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A Web-based Platform for Customer Integration in the Decentralised Manufacturing of Personalised Products

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Abstract

In today's highly customer-oriented market, web-based approaches are the main enablers towards achieving a sufficient level of customer involvement during the design phase of new products. This research work, describes a novel software architecture that facilitates the ability to visualise and manipulate three-dimensional product design parameters under constraints. The manipulation is performed in real-time, over web, comprising Virtual and Augmented Reality functionalities. The approach integrates the customer into the supply chain of the personalised product manufacturing, as the design changes have a direct impact on the supply chain configuration. The software architecture and the description of the offered functionalities are presented, as well as the implementation tools and programming frameworks. The approach is tested on a case study from the automotive sector.

Keywords: Personalisation; 3D modelling; Web technologies

1. Introduction

The customers in today's globalised market express an evident desire towards a greater level of product individualisation [1]. The customer, as a result has to be treated as an individual and not merely as a market segment [2]; his requirements must be efficiently identified and sufficiently satisfied. The quote from Henry Ford: "Any customer can have a car painted any colour that he wants as long as it is black" [3] is no longer valid. The main idea behind product personalisation is to successfully integrate the customers into the design process of their own products [4]. The design changes performed by the customers must be fulfilled by the OEM. The OEM has to configure the supply chain in order to carry out the production of the personalised product. Product customisation is no longer a buzzword; instead it is a common practice, which is realised currently in almost every market domain. Through customer involvement, useful information can be extracted from the manufacturers [5]. The purpose of this research work is the development of methods towards integrating the customers into the design phase of personalised products, granting them an active role in the configuration of the supply chain.

2. State of the Art

The globalisation of the markets that came along with technological innovations reshaped the value added chain in the global manufacturing network. Chryssolouris stated in 1996: "It is increasingly evident that the era of mass production is being replaced by the era of market niches" [6]. A transition is on-going from a Build-To-Stock (BTS) to a Build-To-Order (BTO) paradigm. A BTO system requires significant adjustments in marketing, production and logistics [7]. Assembling directly on order, on the other hand, reduces the risk of loss due to obsolescence, as completed products become obsolete faster than their components. Thus, there is a definite advantage in assembling when the customer has actually ordered a product, exploiting delayed differentiation techniques [8].

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The advent of the World Wide Web (WWW) and software technologies enabled the economic and market globalisation [9] and revolutionised the coordination process within manufacturing networks [10]. Web-based and e-Commerce systems have been implemented, proving their effectiveness in capturing the pulse of the market [2]. The retailers, in almost every industrial sector, offer a wide variety of product variants online. Recent surveys show, that 89% of the buyers prefer shopping online to in-store shopping [11]. The online competition among companies, results at further and rapid evolution of web technologies. Web-based toolkits for mass customisation purposes are deployed, which aim at providing a set of user-friendly design tools that allow trial-and-error experimentation processes, and deliver immediate simulated feedback on the outcome of design ideas [12]. Once a satisfactory design is found, the product specifications can be transferred into the firm's production system, to produce and deliver the customised product to the customer [13]. Nowadays, even more design and assembly work is conducted in terms of collaborative projects across globally distributed design teams, companies and software modules. Proposed approaches include e-Assembly systems for collaborative assembly representation [14] and web-based collaboration systems [15]. A web-based integrated platform was presented by Mavrikios et al. in 2011, to support the collaborative product design activities, allowing real-time collaboration among geographically dispersed user groups during product design activities [16]. A web-based workflow system that focused on the initial design and engineering of a production system was proposed in 2011 [17].

3. Model of user integration in personalised product design

The user integration procedure aims at enabling the integration of a variety of users to the platform. The first goal is to effectively integrate the customers in the initial design, making them a part of the supply chain. In addition, a main goal is to support the collaboration and communication between OEMs, suppliers and sales representatives.

The typical scenario of the system functionality is described below (Fig. 1). The customer registers and logs in to the web-based platform. A product gallery is presented, and the customer browses through the available products. Once a specific product is selected, the customer is provided with the ability to personalise it. The personalisation can be performed utilising a web-based 3D configurator. Each product allows for different modifications, pre-defined by the OEM. The allowed design modifications are strictly defined to ensure manufacturability, branding and operational constraints and specifications. Modifications may include colour selection, material and texture selection, choice of additional features, and geometric manipulation. Moreover, the Augmented Reality (AR) tool is provided as an advanced visualisation means. Once a satisfactory design modification has been performed, the customer may visualise it in AR and place it as an order. The design is tested in real-time for eligibility (geometry and functional constraints, etc.).

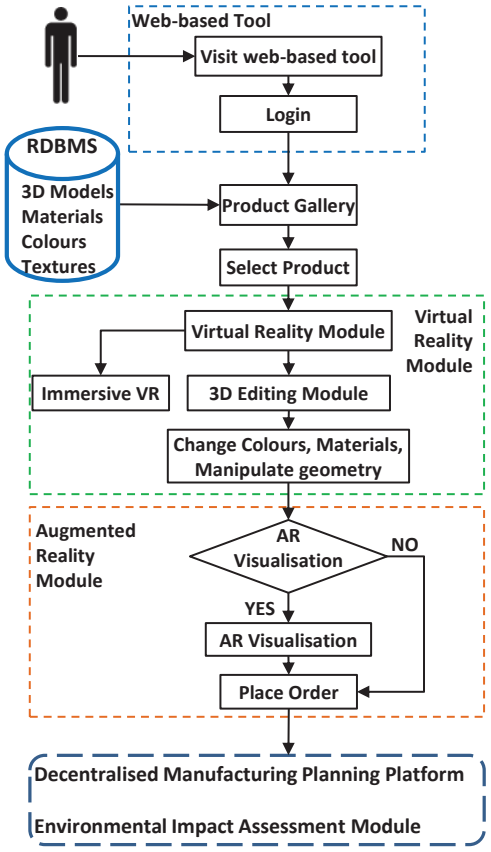

Fig. 1. Virtual and Augmented Reality Tool Workflow

The customer needs, expressed through the customised product, must be fulfilled by the OEMs in a cost-efficient, fast and environmentally friendly way. An integrated platform, namely the Decentralised Manufacturing Planning Platform (DMPP) is responsible for processing the order details. Based on the customisation, tailored Bill of Materials (BoM) and alternative Bill of Processes (BoP) are automatically generated. Moreover, the integrated Environmental Impact Assessment Module (ENIAM) simulates the production and transportation schemes and calculates the environmental indicators. Through a multi-criteria decision-making process, the module evaluates the feasible alternative network configurations for carrying out the customised order. The supply network is