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BUILDING FUTURE FACTORIES: A SMART ROBOTIC ASSEMBLY PLATFORM USING VIRTUAL COMMISSIONING, DATA ANALYTICS, AND ACCELERATED COMPUTING

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neXt
future factories • composites • manufacturing

Welcome Slide

- Clint Saidy
- USC McNAIR Center, neXt
- PhD Candidate

Abstract

Modern manufacturing platforms are defined by the quest for increased automation throughout the production cycle. To address these challenges, this paper discusses the methods developed and deployed by our team (USC neXt) to employ (1) large-scale simulation, (2) system health monitoring sensors, and (3) advanced computational technologies to establish a life-like digital manufacturing platform and to capture, represent, predict, and control the dynamics of a live manufacturing cell.

Outline

- Introduction
- Literature review
- Building future factories
  - Large-Scale Simulations
  - System Health Monitoring
  - Accelerated Computing
- Conclusions

Introduction

- The manufacturing sector is currently reinventing itself by embracing the opportunities offered by digital transformation, industrial internet, automation, and machine learning.
- The convergence between virtual and physical manufacturing systems has been pursued as a goal of data-driven smart manufacturing. However, Smart Manufacturing systems are constrained by the methods used to connect factories to control processes in a more dynamic and open environment.

Introduction

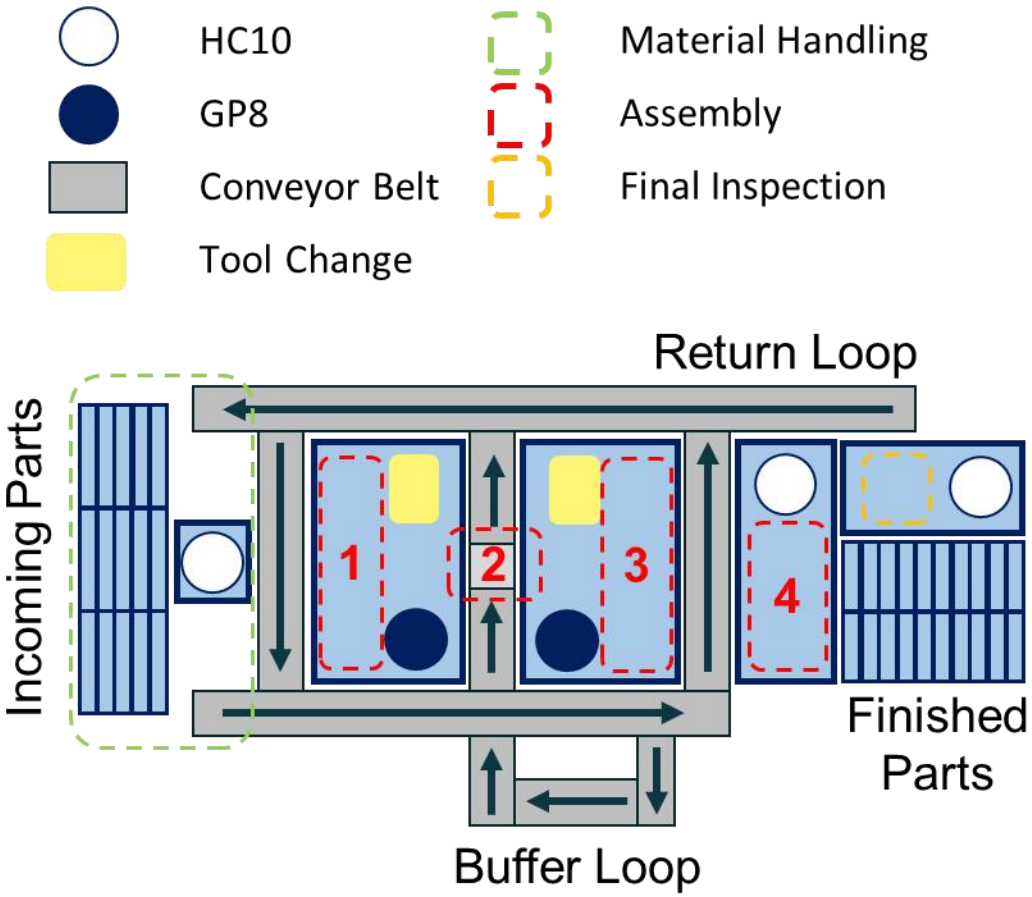
- Virtual Commissioning (VC), intends to verify and validate manufacturing systems and associated control programs through simulation before the physical implementation by enabling the connection between a virtual plant model and a real controller [9].
- In our work, establishing connections with virtual environments is proposed to further overcome these outstanding bottlenecks in the evolution of SM. This research demonstrates that the implementation of Virtual Commissioning as one of the steps to industrial digital twinning will accelerate the training, testing, and validation of smart control systems.

