The Platform of Intelligent Manufacturing System Based on Industry 4.0

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Abstract. Intelligent manufacturing has become a development trend for manufacture industry. But there only have few labs that can demonstrate more comprehensive concepts of intelligent manufacturing. To fill the blank of this area and promote the development of intelligent manufacturing, we start this project and build up a platform that demonstrate how intelligent manufacturing system is working and upon which we can explore the feasible scheme for companies and teach students about intelligent manufacturing visually. We combine hardware like industrial robots, enterprise management software like MES, ERP and cloud platform to build a sustainable system of intelligent manufacturing. This platform is designed for scientific research, experimental teaching, enterprises training and work out solution for enterprises.

Keywords: Industry 4.0 · Intelligent manufacturing · Smart factory
System integration

1 Introduction

Among the major changes emerge in the field of information technology and industry in recent years, intelligent manufacturing, which is a product of the depth of integration of information technology and industrialization [1]. To empower the competitiveness of national manufacturing industry, the research efforts of intelligent manufacturing are carried out throughout the world under governmental projects such as NNMI(National Network for Manufacturing Innovation, USA), Industry 4.0 (Germany), Horizon 2020: Factories of Future (EU), etc., aimed at bringing innovations to manufacturing processes, productivity, and quality [2]. China as a manufacture powerhouse also proposed 'Made in China 2025' as a national strategic plan in 2015.

As a lab of a university, It is designed a website that enable customers to personalized toy house with different styles, materials or colors. The goal of this research is to not only establishing a teaching scene of smart factory or to imitate an existing assemble line, but also to explore reasonable application of cross-layer integration, production lifecycle traceability, preventive maintenance and production line virtualization.

2 Research Objectives

The white book of German Industire 4.0 generalizes three major strategies for cross-layer integration which are vertical integration, horizontal integration and end to end integration. It says that "Industrie 4.0" can serve to create horizontal value networks at a strategic level, provide end-to-end integration across the entire value chain of the business process level, including engineering, and enable vertically integrated and networked design of manufacturing systems [3]. Our project is based on the recommendations of the white book of German Industire 4.0. Vertical integration, horizontal integration and end to end integration are our research objectives.

2.1 Vertical Integration

Vertical integration and networked manufacturing systems describes the intelligent cross-linking and digitalization within the different aggregation and hierarchical levels of a value creation module from manufacturing stations via manufacturing cells, lines and factories, also integrating the associated value chain activities such as marketing and sales or technology development [4]. It can be carried out in two ways: backward integration and forward integration. In the era of global economy and internet, vertical integration becomes even more common to integrate not only whose components but upstream and/or downstream of a industry chain.

2.2 Horizontal Integration

Horizontal integration is to amalgamate firms or departments which have similar or the same functions. It aims to cut intermediate expenditures among departments or companies to reduce the production cost and to carry out mass production. One typical example is that many companies is willing to integrate the storage management system and production management system and quality inspection division and other production related departments to establish resource sharing system for work efficiency promotion and production costs reduction. CPS (cyber Physical System) is mostly used to sustainably support and implement models, designs and implementations of horizontal integration through value networks. Being part of a socio-technical system, CPS are using human-machine interfaces for interacting with the operators [5].

2.3 End to End Integration

The end-to-end engineering across the entire product lifecycle describes the intelligent cross-linking and digitalization throughout all phases of a product life cycle: from the raw material acquisition to manufacturing system, product use, and the product end of life [4]. The goal of achieving end-to-end digital integration throughout the engineering process is to integrate the digital and real worlds across a product's entire value chain and across different companies while incorporating customers' requirements. Modeling plays a key role in managing the increasing complexity of technological systems.

3 Research Contents and Methods

3.1 Personalization Production

Personalization production is one of the highlights of this project and the strongest part for user experience. It is to yield products based on customers' practical requirements. At first, we have succeeded to improve personalization product from selecting a key chain to designing a toy house. Customizing a key chain is to select one style out of several given ones and with human-computer interaction and automatic transport system to deliver the final product to customers. We take a further step to the toy house personalization which customers can design their fond toy house from choosing the materials to coloring their house.

3.2 Vertical Integration in Our Platform

In this research, we actualized vertical integration (see Fig. 1) between equipment layer and business management layer and end to end integration. To produce customized house design and automatic produce scenario, we built connections among hardware devices, which for instance are 4 industrial robots, 2 AGV, 2 production lines and 3D printer, with industrial bus for interconnections and PLC for logic control.
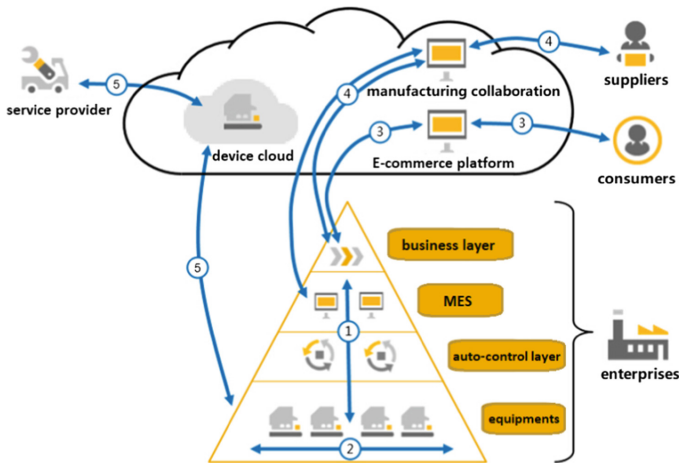

