Extensible 3D (X3D) Part 1: Architecture and base components

Projective Texture Mapping Component

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1 Introduction

1.1 Name

The name of this component is " ProjectiveTextureMapping ". This name shall be used when referring to this component in the COMPONENT statement

1.2 Overview

This clause describes the ProjectiveTextureMapping component of this part of ISO/IEC 19775. Table 1 provides links to the major topics in this clause.

Table 33.1 — Topics

2 Concepts

2.1 Overview

This component provides additional texturing extensions to the basic capabilities defined in X3D. Generally, 2D texture mapping has been used to enhance the quality of an image generated with a camera or to speed up the generation of an image with respect to a given scene including several geometric models. However, there are some constraints for mapping region and shape of textures over objects. As an extension of texture mapping, projective texture mapping has been proposed which allows the texture image to be projected onto a scene in the view volume constructed from a specific viewpoint with a location and an orientation. Figure 1 shows two example screen shots for projective texture mapping.
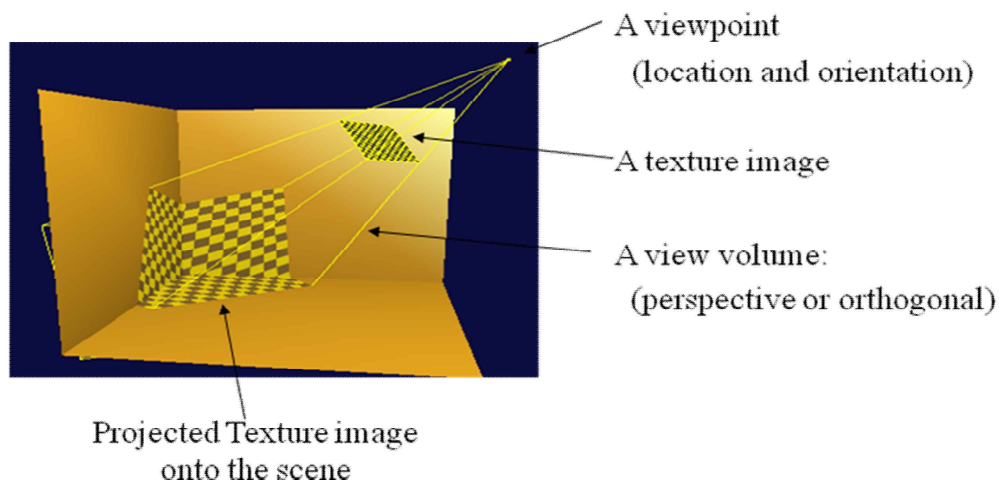

Figure 1. An example of projective texture mapping [1]

Additionally, several texture images can be projected onto the same scene like multi-texturing. Moreover, we can provide multiple projective texture mapping over a common scene with specific objectives such as photogrammetry or reconstruction of endoscope

images. As shown Figure 2, assume that several images are provided, each of which is taken with a different camera. Construction of a terrain surface from those images can be performed by displaying overlapping images obtained after applying several projective textures to the surface model.
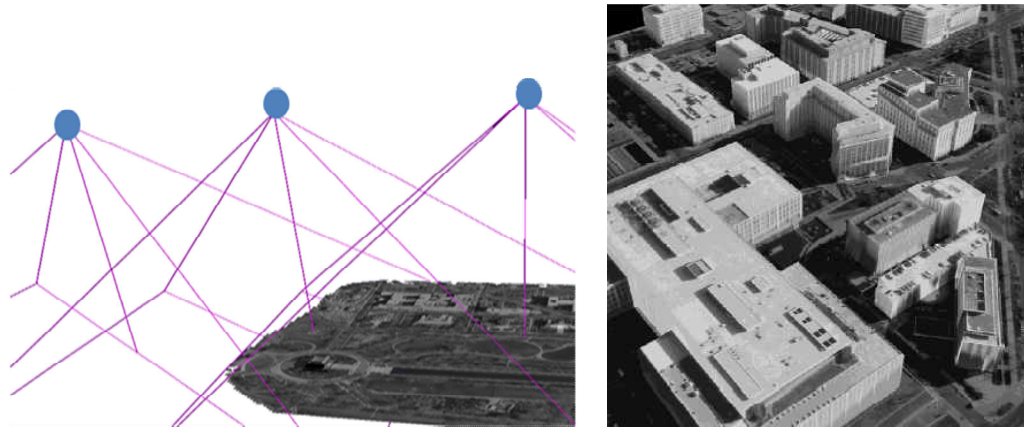

Figure 2. A construction of a terrain surface [2]

