Research Statement -Tianyi Xiang

About Me

My research primarily involves formulating **planning, learning, and optimization algorithms** that allow robot **manipulation** platforms to effectively complete tasks.

The goal of my work is to enable people to **intuitively control or work alongside robot manipulation platforms to perform critical tasks** deemed unsuitable, undesirable, understaffed, or unsafe for people, such as **industrial robotics arm assembly**, **remote teleoperation programming**, **soft robotics**, and even **control with virtual reality**. I use interdisciplinary techniques across robotics and computer science, including motion planning, automation, machine learning, vision, game engine, communication system to formulate and validate solutions within problems in diverse fields. My work is dedicated to creating and validating solutions that balance **feasibility**, **accuracy**, and **computational efficiency**.

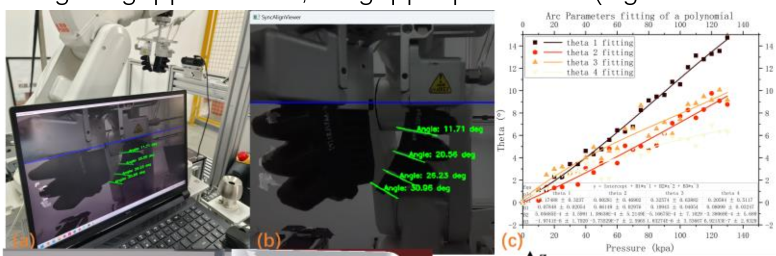
Towards realizing this vision, my research considers following topics: (1) **Vision-approach** to grasping control of **soft robotics gripper** based on digital twin [ICAC 2024; 1]; (2) **Novel teleoperation Digital Twin** framework with **extremely low communication latency** to enhance safety and feasibility [CASE 2024; 2]. Furthermore, I've explored a range of projects, including DIY mars rover design, SLAM navigation, deep learning....

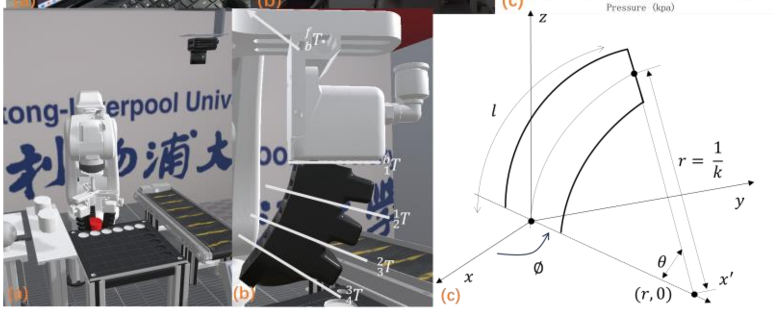
[1] Tianyi Xiang[1], et al. "A Novel Approach to Grasping Control of Soft Robotic Grippers based on Digital Twin". [29th International Conference on Automation and Computing (ICAC 2024) (Accepted)]

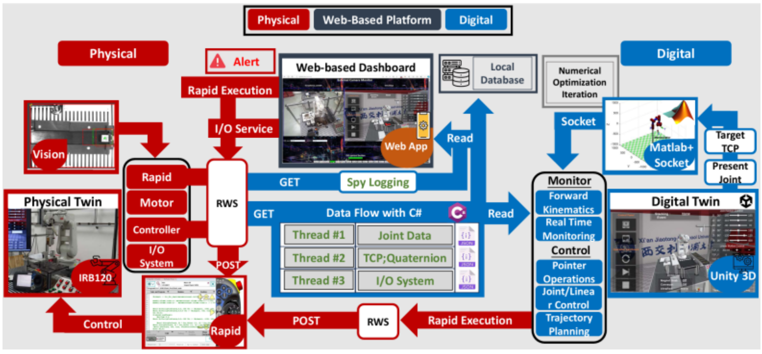
[2] Tianyi Xiang[1], et al. "Development of a Simple and Novel Digital Twin Framework for Industrial Robots in Intelligent Robotics Manufacturing," [20th International Conference on Automation Science and Engineering (CASE 2024)(Accepted)]

Previous and Current Work

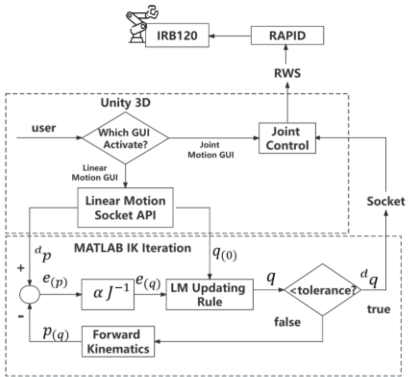
[1]: The developed DT is based on an industrial robot workstation, integrated with our newly proposed approach for soft gripper control, primarily based on computer vision, for setting the driving pressure for desired gripper status in real time. Knowing the gripper motion, the gripper parameters (e.g. curvatures and bending angles, etc.) are simulated by kinematics modelling in Unity 3D, which is based on four-piecewise constant curvature kinematics. The mapping in between the driving pressure and gripper parameters is achieved by implementing OpenCV based image processing algorithms and data fitting. Results show that our DT-based approach can achieve satisfactory performance in real-time control of soft gripper manipulation, and less computational source needed.



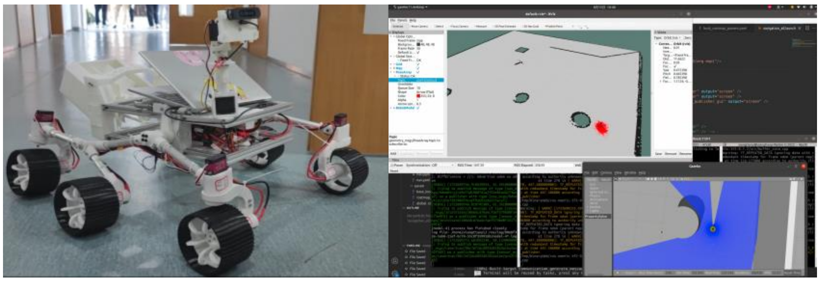




[2]: An easily replicable and novel approach for developing a Digital Twin (DT) system for industrial robots in intelligent manufacturing applications. Our framework enables effective communication via Robot Web Service (RWS), while a real-time simulation is implemented in Unity 3D and Web-based Platform without any other 3rd party tools. The framework can do real-time visualization and control of the entire work process, as well as implement real-time path planning based on algorithms executed in MATLAB. Results verify the high communication efficiency with a refresh rate of only 17ms. Furthermore, our developed web-based platform and Graphical User Interface (GUI) enable easy accessibility and user-friendliness in real-time control.



[3]: A replica of the Mars Perseverance Rover. The rover employs a rocker-bogie suspension system to navigate the challenging Martian terrain. Ackerman steering system is built. 3D depth vision camera Orbbec gemini pro with Yolo V8 is trained to recognize the QR code as trajectory planning method. And a MPC controller is designed to incorporate to follow the trajectory. Furthermore, we also transfer the mars rover into ROS SLAM-based navigation system with AMCL for adaptive localization. achieving an increase in localization accuracy and a 25\% reduction in computational overhead 30\%.



[4]:The dynamic optimization of Automated Guided Vehicle (AGV). Applied dynamic optimization of local trajectory planning through LQR, Dual-loop PID, stanely method, and MPC Motion control algorithms to AGV incorporating B-spline and A-star method, with simulation and modelling in Automation studio, MapleSim, and Scene Viewer. Designed self-supervised spline interpolation techniques to generate control points, achieving a maximum deviation of lower 50\%(in unit) in critical turning areas in rare 3\% occurrence probability