Literature Review

Building Future Factories

- This section will discuss the methods developed and deployed by our team (USC neXt) to employ:
  1. large-scale simulation,
  2. system health monitoring sensors, and
  3. advanced computational technologies to establish a life-like digital manufacturing platform and to capture, represent, predict, and control the dynamics of a live manufacturing cell.
- By creating our future factory using an IIoT platform, we will present data-driven science and engineering solutions to our industrial partners, accelerating Smart Manufacturing Innovation.

Experimental Platform: Current status



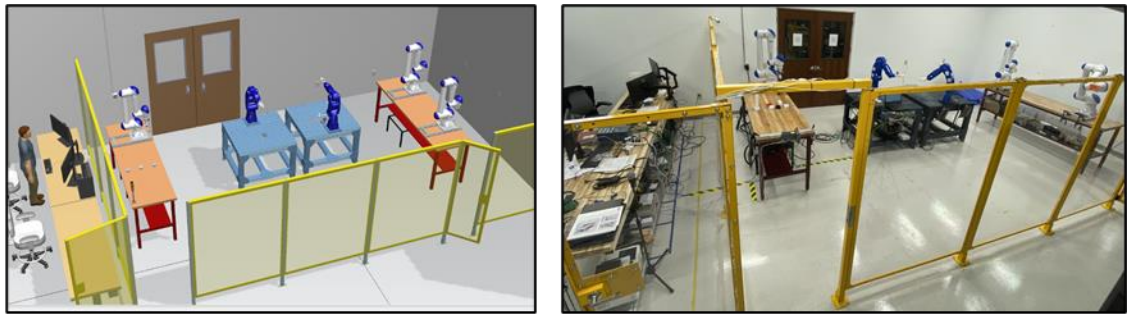


Figure. Current robotic cell

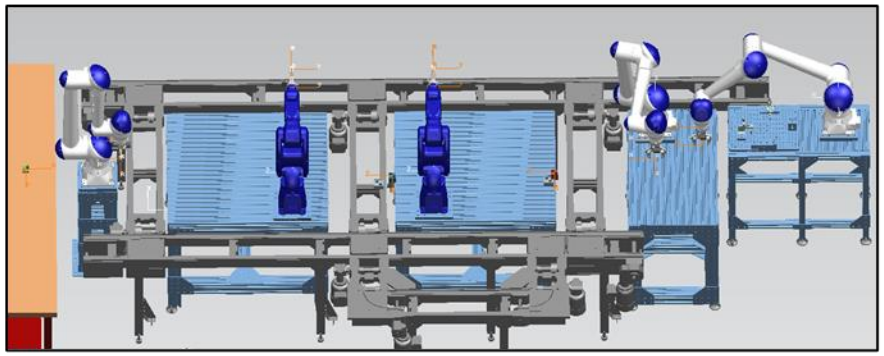


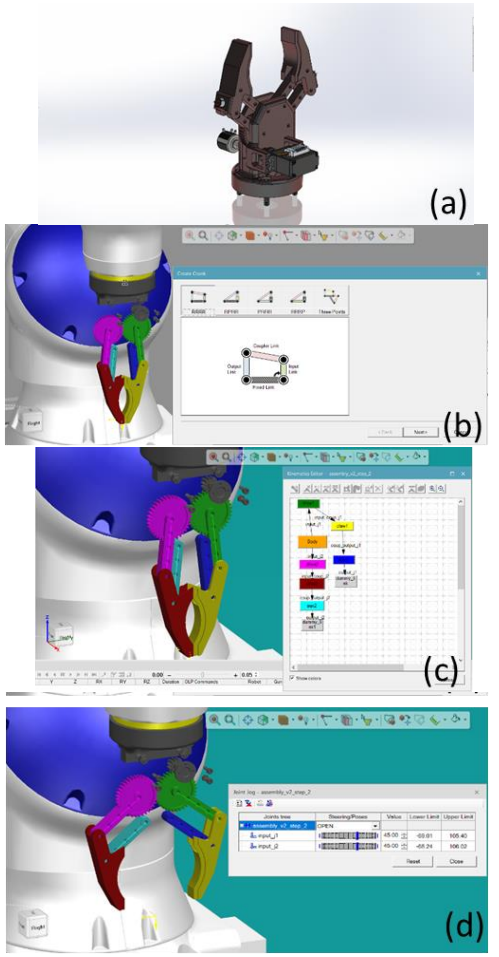
Figure. Planned robotic cell

