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Development and comparison of a full-scale car display and communication system by applying Augmented Reality

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Abstract

By adopting augmented reality (AR) and integrating the functions of wireless communication of a personal digital assistant (PDA) and a head-mounted displays (HMD), we built a design evaluation environment that combines a full-scale car display and a visual evaluation system. The image of a car is transmitted via wireless communication onto the PDA, which provides functions for measuring distances and changing parameters of the virtual car using graphical user interfaces (GUI). The updated car image is constructed on the fly on a PC server and sent back to the HMD and the PDA. Multiple users can look at a virtual car simultaneously and discuss its various aspects, enabling better evaluation of the car design.

Keywords: Augmented Reality; Product design; Visual evaluation; PDA

1. Introduction

It is believed that innovative product design is the best method for sustainable development of a corporation. A finely designed product creates values, increase sales volume, and brings benefits to the company [8]. Cooper (1993) believed that the most important element in product design should be the consideration for the users. Many scholars also agree that a corporation's competitive advantage depends on how useful and valuable their products are to consumers. If this advantage is achieved, the possibility of the products' success is 5.3 times higher than that of an ordinary product [2]. Though product design is only part of product evaluation, it greatly influences the marketing success and the corporate image. Thus, the decision on product style design is critical in the new product development process, particularly for mature products, such as car, that are no longer distinguishable in terms of functions and usability. The purpose of this study is to develop an integrated system that enables multiple people to communicate and interact in visualizing and evaluating the design of a car.

Virtual reality (VR) techniques have been applied to vehicle design many times in the past. Lehner and others have developed a communication interface for remote collaboration in vehicle design by adopting virtual prototyping system. The remotely located designers can participate together for design, review, and interactive redesign of new car models [7]. In 1998, Purshke and his co-workers developed a more intuitive VR system for vehicle design. The designer can change the color, surface structures of the car's interior, or any arbitrary components simply by a wave of hand [9]. Fruend and his colleagues proposed vehicle design review system using Augmented Reality. The designers built different models using different components and could change the collocation of exterior design. This system is established for the purpose of evaluating ergonomic considerations on the interior design of a vehicle [3].

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Stragapede proposed a platform for design review, and discussed the related issues about design review based on virtual reality tools [12]. Klinker and her co-workers started to investigate, from both theoretical and industrial viewpoints, the feasibility of applying Augmented Reality on large product's (e.g. vehicle's) evaluation, and the requirements of system design. Based on their findings, they established a system and provided it to vehicle design companies for testing. The testing generated a lot of suggestions and feedback which are quite valuable for design review system [6]. Raczynski and the others have applied AR and PDA project on Workflow (including WorkflowEditor, WorkflowServer, and WorkflowViewer). The researchers used the WorkflowEditor to enter the operation methods of work or machines into WorkflowServer, then obtain the complete procedure through WorkflowViewer [10].

AR Toolkit was developed by the Human Interface Technology Lab (HIT Lab) in University of Washington. HIT Lab has used AR Toolkit for developing many AR applications: for video conferencing, it proposed the Augmented Reality Conferencing System [4,5] in 1999 and 2001, and the Real Word Teleconferencing in 2002. For Collaborative Augmented Reality, it developed an interface for multi-users to use and operate one 3D scene [1,11]. For vehicle design, the AR-based product design for automobile industry proposed by Fruend was also developed using AR Toolkit [3].

Via related documents we understand that means and types of design communication at the present stage can be divided into conventional meeting, video conference, teleconference, enterprise intranet, coordination, voice mail, E-mail, and fax mainly [13]. These meetings or activities, play a rather important role in communication while the design progresses with a hope to specify the working project discussed and contribute to the design work. But in different design phases, it sometimes requires visual assessment and communication; besides, since people do not always display the design in the same presentation material, it will generate cognitive difference under different situations as listed in the following Table 1.

We understand that in automobile design phases people carry on many design communications. Designers must go through multi-form of design communications in different design stages, therefore each time the communicated material is not all the same. Usually through 3D Modeling or design sketches combining with texts, audio, and images to discuss the design content. But the information presented will influence the quality of communication [13]. The following Table 2 describes the general communication format and material.

In conclusion of the above-mentioned application of Augmented Reality in design communication, we learned how to make the product design simulation more vivid and be used simultaneously at different sites in the course of designing, namely multiple-site (multi-points) simultaneous design communication. With the increase of communication bandwidth of internet more data can be transmitted, through application of Augmented Reality and broadband data communication, it should be easy to be applied to international automobile design communication effectively. In this research we first build up the system platform, second, through comparison and analysis of design communication schemes and methods to study the feasibility of Augmented Reality application in design communication.

2. Purpose

First, we set out to build a design evaluation environment that combines a full-scale car display and a visual evaluation system and communication in virtual design. The basic idea is to combine both AR and PDA techniques. By using AR Toolkit, we can provide an interface for users to browse the full-scale car images freely. This is achieved by placing cameras at eye level with AR Toolkit to obtain the car image. After analyzing the images, the AR Toolkit can be used to obtain the view angle coordinates of the users, redraw the car images according to the view angles, obtain the environment images from the cameras, and then combine environment images and car images together to create a virtual reality experience. When the view angle is changed, the images are re-calculated and drawn synchronously, allowing users to watch the changing images of full-scale car models naturally. These images are displayed in HMD with visual quality similar to that of a 42–54 in. large display.

Though AR Toolkit provides mechanisms for interaction, due to its computing limitation, it cannot simultaneously handle a graphical user interface (GUI) with menus and buttons. The wireless communication function of personal digital assistant (PDA) is employed in this research to provide such a GUI. The image of the car is transmitted onto PDA display through the wireless LAN. The PDA also contains functions for measuring distances, changing the vehicle structure, changing the color of the car, etc., via a GUI. After a parameter of the virtual car is changed, the new image is recomputed on a PC server and delivered wirelessly back to both HMD and PDA. The synchronicity of viewing the virtual prototype of a car, and controlling the prototype through PDA allows the designers to better evaluate the car design in full-scale.

3. ARPDA system

As the display/evaluation system combines both AR and PDA techniques, we shall refer to it as the ARPDA system in the rest of the paper. To display the car model, the virtual prototype is converted into *wrl* file format and checked by AR Toolkit [4]. The size of the virtual prototype is adjusted to reflect the real size when observed in HMD. The users may walk around to observe the virtual product, which is surrounded by environment images simultaneously sent to HMD from the camera. This pro-