



Safe and Efficient Cyber-Physical Operation System for Construction Equipment

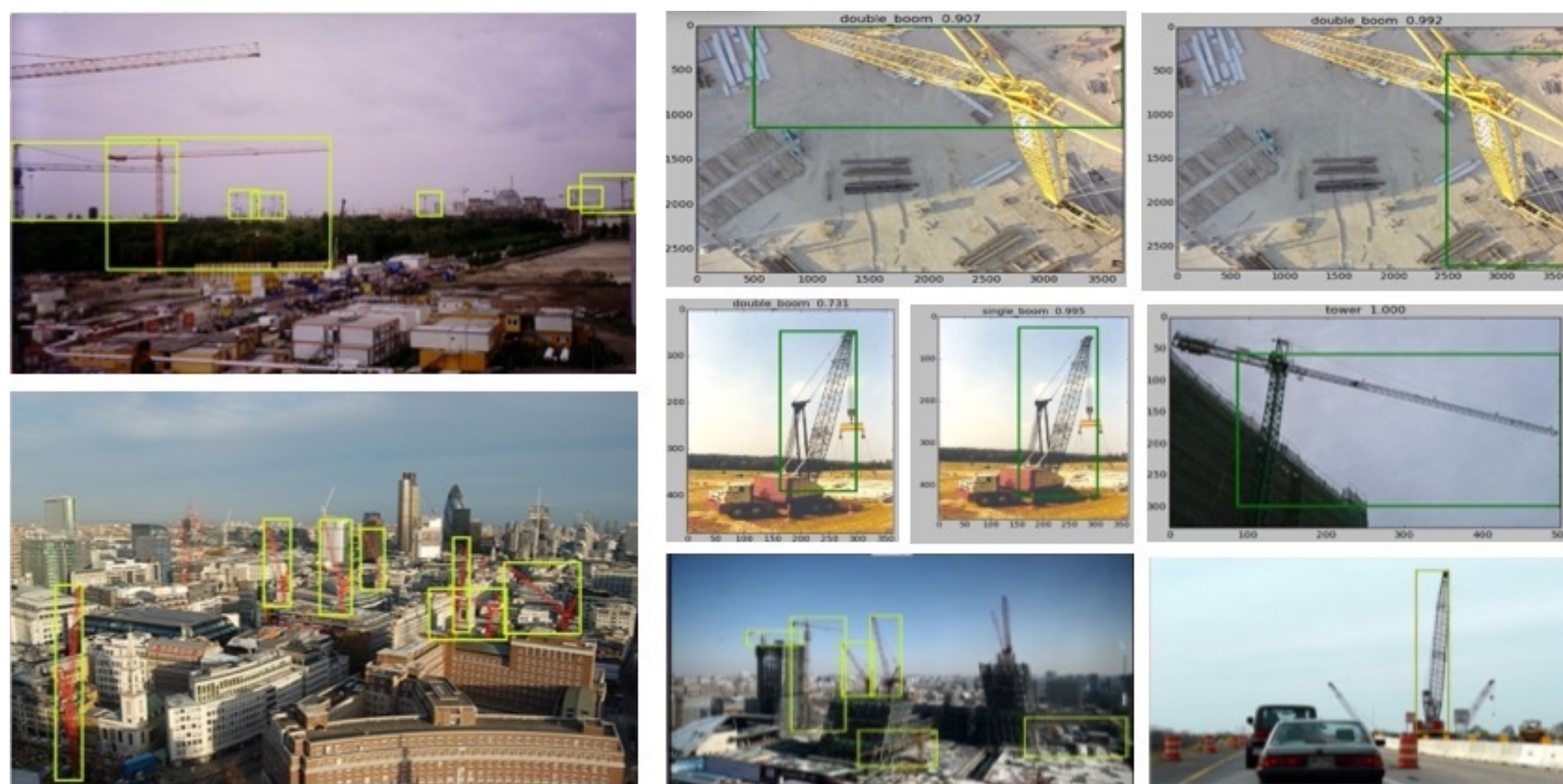
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Physical Environment

