Development of Novel IIoT Based Framework for Teleoperation of Collaborative Robot

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ABSTRACT

A technology that enables a collaborative group of users to teleoperate an industrial robot arm at the same time via the Industrial Internet of Things (IIoT). As a result, we think it is worthwhile to investigate a novel solution: Collaborative control. The proposed IIoT based Framework incorporates the flow of each joint motor characteristics and cartesian position information between physical robot and digital twin. The objective is to develop a IIoT based control with real-time data and alerts visualization to expand the manipulation capabilities over the teleoperation.

OBJECTIVES

Design: Experimental study on a 5 Degree of Freedom(DoF) robotic system, PTC ThingWorx as a IIoT platform and PTC Vuforia studio as IIoT based Augmented Reality platform.

Experimental set-up: At UWM BioRobotics Lab.

Background: In the fourth Industrial Revolution, using modern smart technology and IIoT are interconnected to boost automation, connectivity, and self-monitoring, as well as the development of smart machines that can interpret and diagnose problems through teleoperation side human interaction[1]. Teleoperation is increasing level of safety where performing conditions for human interactions are not safe as well allowing control and visualize industrial assets.

Objectives: To provide a consistent and safe IIoT based teleoperation-control manipulation system for industrial level collaborative robot to perform different trajectories with real-time data and alerts visualization.

MAIN OUTCOME MEASURES

- IIoT platform gives alerts in advance when hazardous condition predict from salve-AR robot.
- IIoT platform provides data visualization with data logs on any kind of iOS, Android, and Windows base devices at anytime.
- Intuitive interface that enables two control modes: manual mode and pre-planned trajectory mode.

METHODS

- The robotic system is an xArm 5 that is capable of 5 degrees of freedom. There is a digital twin of the physical robot that lives on the IIoT platform. As the name implies, the digital twin mirrors the physical robot as it sends telemetry data. The IIoT platform can be configured to respond to changes in data.

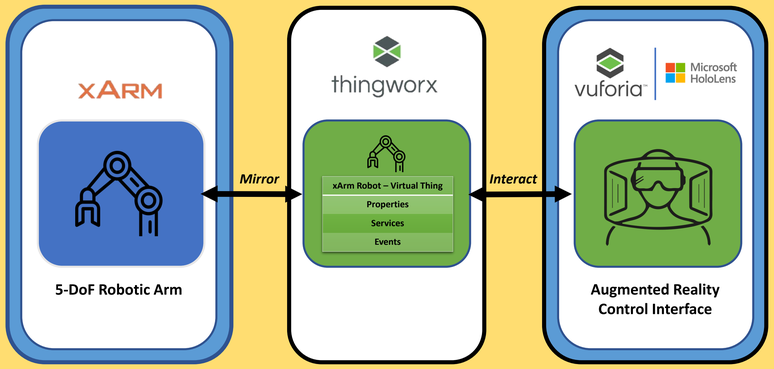

Figure 1. Shows the dataflow between xArm 5-DoF robotic arm, IIoT platform, and client device.

- Manual control mode enables client device users to control the joint angles via sliders. This data is transmitted through IIoT platform to actuate the physical robot. The Graphical User Interface (GUI) is shown below. Users can also switch to trajectory control mode where robot will follow a pre-determined path. Data visualization is available in both control modes.

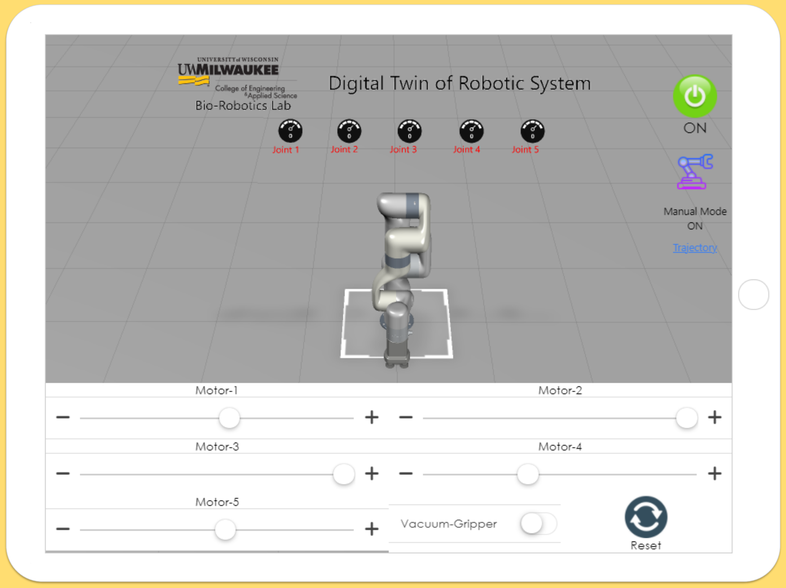

Figure 2. Shows the manual control mode, pre-planned trajectory control mode with data visualization.

RESULTS

- ThingWorx IIoT Mashup provides real-time telemetry data visualization. Below we can see real-time current, torque, and joint angles.

- The alert shown was triggered when the current in one of the motors exceeds a threshold. This allows interested persons to be notified immediately that will ideally prevent further damage and potential downtime.

- We've set up predictive alerts with ThingWorx where we received text messages and emails to interested persons. This is an example of a text message alert that is sent as soon as a property like motor current exceeds a certain threshold. We can design alerts that take output from analytical algorithms that model the physics of the robot.

Alert Name	Source	Property	Timestamp	Alert Type
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 01:35:36.470	Below
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 01:35:33.704	Below
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 01:29:07.891	Below
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 01:29:07.704	Below
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 00:24:03.840	Below
servo_3_high_current_...	xArm5-RemoteThing	current_servo_3	2021-03-04 00:24:02.652	Below

CONCLUSIONS

We successfully implemented an IIoT based framework that enables:

- Real-time telemetry data logging and visualization.
- Remote operation via two control modes.
- Event-driven alerts based on physics model.

LITERATURE CITED

1. M. Moore, “What is Industry 4.0? Everything you need to know,” *TechRadar*, 05-Nov-2019. [Online]. Available: https://www.techradar.com/news/what-is-industry-40-everything-you-need-to-know. [Accessed: 22-Apr-2021].
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3. Su, Hang, et al. "Internet of things (iot)-based collaborative control of a redundant manipulator for teleoperated minimally invasive surgeries." 2020 IEEE International Conference on Robotics and Automation (ICRA). IEEE, 2020.

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