

Augmented Reality as a Comparison Tool in Automotive Industry

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ABSTRACT

Augmented reality (AR) can be used in the automotive industry to compare real parts of a car with their associated construction data. The real parts have to be checked whether they correspond to the latest version of the design and whether they have been manufactured with appropriate precision. With AR, CAD construction data can be superimposed on the real parts striving for maximum correspondence. The real and the virtual part should both be visible at the same time and in the same place. Therefore, for this kind of overlay, a special method of augmentation is needed. We present and discuss some visualization schemes.

Keywords: Augmented Reality, automotive industry, prototyping, CAD, overlay, comparison tool, visualization, visible, shading, transparency, wire frame

1 INTRODUCTION

The automotive industry has to cope with an increasing variety of car models and decreasing product life cycles. In addition to CAD more and more virtual and mixed reality technologies are used to speed up and optimize the development process.

Virtual prototypes are built at the beginning of the product development process. These prototypes can be changed and reproduced easily to optimize the development process [1]. After virtual representations of all car parts are approved based on their appearance, real counterparts are incrementally produced. The first real parts are compared with the virtual CAD engineering master, focusing on two main aspects: Firstly, the real parts must correspond to the most recent version of the construction data. Secondly, the quality and shape of the parts must fit adequately to the CAD master. Both aspects describe a comparison between a virtual reference and the current state of the real engineering model.

Augmented reality can aid this comparison by overlaying the virtual parts directly on the real ones. To allow for intuitive comparisons, real and virtual objects must be shown at the same position and orientation, optically cross-fading real and virtual shapes in matched sizes and contours. The real and virtual parts need to have the same levels of visibility such that discrepancies can be visualized directly on the object. In this way, AR can be used as a comparison tool in automotive industry. To illustrate this kind of application figure 1 shows a real dark blue fender with an augmentation of its engineering master using red wire frame visualization.

2 BACKGROUND AND PROBLEM

For an AR-based comparison tool, a special type of AR is needed. The main objective of augmentation is to enlarge the real scene with additional, new objects [2]. Therefore, cross-fading a real object with its virtual counterpart is a special case of using AR technology.

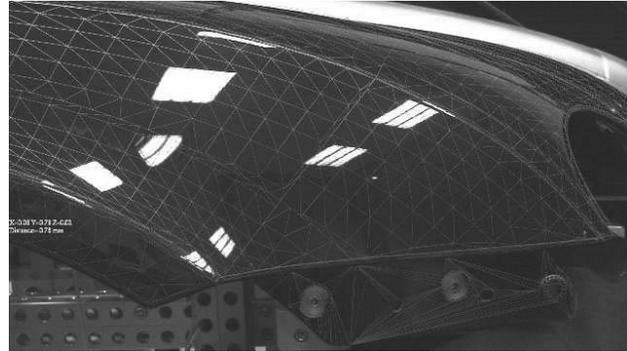


Figure 1: Fender with augmented construction data

A typical approach involves calibrating and validating optical-see-through systems [3, 4]. Bimber uses occlusion shadows to augment a dinosaur skull with virtual muscles and bones [5]. Yet, the virtual bones and muscles are not substitutes of the real structures but rather additions to them. The virtual objects have no direct counterparts in the real scene. Direct geometrical associations between real and virtual objects do exist in navigation or maintenance scenarios when instructions are visualized that indicate how to work with real objects, highlighting the real objects in the process. However, it is the purpose of such augmentations to identify real objects rather than to precisely analyse differences between real and virtual objects.

Thus, the main issue to solve here is: How can this special way of augmentation be realized? What kind of visualization satisfies the shape oriented cross-fade such that AR can be used as a comparison tool?

Another requirement stems from the fact that augmentations should be seen simultaneously by groups of people – with all of them deciding on the basis of similar information. Individual solutions on the basis of optical-see-through HMDs are not suitable for this task because current calibration techniques and the “swimming problems” due to dynamic lags cannot guarantee that all users have a precise enough view of the augmentations. Thus, the current solution is to use a camera for video-see-through augmentations on a monitor or projection wall that can be seen jointly by all users.

3 VISUALIZATION METHODS

In this section we evaluate several visualization methods at the example of a pillar reinforcement of high-strength steel. All subsequent augmentations of this pillar are generated within the framework of the ARVIKA browser [6]. Registration and tracking between real and virtual objects was provided by the vision-based tracking component of the ARVIKA system. It is based on square markers. The AR system can be used for monitor based video-see-through applications.

The first three visualization schemes are

- solid rendering,
- wire frame rendering and
- semi-transparent rendering.

These methods are standard features of common rendering techniques in AR systems. Thus, no special implementation is necessary to provide such visualization schemes, and therefore in this paper no extra explanation is given.

3.1. Mixtures

Transparent rendering reaches good augmented visualizations to compare real and virtual parts. However, it is difficult to exactly understand the boundary and the contour of the superimposed, virtual object. Lines of the wire frame rendering allow users to understand the contour of the virtual object without overfilling the real object.