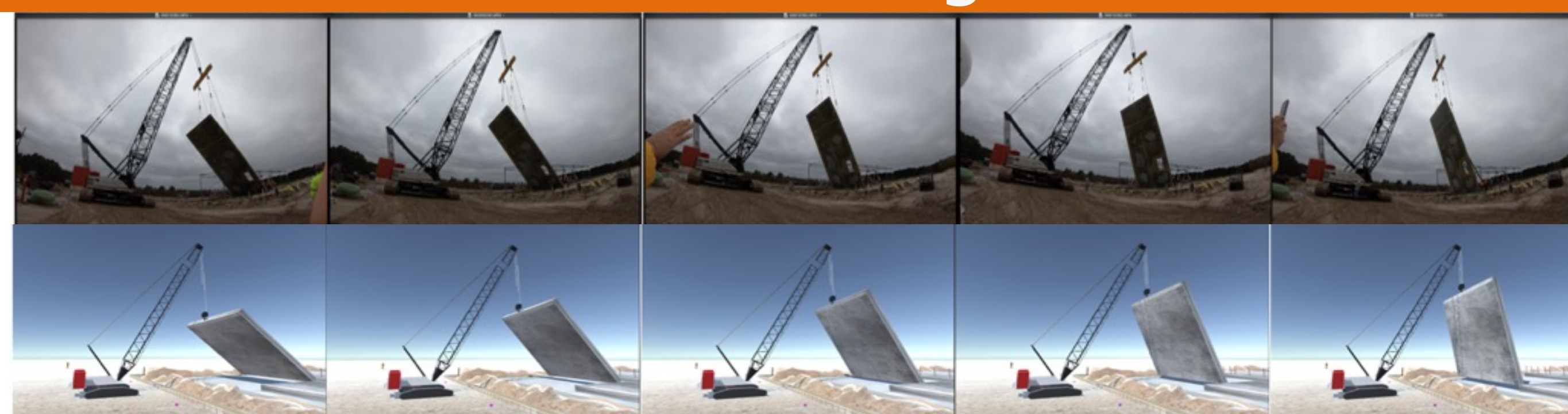
- Joint recognition and pose estimation of mobile crane and payload (a very large-scale real-world dataset was collected)



