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Integrating Artificial Intelligence with Mass Customization

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Abstract: Mass customization is an emerging trend in manufacturing that is driven by market demand and artificial intelligence (AI) technology. Thus, analyzing how AI technology can be integrated with mass customization and summarizing the key technologies involved to achieve this assumes greater significance. Through case studies on, and interviews with experts from, the furniture, household appliances, clothing, and automobile industries, this study analyzes the development trends of multiple key technologies, such as multi-source cross-media heterogeneous database construction, a big data-based mining system for deciding design feature requirements, virtual experience systems and virtual manufacturing, and the automation of information collection for the entire manufacturing process. We further propose suggestions for popularizing mass customization integrated with AI technology from the perspective of top-level design, enterprise, talent, and finance.
Keywords: artificial intelligence; development planning; mass customization; service mode

1 Introduction

With the improvement in living standards, the demand for personalized consumer goods has increased gradually. While manufacturing companies focus on providing use value, meeting the individual needs of customers has become an important way for them to increase their market share and profits. Providing customized products and ensuring a comprehensive improvement in consumer satisfaction has become a tool for enterprises to gain new competitive advantages [1–4].

Mass-customized manufacturing refers to the large-scale production of customized products. It combines the advantages of both mass and customized production to meet individual demands while ensuring economic benefits. Mass production has the advantage of high efficiency and low cost, but it comes at the expense of ignoring the diverse needs of consumers. Customized production can meet the personalization needs of consumers to a certain extent, but it requires more time, raw materials, energy, and labor [5]. Mass-customized manufacturing adopts a flexible production process and organizational structure that can provide customers with a more diversified and personalized range of products and services, while enabling these products and services to compete with the ones manufactured using standardized mass production.

Customized production is widely used in the large machinery industry. However, in the consumer goods industry, which has a large annual output, it is very difficult to implement customized production based on small batches, large variety, and short delivery cycles by using traditional technical means. The new generation of information technology can provide the technical foundation for large-scale production of customized products at a lower cost and energy usage, as well as shorter delivery cycles.

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This new generation of information technology mainly includes big data, Internet of Things, cloud computing, and mobile Internet technology. However, mass customization based on digitalization and networking needs to be improved further in terms of the precision of R&D, and the design and degree of product customization [6]. Artificial intelligence (AI) technology will further promote the development of mass customization.

Based on case studies and expert interviews, this paper probes the necessary and key technologies for integrating mass customization with AI technology, and proposes countermeasures and suggestions according to the emerging trends in mass customization.

2 Research background

Mass customization operates on the premise of universal application of digital technology with the support of network technology. Knowledge accumulation related to mass customization and production scheduling optimization in the furniture, clothing, household appliances, and other consumer goods industries has changed.

2.1 Changes in market demand have driven the shift toward customization

Supply-side reforms have profoundly affected the business model and philosophy of the manufacturing industry. The value chain of home appliances, furniture, and clothing enterprises has gradually changed from being product-oriented to customer-oriented. To meet the needs of an upgraded consumption structure, the product structure in these industries is becoming multi-level and has a greater degree of customization.

First, a rapid response to customer needs has become the focus of competition. In the 19th century, it took about 70 years to take a new product from conception, through design and trial production to the commercial production stage; this shortened to 40 years in the interwar years. It further reduced to 20 years in the 1960s. Post-1970, it shortened to 5–10 years, and now, it only takes about 2–3 years or less, depending on the product and its demand. This situation has inevitably led to a shift in the focus of the market competition. The ability to respond quickly to customer needs can make or break an enterprise's viability when differentiated and low-cost manufacturing methods are used together. Therefore, a differentiated brand positioning becomes a necessary condition for competition. Based on this positioning, enterprises that can achieve fast delivery, high quality, low cost, and environmental protection while meeting personalized needs can gain a new competitive advantage.

Second, limited environmental resources have led to customized solutions to customer needs. For example, rising house prices have forced most people to buy small or tiny houses, which necessitates the use of custom-made furniture to make efficient use of the limited space available. Progressively, people are realizing that energy is precious, and they now look for appliances that consume less energy and/or use household appliances judiciously.

Last, the pursuit of personalization brings in the need for customization. According to the theory of demand, when living standards rise, the consumer is no longer satisfied by the basic functionality provided by a product and starts to look for ways to incorporate his or her personal taste and style sensibilities into the product. Customers are increasingly looking to diversify their clothing style, and want that their clothing should not only reflect their personal taste, but also make them stand out in a group. For example, customers now demand more stylish home appliances. Customers no longer want home appliances that have an ordinary or bland look, but ones that would blend in with, or accentuate, the home décor, as pieces of art do.

2.2 A new generation of information technology provides a technical base for mass customization

The next generation of information technology that can be used for mass customization includes mainly big data, Internet of Things, cloud computing, and mobile internet. After the integration of multi-dimensional data, such as enterprise systems data, mall passenger traffic data and e-commerce data, international trade data and online comment data, the applicable environmental model's data, regional characteristics and cultural demand data, fashion trends-related data and design template data, data mining tools can be used to generate dynamic analysis reports on development trends, network public opinion reports, sales analysis reports, and so on, to provide a basis for decision making to enterprises for customizing their production. Application of radio frequency identification technology and micro-nano systems technology to products, manufacturing workshops, and unit manufacturing equipment can facilitate the capture of transparent big data related to sales and production, providing basis for manufacturing data sharing and customer inquiry. Cloud computing can be used for modularization of data backup, query, analysis, and mining; it can also reduce the cost of enterprise hardware and software, besides accelerating the progress of big data applications. Mobile Internet platforms can be used for network analysis and personalization of demand analysis, interaction design, and sales services.