Large-Scale Simulations

- Current implementations of VC still require manual construction of the virtual system and definition and tuning of system components. However, the development of industrial software solutions to VC has greatly improved the accuracy and user-friendliness of offline programming of robotic systems and verifying control logic over the traditional commissioning process.

Large-Scale Simulations

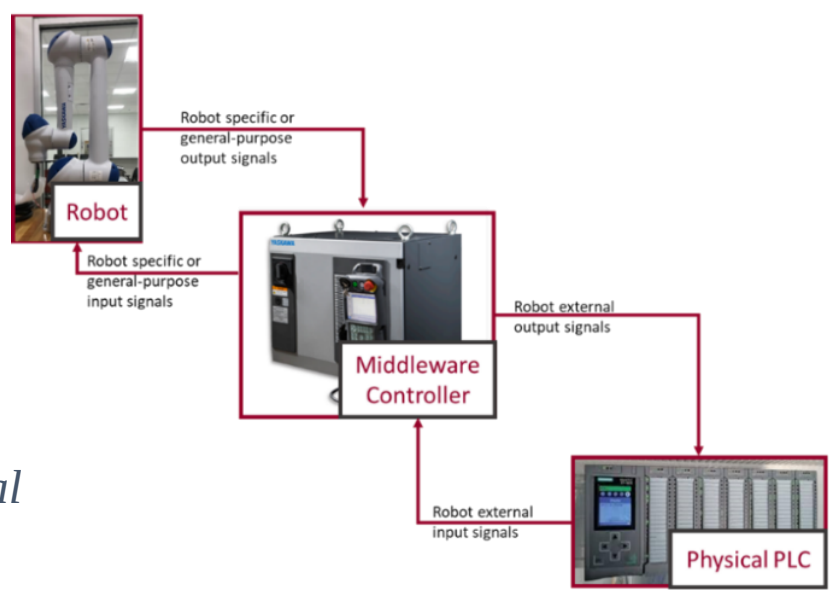
- A functional virtual cell depends on accurate definitions of system components. While CAD models and definitions of well-developed products can be retrieved from manufacturers, some components require manual definition before being imported to Process Simulate.
- For example, the kinematics of an in-house manufactured robot gripper from our stage 1 platform had to be defined.

