THEME-BASED RESEARCH SCHEME
PUBLIC SYMPOSIUM 2024
主題研究計劃研討會

SureFire: Smart Urban Resilience and Firefighting

1. Smart Computer Vision for Fire Hazard Quantification

Motivation

- Early detection reduces fire spread and damage.
- Fire quantification help protect lives and property.
- Current methods have limitations (Fig. 1).

Fig. 1-1. Traditional fire detection methods

Objectives

❖CV-based fire detection, measurement, and calorimetry.

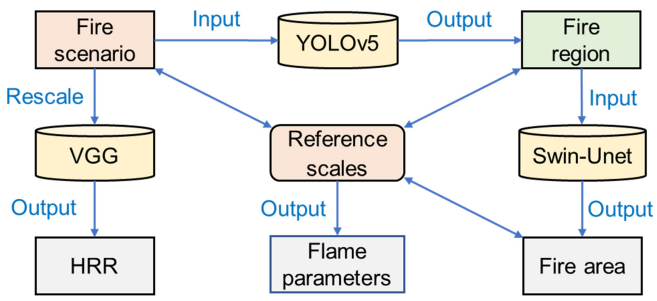

Fig. 1-2. Framework of CV-based fire hazard quantification.

Demonstration

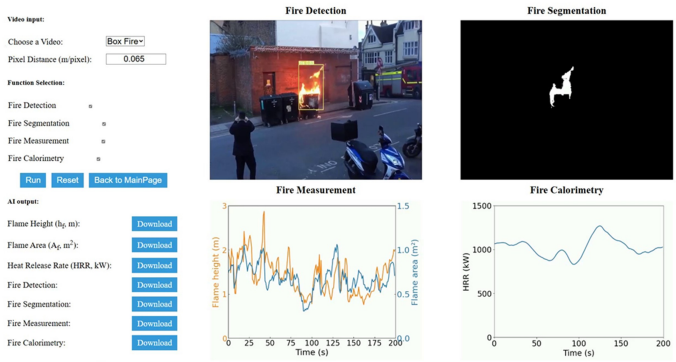

Fig. 1-3. The results of fire hazard quantification

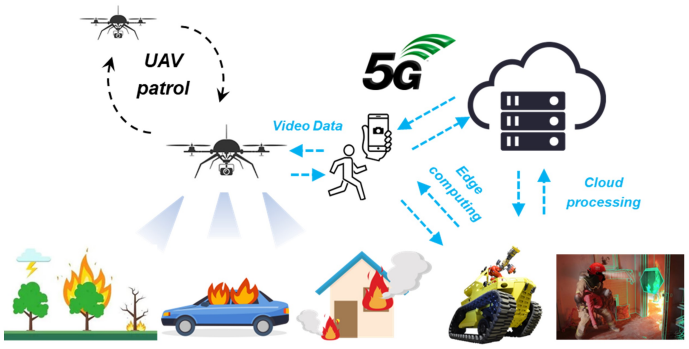

Fig. 1-4. Fire hazard quantification for smart firefighting

[1] Wang et al. (2023) P Combust Inst, 39: 4115-23.
[2] Wang et al. (2024) Applied Intelligence, 54: 1047-62.
[3] Wang et al. (2023) Fire Safety Journal, 140: 103891.

2. AI Forecast of Critical Fire Events

Motivation

- Importance of real-time prediction for critical fire events
- Recognition of flashover and backdraft risks for safe firefighting decisions.
- Difficulty in predicting complex critical fire events using explicit formulas.

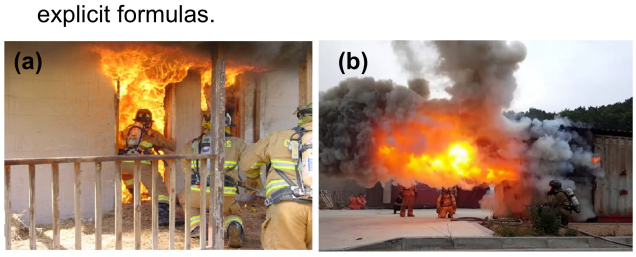

Fig. 2-1. Critical fire events, (a) flashover and (b) backdraft

Objectives

❖AI-based critical fire event forecast with real-time data.

