Scene Understanding and Predictive Monitoring for Safe Human-Robot Collaboration in Unstructured and Dynamic Construction Environments

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Introduction

- Autonomous robots have garnered increased attention in construction industry as a potential means of improving construction productivity and safety.
- However, the robots' situational intelligence is yet limited. Errors could occur. Also, errors by humans could occur.
- This leads to a fundamental question on how we can ensure safe collaboration between workers and robots.
- To address the question, this research introduces a framework for comprehensive robotic hazards detection with holistic and predictive safety monitoring techniques.
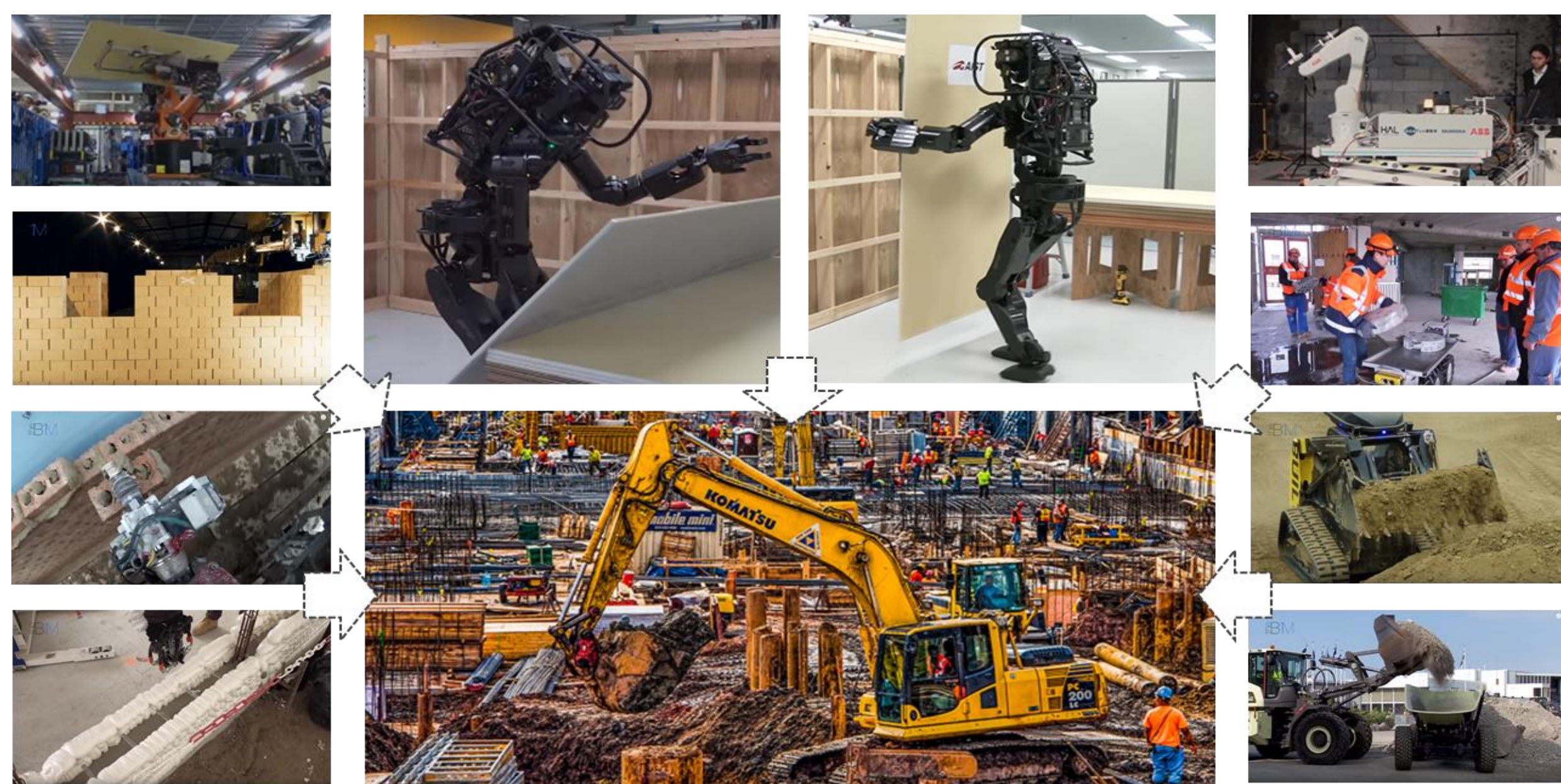
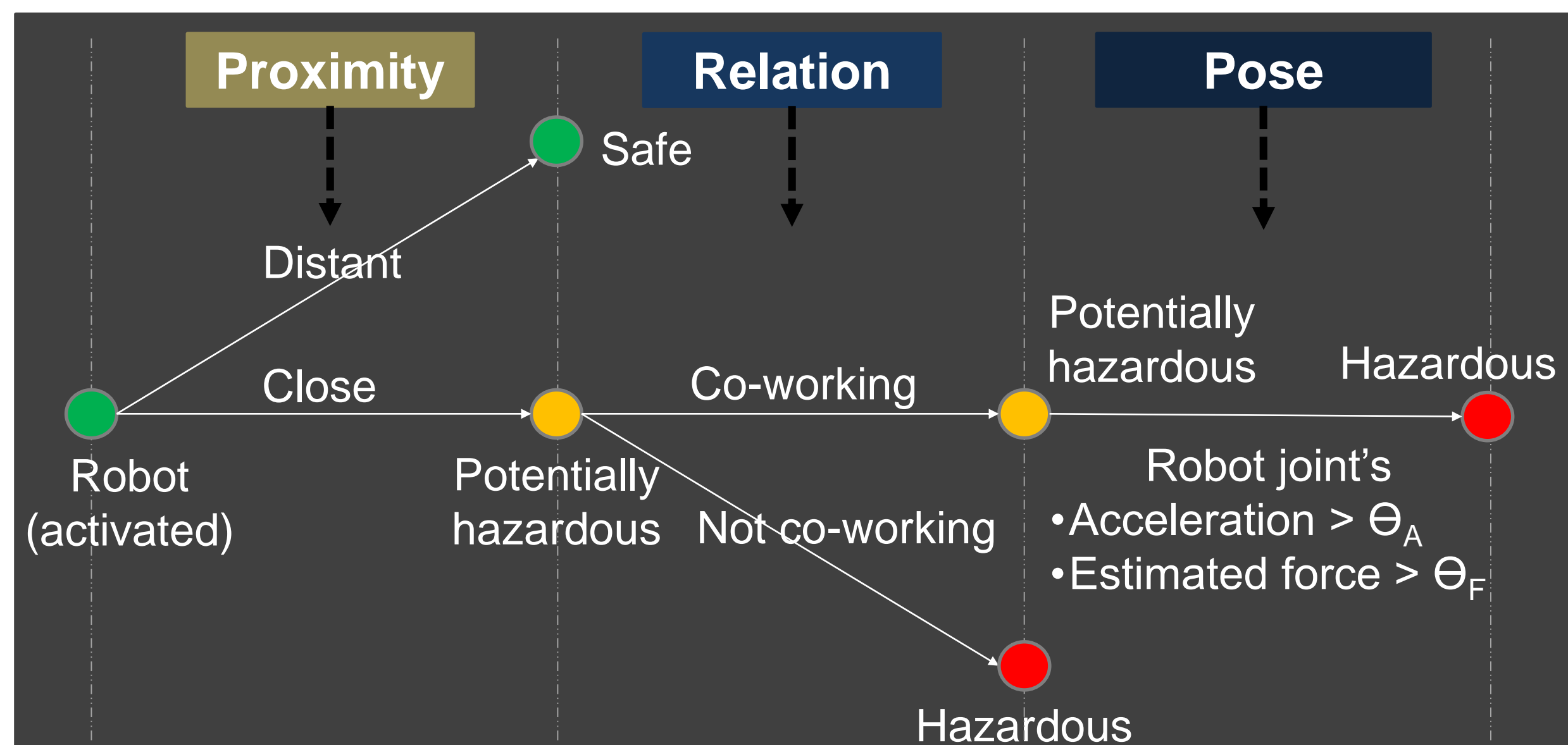

