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Smart Manufacturing

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Abstract

Manufacturing accounts for a quarter of worldwide employment. Employees of this sector earn higher than the median income of a country. Manufacturing contributes up to twenty percent of Gross Domestic Product, GDP of countries. Moreover it has multiplier effect on business services jobs. Manufacturing is vital to country's economic growth and ability to innovate. Hence countries such as Singapore, China, USA, Germany, India, UK, Korea, and Japan have embarked on substantially funded national programs to strengthen manufacturing. Singapore's nineteen billion dollars Research, Innovation and Enterprise plan known as RIE2020 has a major emphasis on Advanced Manufacturing and Engineering, AME. Automation and robots have been part of manufacturing innovation. The following discusses what are on the horizon that will shape the future of manufacturing.

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Keywords:

Digital Manufacturing

The terms "digital manufacturing" or 'smart manufacturing' or 'intelligent manufacturing' refer to communication and computing technologies which enable all players in the value chain of products at the supply chain, enterprise and shop floor levels to be digitally connected and data analytics-driven, thus achieving intelligent coordination for demand and supply matching, faster time to market, mass customization and cost benefits. Engineers are developing Manufacturing Control Tower (MCT) for this purpose. Maintenance of machinery is an

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area of focus. For example, company General Electric, GE reported that at one of its plants, use of Predix software platform connected to sensors led to the detection of gas leakage and preventive measures led to savings of $350,000 per year. Another example, consider cutter tool wear in a CNC milling machine. After each cut, photos from a high fidelity stereomicroscope can be taken to measure the wear of the cutting tool. Measurements from sensors such as vibration sensor and force dynamometer are sampled using data acquisition cards and the data are stored on computers. After data acquisition, the sensor readings are used for feature extraction and selection. These selected features can be used to train and cross-validate advanced neural network (NN) or Hidden Markov Model (HMM) models of the tool wear, e.g. via an offline computing platform away from the machine. When the models are trained and cross-validated, they can be used for: (a) diagnostics where the degree of tool wear in the current time step can be determined from the model given the current and past sensor readings, and (b) prognostics so that the tool wear is predicted. These predictions enable maintenance to be scheduled when necessary, thus reducing downtime while increasing reliability.

Smart Sensors and Processors

Success of digital manufacturing is contingent on the availability of robust, power efficient and cost effective smart sensors and processors, and wireless networking interfaces. For this purpose nanotechnology and 3D Printing enabled next generation flexible sensors, electronic skins, self-powered, and disposable sensors are being developed. More over the smart manufacturing requires a variety of processors from small low end cores for sensors and actuators to more compact and power efficient for robots and intelligent devices to highest performance cores for servers. Various processors could be grouped into two blocks. The powerful but complex and expensive Intel processors, and the low cost and low end ARM cores. At the very low end side of processors a multitude of non-compatible devices exists usually focused on certain specific tasks. Intel processors have been combined with specialized graphics processors GPUs and FPGAs to increase both processing performance and power efficiency. ARM processor cores are combined with a number of accelerator units to reach acceptable overall performance. Yet, they lag in meeting the demands of smart manufacturing. Other requirements include easy connectivity and integration with overall system, cost, size and cooling budget. Even more demanding requirement is the homogenous software system so as to interact intelligently and lower the risk of failure. This requires a processor architecture which scales from small low end cores to very powerful high end processors. Such an architecture requires rethinking of traditional processor architecture from the scratch. For example, Hyperion-Core, a tech start-up is proposing polymorphous architectures (2). They are based on a data-processing array capable of emulating FPGA and GPU like data processing. They also process efficiently emerging Artificial Intelligence Algorithms while fully compatible with different programming environments and codes. Such developments are leading towards a single processor platform and a single open source software platform for the complex manufacturing system.

Internet of Things (IoT) or Industrial Internet of Things (IIoT)

Based on the aforementioned technology advances it is feasible to digitally connect many physical objects and equipment in what has come to be known as the Internet of Things (IoT). The pervasive connectivity provides many benefits such as information sharing and coordination leading to new functions and services that were previously not feasible, as well as greater equipment reliability since their status can be queried on a regular basis. These benefits have far-reaching implications for manufacturing as they have the potential to make manufacturing more agile and responsive, reduce equipment downtime and achieve greater efficiencies in operations leading to reduced costs. They also enable better matching of demand and supply, and can potentially increase revenue as well. Engineering companies as well as aerospace companies are betting on IoT. It is estimated that more than 50 billion machines will be connected by 2020.