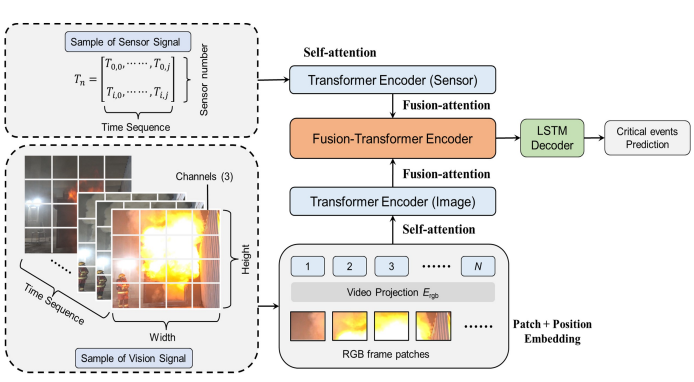

Fig. 2-2. Framework of the AI-based critical fire event prediction method

Demonstration

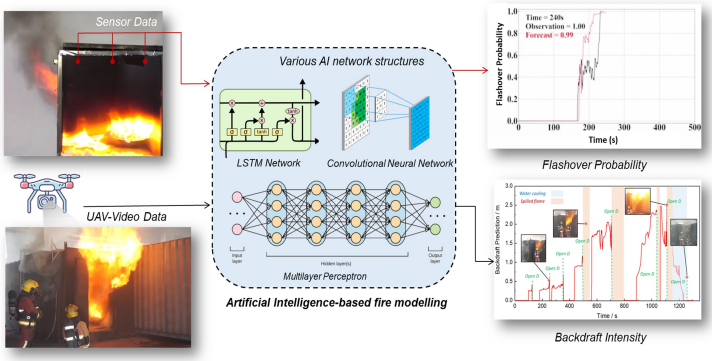

Fig. 2-3. Demonstration of the fire forecast with multiple-scale tests

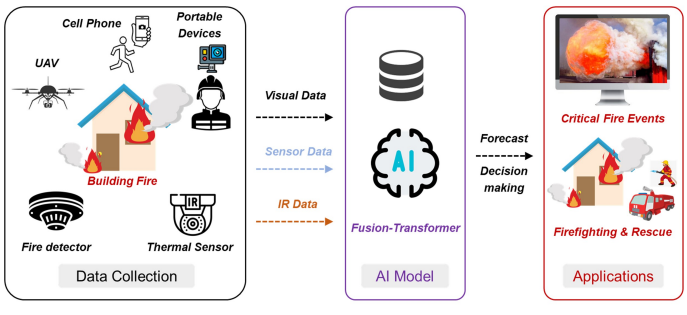

Fig. 2-4. Application of the framework in smart firefighting

[1] Zhang et al. (2022) Fire Saf. J., 130: 103579.
[2] Zhang et al. (2024) Eng. Appl. Artif. Intell., 132: 107939.
[3] Khan et al. (2022) Int. J. Disaster Risk Reduction, 83, 103412.
[4] Wu et al. (2021) Fire Technology, 57(2), 657-682
[5] Khan et al. (2023), Process Saf Environ Prot, 177, 1294-1306.

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3. AI Powered Fire Safety Design

Current fire safety design process suffers from **time-consuming** and **computational-expensive** analysis of fire-smoke behaviours, as well as **intensive workloads** and **inevitable human errors** due to manual preparation of the engineering drawings.

With AI method, computational time of performance-based fire analysis can be reduced **from days to seconds**, and time for fire service system designs can **be reduced by 76%.**

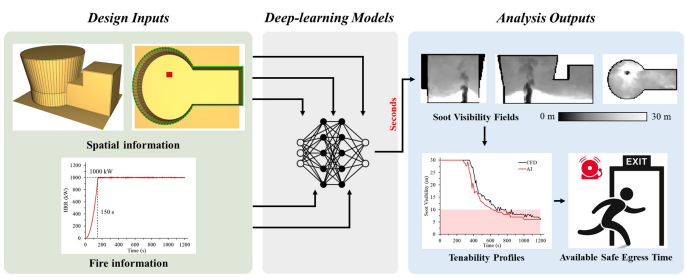

Fig. 3-2. AI-driven smoke flow analysis.

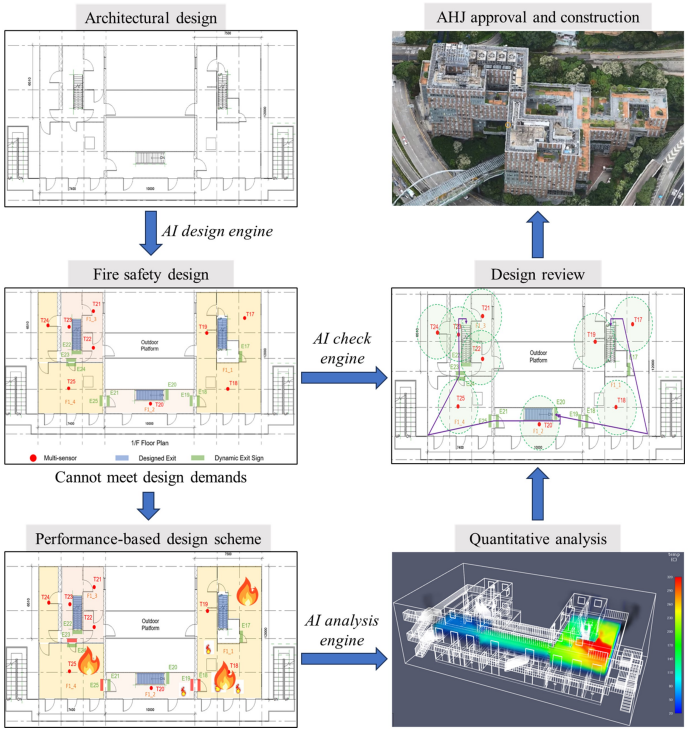

Fig. 3-1. Framework of AI-powered fire safety design.

