A State-Aware, Hierarchical Deep Learning Framework for Automated Visual Glitch Detection in Games

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Abstract

Visual anomalies in video games can degrade user experience and impact overall software quality, highlighting the need for scalable methods within modern quality assurance (QA) pipelines. Manual testing remains resource-intensive and difficult to scale, while existing AI-based approaches often struggle to generalize across diverse rendering styles and gameplay scenarios. This paper presents a hierarchical visual anomaly detection framework that integrates game state information to enhance contextual awareness and detection accuracy. A synthetic data generation pipeline is introduced to create high-fidelity, game-specific training samples that capture the visual characteristics and edge cases of individual titles. Human-in-the-loop mechanisms support the identification of challenging scenarios and the definition of functional test conditions suitable for continuous integration workflows. The system operates continuously during production, enabling real-time detection of rendering anomalies without interfering with gameplay. The proposed framework is evaluated across three commercial game titles, demonstrating its effectiveness and adaptability. It comprises a configurable data generation pipeline, a state-conditioned detection model, and an automated anomaly identification tool, forming a modular and extensible QA solution for interactive software systems.

Keywords: Software Engineering, Deep-Learning, Quality Assurance, Empirical Study, Human-in-the-loop, Video Games

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