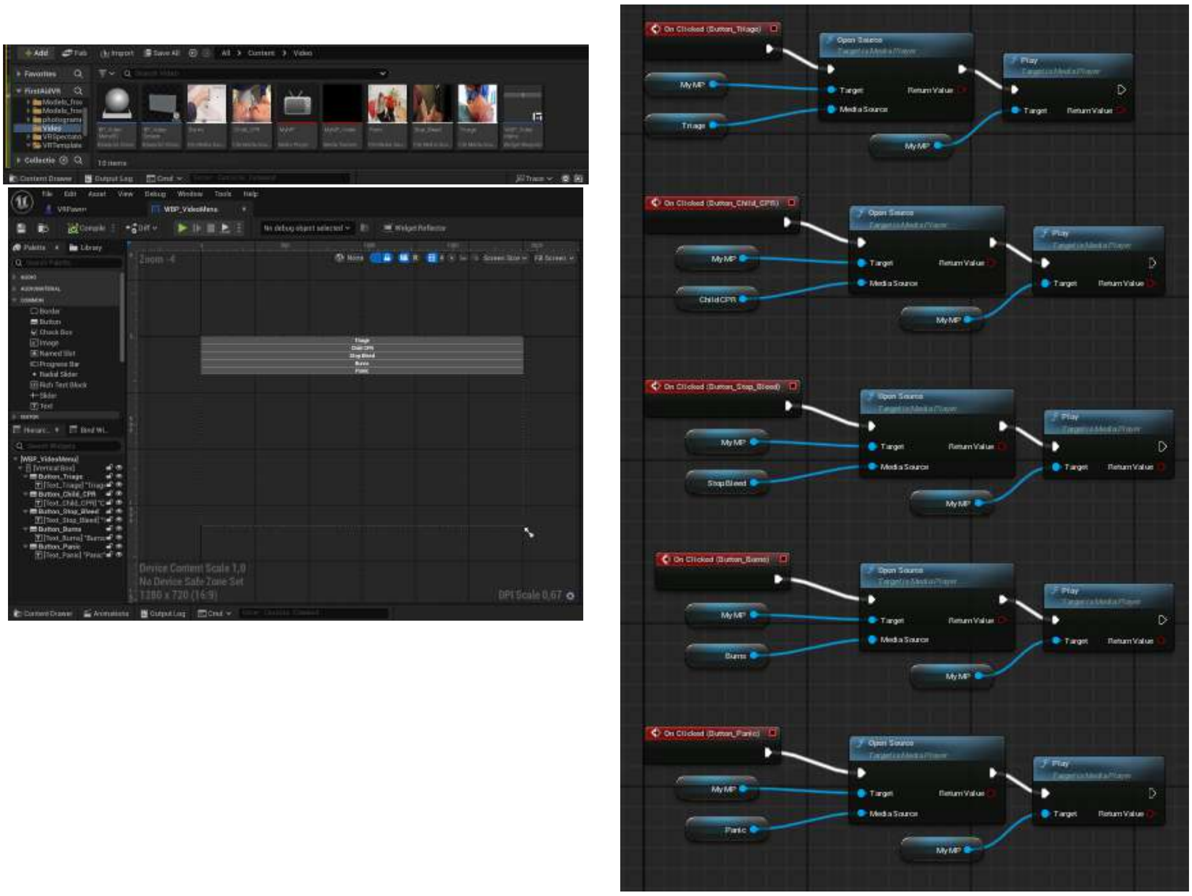

Figure 56: Scheme for the implementation of the display of the educational video

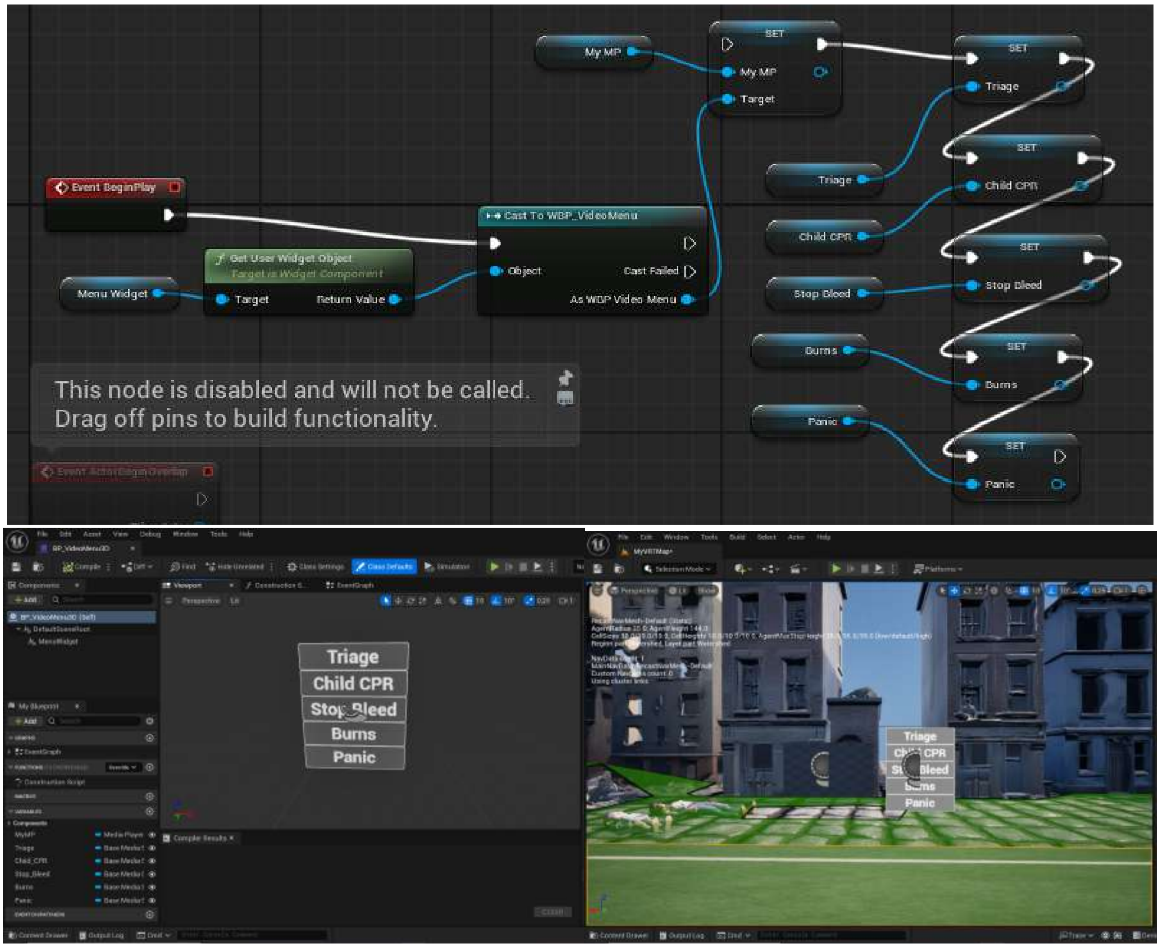

Figure 57: Menu to control the screen for displaying the instructional video

Created your own Blueprint Actor. The following settings are activated in the Static Mesh component: Simulate Physics (true) and Collison Preset (PhysicsActor). Scissors and a tourniquet can now be picked up and used in a VR scene (Fig. 58).

Figure 58: Objects that can be physically captured and used in a scene

The basic VR menu has been modified, with new function buttons that incorporate their own logic (instructions and settings) added. Spatial audio accompaniment (e.g., siren, missile hit) has been implemented, along with added educational video content in the form of a multimedia screen with interactive selection options. An improved object capture system has been introduced, and physics have been adjusted for first aid items, including the harness and scissors. Screenshots from the test are shown in Fig. 59.

Figure 59: Screenshots from testing and 3D models created in RealityScan

A 3D scan of objects of the real environment was carried out – children's swings located on several playgrounds in my city. These objects are chosen because of their characteristic shape, the presence of clear structures (such as supports, seats, and chains), and their ability to be applied in scenes of a gaming or training VR environment. To perform the scan, the following was used:

- Smartphone: Samsung Galaxy A52 (64 MP primary camera)
- Photogrammetry app: RealityScan by Epic Games (Fig. 60).

