

NRI: INT: COLLAB: Manufacturing USA: Intelligent Human-Robot Collaboration for Smart Factory

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Partners:



Overview

Challenges & Solutions

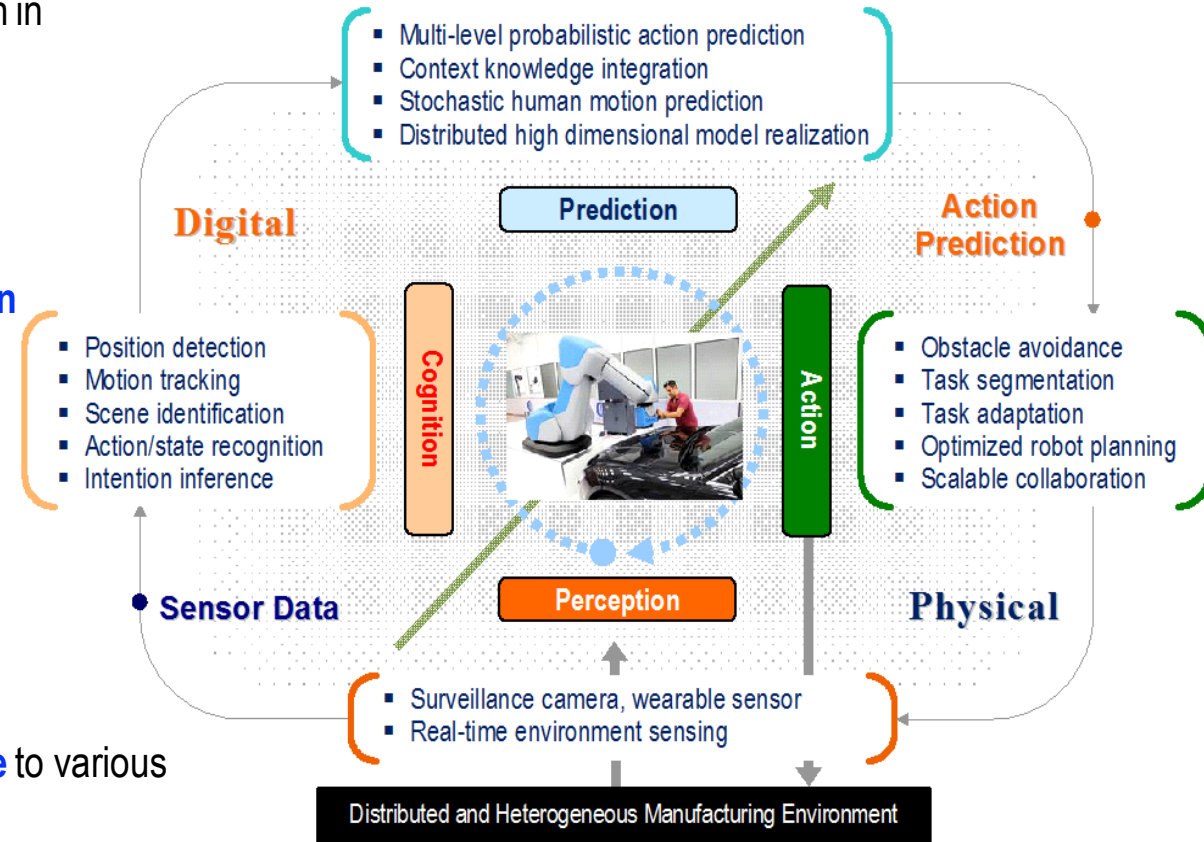
- Separating and highlighting relevant content from irrelevant/ambiguous information in **sensing** data for human action and command **recognition**
Solution: Background aware network, attention mechanism, and sensor fusion
- Accounting for uncertainty in human action and trajectory **prediction**
Solution: Probabilistic sequential modeling for uncertainty quantification
- Estimating collision risk between robot and human trajectory in collaborative **action**
Solution: Temporal point clouds for trajectory evaluation and collision prediction

