



AI-Aided Abnormal Events Detection in Multi-Camera Surveillance Systems

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This paper proposes an abnormal event detection system designed for real-world multi-camera CCTV surveillance applications. Current state-of-the-art systems suffer from limitations imposed by single-camera and computationally predefined or infeasible approaches. Traditional surveillance relies on manual monitoring processes, whereas state-of-the-art systems cannot circumvent problems related to low sensitivity, poor scalability, and inability to generalize to unseen anomaly cases. The proposed solution incorporates deep learning, multi-modal analysis, contextual reasoning, and adaptive learning to deliver a lightweight yet robust anomaly detection framework. It is based on a Multi-Task Temporal Anomaly Detection Network (MT-TADN) that encompasses three key components: the spatial feature extractor EfficientNet-B0, the short-term temporal pattern learner BiLSTM, and the global sequence modeling Transformer encoder. This network was trained on weakly labeled videos for fourteen kinds of anomalies, covering violent, property, and situational events, from the UCF Crime dataset. This work complements the deep model using a multi-modal fusion engine that integrates object, pose, motion, and object tracking information using weighted decision fusion to address ambiguous scenarios and reduce false positives. Reinforcement learning has been used with human operator feedback to adaptively adjust decision thresholds continuously during deployment. Empirical evaluation yields high accuracy with improved class sensitivity, especially for rare events, and strong real-world robustness across varying lighting, motion, and camera angle conditions. The system reliably processes multiple synchronized camera streams with low latency and provides contextualized alerts suitable for practical security applications. Overall, the results demonstrate that hybrid deep learning combined with multi-modal fusion and adaptive thresholding significantly enhances anomaly detection reliability, making this approach suitable for smart surveillance, public safety monitoring, and real-time operational environments.

Keywords: Abnormal events detection, CCTV surveillance, Deep learning, Multi-camera systems, Online AI