

# **Boosting Manufacturing through Virtualization and Intelligence**

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Digitization and distributed intelligence promise great benefits for the manufacturing industry. As full-fledged digital models, which capture in high fidelity the dynamics of processes and production machinery, become available, they enable complex manufacturing operations to be conducted, inspected, and optimized inside a virtual environment. This can circumvent the material, time, labor, and energy waste typically associated with trial and error based process development in industry. Intelligence, on the other hand, in the form of advanced monitoring, model updating, optimization, and real-time control capabilities, holds key value towards furthering the productivity, part quality, and resource efficiency of manufacturing operations. Paired together, virtualization and intelligence constitute highly innovative, value enhancing, but also difficult to achieve, building blocks essential to the 4th Industrial Revolution, also referred to as 'Industry 4.0'.

This presentation will introduce case studies from on-going research at the University of Waterloo, Precision Controls Laboratory, targeting the new virtualization and intelligence capabilities for high performance manufacturing. These case studies, which are also undergoing validation cycles on industry-scale machines, include:

- Machine tool and process dynamic model extraction from real-time manufacturing data;
- Time-optimal trajectory planning for 5-axis laser drilling and continuous toolpath machining;
- Active damping of chatter vibrations in large machine tools using servo and/or inertial actuators ;