Figure 1. Various Construction Robots

Figure 2. Robotic Hazards Detection Framework

Proximity Monitoring & Prediction

Proximity monitoring error: < **0.61 meters**
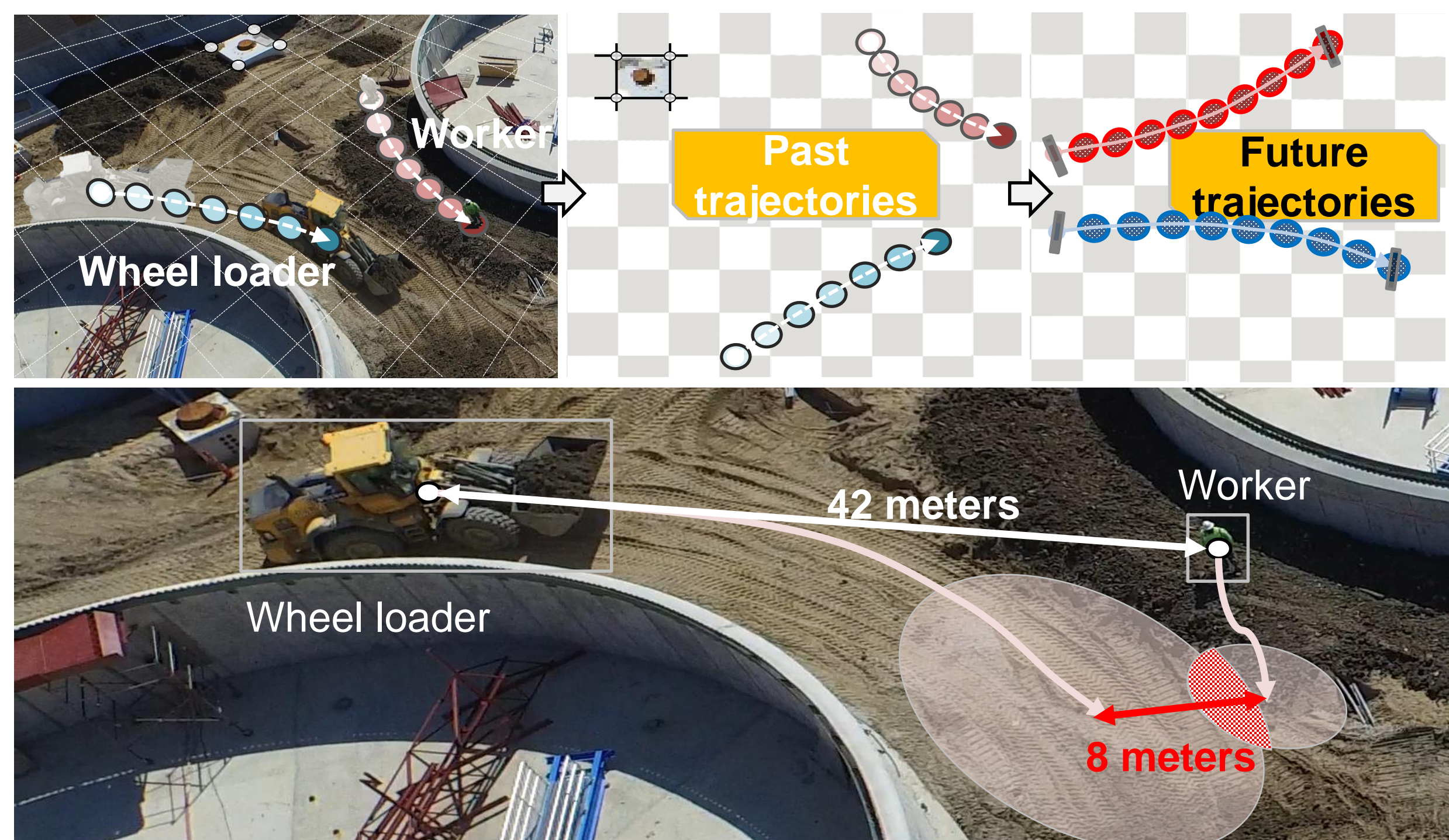Proximity prediction error: < **0.95 meters** (for 5.28 seconds prediction)

