NSF Engineering Research Center for
Reconfigurable Manufacturing Systems
University of Michigan

Virtual Fusion: The Complete Integration of Simulation for Reduced Ramp-up and Reconfiguration Cost

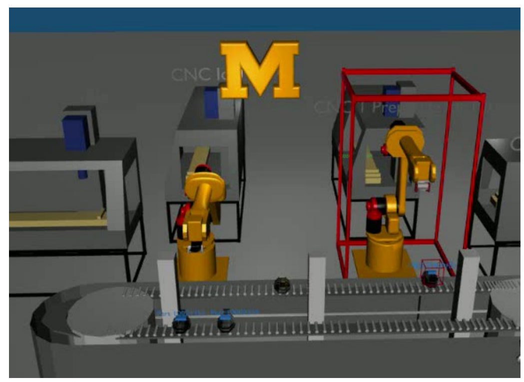
MOTIVATION AND CHALLENGE

In the report titled *Visionary Manufacturing Challenges for 2020*, the authors say being able to "reconfigure manufacturing enterprises rapidly in response to changing needs and opportunities" is one of the grand challenges of the future. The use of simulation as a planning and development tool can aid in flexibility for reconfiguration, by decreasing manufacturing ramp up and changeover time. Simulations can be used to test process feasibilities before large amounts of resources are spent. Currently simulations are only used in the very beginning stages of a process development. During the implementation and product life cycle, simulations become virtually useless. Virtual Fusion (VF) is a methodology where simulations can be used throughout all parts of development and implementation. VF methodology will mean less time is needed for component testing and integration.

One of the challenges VF address, is how to integrate simulation into the entire development process (planning the process, physically implementing the process, and managing the process). VF uses the integration of simulation to decrease the iterations needed to go from simulation to prototype. It would also make the simulation itself more useful to the manufacturer.

BENEFITS

- ✓ Provide an understanding of the state-of-the-art for simulation in process automation
- ✓ Reduce launch time and downtime due to unanticipated behavior
- ✓ Provide a platform for testing difficult-to-simulate components
- ✓ Provide a mechanism for 'play back' and 'play forward' of factory operations to predict downtime, adjust inventory and product levels, balance resources, and apply 'what-if' scenarios



A virtually fused environment with two way communication between user and the process

OVERVIEW OF THE WORK

Virtual Fusion (VF) is a methodology developed at The University of Michigan that builds on existing concepts from hardware-in-the-loop (HIL). HIL is a testing methodology whereby hardware or software are tested using simulated signals. A virtual component can replace a real component to test scenario feasibility and validate logic control. *VF* integrates simulation in a way that increases flexibility on three main fronts.

- VF uses simulation in parallel with physical implementation.
- VF uses simulations after the complete physical deployment. The simulations are used for process monitoring, giving the operator a view into the process past, present, and future.
- VF uses simulations and virtual reality for operator training.

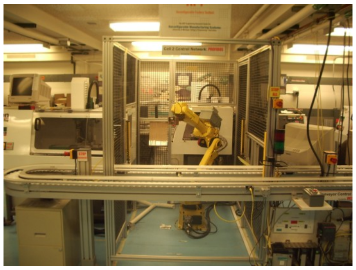
This work will result in a methodology that allows simulations to be used, not just for process planning, but for component testing and integration. Logic code can then be developed and tested earlier in the process development. Additionally, the simulations are now decentralized, meaning that the individual simulations come from the component vendors. Manufacturing process planners now do not have to purchase wide-reaching expensive simulation packages. The manufacturing process planner also has a "try before you buy" option for all components because of the decentralized simulations.

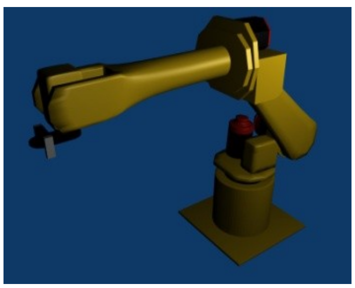
GOALS

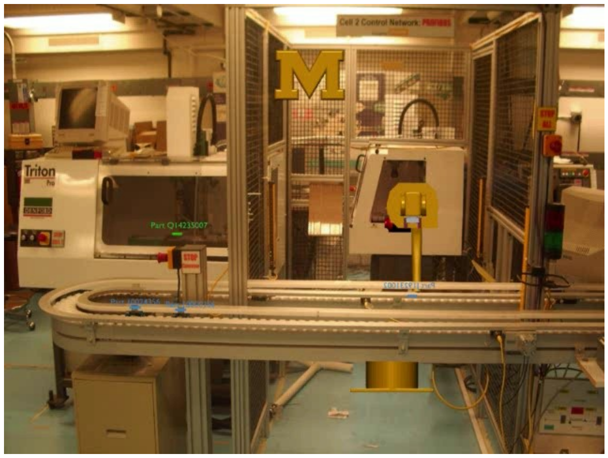
- Develop a simulation methodology for logic control validation
- Create a VF platform for online monitoring and operator training
- Extend VF technology to implement a method for 'play back' and 'play forward' whereby simulation, in lock-step with actual production and production monitoring, can be utilized to 'play forward' operation into the future thereby providing a prediction capability for factory management

PRELIMINARY RESULTS

A VF implementation has been developed and applied to the Reconfigurable Factory Testbed (RFT) at the University of Michigan. The RFT is a manufacturing process built to create toy wax trains. The RFT consists of two robots and 4 CNCs. VF methodologies have been used to test a simulated robot and two simulated cells. These tests represent a possible change of a component, a possible replacement of a cell, and a possible addition of a cell.







An implementation of VF which includes robot simulation replacement

An example of one of the test setups was to replace a real existing component with a simulated component of similar capability. The real Fanuc robot (top left) was replaced by a similar virtual version (bottom left). This allowed the virtual robot to work in place of the real robot without changing anything else in the system (right).

CURRENT STATUS

With the VF concept demonstrated on the RFT, current plans are focused on developing a transferable infrastructure for generic application of the VF concept in manufacturing facilities, thereby allowing simulated pieces to work in parallel with their real counterparts. This will allow for process monitoring and two-way interaction between the process and the user.

REFERENCES

Gu, F., Harrison, W., Tilbury, D., and Yuan, C., 2007. “Hardware-in-the-loop for manufacturing automation control: current status and identified needs”. In Proceedings of the Third Annual IEEE Conference on Automation Science and Engineering.

Harrison, W., Tilbury, D., 2008. “Virtual fusion: hybrid process simulation and emulation-in-the-loop”. In Proceedings of the 9th Biennial ASME Conference on Engineering Systems Design and Analysis.

DELIVERABLES

- HIL tools and logic validation survey
- VF implementation on ERC-RFT
- Methodology on use of HIL for logic validation
- Solution for VF use in monitoring and operator training
- Transferable VF concepts and prototype solution
- Extension to the VF solution to support play back / play forward capabilities

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