

Cyber-Physical Framework for Real-Time Chemical Spill Detection and Evacuation Routing

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Abstract: The increasing risks associated with chemical spills in industrial zones, transportation systems, and storage facilities demand rapid detection and efficient emergency response mechanisms. This study proposes a cyber-physical framework designed for real-time chemical spill detection and dynamic evacuation routing. The framework integrates environmental sensors, Internet of Things communication networks, and intelligent decision-making algorithms to monitor hazardous chemical concentrations continuously. The system processes sensor data using advanced filtering and threshold-based detection methods to identify spill events promptly.

Once a spill is detected, an adaptive evacuation routing algorithm calculates safe and optimal escape routes by considering real-time hazard distribution and environmental conditions. Simulation results demonstrate that the proposed framework significantly improves detection accuracy, reduces response time, and enhances evacuation efficiency compared to conventional monitoring and routing systems. The framework offers a scalable and reliable solution for improving public safety and disaster management in chemical hazard-prone environments..

Keywords: Cyber-Physical Systems, Real-Time Monitoring, Evacuation Routing