?Development of an FDS-Grounded Risk-Aware Evacuation Route Design and Visualization System for Incident Support

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This study developed a dynamic evacuation route guidance system that reflects time-varying fire risk by integrating Fire Dynamics Simulator (FDS)-grounded prediction models with the A* pathfinding algorithm. Conventional static evacuation systems, such as fixed exit signs, provide unchanging directional guidance regardless of fire progression, which may lead evacuees toward hazardous areas. To overcome this limitation, we proposed an end-to-end system comprising four stages: (1) automated building structure recognition from architectural floor plans using an OpenCV-based image-processing pipeline, (2) fire and toxic-gas spread prediction using a lightweight model trained against FDS-derived data, (3) dynamic optimal evacuation route search incorporating time-varying risk into the A* cost function, and (4) real-time visualization through a low-cost Raspberry Pi-based display panel. In the extended system, the routing layer also supports multi-floor connector-aware hazard transfer and sensor-adjustable risk updates so that routes can be recomputed when floor-side observations indicate changing spread behavior. The OpenCV pipeline achieved structural recognition accuracy of IoU 0.90, precision 0.92, and recall 0.89. Additional validation expanded the original study with a truth-backed evaluation pack of 12 selected cases across 10 corpora and a bounded multi-floor validation set covering 10 engineered cross-floor cases, 10 temporal distribution cases, and 3 sensor-feedback cases, including a five-stage office reroute demonstration with two route switches. These results show that the proposed system can improve evacuation guidance by prioritizing cumulative hazard-exposure reduction over shortest distance while remaining practical for low-cost deployment.

Awards Won:
Association for the Advancement of Artificial Intelligence: AAAI Student Memberships for each finalist that is part of the 1st, 2nd, and 3rd Prize Winning projects and 5 Honorable Mention winning projects (up to 3 students per project) (in-kind award / part of the 1st-3rd prize)