Figure 3 describes an example for reconstructing endoscope images over a cylinder by applying projective texture mapping. In a similar manner, each image is captured from an endoscope with perspective view information inside human body.
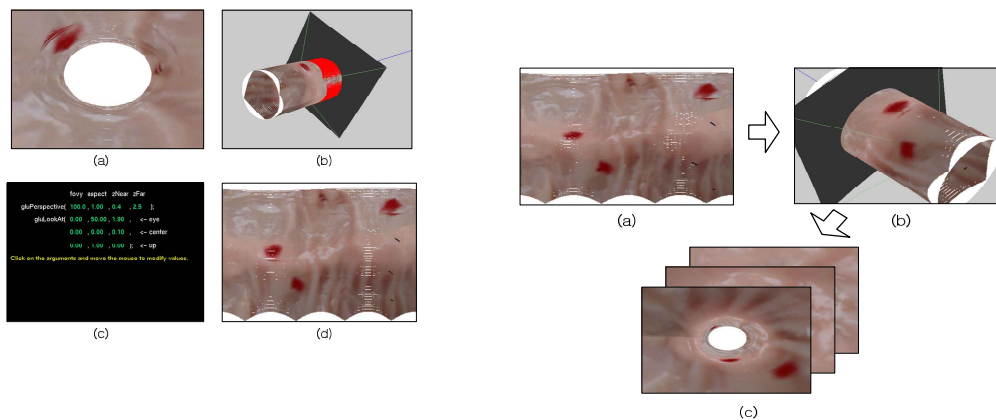

Figure 3.An example for reconstructing endoscope images by applying projective texture mapping [3]

2.2 Projective Texture Mapping Concepts

Projective Texture Mapping can be defined with a viewpoint, a view volume, a texture image and scene objects, where a viewpoint and a view volume can be specified similar to camera specification information. In the other hand, projective texture mapping allows the texture image to be projected onto a scene in the view volume constructed from a specific viewpoint with a location and an orientation as shown Figure 1. The texture image projected onto scene objects can be changed according to transformation of specific viewpoints and scene objects.

2.3 Projective texture map image formats

Node types specifying projective texture maps may supply data with a number of color components between one and four. The valid types and interpretations of projective textures are identical to that for 2D textures. The definition of texture formats is defined in 18.2.1 Texture map formats.

3 Specify projective texture mapping into X3D specification

3.1 Overview

As illustrated in Section 2, projective texture mapping can be specified by using the following three items: a texture image or multitexture image, a slider projector including a viewpoint and a view volume, and scene objects. Since there are the existing nodes in X3D specification related to texture images and scene such as Texture nodes (ImageTexture, MovieTexture, MultiTexture, MultiTextureCoordinate, MultiTextureTransform, PixelTexture, TextureCoordinate, TextureCoordinateGenerator, TextureProperties, TextureTransform) and Object Nodes, there is no any problem in specifying texture images and objects for projective texture mapping. For a slider projector, the existing nodes in X3D such as X3DViewpointNode may be used. Clearly, the node defines a specific location in the local coordinate system from which the user may view the scene and is used as Bindable children nodes (using stack). There are three nodes including OrthoViewpoint: for an orthographic view, Viewpoint for a perspective

view, and ViewpointGroup for supporting a group. Assume the navigation nodes are directly used to specify a slide projector. There are the following problems: first, confuse to distinguish navigators in browsers and a slider projector in projective texture mapping, and second cannot identify between both.

Due to the reasons, a specification of projective texture images within specific slide projector cannot be performed into X3D by using the existing nodes of X3D. Therefore, new nodes for projective texture mapping must be defined additionally as follows.

- X3DProjectiveTextureNode
  - OrthoTexture
  - PerspectiveTexture
  - ProjectiveTextureGroup

- Abstract Nodes related to X3DProjectiveTextureNode
  - *X3DProjectiveTextureCoordinateNode*
  - *X3DProjectiveTextureTransformNode*

4 The proposed nodes

4.1 *X3DProjectiveTextureNode*

X3DProjectiveTextureNode : X3DAppearanceChildNode {
    SFNode [in,out] metadata NULL [X3DMetadataObject]
    SFBool []   repeatS   TRUE
    SFBool []   repeatT   TRUE
    SFNode []   textureProperties NULL [TextureProperties]
}

This abstract node type is the base type for all node types which specify sources for projective texture mapping.

4.2 *X3DProjectiveTextureCoordinateNode*

```
X3DProjectiveTextureCoordinateNode  {
    SFNode [in,out] metadata NULL [X3DMetadataObject]
}
```

This abstract node type is the base type for all node types which specify projective texture coordinates.