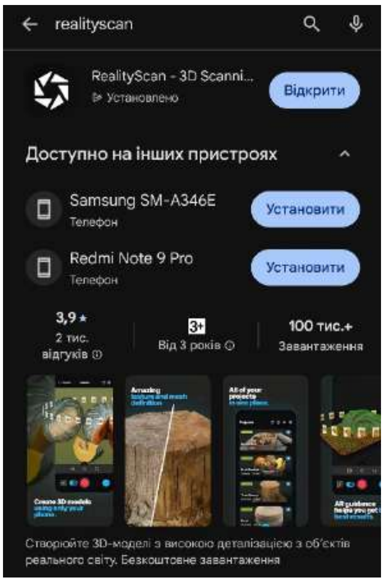

Figure 60: RealityScan by Epic Games

The 3D shooting process was carried out in Camera Control mode, which allows you to independently determine the angles and shooting positions. We walked around the subject in a circle, swinging at different heights. However, instead of the recommended 80-100 frames, we deliberately limited ourselves to a smaller number of photos (about 30-50 per model). The goal was to achieve the effect of incomplete detail and non-critical artefacts during processing, so that the result appears "damaged", as if an explosion had damaged an object. It is essential to clarify that the swing itself was in good technical condition, without visible deformations or breakdowns. However, given the theme of my VR project – the scene of providing first aid in the city after a missile strike, I needed to adapt the 3D models to the appropriate visual style. That is why reducing the number of shots made it possible to get models with a "damaged" appearance — partial mesh distortions, unfilled areas, and inaccuracies in textures that look quite logical in the affected area. Once the shooting was complete, RealityScan automatically processed the image and formed a three-dimensional model. The models were not uploaded to Sketchfab, but exported locally in a .zip format that contained .glb files and their corresponding textures. In the future, we plan to import these models into Unreal Engine, where they will be placed in the scene – specifically, in the destroyed courtyard of a high-rise building near the epicentre of the explosion. In total, dozens of swing models have been created, each of which has individual features of the shape and level of detail. They will be used as part of the statistics in the first aid simulator project. Screenshots of the models are shown below in Fig. 61:

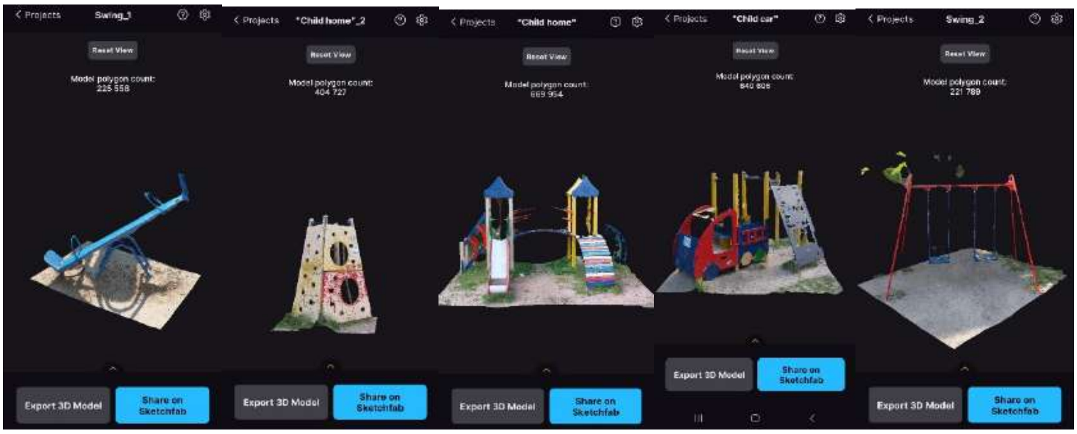

Figure 61: Photogrammetry with a smartphone

7. Discussion

During the experimental validation, the basic concept of a VR/AR simulator for first aid was developed, and scenarios for training (tourniquet application, CPR, and burn assistance) were created. A system of evaluation and gamification (Triage, missions, difficulty levels) is proposed. Graphic content generation (2D sketches, 3D models of the environment and characters) was performed. The potential impact is demonstrated: reduced panic, skill development, and accessibility for various user groups. As a result of the work, a conceptual model of an intelligent VR/AR system for teaching first aid was created. The model includes:

