Intelligent Co-robots for Complex Welding Manufacturing through Learning and Generalization of Welders Capabilities

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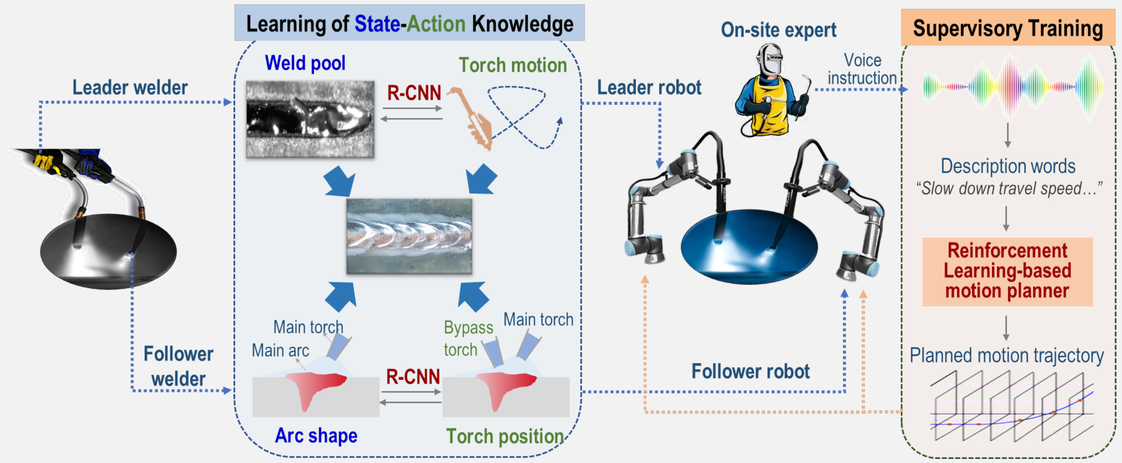
Objective

- Formulate a systematic solution for advancing robotic capabilities on **acquiring domain-specific knowledge**, **interactive learning**, **adaptive decision making**, and **collaboration**, for realization of fully robotic automation of complex welding processes that can only be handled by human in the past



Intellectual Merit

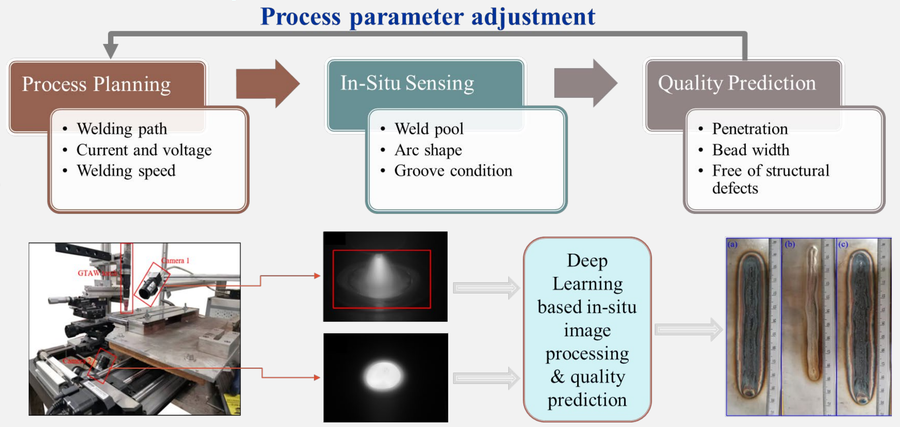
- The research improves the understandings related to robotic perception and learning:
  1) **Dynamic characterization** of weld scene under continuous operation, in an immersive VR system;
  2) **Modeling** of human welders' operations w.r.t weld scene evolution, through explainable deep learning-enabled in-situ sensing data analysis and causal analysis;
  3) **Generalization** of welding knowledge learned from human welders, considering human's heterogeneity, by using transfer learning to extract common latent knowledge;
  4) Develop an **interactive learning** module, to welding robots to be supervised by human welders through the reinforcement learning-based perception of language instructions.

Broader Impacts

- The project outcome will contribute to enhancing the science base for robotic control, and facilitate the transition of industrial manufacturing to fully automatic, robotic, and intelligent manufacturing;
- The research creates a virtual reality test platform for co-robotic welding that will be made available to the research community, welding companies, and students;
- The research involves multiple disciplines, will broaden the participation of students from diverse backgrounds in research, and the knowledge gained will be incorporated in curricula in robotic and intelligent manufacturing.

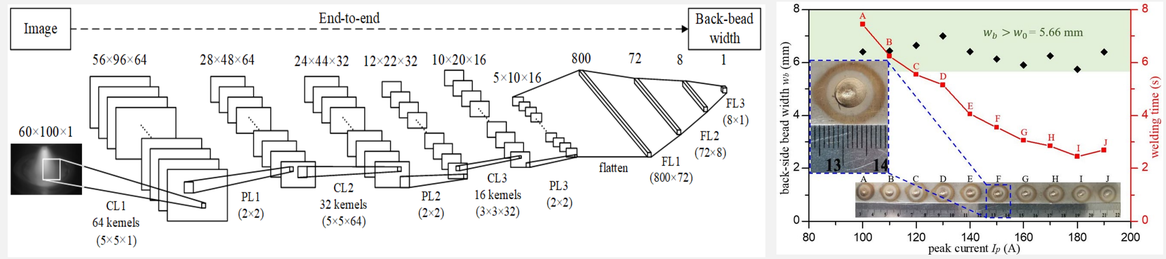
Year 1 (08/2020-07/2021) Goal: Adaptive Robotic Welding

Have welding robot automatically and adaptively adjust welding parameters to optimize welding quality, through **in-situ sensing**, **deep learning-based quality prediction**, and **computationally efficient optimization** algorithms, in GTAW.



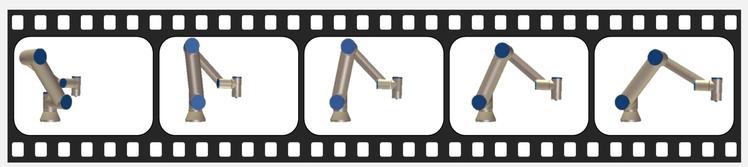
Deep Learning for In-situ Welding Quality Prediction

Apply convolutional neural networks to process in-situ weld pool images to predict back-side bead width



Automatic Welding Parameter Adjustment

- Upon predicted bead width, computationally efficient process optimization has been developed for real-time welding speed adjustment to improve and maintain welding quality
- Both simulation and experimental studies have been performed



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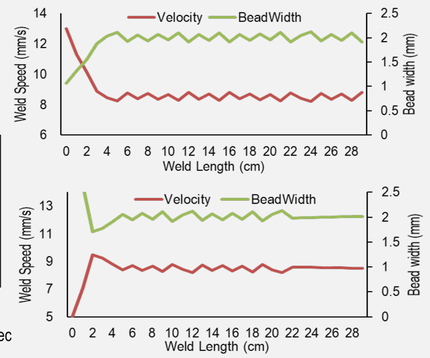

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