Chapter 3
An Integrated System for Real-Time Safety Helmet Monitoring and Advanced Environmental Prediction

Qizheng Zhu
https://orcid.org/0009-0008-8863-6180
The Hong Kong Polytechnic University, Hong Kong

Changyu Zhang
The Hong Kong Polytechnic University, Hong Kong

Zhenming Xu
The Hong Kong Polytechnic University, Hong Kong

Qinyan Wang
The Hong Kong Polytechnic University, Hong Kong

Haoting Wan
The Hong Kong Polytechnic University, Hong Kong

Aquil Mirza Mohammed
The Hong Kong Polytechnic University, Hong Kong & School of Low-Altitude Digital Intelligence, Liaoning Technical University, Huludao, China

Cong Wu
Liaoning Technical University, Huludao, China

ABSTRACT

The current automatic safety helmet detection system does not include real-time environmental data such as temperature, humidity and wind speed. This information is very important for a comprehensive assessment of the risks at the work site. This study aims to combine real-time helmet compliance monitoring with an advanced environmental forecasting framework. It solves the limitations of traditional methods, which rely on manual supervision and do not include environmental data. We

DOI: 10.4018/979-8-3373-9245-5.ch003

have created a complete cycle from monitoring to warning, using a module design connected through Internet of Things communication. It includes reliable data transmission, dynamic visualization, multi-level alerts, environmental assessment and security storage. The environmental prediction part uses wavelet decomposition to clean up noise sensor data, uses long- and short-term memory (LSTM) networks for accurate time series prediction, and Gaussian process regression (GPR) to provide probability prediction and measurement uncertainty.

1. INTRODUCTION

Real-time monitoring systems and predictive environmental analysis are changing the safety management of construction and other industries. In these places, it is essential to ensure the safety of workers' lives. This means ensuring that they wear protective equipment such as helmets and accurately predict environmental conditions such as temperature, humidity and wind speed. These environmental factors will affect the safety of workers and structural safety.

However, the current security methods still rely heavily on manual inspection or simple automatic detection. These may be inefficient, error-prone, and difficult to expand. Computer vision systems for helmet detection have taken a step forward, but they usually only focus on people and do not include real-time environmental data. Sudden changes in temperature, humidity or wind may increase the risk of accidents, and even wearing helmets can put people and buildings at risk.

In addition, common environmental prediction models are often related to real sensor data, which may be noisy and nonlinear. This leads to unreliable forecasts and incomplete risk assessment. Many systems also lack powerful real-time communication, clear visualization, fast alerts and reliable data storage. This limits their usefulness in active security management.

This study aims to solve these problems by building a comprehensive system. It combines real-time helmet compliance monitoring with an advanced environmental forecasting framework. Environmental forecasting mainly depends on the LSTM network. In order to improve data quality, wavelet decomposition is used to reduce noise, and Gaussian process regression is used for probability prediction and uncertainty measurement.

2. BACKGROUND AND LITERATURE REVIEW

In order to obtain real-time and continuous building structure data and surrounding environment data. Structural health monitoring system (SHM) has been widely

Real-Time AIoT-Based Fatigue Detection System for Enhancing Worker Well-Being and Learning Efficiency

Mengjia Long, Ka Ni Lo, Lin Peng, Aquil Mirza Mohammedand Cong Wu (2026). *Intelligent Construction Monitoring Systems: Real-Time Safety, Environmental Prediction, and Risk Management (pp. 103-132).*
www.irma-international.org/chapter/real-time-aiot-based-fatigue-detection-system-for-enhancing-worker-well-being-and-learning-efficiency/401479