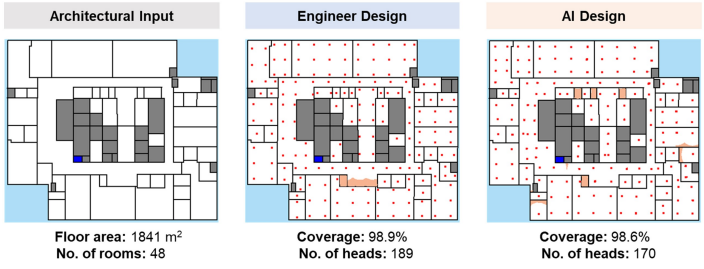

Fig. 3-3. AI-generated fire sprinkler layout drawing.

[1] Zeng et al. (2024) J. Comp Design Eng. 11(3): 359–373.
[2] Zeng et al. (2023) J. Building Eng., 107858.
[3] Zeng et al. (2022) Case Studies in Thermal Eng., 102483.
[4] Su et al. (2021) J. Building Eng., 43, 102529.

4. Intelligent Digital Twin For Building Fire Management

Effective fire safety management are essential to minimize fire hazard. Emerging technologies like **Artificial Intelligence of Things (AIoT)** and **Digital Twin** are promised that is widely used in the near future to improve fire safety.

Four Layers in Intelligent Digital Twin system

1. **Sensing Layer** for data collection from physical environment;
2. **Network Layer** for signal transmission of different layers;
3. **Virtual Layer** for data management and functional realization;
4. **User Layer** for delivering services to end users.

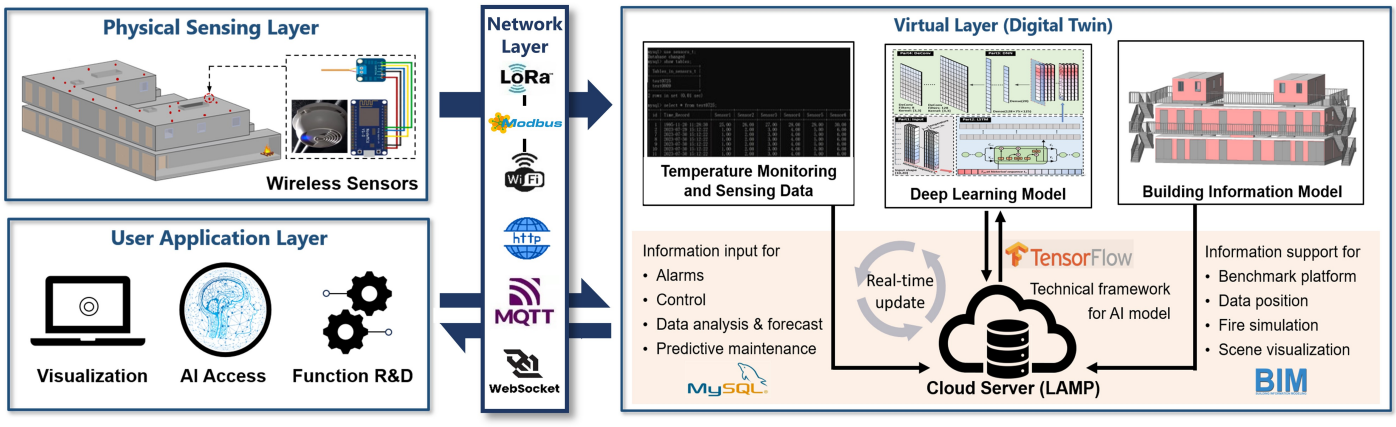

Fig. 1. Schematic of AIoT-powered intelligent digital twin for building fire management.

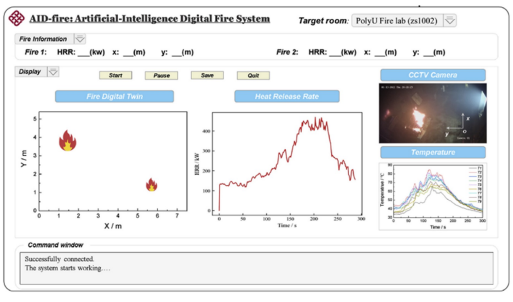

Fig. 2. Artificial-Intelligence Digital Fire System

Fig. 3. Smart Tunnel Fire Digital Twin System

[1] Zhang et al. (2024), Safety Science, 106563.
[2] Zhang et al. (2024) Develop Built Environment, 100381.
[3] Jiang et al. (2023), Advanced Eng. Informatics, 56, 101951.
[4] Zhang et al. (2022) J Building Engineering, 62, 105363
[5] Wu et al. (2022) Tunnelling and Underground Space Tech, 104301.