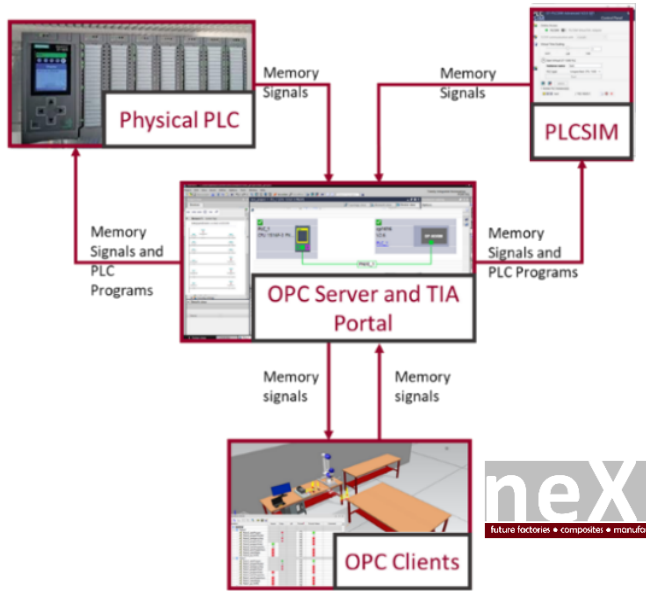


Gripper kinematics definition

Large-Scale Simulations

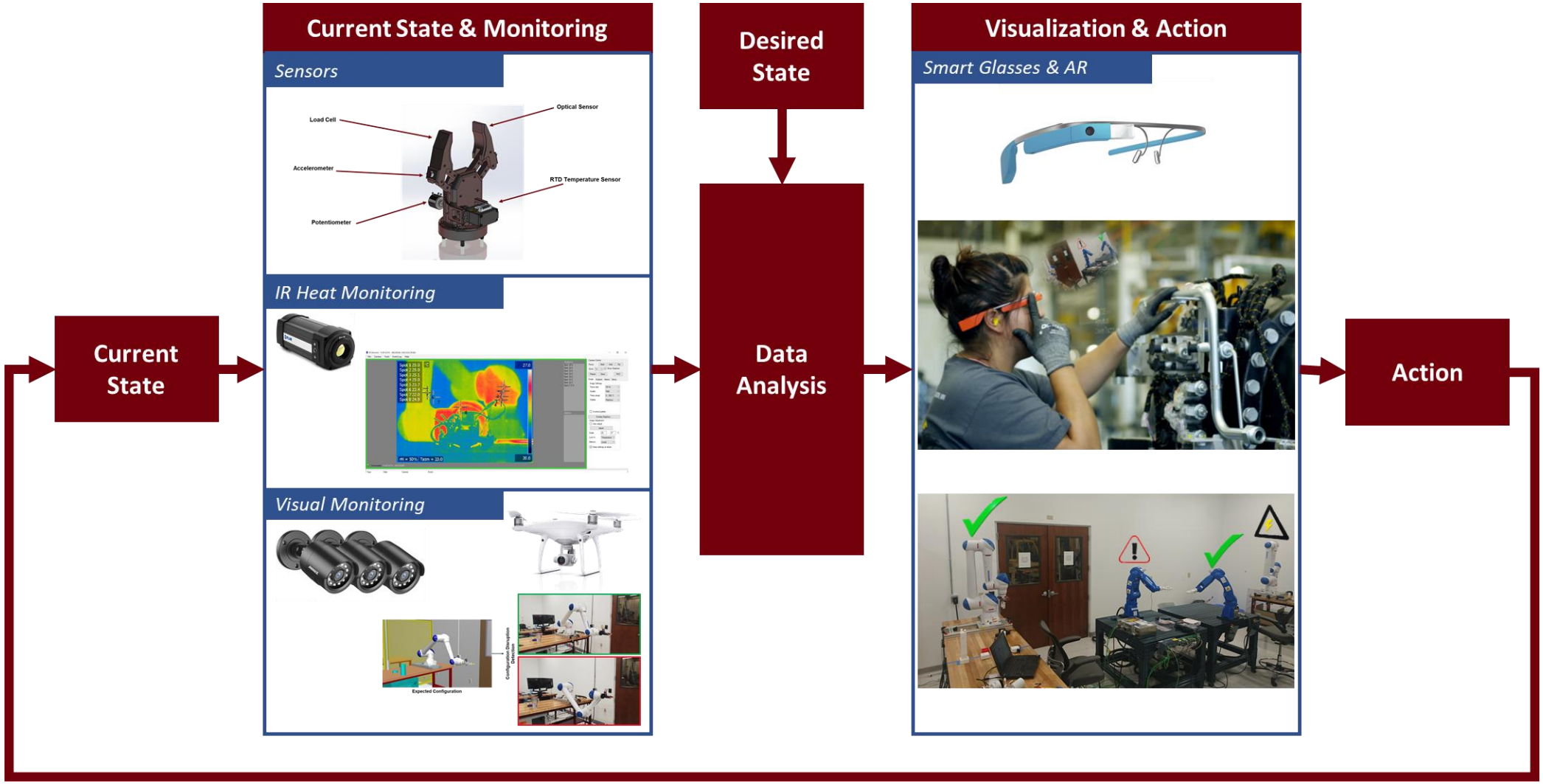
- This completes the system data flow proposed by our previous work and implies that the simulation-based digital twin of production systems can be used as an augmented tool to commission robotic manufacturing cells with significantly reduced safety and cost concerns by constructing virtual cell environment and enabling the communication pathways between system components.





Control loops of physical and virtual robot platform.