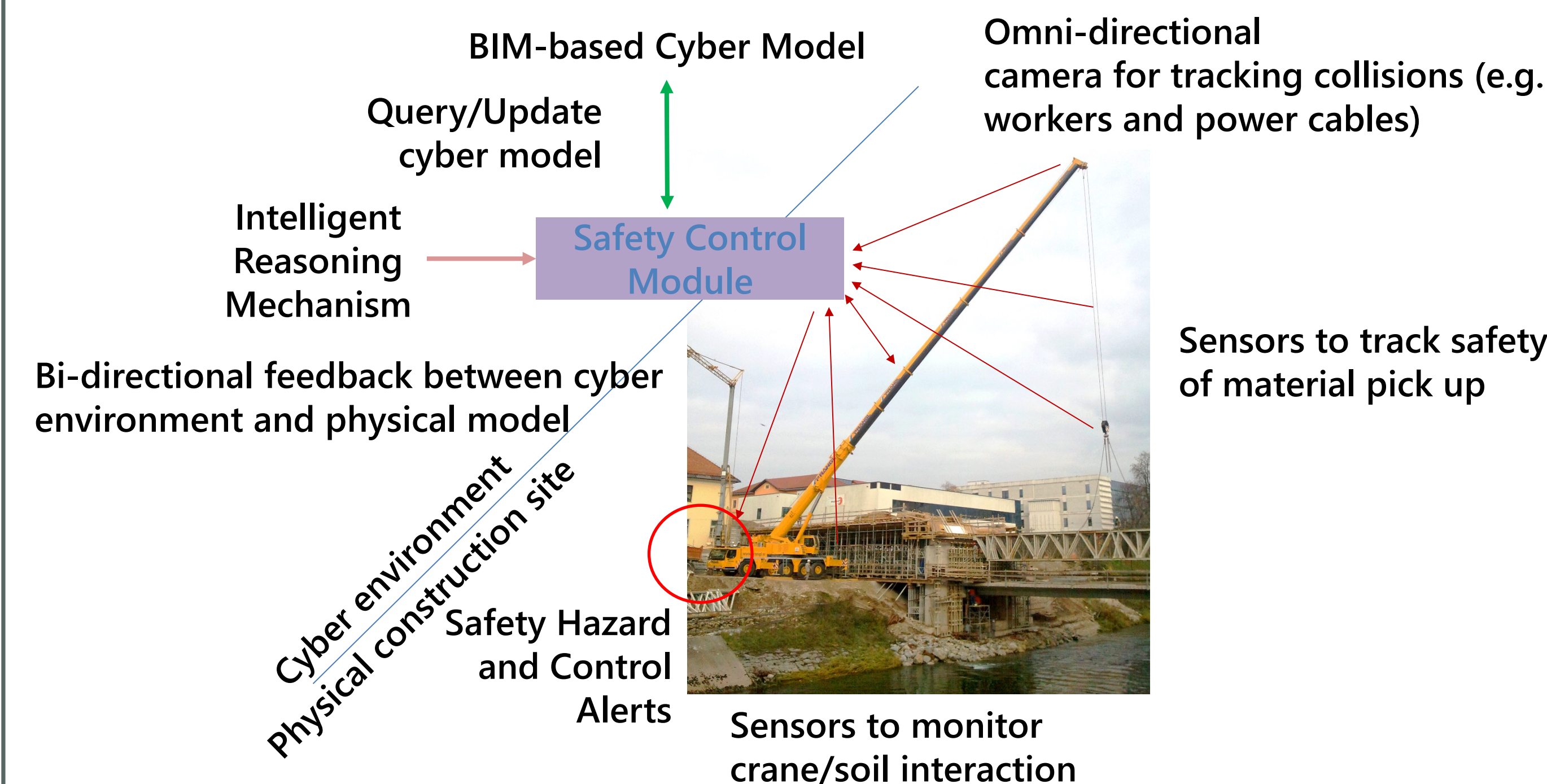
- Sensing system deployed on/in the mobile crane for pose estimation



