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Synthetic Data Generation with Unity 3D and Unreal Engine for Construction Hazard Scenarios: A Comparative Analysis

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Extended Abstract: The construction industry, known for its inherent risks and multiple hazards, necessitates effective solutions for hazard identification and mitigation [1]. To address this need, the implementation of machine learning models specializing in object detection has become increasingly important because this technological approach plays a crucial role in augmenting worker safety by proactively recognizing potential dangers on construction sites [2], [3]. However, the challenge in training these models lies in obtaining accurately labeled datasets, as conventional methods require labor-intensive labeling or costly measurements [4]. To circumvent these challenges, synthetic data generation (SDG) has emerged as a key method for creating realistic and diverse training scenarios [5], [6]. The paper reviews the evolution of synthetic data generation tools, highlighting the shift from earlier solutions like Synthpop and Data Synthesizer to advanced game engines [7]. Among the various gaming platforms, Unity 3D and Unreal Engine stand out due to their advanced capabilities in replicating realistic construction hazard environments [8], [9].

Comparing Unity 3D and Unreal Engine is crucial for evaluating their effectiveness in SDG, aiding developers in selecting the appropriate platform for their needs. For this purpose, this paper conducts a comparative analysis of both engines assessing their ability to create high-fidelity interactive environments. To thoroughly evaluate the suitability of these engines for generating synthetic data in construction site simulations, the focus relies on graphical realism, developer-friendliness, and user interaction capabilities. This evaluation considers these key aspects as they are essential for replicating realistic construction sites, ensuring both high visual fidelity and ease of use for developers. Firstly, graphical realism is crucial for training ML models to recognize the nuanced nature of construction environments. In this aspect, Unreal Engine stands out with its superior graphics quality compared to Unity 3D which typically considered to have less graphical prowess [10]. Secondly, developer-friendliness is vital for those generating synthetic data. Research indicates that Unity 3D is praised for its user-friendly interface and the use of C# scripting, which is widely used in educational settings, making it a popular choice for those new to game development or synthetic data generation. Whereas Unreal Engine, while offering powerful capabilities in terms of realistic graphics, is often viewed as more complex due to its use of C++ scripting and the blueprint system. While the blueprint system is a visual scripting tool that does not require traditional coding, it can be intricate and may present a steeper learning curve, especially for those without prior experience in game development [11]. Lastly, regarding user interaction capabilities, Unity 3D is known for its intuitive interface and versatility, particularly in VR/AR development for various skill levels. In contrast, Unreal Engine, with its advanced graphics and blueprint scripting, is better suited for creating high-end, immersive experiences [12].

Based on current insights, this comparative analysis underscores the user-friendly interface and adaptability of Unity 3D, featuring a built-in perception package that facilitates automatic labeling for SDG [13]. This functionality enhances accessibility and simplifies the SDG process for users. Conversely, Unreal Engine is distinguished by its advanced graphics and realistic rendering capabilities. It offers plugins like EasySynth (which does not provide automatic labeling) and NDDS for SDG [14], [15]. The development complexity associated with Unreal Engine presents challenges for novice users,

whereas the more approachable platform of Unity 3D is advantageous for beginners. This research provides an in-depth review of the latest advancements in SDG, shedding light on potential future research and development directions. The study concludes that the integration of such game engines in ML model training markedly enhances hazard recognition and decision-making skills among construction professionals, thereby significantly advancing data acquisition for machine learning in construction safety monitoring.

Key words: Synthetic Data Generation, Unity 3D Game Engine, Unreal Engine, Machine Learning, Comparative analysis, Construction Hazard Scenarios

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