Figure 3. Proximity Monitoring & Prediction

Semantic Relation Detection

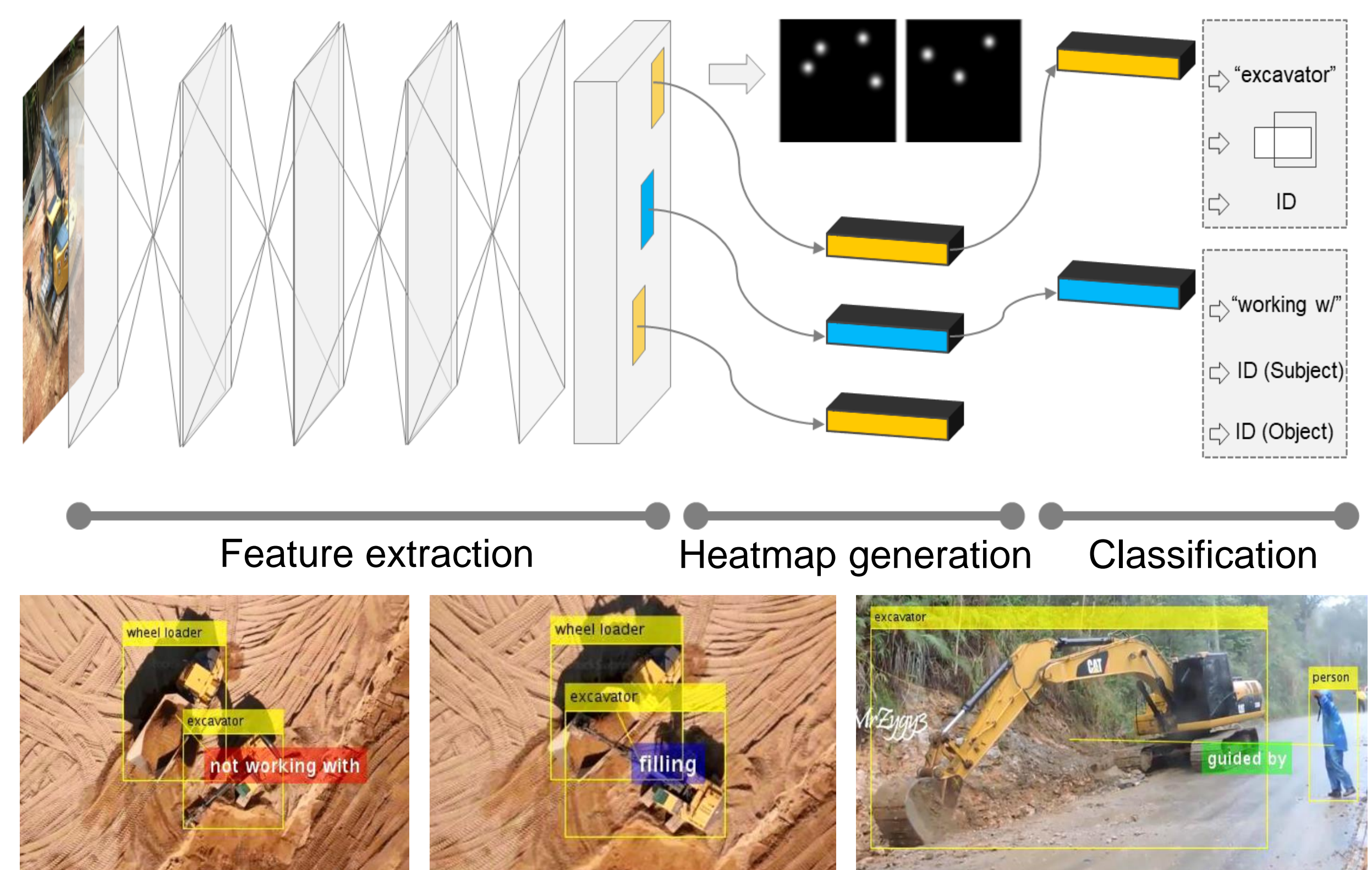Recall@5: 81.89**%** (when objects' locations are given: **91.54%**)

