



Article

Integration of 3D Gaussian Splatting and Neural Radiance Fields in Virtual Reality Fire Fighting

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Abstract: Neural radiance fields (NeRFs) and 3D Gaussian splatting have emerged as promising 3D reconstruction techniques recently. However, their application in virtual reality (VR), particularly in firefighting training, remains underexplored. We present an innovative VR firefighting simulation system based on 3D Gaussian Splatting technology. Leveraging these techniques, we successfully reconstruct realistic physical environments. By integrating the Unity3D game engine with head-mounted displays (HMDs), we created and presented immersive virtual fire scenes. Our system incorporates NeRF technology to generate highly realistic models of firefighting equipment. Users can freely navigate and interact with fire within the virtual fire scenarios, enhancing immersion and engagement. Moreover, by utilizing the Photon PUN2 networking framework, our system enables multi-user collaboration on firefighting tasks, improving training effectiveness and fostering teamwork and communication skills. Through experiments and surveys, it is demonstrated that the proposed VR framework enhances user experience and holds promises for improving the effectiveness of firefighting training.

Keywords: neural radiance fields; 3D Gaussian splatting; fire; immersive virtual reality



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1. Introduction

Frequent occurrence of fires poses significant threats to both human lives and property. The causes of fires frequently stem from factors such as a lack of sufficient safety awareness, negligent fire prevention practices, and inadequate familiarity with the proper use of fire extinguishing equipment [1]. Therefore, it is imperative to prioritize enhancing public awareness and implementing comprehensive fire safety training programs. Although fire drills are a prevalent and efficacious approach, they can impose significant demands on resources, necessitating substantial allocations of manpower, materials, and financial assets [2]. Moreover, the creation of realistic fire scenarios for drills can potentially engender safety hazards, while logistical support complexities often impede broader accessibility to such training programs for diverse populations. Consequently, conventional fire drills may inadequately address comprehensive societal needs. To meet these challenges, there is an increasing need for pioneering fire safety education methods that effectively guide individuals to overcome the limitations of traditional drills.

Utilizing virtual reality (VR) technology allows for the recreation of necessary scenarios in a virtual environment, providing users with interactive platforms to engage with characters or objects via interactive devices, facilitating task completion. In industrial production, VR technology is progressively employed for workforce training, process simulation, and quality assurance [3]. However, a significant challenge in these applications

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