Scientific Impact

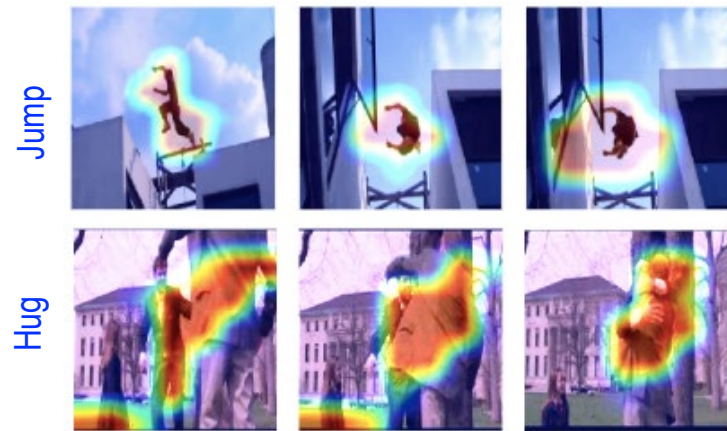
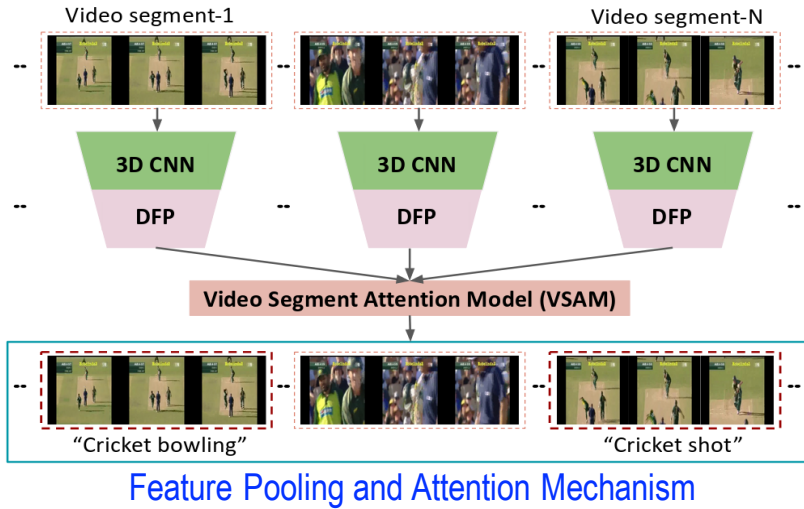
- Improved understanding of: 1) discriminative **features** in sensing data relevant to action recognition, and 2) sequential **pattern** underlying human motion trajectory
- Ensured **safety** with mitigated risk of robot mis-trigger and collision

Broader Impact

- Demonstrated **viability** of human-robot collaborative solution that is **generalizable** to various sectors, from education to healthcare
- Improved human **trust** in collaborative robots



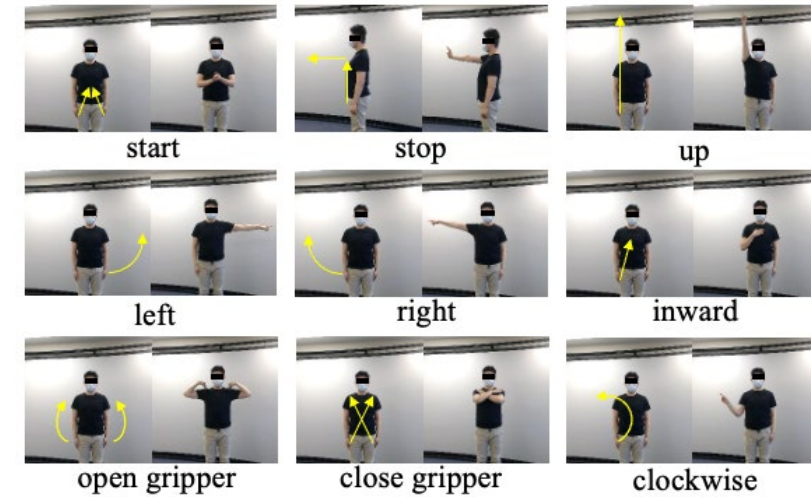
Perception & Cognition



Visualization of Regions Relevant to Action Recognition

Human Action Recognition

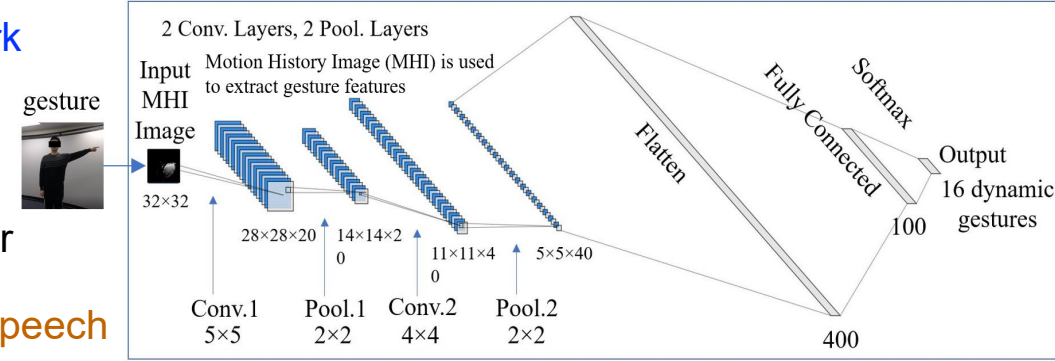
- Feature pooling and attention mechanism to highlight discriminative video features for human **action recognition** (left figures)
- Action completeness modeling with **Background Aware** networks for temporal **action localization** from ambiguous video frames.