Monitored Lifting Scene



A Safe and Efficient Operation System



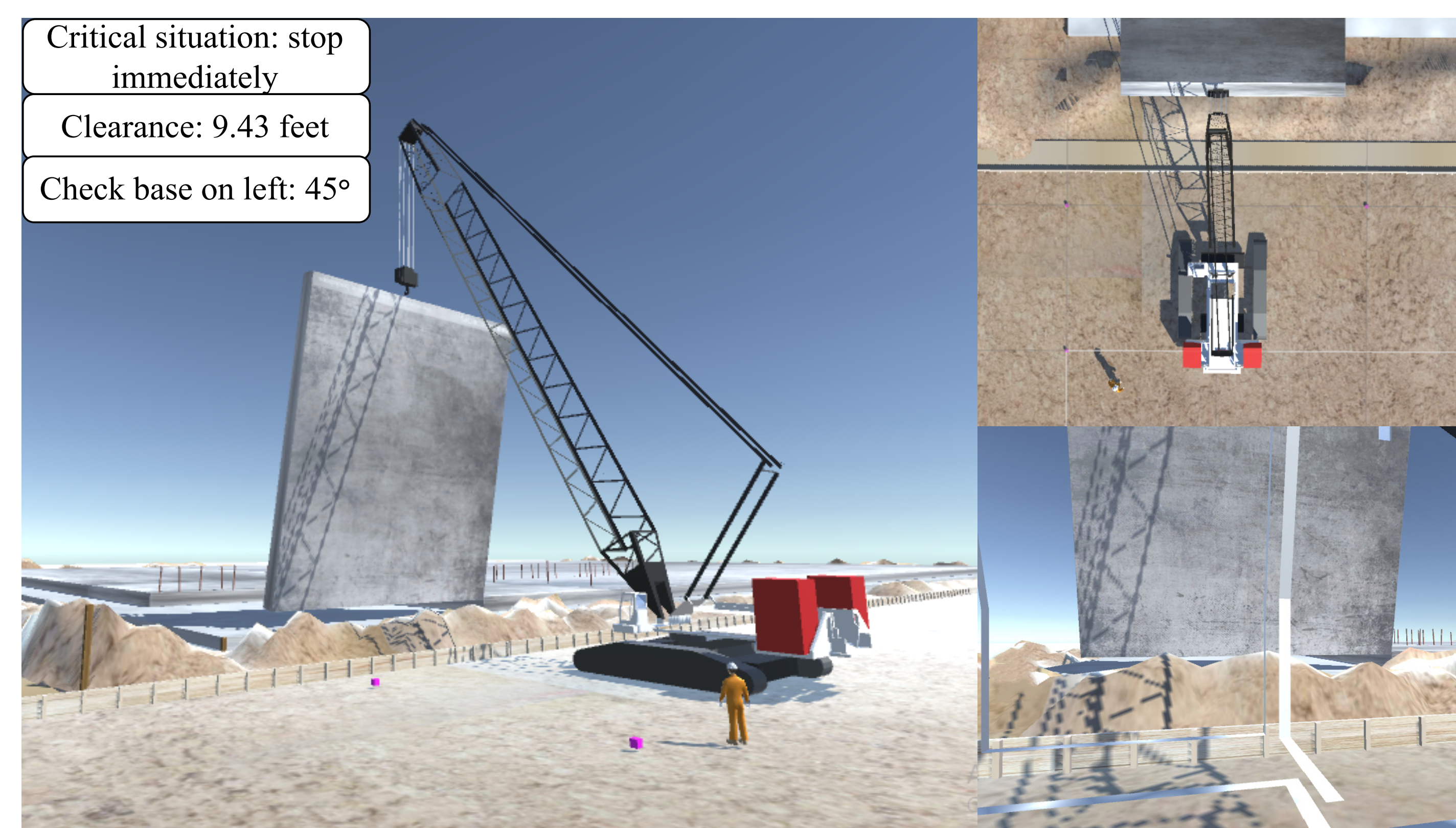
Project Objectives

Improve the safety and efficiency of construction equipment operations through advances in robotics, computer vision, and construction management. We improved frequency, detail, and applicability of safety planning, monitoring, and control of equipment operations, with five key components:

- Planning:** virtual models of the physical environments by building 4D semantically rich CAD models, wherein the actual location and working condition of the crane are simulated in real-time.
- Estimation and analysis on the state of equipment:** estimate (a) payload position, orientation, size, shape, mass distribution, and connection point (b) the ground type and the ground force distribution; (c) stress and strain on the entire crane structure. predict the trajectory of crane and of payload and will compute worst-case time to collision with obstacles in the environment.
- Monitoring crane environment:** simultaneously localize and map the crane in the 3D surrounding environment. When available, we will also leverage RFID tags – together with these video feeds– to detect and track current and forecasted location of workers, equipment, materials, and other site objects (e.g. power lines) with respect to the crane using feedback from visual sensors.
- Control feedback to the operator:** a higher resolution mapping between the center of pressure of the crane and the position of stimulation on the operator's body, and in turn significantly reduce the variance of the center of pressure position when the user is presented with feedback.

Cyber Environment

- Virtual platform developed in Unity for lifting scene visualization and displaying of control feedback



Control Feedback to the Operator

- Control feedback delivered to the crane operator through a tablet computer installed in the crane cabin