Fig. 1. Vertical integration of our platform

Moreover, cooperating with SAP University Alliances, we set up a complete software system include MES, ERP and SAP HANA. After MES get all the data from ERP system, the industrial automatic system will control all the robots to assemble the product. In this scene, we successfully integrate industrial robots production line with ERP and MES for the customization platform.

3.3 Preventive Maintenance

To strategically work on preventive maintenance, it means to monitor the platform precisely and process data rapidly. To achieve the goal, we preset the vibration sensors, velocity sensors, temperature sensors onto the assemble robots of the production line so that we can get running statuses of these robots while continuous production process. These statuses data will storage at the cloud database servers through IoT (Internet of Thing). In this project, the robots state information of this project will upload to the SAP HANA cloud for classification learning of the failure robots may occur. Moreover, this project will establish a model to analysis the state information of the robots in case that if the evidences of failure occur, we can implement preventive maintenance immediately.

4 Application of the Platform

4.1 Support Multidisciplinary Integration

The mechanism, functions, structures and development of complex products are complicated and concerned with multidisciplinary knowledge and require an approach of collaboration among product development teams and organizations [6]. Currently, innovation talent training is one of the important teaching forms in the universities but lacks the integration of the different disciplines. This paper integrated personalized customization, customer end-to-end integration, vertical integration, product lifecycle traceability, automated production and preventive maintenance of intelligent manufacturing into the platform.

4.2 Provide Solution for Enterprises

Intelligent manufacturing system provides core support to build up intelligent factories. At present, manufacturing industry in China is still at the stage of co-existence mechanization, electrification, automation and informatization which has a long way to intelligent manufacturing. Our work is to help enterprises solve the bottleneck of technological development with the integration of intelligent manufacturing system though three driving links which are intelligent factory, intelligent production and intelligent interconnection.

5 Conclusion and Prospect

5.1 Technical Feasibility

The design of this project is an experimental platform of intelligent production line that demonstrates personalized and customized production. This platform is designed and installed small toy houses. We set up a production line demonstrating typical concepts of industrial 4.0 and intelligent manufacturing in the laboratory. This experimental platform mainly includes six intelligent modules: personalized and customized

production; vertical integration from the equipment layer to the business layer; preventive maintenance of equipment; This system embodies the latest smart manufacturing technology and is an interpretation of the concept of smart manufacturing or Industry 4.0.

5.2   Sustainable Development

The current globalization is faced by the challenge to meet the continuously growing worldwide demand for capital and consumer goods by simultaneously ensuring a sustainable evolvement of human existence in its social, environmental and economic dimensions. In order to cope with this challenge, industrial value creation must be geared towards sustainability. The eco-system which builds tunnels among human, equipment and final products with the usage of sensors, industrial software, network communication systems and new forms of human-computer interaction. Eventually, cooperating closely with the enterprises, this project aims to build an ecosystem based on the platform of the lab.

5.3   Resources Sharing Management

This platform is also an innovation of resource integration, it applies the economic characteristics of the Internet platform to the scientific research and teaching platform. Through the integration of this equipment, we integrate robotic equipment, enterprise management software suppliers and universities' research teams to create a solid technology platform. Through joint teaching of schools and training of companies, the participants' knowledge and technology markets are promoted.

References

1. Kagermann, H., Lukas, W., Wahlster, W.: Abschotten ist keine Alternative. In: VDI Nachrichten, no. 16 (2015)
2. Kang, H.S., et al.: Smart manufacturing: past research, present findings, and future directions. Int. J. Precis. Eng. Manuf. Green Technol. **3**, 111–128 (2016)
3. Acatech: Recommendations for implementing the strategic initiative INDUSTRIE 4.0. acatech (2013)
4. Acatech: Umsetzungsstrategie Industrie 4.0 Ergebnisbericht der Plattform Industrie 4.0. acatech (2015)
5. Hirsch-Kreinsen, H., Weyer J.: Wandel von Produktionsarbeit – Industrie 4.0. Soziologisches Arbeitspapier 38, TU Dortmund (2014)
6. Zhang, H.M., Fan, W.H., Wu, C.: Concurrent design approach and its collaborative environment for integrated complex product development. J. Integr. Des. Process Sci. **8**(3), 89–97 (2004)