

# Texture Overlay onto Deformable Surface Using HMD

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## Abstract

We propose a system that overlays textures onto the deformable surface of an object in real time using HMD. We assume that the surface projected onto an HMD image consists of curved surfaces which can be approximated by 2D geometric curved surface, so that we can deform textures using the matrix of 2D geometric transformation and the deformed textures are overlaid onto the HMD image. The system computes the transformation matrix in each frame, the textures are overlaid in real time even if an observer with HMD moves or deforms the surface. In the system, we select a book as the object with deformable shape and documents as the textures. Therefore, the observer can read digitized documents as if he reads real books.

## 1 Introduction

Recently, there are projects that digitally archive cultural heritages, such as rare books [3]. Such digital archiving does not only preserve the cultural heritages, but also broaden the way of using them. CRT or LCD displays are generally used for viewing such digitally archived contents, but the reality of the original objects are lost because such displays can only show 2D images and also because we cannot touch them. Therefore, it is important for studying such digital archives to develop a new display system such that an observer can touch and see them in a real space.

On the other hand, there are researches which use a book as an AR interface, such as MagicBook [1]. However, They assume that the surface of the book is a plane.

In this paper, we propose a system to overlay textures onto a deformable surface of an object in real time using video see-through HMD. In the system, we select a book as the object and documents as the textures. Therefore, using the system, the observer can read digitized documents as if he reads real books.

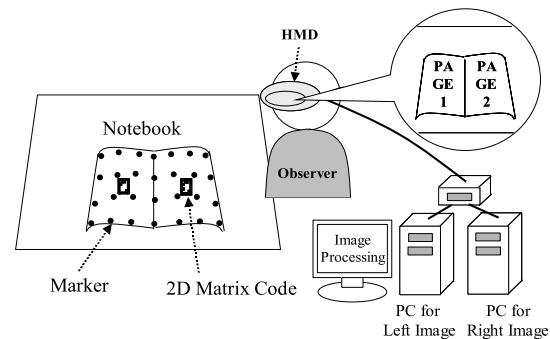


Figure 1. The outline of a system.

## 2 Outline of the System

Fig.1 shows the scheme of a texture overlay system. An observer with a video see-through HMD watches a book on which 2D matrix codes and markers are printed. 2D matrix code expresses a page number and a book ID number of the page on which the code is printed. Markers are used for computing a texture transformation matrix. The HMD has two CCD cameras which are attached at the front of the left and right eyes. The HMD images captured by each camera are processed by a PC. Digital documents are stored in the PCs. A texture which corresponds to the page is overlaid onto the HMD image, and the overlay images are displayed inside the HMD. So, the observer can feel as if he is reading a real book.

## 3 The Method for Texture Overlay onto a Deformable Surface

In this system, the texture overlaying is performed according to the following procedure.

1. 2D matrix codes [2] and markers are detected in an HMD image.
2. Page number and book ID number of a page are known from 2D matrix code, and the texture which should be overlaid onto the page is selected.

3. The arrangement of markers on the page are decided, and a texture transformation matrix is computed.
4. The texture is deformed by using the texture transformation matrix, and the deformed texture is overlaid onto the HMD image.

### 3.1 Geometric Transformation

We use following equations to deform textures.

$$\begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix} \simeq \begin{pmatrix} P_{00} & P_{01} & P_{02} & P_{03} & P_{04} \\ P_{10} & P_{11} & P_{12} & P_{13} & P_{14} \\ P_{20} & P_{21} & P_{22} & P_{23} & P_{24} \end{pmatrix} \begin{pmatrix} x_1^2 \\ y_1^2 \\ x_1 \\ y_1 \\ 1 \end{pmatrix} \quad (1)$$

$$\begin{pmatrix} x_2 \\ y_2 \\ 1 \end{pmatrix} \simeq \begin{pmatrix} P_{00} & P_{01} & P_{02} & P_{03} & P_{04} \\ P_{10} & P_{11} & P_{12} & P_{13} & P_{14} \\ P_{20} & P_{21} & P_{22} & P_{23} & P_{24} \end{pmatrix} \begin{pmatrix} x_1^3 \\ y_1^3 \\ x_1 \\ y_1 \\ 1 \end{pmatrix} \quad (2)$$

In this paper, we call the transformation described by eq.(1) a quadratic geometric transformation, and call the transformation described by eq.(2) a cubic geometric transformation.

### 3.2 The method for deforming a texture

We propose two methods for deforming a texture.

One is the method for using nonlinear geometric transformation. We assume that a curved surface of an object is a nonlinear geometric curved surface, and deform a texture by using either quadratic or cubic geometric transformation which gives better approximation to the surface.

The other is the method for using homographies. We assume that the surface is the aggregate of many planes, and deform a texture by using homographies.

We select the better method of the two in each frame.

## 4 Implementation

We develop a system to overlay textures onto a deformable surface. We use a stereo video see-through HMD. The size of an HMD image is 640×480 pixels. Fig.2 shows the digitized images of rare books as textures. The texture images' size is 350×500 pixels. An A4-sized notebook is used as a sample of a book.

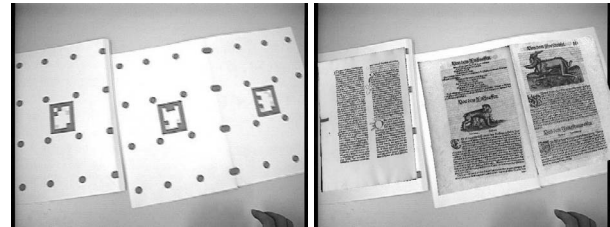
Fig.3 and Fig.4 show the result of texture overlay. The textures are overlaid adequately according to the page number, the type of the book, and the deformation of the notebook surface.



(a) Gutenberg Bible

(b) Thierbuch

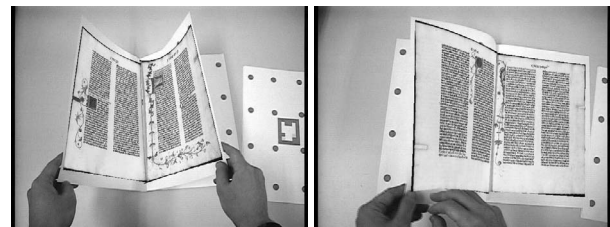
Figure 2. Texture images



(a) original image

(b) overlay image

Figure 3. Result of texture overlay-1



(a) overlay image 1

(b) overlay image 2

Figure 4. Result of texture overlay-2

## 5 Conclusion

In this paper, we proposed a system to overlay textures onto the surface of an object with a deformable shape.

We proposed two methods for deforming a texture. One is the method for using nonlinear geometric transformations by assuming that the surface is a nonlinear geometric curved surface. The other is the method for using homographies by assuming that the surface is the aggregate of many planes.

We select a book as the object with a deformable shape, and digital documents as the textures. So, we can make an observer feel as if he is reading a real book by using the system.

## References

- [1] Mark Billinghurst, Hirokazu Kato, Ivan Poupyrev, "The MagicBook: a transitional AR interface", *Computers & Graphics* 25 (2001) 745-753
- [2] Jun Rekimoto, "Matrix : A Realtime Object Identification and Registration Method for Augmented Reality", *APCHI'98*
- [3] <http://www.humi.keio.ac.jp/>