4.3 *X3DProjectiveTextureTransformNode*

```
X3DProjectiveTextureTransformNode : X3DAppearanceChildNode {
    SFNode [in,out] metadata NULL [X3DMetadataObject]
}
```

This abstract node type is the base type for all node types which specify a transformation of projective texture coordinates.

4.4 OrthoTexture

OrthoTexture : X3DProjectiveTextureNode {

    SFNode [in,out] metadata NULL [X3DMetadataObject]

    SFBool []   repeatS   TRUE

    SFBool []   repeatT   TRUE

    SFNode []   textureProperties NULL [TextureProperties]

    SFVec4f/d [in, out] position 0 0 1 0

    SFVec3f/d [in, out] direction 0 0 1

    MFFloat [in,out] viewVolume -1 1 -1 1 -1 1   // (viewvolume)

    //   specify nodes related to single or multi-texture mapping

    SFNode [in, out] texture NULL [X3DTextureNode]

}

The OrthoTexture node defines a projective texture map by specifying general parameters for orthogonal texture mapping.

The position and direction fields define position and direction for doing orthogonal projection. The 4th value of the position field is always zero.

The viewvolume field specify the view volume of orthogonal projection.

The texture field contains a single texture node such as ImageTexture, MovieTexture, MultiTexture, and PixelTexture.

4.5 PerspectiveTexture


```
PerspectiveTexture : X3DProjectiveTextureNode {
    SFNode [in,out] metadata NULL [X3DMetadataObject]
    SFBool []      repeatS       TRUE
    SFBool []      repeatT       TRUE
    SFNode []      textureProperties NULL [TextureProperties]
    SFVec4f/d  [in, out] position 0  0  10 1
    SFVec3f/d  [in, out] direction 0 0 1
    SFFloat    [in,out]  fovy n/4  (0, n)   // field of view
    SFFloat    [in, out] aspectRatio  1     // aspect ratio
    MFFloat    [in, out] depth  1 10      // min-max z value
        // specify nodes related to single or multi-texture mapping
    SFNode [in, out] texture  NULL [X3DTextureNode]
}
```

The PerspectiveTexture node defines a projective texture map by specifying general parameters for perspective texture mapping.

The position and direction fields define position and direction for doing perspective projection. The 4th value of the position field muse be always one.

The fovy, aspectRatio, and depth fields define the values of fovy, aspect ratio, and depth of perspective projection.

The texture field contains a single texture node such as ImageTexture, MovieTexture, MultiTexture, and PixelTexture.

4.4 ProjectiveTextureGroup

ProjectiveTextureGroup: X3DChildNode {

    SFFloat [in,out] alpha   1   [0,1]
    SFColor [in,out] color   1 1 1 [0,1]
    MFString [in,out] function []
    SFNode   [in,out] metadata NULL [X3DMetadataObject]
    MFString [in,out] mode   []
    MFString [in,out] source   []
    MFNode   [in,out] projectiveTextures [] [X3DProjectiveTextureNode]

}

The ProjectiveTextureGroup node specifies the application of several individual projective textures to 3D objects in a virtual world to achieve a more complex visual effect.

The *projectiveTextures* field contains a list of projective texture nodes (*e.g.*, OrthoTexture, PerspectiveTexture). The *projectiveTextures* field may not contain another ProjectiveTextureGroup node.

The *color* and *alpha* fields define base RGB and alpha values for SELECT mode operations.

The *mode* field controls the type of blending operation of projected overlapping geometry area in a virtual world from two or more than two projective texture mappings. The available modes include MODULATE for a lit Appearance, REPLACE for an unlit Appearance, and several variations of the two. The *mode* field may contain an additional blending mode for the alpha channel.

EXAMPLE The mode value '"MODULATE", "REPLACE"' specifies Color = (Arg1.color × Arg2.color, Arg1.alpha).

The source and function fields are equally defined in those in MultiTexture node.

5. Future Direction

 We are going to specify the nodes such as coordinate and transform, related to control of projective texture mapping more concretely.

References
[1] Cass Everitt, Projective Texture mapping, 1999
[2] J.R. Spann and K.S. Kaufman, Photogrammetry using 3D Graphics and Projective Textures, IAPRS, 2000
[3] Eunjung Kim, Kwan-Hee Yoo, Je-Hoon Lee, Yong-Dae Kim, and Younggap You, Composite Endoscope Images from Massive Inner Interestine Photos, Lecture Notes on Artificial Intelligence 4570, pp.1042-1051, 2007 .
[4] http://www.users.globalnet.co.uk/~tomh