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Augmented Reality supported Product Design towards Industry 4.0: a Teaching Factory paradigm

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Abstract

Nowadays, product design and evaluation are important phases of product manufacturing and thus it is important to develop new ways to effectively introduce young engineers to that phases. In the new Industry 4.0 environment, the training and introduction of young engineers in the product design and evaluation phases are facilitated through advanced visualization technologies. Towards that end, this paper presents an approach for applying advanced visualization techniques in product design using Augmented Reality (AR) that aims to be utilized by engineer students to envision the product design, interact with it, evaluate the current design and improve it. The developed system is applied in a radio-controlled car design.

1. Introduction

Product design is a core activity in product development. Its success highly affects the development and production of the final product and any errors and potential dangers that have not been foreseen may lead to increased costs or even redesign [1]. Digitalization of design information supports its integration with novel technologies that allow the designers to review their designs in a more realistic scale and possibly evaluate multiple designs together or compare it with existing parts. As the design of the product may be supported by different design groups from the same or

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different companies, these technologies assist the designers to evaluate the resulting product and detect earlier any faults and misconceptions.

Digital technologies lay fertile ground for young engineers that are trained in product design. Advanced visualization techniques may be used to project the design in a way that simulates the actual product and provide increased realism, making it easier to perceive the final result. The rise of augmented and virtual reality technologies and their gradual integration in manufacturing support offer a digital environment where the designers may interact with the designed product and review its co-existence with existing parts and other designs. Moreover, the design may be evaluated by themselves, teaching personnel or senior designers in a more intuitive and comprehensive way.

Towards that end, this paper presents an approach for integrating advanced visualization and interaction technologies in product design using augmented reality technology through a head- mounted display. The developed approach is evaluated in a teaching factory use case, where the engineering students are called to design a product and evaluate it, in close collaboration with experienced engineers, before manufacturing it.

2. State of the Art

Product design is a core activity in manufacturing, in which the solution requirements become depicted in a product. The decisions taken at this level are crucial and affect the cost and the success of the whole product [1]. It's a complex process that goes beyond creativity and sketching; it includes the integration of target market opinions and particularity, research on the current technologies, evaluation of the available manufacturing resources and requires the collaboration of a group of people, usually with different backgrounds, so as to achieve the desired result [2]. Different methods and models have been reported in the literature to formalize the product design process [3-5]. Moreover, product design ought to be connected with the production of the final product, thus considering how the required parts will be manufactured and assembled together in the final product [1]. Thus, it is important to secure that the involved experts maintain a high level of knowledge and experience, increasing the effectiveness of this crucial part of manufacturing.

To support effective product design, it requires the involved stakeholders to have the required level of knowledge and a good perception of the product design. This highlights the need for young engineers that aspire to be involved in manufacturing to have the proper competences to be able to perform well in an industrial environment. Towards that goal, educational institutions need to provide proper learning environments, which will enable the aspiring engineers to have enough experience and technical background in simulating environments, prior to their involvement with industrial cases [6]. Courses, seminars and presentations offer a theoretical knowledge on product design, but lack the hands- on experience. An approach that is becoming more and more popular in literature and institutions is the teaching factory example [7]. The involved persons are called to deal with a realistic scenario of product development and production in collaboration with experienced engineers from a real factory under a real product development case. In this approach, the aspiring engineers are endorsed in a real case that calls them to design a product, but their lack of expertise and insights on how the designed product will eventually be manufactured and assembled, usually leads in faults in design that need to be corrected in the process by the supervisors [8, 9].

Having insight of the designed product is a big challenge, even for experienced designers, especially in complex product designs or in the case where multiple design teams come together to create the final product. As technology advances, contemporary visualization techniques offer new capabilities in projecting the sketched products in a more realistic way than using PC monitors. Holographic projections are an innovative way to render the geometry that allows the user to see the geometry in 3D and interact with it, though the existing approaches usually lack of rendering quality or offer limited field from where the user may accurately see the projection [10, 11]. Virtual reality is another key enabling technology that enables the designer to be immersed in a virtual environment, where the geometry is projected and may interact with it, examine it in a lifelike scale isolated or together with other product designs [12]. Moreover, through holographic projections, the designer is provided with a novel 3D way of visualization that is also combined with gesture tracking that enables realistic interaction [13]. On the one hand, virtual reality has increased its usage in the early phases of design, as this technology offers the capability to also simulate the product's functionality as an early digital prototype [14]. Additionally, it facilitates knowledge management in group product design [15]. On the other hand, virtual reality immerses the user in a completely digitalized environment, cutting of the connection with real products and previous designs that could be used as a comparison reference. On the contrary,