Prediction-Enabled Collision Risk Estimation for Safe Human-Robot Collaboration on Unstructured and Dynamic Construction Sites

Jiannan Cai, Ph.D., A.M.ASCE,[1] Ao Du, Ph.D. A.M.ASCE,[2] and Shuai Li, Ph.D., A.M.ASCE[3]

[1*]Department of Construction Science, The University of Texas at San Antonio, 501 W César E Chávez Blvd, San Antonio, TX 78207; e-mail: jiannan.cai@utsa.edu (Corresponding author)
[2]Department of Civil and Environmental Engineering, The University of Texas at San Antonio, One UTSA Circle, San Antonio, TX 78249; e-mail: ao.du@utsa.edu
[3]Department of Civil and Environmental Engineering, University of Tennessee, Knoxville. 851 Neyland Drive, Knoxville TN 37996; e-mail: sli48@utk.edu

ABSTRACT

With the emergence of automation and robotics, construction robots have been increasingly introduced to construction projects to relieve human workers from physically demanding and hazardous tasks. The co-existence of and interaction between workers and robots on the unstructured and dynamic sites will pose new safety challenges due to the potential risk of human-robot collision. This study proposes a new method to model the risk of collision based on predicted trajectories and associated uncertainties of construction workers. First, the movements of construction workers are predicted using uncertainty-aware long short-term memory (LSTM) network. Second, at any given time, the probability of human-robot collision on any location of the site is computed considering the distributions of predicted trajectories for all workers, resulting in a probabilistic representation of the collision risk on the dynamic site. Construction videos are used to demonstrate the proposed framework, which achieves 9.3 pixels of average displacement error in trajectory prediction. The result also suggests that the proposed method can effectively capture the collision risk at any given location over a time period.