College of Design, Construction and Planning

UF DCP Research Agenda-Setting White Paper

AI-Enabled Safety Management in Construction (SMART EYES)

Executive Summary:

The construction industry remains one of the most hazardous work sectors worldwide, facing persistent safety challenges such as high rates of worker injuries and fatalities. Traditional safety protocols often rely on reactive measures, which can be insufficient to address the dynamic nature of construction sites. Recent advances in Artificial Intelligence (AI), Internet of Things (IoT), and collaborative robotics present a transformative opportunity to predict and mitigate risks in real time.

This white paper introduces a research agenda for the development of "SMART EYES," an AI-enabled, networked system of compact collaborative robots (cobots) and sensors that continuously monitor environmental conditions, worker behaviors, and equipment operations. By integrating multi-modal data sources—ranging from Building Information Modeling (BIM) to inspection drones—SMART EYES delivers proactive alerts, predictive analytics, and data-driven decision support. The system aims to reduce incident rates, enhance regulatory compliance, and improve worker well-being through real-time risk mapping and responsive safety interventions.

We outline the key research directions including the development of risk analysis models, multi-agent data integration, and ethical considerations. This agenda places a particular emphasis on user training and the creation of policies that address data privacy and fairness in AI. Through pilot implementations, performance assessments, and ongoing refinement, SMART EYES aspires to significantly lower the human and economic costs associated with construction-related incidents, ultimately contributing to a safer and more efficient built environment.

WG Members:

Name/ Title	Affiliation	Academia / Industry / Government
Lead: Idris Jeelani	Rinker School of Construction Management, UF	Academia
Members: Masoud Gheisari	Rinker School of Construction Management, UF	Academia
Members: Aaron Costin	Rinker School of Construction Management, UF	Academia
Members: Jahidul Islam	Department of ECE, UF	Academia

Description of the Problem

- The construction industry incurs over 1,000 fatalities annually in the U.S., accounting for 20.7% of workplace deaths, plus more than 200,000 severe injuries. Globally, a construction worker is lost approximately every nine minutes to work- related causes.
- Unsafe work practices contribute to ~90% of workplace injuries, underscoring the necessity for proactive, real-time safety monitoring rather than traditional reactive protocols.
- Economic losses from safety incidents exceed $11 billion in direct costs alone, not accounting for indirect expenses like lost productivity and increased insurance premiums.

Key Research Areas / Priorities

1. **AI-Driven Risk Identification:** Develop machine learning algorithms capable of synthesizing data from BIM, stationary sensors, drones, and wearable cobots to predict and prevent accidents.

2. **Real-Time Data Integration:** Implement multi-agent, multi-modal sensor networks that can share information seamlessly and produce an up-to-date, site-wide risk map.
3. **Proactive Intervention and Alerts:** Employ wearables and communication tools for immediate hazard notifications to workers and supervisors, enabling swift preventive actions.
4. **Ethical, Legal, and Regulatory Frameworks:** Investigate data privacy, bias prevention, and compliance with relevant regulations, ensuring transparent and fair use of AI insights.

Primary Research Question

1. How can AI algorithms effectively fuse real-time data from multiple onsite sources for accurate and predictive risk identification?
2. What are the best strategies for integrating wearable cobots into existing safety protocols and daily construction workflows?
3. How can ethical and privacy considerations be embedded in system design, ensuring that worker data is protected and used responsibly?

Solutions and Methodological Considerations

The HBE initiative encourages innovative ideas for implementing novel networking

- **SMART EYES System Design:**
    - Compact collaborative robots (“cobots”) mounted on workers or assets, equipped with sensors (e.g., cameras, IMUs, volatile detectors).
    - Continuous monitoring of environmental conditions, worker biometrics, and potential hazards like fall risks and heavy equipment movement.
    - Instantaneous communication of alerts and data to a centralized command center, enabling proactive safety responses.
- **Risk Modeling and Predictive Analytics:**
    - Use of CNNs for image-based hazard detection and RNNs/LSTM models for predictive analysis of time-series data.
    - Integration of drone and stationary sensor data into a unified real-time risk map.
- **Pilot Testing and Implementation:**

  - Structured pilot programs on diverse construction sites to evaluate system performance, user acceptance, and overall impact on incident reduction.
  - Performance metrics include incident rate reduction, accuracy of hazard detection, and user adoption rates.
- **Ethical and Regulatory Compliance:**
  - Clear data governance policies for anonymizing personal data and obtaining informed consent.
  - Mechanisms to safeguard against algorithmic biases, plus human oversight to validate AI-driven recommendations.

WG's Strengths, Weaknesses, Opportunities, and Challenges:

Strengths	• Strong multidisciplinary expertise in AI, robotics, Human Factors and IoT. • Established connections with construction industry stakeholders.	• High upfront costs for system development and deployment. • Limited availability of labeled datasets for AI model training.	**Weakness**
Opportunities	• Growing industry adoption of Industry 4.0 solutions. • Potential for significant reduction in workplace injuries and fatalities.	• Regulatory uncertainties and evolving standards for AI in construction. • Ensuring worker acceptance and addressing privacy concerns.	**Challenges**

References

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[4] Waehrer, G. M., et al. (2007). "Costs of occupational injuries in construction in the United States." Accident Analysis & Prevention, 39(6), 1258-1266.