SMART MACHINES

(Machines that Learn from Previous Experience)

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Today, in computer integrated manufacturing world we live in, machine tools must be capable of running more autonomously than they ever did before. They must be able to automatically avoid and correct processing errors or failures. The key to such capabilities is to increase accuracy and power of machining process modules. Accomplishment of such will require increased use of basic knowledge, both practical and science-based, created by past research on modeling of machining.

Moving into the Next Century

As we move into the next century, the success of the machining and electromechanical industries will depend on their ability to use the best information and machine technology into their products and processes. Smart Machines and Systems 2010 was a technology program focusing on the mechatronics approach.

The program has helped companies discover and use new technologies to respond to new market demands including changing customer values in the 21st century. Instead of developing totally new technologies as such, the program concentrates on introducing and implementing emerging technologies in machines and systems and new methods in the product development phase. The focus was on long-term technology development and 15 companies, 10 university and research center units contributed the program.

Scope of the Program

The program mainly included two different types of project: confidential industrial company projects and public research projects with a broader scope. However both worked in close contact and cooperation with each other. The principal aim of the industrial projects was to develop and evaluate longer-term product and technology scenarios to function as product development incentives in companies during and after the project. The public research projects collected and transferred know-how on the latest information technologies and electronics development, together with the knowledge needed in practical applications, for the industrial

projects and for industrial companies more generally. The participating research institutions represent the top expertise in their respective fields.

The advances in Internet, telecommunications, and sensing technologies have substantially facilitated the above studies and spawned a wide range of new research and development opportunities. The applications of the outcome have been extended well beyond the traditional manufacturing context to areas such as smart machines, smart factories, e-manufacturing, and enterprise resource planning.

Research Groups

The objective of one research group was to develop building blocks and architecture for smart machines, smart factories, and e-manufacturing. The main thrusts include the development of the following:

- **A machine and structure management system** for detecting, classifying and locating faults, predicting their growth, and recommending actions. A wide range of signal processing tools such as various wavelet transform techniques, de-noising and filtering methods, blind source separation methodologies, ICA, EMD, and hidden Markov model have been or are being applied in the development of the system.
- **An intelligent machining control system for adaptive control** of different machining processes in response to dynamic changes of tool/machine conditions, cutting geometry and workpiece material properties. Both conventional and fuzzy control approaches have been adopted. The focus is on versatility and planning-goal guidance.
- **An integrated planning system** that is able to: a) synchronize various manufacturing activities for maximizing profitability; and b) reconfigure manufacturing systems for rapid and sustainable responsiveness to changes. A network of models/agents is being developed for a distributed and collaborative planning environment. Neural, fuzzy and evolutionary computing tools are used to design algorithms for on-line decision making.

The goal of smart machines is to be able to sense, analyze situations, decide what must be done, and implement control actions. Humans working with smart machines often suffer negative consequences of automation, such as the out-of-the-loop performance problem, loss of situation awareness, automation surprises. It is not easy for humans to keep perfect awareness on

mode and intention of intelligent machines, partly due to difficulty in constructing mental models for various context-specific functions of the automation.

Conclusion

Where is Manufacturing Heading?

A good indication of where manufacturing is headed, according to on the Integrated Manufacturing Technology Roadmapping Initiative's (IMTR) 2015 Vision Statements, is as follows:

- Automated product design and simulation ten times faster.
- Model-driven virtual prototyping, to provide the best designs for performance and manufacturing.
- Common product data structures shared globally during all product life cycle stages.
- Best practice design advisors to optimize process designs.
- On-the-fly modification of process plans based on workload, equipment, staffing, and other factors.
- Autonomous shop floor scheduling, and control.
- Self-analysis and self-repairing capabilities to keep decision-support tools current.
- Major improvement in machine tool accuracy and repeatability.
- Self-diagnosis/healing machine tools.
- Modular manufacturing equipment with intelligent, model-based, open-based architecture controls.

Although most of these statements seem visionary, they are not so shocking considering where manufacturing is today. A recent theory of manufacturing that rattles the mind is in the area of nanotechnology. The marriage of chemistry and engineering will allow the manufacture of most goods using atoms and molecules as raw material. There will be no consuming of raw materials and no pollution caused by the manufacturing process.

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