With the help of a new generation of information technology, enterprises can, on the one hand, employ user interaction platforms to aggregate fragmented and personalized requirements into bulk orders. On the other hand, through a cyber-physical system, the digital management of manufacturing processes can be matched with the demand for personalized consumer products, thereby achieving scale-based production. At present, the home appliances, furniture, and clothing industries have completed the pilot demonstration using digital networks for mass

customization. Individual companies have made preliminary explorations regarding the application of AI technology.

3 The development trend of mass customization

According to case studies and interviews with experts in the furniture, home appliances, clothing, and automotive industries, mass customization based on digital networking needs further improvement, and AI technology is expected to provide solutions to break through the existing bottlenecks.

3.1 The need to integrate AI technology

The following two aspects of mass customization based on digital networks need further improvement: the accuracy of R&D design and the degree of customization of products.

Currently, R&D design is based on interaction between customers and designers. On the one hand, designers make designs based on experience. Owing to the uneven skill levels of designers, the design does not necessarily meet the customization needs of customers. On the other hand, the question of whether the customized products can meet production conditions is also based on the judgment of the designer and this limits the creativity and personalization possible in the customized products. Achieving efficiency and precision in customized product development and design requires the integration of more complex multidimensional data and more efficient data processing and data mining techniques.

The degree of customization is a process condition to meet the customers' needs. General production modules of a customized product have room for still further deconstruction. The existing digital network technology has not been able to effectively realize the process optimization of the more complex and diverse production modules. The efficient use of resources and energy in the manufacturing process needs to be strengthened. Automatic scheduling can be achieved using digital network technology. Under more complex production conditions, the scheduling model and method would need to be updated.

3.2 Key technology to break through the bottleneck

Considering the problem of mass customization in the home appliances, furniture, and clothing industries, our research shows that using AI technology to enhance information feedback and data mining capabilities can upgrade existing R&D design systems, virtual manufacturing simulation optimization systems, and mass customization production systems. We focused on four key technologies.

The first is a multi-source cross-media heterogeneous database. The product database, use-environment database, solution database, and production process database should be integrated heterogeneously. Further, a networked intelligent measurement system and an online interactive platform for determining customer demand should be developed to collect customer data; furthermore, the customer data, design data, virtual manufacturing data, and production data are then incorporated in the cloud, thereby providing the basis for the operation of algorithms, such as neural networks and deep learning.

The second key technology is a mining system based on big data for determining design feature requirements. Based on community ecology, this technology refers to collecting and aggregating customer source information, basic customer information, personalized demand information (including information about optional and physical features of a product), and customized product service information; these details are then matched with those from heterogeneous databases. Using intelligent analysis techniques, such as machine learning algorithms, depth learning model, pattern recognition, text mining, three-dimensional model recognition, product use environment model matching, image processing, and so on, can help with deep data mining, intelligent solution recommendation, intelligent designer recommendation, intelligent optimized product design, and intelligent raw material procurement prediction.

The third technology concerns virtual experience systems and virtual manufacturing. A variety of virtual reality (VR) technologies, cloud rendering platforms, and VR interactive experience technologies can be used to quickly create a virtual simulation of the design scheme and help customers get a complete product experience at the design stage. Orders of different materials and types of customized products can be split quickly and organized reasonably into batches using multiple scheduling models and algorithms. Order management and intelligent production scheduling can be achieved in a virtual manufacturing system. This would blur the line between R&D design and virtual manufacturing and solve the contradiction between customized design and large-scale production.

The fourth covers information acquisition, production control, and collaborative system optimization for the entire process. Virtual manufacturing, micro-nano sensors, and bar code labels can aid in the online inquiry and real-time control of production's processes, plans, status, equipment, and quality analysis in the mixed-flow production of mass-customized products; they can also support and optimize the warehousing, equipment, quality, logistics management, and sales functions. The data feedback from the R&D design link can achieve collaborative optimization of the whole process.

4 Countermeasures and suggestions

This study puts forward the following recommendations to promote the integration of AI technology with mass customization.

First, there is a need to strengthen top-level design and planning guidance. This paper demonstrates the developing trends, as

well as the medium- and long-term goals of mass customization in the furniture, household appliances, and clothing industries, and formulates effective promotion strategies. We study the development potential and bottlenecks in moving to mass customization in other industries, such as the automobile industry. New situations and problems in the development process of mass customization should be monitored and tracked; the study of special issues should be strengthened; and a good policy reserve should be created.

Second, enterprise growth should be stimulated. Innovation is the driving force for the rapid development of enterprises. It is necessary to formulate strategies that strengthen the protection of intellectual property rights to encourage technological innovation. Technological innovation stimulates market demand, which, in turn, would drive enterprise growth.

Third, to promote customized production, the right talent should be cultivated. A talented workforce is at the core of industry development and a precondition for the manufacturing industry to enter a new business form or mode. We should focus on multi-level and multi-faceted training of employees, carry out educational system reforms, optimize curriculum design, strengthen systematic vocational training, improve the professional ability of employees, and ensure a steady supply of talent to ensure the rapid development of mass customization.

Fourth, there should be greater financial support for mass customization. We should strengthen the use of flexible financial policies, provide a variety of financing methods, reduce the cost of enterprise financing, optimize the allocation of resources, reduce the startup cost and risks of mass customization, and support the transformation and upgradation of traditional manufacturing.

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