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Ubiquitous Manufacturing

Matthew N. O. Sadiku, Emmanuel Dada, Sarhan M. Musa, Kazeem B. Olanrewaju

Roy G. Perry College of Engineering, Prairie View A&M University, Prairie View, TX 77446
Email: sadiku@ieee.org; eadada@pvamu.edu, smmusa @pvamu.edu; kaolanrewaju@pvamu.edu

Abstract The demand for highly customized products and the increasing popularity of outsourcing have given birth to the concept of ubiquitous manufacturing (UM). UM is an application of ubiquitous computing in the manufacturing sector. It is the next generation manufacturing paradigm. UM enables ubiquitous, convenient, on-demand access to a shared pool of manufacturing resources. This paper provides a brief introduction to ubiquitous manufacturing.

Keywords ubiquitous manufacturing, ubiquitous factory, ubiquitous computing

Introduction

Manufacturing involves the industrial production processes, through which raw materials are transformed into finished products which can be sold in the market. It is crucial to the national economy; it is the key element of industrial competitiveness.

Modern manufacturing is facing tougher multinational competition, flexibility and reconfigurability requirements. It requires a new generation of production system with better interoperability and new business models. With the recent development of network technology, communication technology, sensor network technology, and computing technology, manufacturing resources, services, facilities, and products can now be deployed ubiquitously.

Ubiquitous manufacturing (UM or UbiM) is an application of ubiquitous computing (or pervasive computing), which is a concept where computing is made to appear everywhere and anywhere. UM emphasizes the mobility and dispersion of manufacturing resources, products, and users [1].

The emergence of advanced manufacturing technologies has led to ubiquitous manufacturing. Such technologies include lean manufacturing (LM), cloud manufacturing (CM), global manufacturing (GM), virtual manufacturing (VM), Internet manufacturing (IM), and additive manufacturing (AM) [2]. Ubiquitous manufacturing can handle many problems that have not been properly solved by previous manufacturing paradigms. It suggests a nontraditional classification of industry and the inclusion of market-oriented manufactures [3].

UM Characteritics

UM has the following characteristics [1,4]:

(1) UM is a "design anywhere, make anywhere, sell anywhere, and at any time" concept that allows manufacturers an unlimited production capacity and permanent service availability.

(2) It applies integrated manufacturing technology (MT), information technology (IT), and ubiquitous technology (UT) to the manufacturing domain. MT is for effective production, IT is for communication, while UT is for data acquisition and transmission. The ubiquitous environment in the manufacturing domain is characterized by being capable of producing product-centric digitized information.

(3) Ubiquitous computing technologies address a wide range of issues in the manufacturing industry. Such issues include manufacturing processes and equipment, manufacturing management and planning.
(4) UM is a web-based manufacturing system, which can improve the efficiency and quality of product design, production, life cycle integration, enterprise management, and customer service. It transparently collects and utilizes data on product and product-related context;.
(5) It supports real-time collaborative activities between stakeholders in a distributed environment.

UM Technologies

Advances in electronics (e.g. sensors, mobile devices, information and communication technology) have significantly contributed to the emergence of ubiquitous manufacturing. UM employs technologies such personal digital assistant (PDA), web camera, global position system (GPS), ZigBee, mobile Internet, and industrial robots. Thus, UM enabling technologies include:

(1) *Sensors:* Ubiquitous sensing technologies include radio frequency identification (RFID), auto ID, virtual reality, GPS, and Wi-Fi. A regular sensor can be converted into a ubiquitous sensor by connecting a networking module to it. The sensors (temperature, vibration, force, etc.) are used to monitor manufacturing processes.
(2) *RFID*: Manufacturing resources like machines, materials, and personnel are equipped with RFID devices and they become smart manufacturing objects. RFID technology enables real-time traceability, visibility, and interoperability in improving the performance of shop-floor planning, execution, and control of manufacturing systems.
(3) *Robots*: Industrial mobile robots are used in handling and transporting materials. This is appropriate for UM due to their flexibility and ability to communicate.
(4) *Cloud Manufacturing*: This represents a shift from production-oriented to service-oriented manufacturing. It extends and adopts the concept of cloud computing for manufacturing. It is applied extensively to manufacturing because it enables collaborative product designing by designers in different locations.

Challenges

Several challenges are open for investigation to improve work-cell productivity and quality in a UM environment facilitated with RFID technology. One challenge is to determine which kind of real-time information should be provided for adaptive decision making and how to deliver the information with existing information technologies [5].
Challenges still exist in applying RFID technologies to real-life UM environment. it is both labor and skill intensive to integrate and manage various kinds of RFID devices for various industrial applications. Requirement changes of applications is a challenge for RFID system in manufacturing environment [6].
It is a big challenge to develop big data-based UM application systems to deal with the high volume, heterogeneous data produced by complex manufacturing operations. The selection of appropriate cloud services for big data analytics is also a challenge [7]. The privacy and the security of manufacturing data are also issues to be addressed.

Conclusion

Ubiquitous manufacturing technologies have been widely deployed in a variety of manufacturing processes. The trend is to integrate logistics planning with the UM task scheduling using big data analytics of the manufacturing data. Since UM involves the whole lifecycle of a product, it should involve the collaboration of government, R&D centers, and enterprises. Government handles legislation, while R&D centers conduct research and development, and the enterprises invest in the technologies.

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About the Authors

Matthew N.O. Sadiku (sadiku@ieee.org) is a professor at Prairie View A&M University, Texas. He is the author of several books and papers. He is a fellow of IEEE.

Emmanuel Dada (eadada@pvamu.edu) is an assistant professor at the Department of Chemical Engineering at Prairie View A&M University. He is the author of several papers and patents. He is a fellow of AIChE.

Sarhan M. Musa (smmusa@pvamu.edu) is a professor in the Department of Engineering Technology at Prairie View A&M University, Texas. He has been the director of Prairie View Networking Academy, Texas, since 2004. He is an LTD Sprint and Boeing Welliver Fellow.

Kazeem B. Olanrewaju (kaolanrewaju@pvamu.edu) is an assistant professor at the Department of Chemical Engineering at Prairie View A&M University. He is a senior member of AIChE