- Training scenarios include tourniquet application, bleeding control, cardiopulmonary resuscitation (CPR), assistance with burns, and actions during mass casualty incidents.
- Interaction mechanics: use of VR controllers, AR overlay on a physical mannequin, and a feedback system.
- Evaluation system: integral metric of the quality of performance of actions Q.

The developed scenarios take into account the conditions of damage to civilian infrastructure after missile strikes. For each scenario, a set of victim states S and a transition function are defined:

$$s_{t+1} = f\left(s_t, a_t, \tau\right). \quad (7)$$

The analysis showed that the timely and correct execution of actions reduces the likelihood of transition to a critical state by 35-40% compared to no intervention.

Figures 62-63 show graphs that visualise the key quantitative results of the study. The graphs visualize the time distribution into the main phases of MVP development (WBS) and the results of the photogrammetry experiment (comparison of input data).

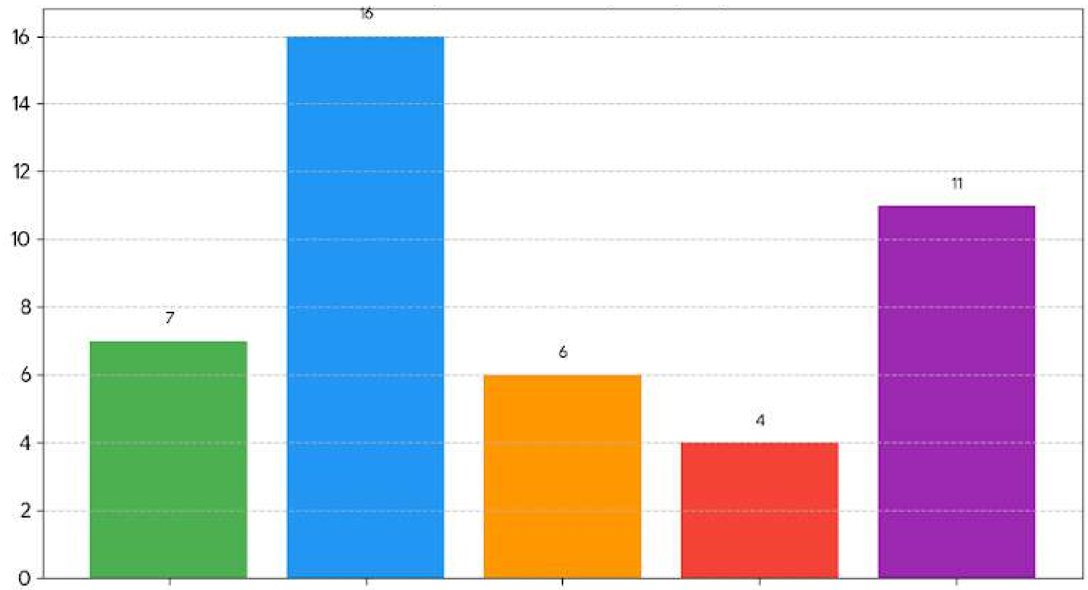

Figure 62: Division of time into MVP development phases, where X is the project phase, Y is the duration (weeks), green is research and planning, blue is MVP development, orange is testing and improvement, red is marketing and promotion, purple is scaling and partnership

