Closed-loop Design Evolution of Engineering System using Condition Monitoring through Internet of Things and Cloud Computing

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ABSTRACT

Flexibility of a manufacturing system is quite important and advantageous in modern industries, which function in a competitive environment where market deviation and the need for customized product are growing. Significant machinery of a manufacturing system should be reliable, flexible, intelligent, less complex, and cost effective. To achieve these goals, the design methodologies for engineering systems should be revisited and improved. In particular, continuous or on-demand design improvements have to be incorporated rapidly and effectively in order to address new design requirements or resolve potential weaknesses of the original design. Design of an engineering system, which is typically a multi-domain system, can become complicated due to its complex structure and possible dynamic coupling between domains. An integrated and concurrent approach should be considered in the design process, in particular in the conceptual and detailed design phases. In the context of multi-domain design, attention has been given recently to such subjects as multi-criteria decision making, multi-domain modeling, evolutionary computing, and genetic programing. More recently, machine condition monitoring has been considered for integration into a scheme of design evolution even though many challenges exist for this to become a reality such as lack of systematic approaches and the existence of technical barriers in massive condition data acquisition, transmission, storage and mining. Recently, the Internet of things (IoT) and cloud computing (CC) are being developed quickly and they offer new opportunities for evolutionary design in such tasks as data acquisition, storage and processing. In this paper, a framework for the closed-loop design evolution of engineering system is proposed in order to achieve continuous design improvement for engineering system through the use of a machine condition monitoring system assisted by IoT and CC. New design requirements or the detection of design weaknesses of an existing engineering system can be addressed through the proposed framework. A design knowledge base that is constructed by integrating design expertise from domain experts, on-line process information from condition monitoring and other design information from various sources is proposed to realize and supervise the design process so as to achieve increased efficiency, design speed, and effectiveness. The framework developed in this paper is illustrated by using a case study of design evolution of an industrial manufacturing system.

KEYWORDS: Engineering system design, design evolution, multi-domain modeling, machine condition monitoring, internet of things, cloud computing.

1. INTRODUCTION

Globalization has intensely changed the engineering manufacturing sector as is the case in many other areas. The growing demand for novel, high quality and highly customized products at low cost with rapid adaptation to market deviation is fundamentally changing the way production systems are designed and implemented [1]. With the development of information, communication, management, sensing and other technologies and theories, various advanced manufacturing system methodologies have been proposed such as lean manufacturing, agile manufacturing, flexible manufacturing, concurrent manufacturing, sustainable manufacturing, global manufacturing, and so on, in order to accommodate the current extremely dynamic operating environment of manufacturing companies such as market variations, changes to time and quantity of product demand and manufacturing system failure [2]. Most of these new research and development have contributed to advanced manufacturing system at the level of manufacturing and planning. However, one fundamental and significant element in forming a competitive manufacturing system that can adapt to rapid market changes is the capability of automated and evolutionary reconfiguration and design improvement of the system.