Industry 4.0 and smart manufacturing

1 Industry 4.0 and cyber-physical systems

Manufacturing is on the brink of massive change as new connected automation systems are now making their way onto the factory floor.

Steam power created the first industrial revolution. The conveyor belt drove the second wave with the emergence of the mass production approach. In the third wave we have seen the rise of the Internet and the proliferation of computer-controlled machines. Now we are moving into the fourth wave – Industry 4.0. This next wave of manufacturing systems will be built with a new generation of cyber physical systems that improve productivity by delivering fully connected, intelligent manufacturing systems capable of supporting much more customization, much more manufacturing flexibility, and end-to-end manufacturing process automation.

In the future we can expect to see factories that operate as a single complex machine. Separate automated manufacturing devices will be connected as part of a complete manufacturing process. These connected machines will operate alongside an automated business process that controls materials flow and logistics. Connecting these intelligent factories to computer aided design will allow the manufacturing flow to be changed as the product design is evolved or new products are introduced. These flexible factories might be connected to the sales systems and the company web site, or might receive information directly from retail outlets. Production flows and logistics might be varied based on demand and products might be customized to match customer's specific orders and requests.

With increasing competition and consumer demands for innovative products – these flexible and scalable Industry 4.0 factories can be adapted to support new demands and will allow companies to respond to emerging trends.

This is not to say that the human factor will become unimportant. Human intelligence is, and will remain, uniquely suitable for certain tasks. For example, mechanical intelligence is generally limited to choosing between a number of pre-defined options: in contrast humans can bring creativity, flexibility, and the ability to learn. A key capability of the Industry 4.0 factory will therefore be the capability to provide the information and tools required by people to fulfil these roles.

The physical manufacturing world will become a form of information system. With sensors and actuators embedded in physical objects and linked through wired and wireless networks, all interconnected – factories will start to look like cloud compute warehouses. But instead of producing information from data they will produce physical objects from commands and information instead. These new cyber-physical-systems need new embedded processor technologies that can support the new demands for real time connectivity and distributed control.

2 Connected

The first step towards a more intelligent manufacturing system is connectivity. The cyber physical systems need to be connected to a network so that information can flow alongside the raw materials. This network doesn't just exist within the factory – the cyber physical system can be connected to the Internet and becomes part of the Internet of Things. In this way the physical manufacturing device can become an active part of the manufacturing process and also part of the business process as a whole.

The industrial environment however, places additional demands on the network system. It is not enough to just support best-effort delivery. The reliability of the network connection becomes critical and data delivery not only needs to be guaranteed, it needs to meet demanding real-time requirements. A number of de facto industrial Ethernet standards have emerged and these are often linked with other fieldbus and automation communication standards such as CANbus.

Embedded processors that are flexible enough to support these different standards but which are also responsive enough to meet the real-time requirements are now being demanded.

3 Distributed control

Using the network to provide fine-grained control over the machine is now possible. However if the control of the machines is centralized, this places massive demands on the network system. The fine grain control commands need to be passed over the network back and forth to the machine, adding network delays and slowing down the system's response. The centralized compute also limits flexibility and scalability, and creates reliability issues by introducing a single point of failure within the system.

The solution is to push the control intelligence out to the machine and even across the machine. For example, an embedded solution that can perform complex motion control inverse kinematics calculations at the level of an individual robot joint allows the central control system to send much higher-level commands. With powerful and responsive embedded processors it is possible to add intelligence across the machine. This adds much more performance and dramatically reduces response times – speeding up control loops by an order of magnitude. These intelligent systems can respond more quickly and can move much more precisely. Quality improves along with flexibility.

4 Scalability

Some tasks and some process flows will be simple and place limited demands on the cyber physical system. However, more advanced requirements create greater demands. If the system needs to support a flexible manufacturing process, it must be scalable. It may need to support a high degree of freedom of motion. It must respond quickly but must also be simple to control as part of an integrated business process.

The ideal solution allows compute to be added at each point of freedom so that intelligence can be distributed across the machine. In this scenario, each joint (or degree of freedom actuator) and each sensor has its own local intelligence. These nodes are interconnected, and designed to work together. With the correct communication system and distributed compute these separate embedded processors can form a larger, more complex system. Traditional approaches cannot deliver this seamless scalability; new solutions are required.

5 Current status and trends

Industry 4.0 is a theme that is being driven strongly in Europe by a number of leading industrial players and in particular forms part of the high-tech strategy of the German government. Meanwhile in the US the Smart Manufacturing Leadership Coalition is pushing similar goals and large manufacturing companies have their own internal initiatives – GE's 'Industrial Internet' is just one example. Companies in China are also starting to focus on ways that they can increase productivity and quality and improve manufacturing flexibility.

New intelligent robots are starting to emerge and major players such as Google and Amazon are starting to show a strong interest in robotics.

The automation industry is undergoing a transformation that is similar to the massive changes we have seen with the emergence of the Personal Computer and then the Internet. We are just at the start of what promises to be a massive change.

6 Summary

In manufacturing, the potential for cyber-physical systems to improve productivity in production and in the supply chain is vast. We may start to think of the future factory as massive 3D-printer that can turn product ideas into mass-produced physical objects, almost at the touch of a button. By connecting these intelligent factories to our automated design systems and linking them with our sales channels, the potential for customization and differentiation is huge.

This next wave of intelligent systems is creating a whole new set of demands on the underlying technology and making automation companies re-look at the way they build their systems. The embedded processors that power these cyber-physical systems need to be intelligent, scalable and responsive. Intelligent multicore processors are starting to emerge as a leading embedded processor for these new cyber-physical systems.