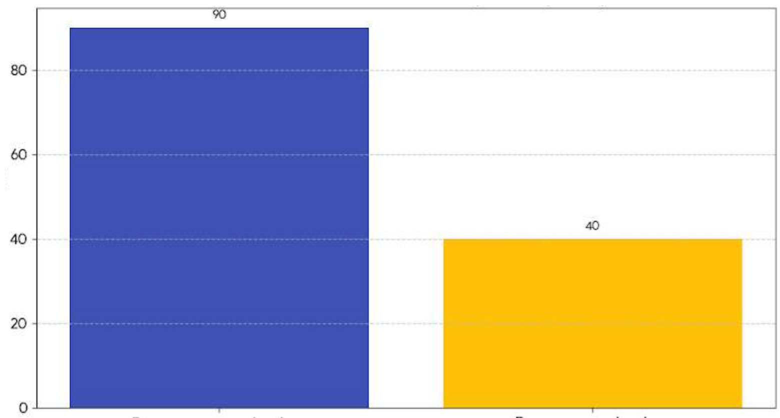

Figure 63: Number of inputs for Photogrammetry (average), where X is the type of input, Y is the amount used, blue is the recommended amount, and yellow is the amount used

According to the results of beta testing (50 participants: students, volunteers, civilians), the average level of success was recorded:

$$P = \frac{N_{correct}}{N_{total}} \cdot 100\%. \tag{8}$$

Obtained values (Fig. 64) are for rourniquet application $P = 87\%$, CPR $P = 78\%$, burns and shock $P = 72\%$. Compared to the control group trained by traditional methods, the results were 20-25% higher. The use of generative models (Stable Diffusion, Trellis3D, Meshy) allowed:

- reduce the time for prototyping training scenes from 2-3 weeks to 2-3 days,

- automate the generation of 3D characters and environments,

to provide a variety of scenarios without a significant increase in costs.

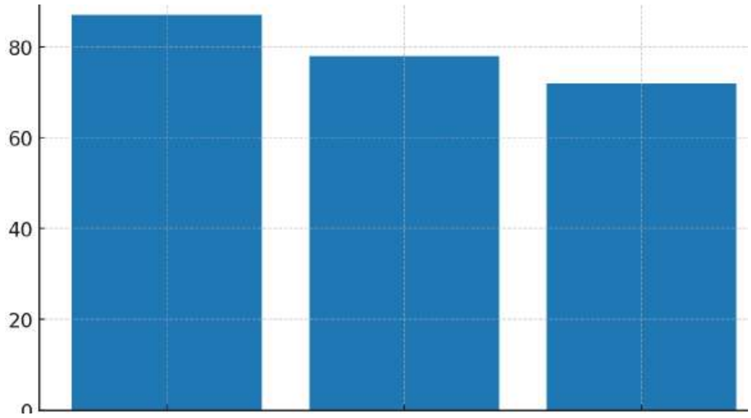

Figure 64: Graph of the level of success P (Y-axis) according to training scenarios (X-axis), where from left to right - jute overlay, CPR, as well as burns and shock

Loss function of the generative model:

$$L = E_{x \sim p_{data}}[|G(z) - x|^2], \quad (9)$$

showed a stable convergence in different text outputs, which guarantees the quality of content for VR/AR environments. Overall assessment of learning effectiveness by the E integral indicator:

$$E = \frac{\sum_{i=1}^{n} w_i \cdot p_i}{\sum_{i=1}^{n} w_i}, \quad (10)$$

where are the indicators of correctness, speed and consistency, showed a value p_i = **0.84** (on a scale from 0 to 1), which indicates the high quality of training. Comparative analysis (Fig. 65): Traditional training (lectures and mannequins: medium $P \approx 60\%$) and VR/AR system (medium). Thus, the use of an intelligent VR/AR system increases the level of readiness for first aid by 30% compared to classical methods.

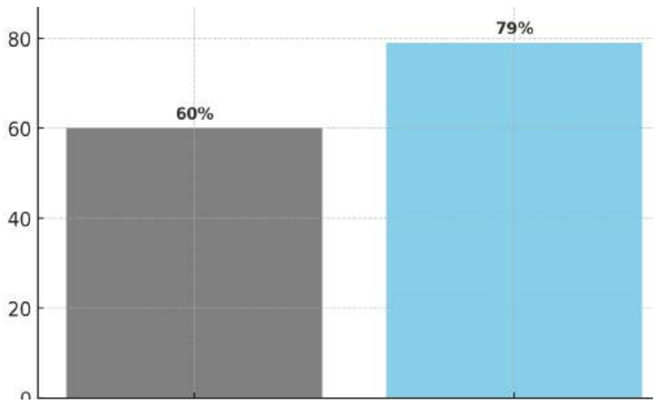

Figure 65: Graph comparing the average performance of P of traditional training with VR/AR, where grey is traditional learning, and blue is VR/AR.