Sample Dynamic Gestures Designed for Human-Robot Collaboration

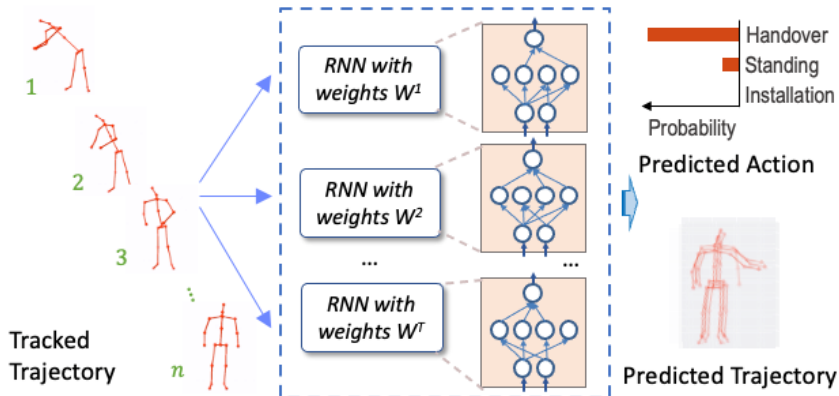
Human Gesture/Speech Recognition

- Convolutional neural network (CNN) for human **gesture recognition** with >95% accuracy (right figures)
- Software interface design for robust human command recognition with combined **speech and gesture recognition**.



CNN for Dynamic Gesture Recognition

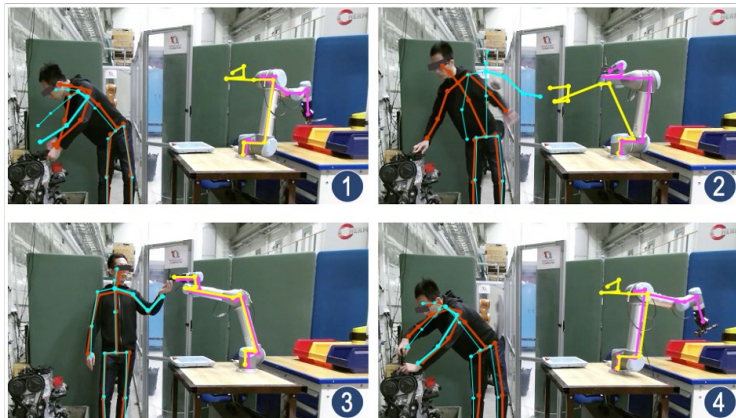
Prediction & Action



Probabilistic RNN for Action and Trajectory Prediction

Human Action/Trajectory Prediction

- Probabilistic recurrent neural network (RNN) for uncertainty quantification in human action and trajectory prediction (left figures).
- Eliminated uncertainty-induced robot mis-trigger for part/tool handover, as compared to deterministic method.

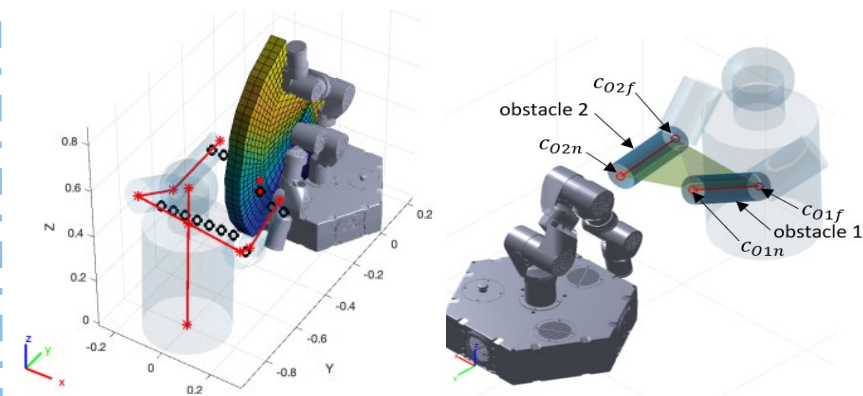


Actual human pose: red; Predicted human pose: cyan;
Actual robot position: pink; Target robot position: yellow

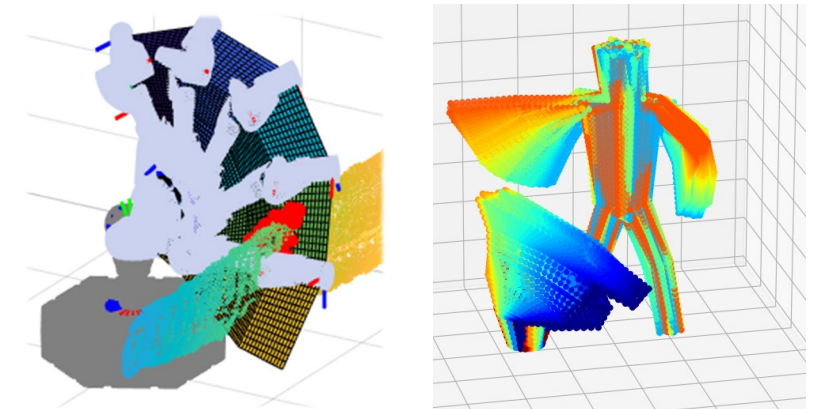
Sample Sequence of Collaborative Assembly

Adaptive Robot Action

- Uncertainty quantification in robot nominal trajectory completion and new trajectory generation for reduced production disruption (top-right figures).
- Temporal point clouds of human and robot trajectory for real-time collision prediction (bottom-right figures).



Uncertainty Quantification of Nominal Trajectory Completion



Temporal Point Clouds for Collision Prediction