t a missile plant in Huntsville, Ala., for instance, Raytheon Corp. monitors its assembly operations down to the turn of a screw. If a screw is supposed to turn 13 times after it is inserted in a missile component, but it turns only 12 times, an error message flashes, and production is halted until the anomaly is understood and rectified.

Just how much smarter factories can become will be determined largely by the research and development of systems to manage information. Smart factories, after all, are part of the phenomenon popularly known as Big Data.

The challenge of Big Data is that it requires management tools to make sense of large sets of heterogeneous information. In the case of a factory, sources of data include CAD models, sensors, instruments, internet transactions, simulations—potentially, records of all the digital sources of information in the enterprise. The data bank is large, complex, and often fast-moving, and so it becomes difficult to process using traditional database analysis and management tools.

Raytheon’s monitoring technology is often called “manufacturing execution software,” and several manufacturers are currently using MES to collect and analyze factory-floor data. The systems enable the real-time control of multiple elements of the production process.

Industry stands to reap many benefits from Big Data as more sophisticated and automated data analytics technologies are developed. These technologies
Smart manufacturing aims at integrating these islands, enabling data sharing throughout the plant and among plants in a company. A new wave of inexpensive electronic sensors, microprocessors, and other components enables more automation in factories, and huge amounts of data to be collected along the way. Managers can get instant alerts about potential problems or study the data to find ways to boost efficiency and improve performance. In addition, enhanced knowledge of the workplace promises to improve worker safety and to protect the environment because it can make zero-emission, zero-incident manufacturing possible.

In automated manufacturing, Big Data can help reduce defects and control costs of products. By tracking every detail about every part that goes into a product, from its original manufacturer, to where it was stored, to when it was installed, the data bank lets manufacturers retrace problems for better resolution. Monitoring defect ratios and on-time delivery can help with supplier selection and performance assessment.

Inside the factory, having the ability to utilize the mass of data on orders and machine status allows production managers to
The exponential increase in the volume, variety, and speed of data generated by simulations, sensors, and other sources is expected to continue in the coming years. The data generated by large-scale simulation is predicted to reach terabytes per second. There is a need for developing novel intelligent software agents, or cybernetic assistants, to harness the power of Big Data, and to enhance the productivity of the engineering workforce. They can help in crowd sourcing, and collaborative inventions, resulting in pushing the limits of what is possible for engineering systems.

The cybernetic assistants combine machine learning, natural language understanding, and novel modalities of human interaction to complement human intellect in new ways. Cybernetic assistants can leverage Big Data analytics tools and computational knowledge technologies developed by the research teams at the IBM Watson project, Wolfram Alpha, and other organizations. They can exploit the new types of predictive search facilities for dynamic applications, where information is flowing continuously. An example of predictive search facilities is the MindMeld developed by Expect Labs. It is a smart phone app that listens to conversations and searches for related material on the internet. As Expect Labs describes it: “As your conversation changes, MindMeld continuously finds and displays relevant pictures, videos, articles, and documents so that any information you may need is at your fingertips.”

The cybernetic assistants may eventually provide specific answers to questions and summary reports on any subject, or recommend a course of action in addressing a problem. In addition, the virtual assistants will have the capability of tracking every action that the users make on a computing device, and through the use of state-of-the-art sensors (such as gaze-tracking cameras, touchscreens, and gesture detection) and predictive analytics tools, deliver information without the users needing to ask.
optimize operations, factory scheduling, maintenance, and workforce deployment.

A number of developments under way now aim to realize the greater potential of Big Data in smart manufacturing.

The Smart Manufacturing Leadership Coalition, officially incorporated as a non-profit organization in July 2012, aims to overcome the barriers to the development and deployment of smart manufacturing systems. The coalition’s members include stakeholders from industry, academia, government, and manufacturing. The organization supports development of “approaches, standards, platforms, and shared infrastructure” that will encourage adoption of smart manufacturing by providing easy access, lowering cost, and resolving serious technological barriers found in today’s manufacturing environment.

Teams of members are currently developing a shared, open-architecture infrastructure called the Smart Manufacturing Platform that allows manufacturers to assemble a combination of controls, models, and productivity metrics to customize modeling and control systems, making use of Big Data flows from fully instrumented plants in real-time. The development of a smart manufacturing platform is intended to help management across the manufacturing ecosystem, and to forecast activities that, for example, can be used to slash cycle times and reduce the risks of product development.