The graph clearly shows that the VR/AR system increases the average level of learning success from ≈60% to ≈79%, that is, by 30%. The results confirm that the VR/AR system can become an effective training tool for civilians, students, volunteers and doctors, and also has the prospect of being implemented in military training.

8. Conclusions

Modern military realities and large-scale attacks on Ukraine's civilian infrastructure create a critical need for rapid and practical training of the population in first aid skills. In the conditions of missile strikes, mine explosions, mass casualties and emergencies, the lives of the victims depend on the correctly performed priority actions. Traditional training methods, based on lectures or the use of mannequins, have limited effectiveness because they fail to replicate the stress factors, dynamics of combat wounds, and realistic scenarios that occur in actual combat. At the same time, the development of virtual and augmented reality (VR/AR) technologies opens up new opportunities for creating interactive learning environments. Intelligent VR/AR simulators enable you to simulate realistic scenarios – from applying a tourniquet to stop bleeding and performing cardiopulmonary resuscitation to assisting victims in states of shock or with burns. Thanks to the integration of gamification, the Triage system and automatic evaluation of user actions, such systems combine the effectiveness of training with safe training conditions, eliminating risks to life. The target audience of such solutions is not only doctors and the military, but also pupils, students, volunteers, and ordinary citizens who must be ready to act in crises. It is also essential that VR/AR systems provide accessibility, allowing learning to be possible anywhere and at any time, even using mobile devices with AR applications. It makes the technology a universal tool for preparing society for the challenges of wartime. As a result, the features of the proposed information technology are as follows:

- VR/AR technologies are an effective tool for teaching first aid in wartime.
- The intelligent system enables you to safely practice skills, develop psychological readiness, and ensure the repeatability of scenarios.
- Generative AI significantly speeds up the creation of educational content.
- The proposed approach can be integrated into the curricula of schools, universities, military academies and community organisations.
- Further research involves scaling the system, expanding scenarios, and certifying the product to medical standards.

Thus, the development of an intelligent VR system for first aid aims to enhance the population's safety level, develop practical skills in crisis conditions, and reduce panic levels during emergencies. This article explores the concept of creating such a system, its key elements, and the potential applications in the fields of education, medicine, and military training.

The materials of our project align with key trends, including a combination of realistic scenarios (urban destruction), integration of the Triage system, gamification, and automatic assessment, as well as the active use of generative AI to accelerate the creation of 2D/3D content. Our empirical results (increased P in VR/AR compared to traditional training, improved tourniquet performance, CPR, etc.) correlate with global findings on the effectiveness of VR/AR and illustrate practical applicability in wartime settings. It makes our work relevant to both the scientific community and practitioners in the field of civilian and military training. Review findings and recommendations for further research:

- To prove transference to real-world settings, in particular, long-term quasi-experiments or RCTs with a focus on behavioural transference of skills in real-world training/interventions are needed.
- Unifying metrics, including the use of a standard set of indicators (P, τ, consistency, correctness, quality of manipulations), will facilitate meta-analyses.

- Optimise the pipeline of generative content, particularly the combination of text-to-3D models (Hunyuan3D, **etc**.) with post-processing stages (LOD, packaging for VR), which will enable you to scale scenarios without compromising performance.
- Combining an AR mannequin and VR scenes, for example, a combined approach (tactile and visual) is promising for skills that require a sense of strength/position.

Declaration on Generative AI

During the preparation of this work, the authors used Grammarly in order to: Grammar and spelling check. Further, the authors used DALL, ChatGPT, KREA, Ideogram, Cabina.Ai (Flux and Leonardo.Ai) for figures 3-16 in order to: Generate images. After using these tools/services, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

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