System Health Monitoring



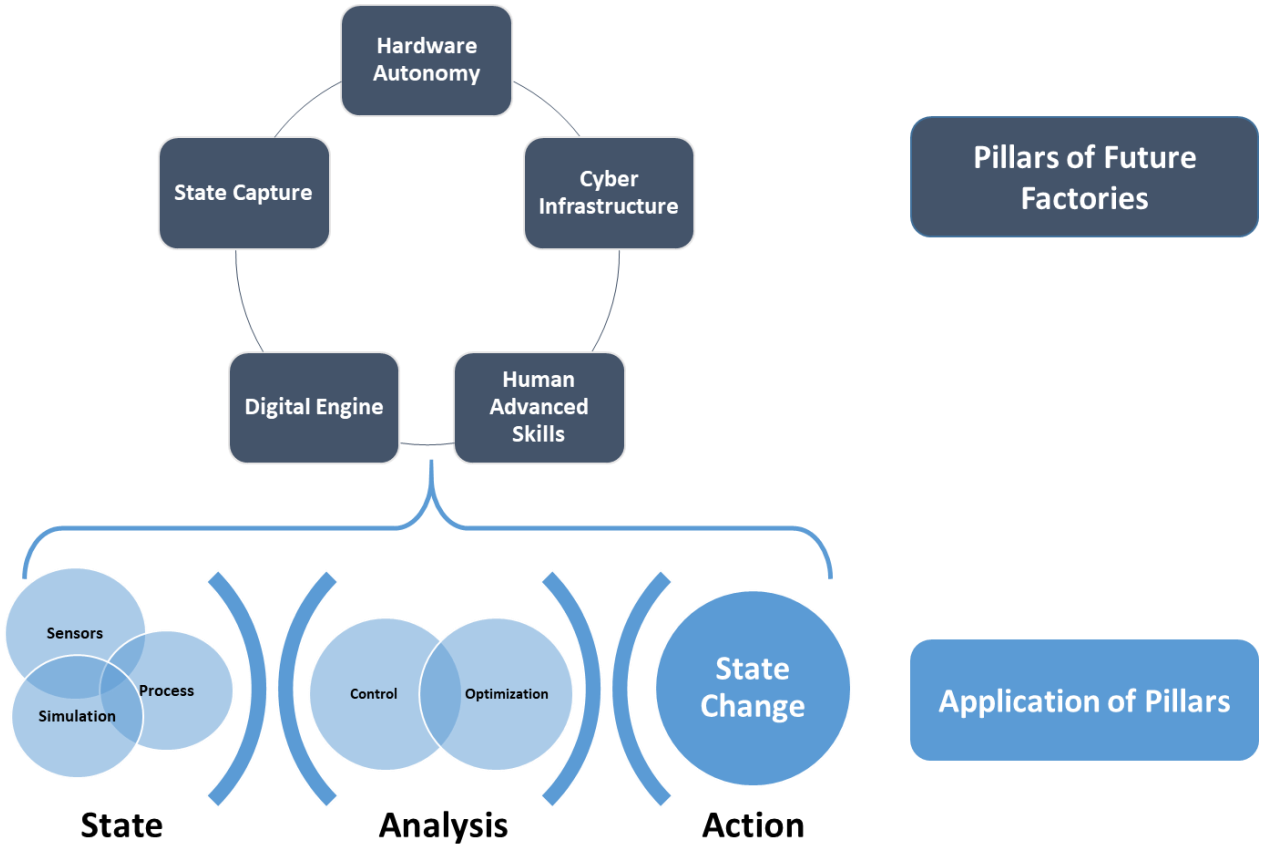
Monitoring and Predictive analytics

Accelerated Computing

- In the context of the neXt manufacturing, FPGA and GPU-based acceleration is being used to dramatically increase the performance of the Digital Engine. Both have demonstrated significant speedups in the operation of neural networks. In the DE application, a GPU training loop interfaces with the software side of the DE, continuously updating network weights.
- For the operation of the DE in the physical system, the network generated in the training loop is pushed to an FPGA and operated in a direct loop with the platform. With this in mind, a novel solution to dynamic path planning involving rapid inverse kinematics calculations accelerated on FPGA are currently being developed.

Conclusions

- Filling the gaps between virtual and physical systems will open new doors on Smart Manufacturing. The scope of a smart automated manufacturing system is also limited due to the inability of manufacturing process measurements.



The pillars of Future Factories

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Thank you.