The infrastructure will enable third parties to develop networked industrial applications that provide tools for resource metering, intuitive user interfaces, and Big Data analytics. Enhanced computing power, an enabling open-architecture infrastructure, and software advances can make data management invisible to the engineer, the bulk of it happening in the background.

Applications do not end at the factory. Future products can be outfitted with sensors that connect to the cloud, enabling after-sales service offerings. There could be an option in cars, for instance, that will alert drivers or service centers when maintenance is needed. Data showing how customers use products can suggest improvements in design or manufacturing.

Smart manufacturing is likely to evolve into the new paradigm of cognitive manufacturing, in which machining and measurements are merged in order to form more flexible and controlled environments. When unforeseen changes or significant alterations happen, machining process planning systems receive on-line measurement results, make decisions, and adjust machining operations accordingly in real time.

It is conceivable that one day machines and processes in a factory will be equipped with capabilities that allow them to assess and increase their scope of operation autonomously. This changes the manufacturing system from a deterministic one, where all planning is carried out off-line, to a dynamic one that can determine and reason about processes, plans, and operations.

Because of smart and dexterous robots, and novel
fyl

FORD MOTOR CO.
corporate.ford.com

HEADQUARTERS: Dearborn, Mich.
FOUNDED: 1903
EMPLOYEES: 175,000
REVENUES: $134.3 billion.

Ford, one of the traditional Big Three automakers in the United States, has worldwide operations that include 65 factories. The company sells more than 5.5 million vehicles a year.

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The website, created as a companion to this Mechanical Engineering magazine feature, contains links to material on Big Data information, current activities, technologies and tools, educational and research programs, including Big Data University.

The emerging tools being developed to process and manage the Big Data generated by myriads of sensors and other devices can lead to the next scientific, technological, and management revolutions. The revolutions will enable an interconnected, efficient global industrial ecosystem that will fundamentally change how products are invented, manufactured, shipped, and serviced. ME

traditional data warehouses are not able to handle the processing demands posed by Big Data. As a result, a new class of technology has emerged.

The Apache Hadoop, for example, is an open-source platform that can be used for processing a complex mixture of data, including log files, pictures, audio files, communications records, or e-mail, regardless of native format. Hadoop keeps all the data online for real-time interactive querying, analysis, visualization, and business intelligence. It is now widely used across industries, including telecom, healthcare, finance, and entertainment, and in government.

GE uses Hadoop software to manage time-series data, allowing it to scale data across multiple nodes, helping to manage the influx of tiny pieces of data that come in almost constantly.

Microsoft has developed a suite of tools for Big Data applications, including Microsoft Upstream Reference Architecture created to meet the needs of the oil and gas industry. It provides a bridge between the needs of the business and the Microsoft technology that supports it. It offers statistical and analysis packages for data mining, discovery, and reporting for diverse information consumers.

It also integrates decision-making processes and results to create and retain information relationships, history, and context.

IBM developed predictive analytics products for a variety of applications. The IBM platform covers system management, application development, and visualization and discovery. Several automakers use the platform in projects to develop and deploy connected car solutions that enable vehicle-to-vehicle, vehicle-to-driver, and vehicle-to-infrastructure communication in real time.

Fast, Google-like search of data can be made by using software systems like Clusterpoint. BigQuery is a cloud-based interactive query service, developed by Google for massive datasets.

Cisco Industrial Smart Solution is a portfolio of validated IP-networking technologies that connects factory automation and control systems to enterprise business systems.

Grok, a cloud-based service company, formerly known as Numenta, is building a neuroscience-inspired engine to find patterns in large data streams and to generate practical predictions in real time.

A number of attempts are being made to develop cognitive computers that can effectively process Big Data, through emulating the human brain’s billions of interconnections, computing efficiency, size and power usage without being programmed. These attempts take advantage of recent focus on understanding the human brain’s ability to learn, recognize patterns, adapt, and respond to changes in the environment. They include the Defense Advanced Research Project Agency’s Systems of Neuromorphic Adaptive Plastic Scalable Electronics (SyNAPSE) Project. The goal of the project is to develop electronic neuromorphic machine technology that scales to biological levels.

Researchers include teams from IBM, Hughes Research Labs, and Academic institutions.

almost like thinking

In 2011, IBM demonstrated a building block for a chip architecture based on a scalable and configurable network simulating brain activity.