Chapter 9
A Python-Based AIoT Simulation Platform for Multi-Parameter Construction Safety Monitoring:
An Educational and Research Tool

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ABSTRACT

Construction sites face critical safety challenges from environmental hazards, structural risks, and PPE non-compliance, yet traditional manual monitoring remains inefficient and error-prone. This paper presents a Python-based Smart Construction Monitoring Simulator demonstrating AIoT principles for comprehensive safety management without physical infrastructure. The simulator integrates six modules: sensor data simulation (temperature, humidity, structural strain, PPE compliance),

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MQTT communication, threshold analytics, real-time visualization, intelligent alerting, and logging. Systematic validation demonstrates 94.12% detection accuracy, 96.3% environmental alert precision, and stable 72-hour operation processing 259,000 data points. The modular architecture enables rapid prototyping and serves as an educational platform, demonstrating that simulation effectively replicates real-world AIoT workflows while supporting machine learning, cloud integration, and robotic extensions.

1. INTRODUCTION

1.1 Background and Motivation

Hong Kong is synonymous with prosperity and economic dynamism, manifested through its continuous urban development and extensive construction activities. The territory's limited land area juxtaposed with high population density necessitates vertical expansion and sophisticated infrastructure projects (Development Bureau Hong Kong, 2024), driving an exceptionally active construction sector. However, this economic vitality comes at a significant human cost. According to the Hong Kong Labour Department's 2024 statistics, the construction industry recorded 3,097 industrial accidents in 2023, maintaining the highest accident rate among all sectors at 27.6 per 1,000 workers; nearly double the all-industry average of 12.3 per 1,000 workers (Hong Kong Labour Department, 2024). These figures represent not merely statistics but individual tragedies affecting workers and their families, highlighting the urgent need for enhanced safety measures.

The nature of construction work inherently involves multiple hazards: working at heights, operating heavy machinery, exposure to extreme environmental conditions, and complex coordination among numerous workers and subcontractors. Traditional safety management approaches rely heavily on human inspectors who conduct periodic site assessments, enforce PPE compliance through visual observation, and respond to incidents after they occur. However, human-based monitoring suffers from fundamental limitations. Inspectors cannot be omnipresent; they experience fatigue, may overlook subtle hazards, and their effectiveness varies with experience and attentiveness. Moreover, the reactive nature of traditional approaches means that interventions typically occur after hazardous conditions have developed rather than before accidents manifest.