Thus, it makes sense to combine or mix wire frame rendering and solid visualization methods. In addition to the wire frame rendering, it makes sense to show a rendering of the solid frame in weak transparency. The mixture is shown in figure 2.

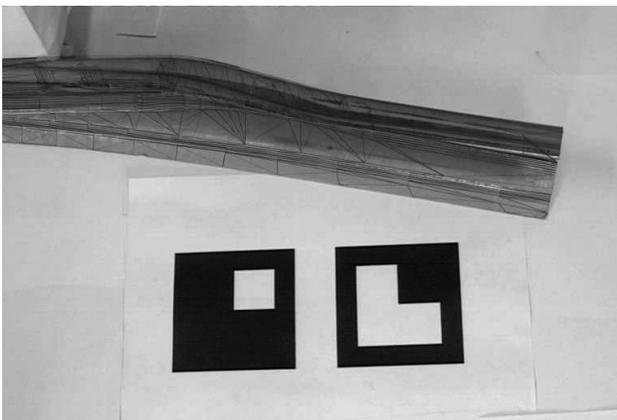


Figure 2: Combination of a transparent wire frame and a transparent solid rendering

3.2. Shuttering and checkerboard patterns

When using transparency, each augmented pixel blends the colour of the video picture with the colour of the augmented geometry. As a consequence, the original colour of the real object is not maintained.

One concept towards keeping the original colour values of the real part while superimposing the virtual part involves rapid alternations between showing virtual and real objects. The speed of the alternations must be high enough to fuse real and virtual objects in the user's perception.

Unfortunately, not all display systems – such as flat panels or HMDs – can render images at sufficiently high frame rates.

Therefore, we extend the concept of shuttering to a lower level – the pixel structure, alternating between pixels stemming from the real and the virtual object part: The odd pixels show the real object and the even pixels show the virtual object. The effect is a checkerboard-like pattern on the pixel level (figure 3).

The main drawback of this method is the fact that only half the amount of possible pixels is used to visualize each of the objects.

Especially when displays with low resolution are used, strong aliasing effects appear, e.g., at the edges and the sharp features of the objects in the enlargement of figure 3. This problem can be partially cured by using high resolutions or by choosing a viewing perspective such that the object fills nearly the entire screen.

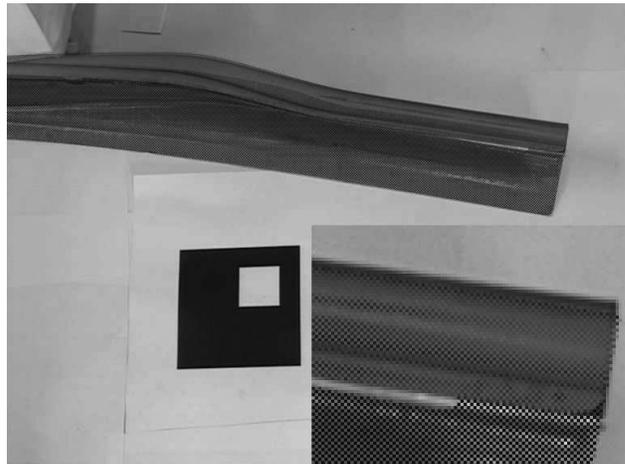


Figure 3: Checkerboard visualization

4 CONCLUSION AND FUTURE WORK

We have described how to use AR as a comparison tool in the automotive industry. The main idea is to use shape oriented augmentations between real and virtual parts, using novel visualization schemes. A mixture of different rendering concepts delivers a good augmentation result.

Further work could be the implementation of the checkerboard-like visualizations in an AR system to operate in real-time. This visualization scheme contains much potential.

Plenty user studies and evaluations should be done to obtain the best visualization method for this kind of application.

Note: The Volkswagen Group is not necessarily owner of the results, opinion and conclusions mentioned in this paper.

REFERENCES

- [1] Dai, F. (Hrsg.): *Virtual Reality for Industrial Applications*. 1. Auflage, Berlin, Springer Verlag, 1998
- [2] Milgram, P.; Colquhoun H.: *A taxonomy of real and virtual world display integration*. In: Ohta, Y. (Hrsg.) ; Tamura, H. (Hrsg.): *Mixed Reality: Merging real and virtual worlds*. Berlin, Springer, 1999
- [3] Whitaker, R. T.; Crampton, C.; Breen, D. E.; Tuceryan, M.; Rose, E.: *Object Calibration for Augmented Reality*. Proceedings of Eurographics '95, Maastricht, 1995
- [4] Tuceryan, M.; Navab, N.: *Single Point Active Alignment Method (SPAAM) for Calibrating an Optical See-through Head Mounted Display*. Proceedings of ISAR '00, 2000
- [5] Bimber, O.; Fröhlich, B.: *Occlusion Shadows: Using light to generate realistic occlusion effects for View-Dependent optical-see-through displays*. Proceedings of ISMAR '02, 2002
- [6] Friedrich, W. (Hrsg.): *ARVIKA, Augmented Reality in Entwicklung Produktion und Service*. In: Siemens AG, Publics Corporate Publishing, Erlangen, 2004