Figure 4. Relation Detection's Network Architecture & Test Examples

Pose & Potential Damage Analysis

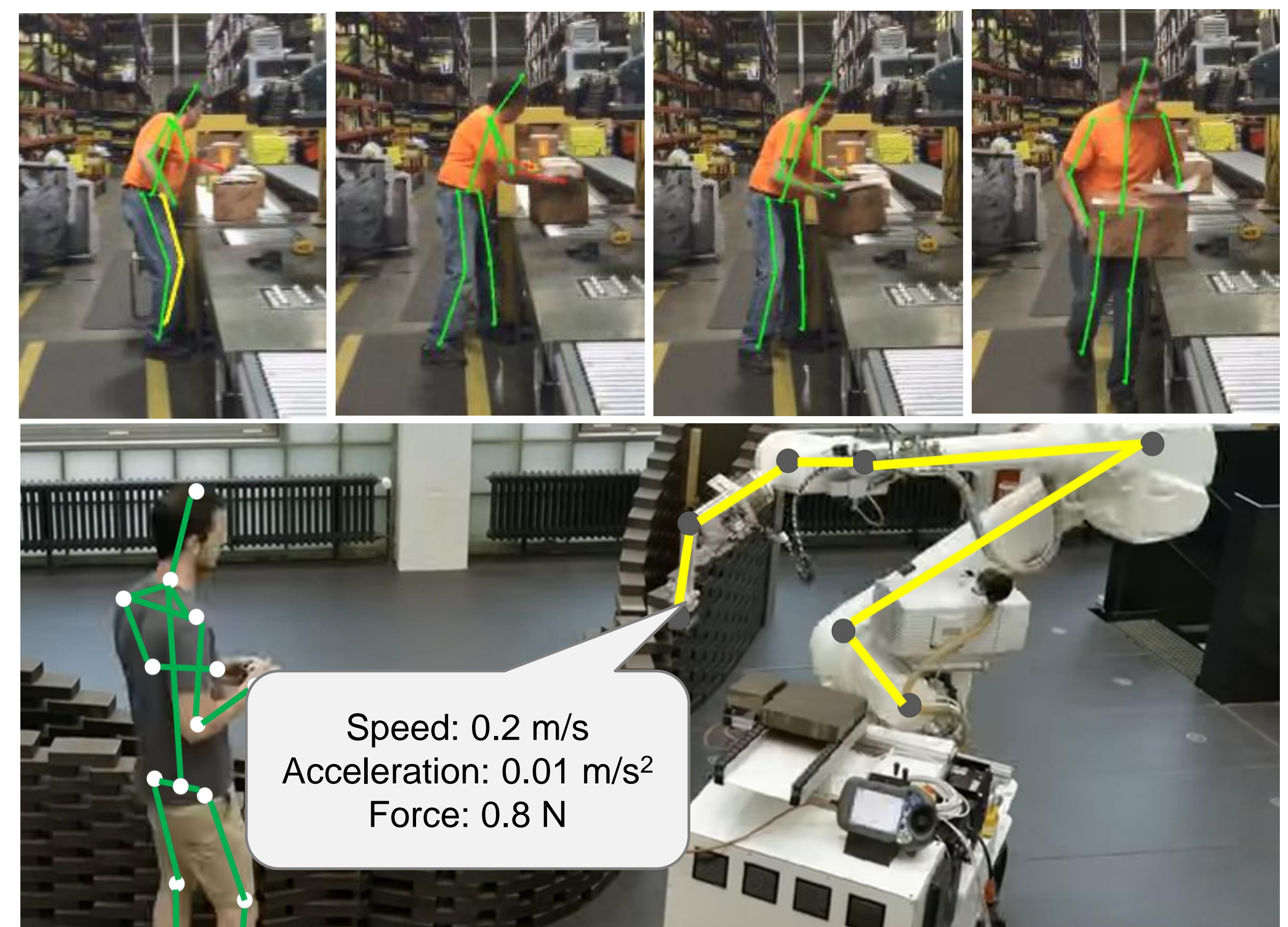Speed: 0.2 m/s
Acceleration: 0.01 m/s^2
Force: 0.8 N

Figure 5. Pose and Potential Damage Analysis of Articulated Robots

Conclusions

- The proposed framework can enable comprehensive detection of impending collisions between robots and workers during construction operations, thereby making pro-active interventions possible.
- Specifically, the framework would allow robots to make alternative path planning and rerouting beforehand and enable providing advance alerts to workers via wearable devices.
- The outcomes from this research promise support for holistic and predictive safety monitoring in construction. It will ultimately contribute to promoting safer human-robot collaboration in unstructured and dynamic construction sites.