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Watermarking Scheme of MPEG-4 LASeR Object for Mobile Device

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Abstract

It is important to represent MPEG-4 BIFS with LASeR format to service the existing MPEG-4 scene in mobile environments. 2D and 3D graphics are represented by MPEG-4 BIFS but LASeR supports only 2D nodes. Because it is difficult to represent the 3D geometry nodes of BIFS with LASeR, converting process is needed.

In this paper, watermarking scheme of 3D object based on MPEG-4 LASeR is proposed. Watermarks are embedded while MPEG-4 BIFS 3D geometry nodes are converted into LASeR 2D graphic nodes. Proposed watermarking algorithm uses vector information of polygon and original model is needed in extraction procedure.

This proposed watermarking algorithm has good imperceptibility and robustness against the geometrical attacks such as noise addition, smoothing, mesh simplification and compression. And it is proved that this proposed algorithm is good for integrity authentication by the experiment.

Keywords: *Watermark, MPEG-4 LASeR, MPEG-4 BIFS, 3D Object Representation*

1. Introduction

With the development of mobile communication technology and expansion of various mobile device market, rich media services are being diversely provided to current internet based PC environment which try to provide diverse and affluent interactive services using multimedia data including audio, video, graphic and texts. For this interactive multimedia services, MPEG-4 is providing multimedia object coding technologies like image, video and audio and BIFS(Binary Format For Scene) which is a scene description language and can create contents by organizing them into scenes [1]. BIFS is a technology which is selected as the standard of graphic data and interactive contents in DMB.

As a research to play MPEG-4 in various environments, there are diverse techniques like MPEG-4 XMT creation and conversion technique from XMT to BIFS. XMT is a textual format of MPEG-4 BIFS and was defined with the purpose of playing MPEG-4 contents in various environments [2-3]. XMT is XML based language and defines XMT-A and XMT-O. XMT-A corresponds with BIFS structure and is similar with X3D. XMT-O is a higher level description language and is written based on SMIL. There are IBM Toolkit [4] and GPAC project [5] for XMT conversion tools. These researches provide conversion functions mainly from XMT-A to BIFS or VRML and from XMT-O to XMT-A.

BIFS is composed of binary formats and can represent the time, space and event information of visual and auditory objects. Additionally, even though BIFS has an advantage to provide rich media because both 2D and 3D objects are supported, it is difficult to apply BIFS as it is in the environments where the performances are restricted like mobile device.

As DMB service which is current digital broadcasting technology started in full scale, the importance to provide rich media service in various environments has been greatly increased. Therefore, researches are required that MPEG-4 contents can be played in mobile environment. These researches have a meaning in that already created standard

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format contents can be reused and also have an advantage that once created contents can be played in various individual users' terminal environments.

MPEG-4 BIFS is targeting P.C. environments, but its specifications are complicated even though it can represent 2D and 3D scenes based on VRML. On the other hand, LASeR(Lightweight Application Scene Representation) is targeting mobile environments, and can represent only 2D graphic based on SVG(Scalable Vector Graphics)[6], and has simple specifications. To process more light-weighted resources, LASeR uses SVG which is 2D graphic language of W3C to represent graphic animation. Therefore, it has limited scene description and scene information can be easily converted to other graphic formats. Because of these reasons, various researches are being conducted to convert to MPEG-4 LASeR format in order that MPEG-4 contents can be played in mobile terminals [7-8].

In order to serve existing MPEG-4 scenes in mobile environment, Ko [9] suggested a technique to represent MPEG-4 BIFS as LASeR format. While MPEG-4 BIFS can represent 2D and 3D graphic, there is a problem LASeR cannot represent 3D geometry node of BIFS because it only supports 2D nodes. But, in order to represent MPEG-4 rich media in mobile environment, expression and conversion of 3D node using LASeR is important. In this study, expression method of 3D graphic nodes in MPEG-4 BIFS to LASeR 2D graphic nodes was suggested. 3D geometry nodes in BIFS were represented by creating 2D coordinates through coordinate conversion and projection and transformation in BIFS 3D nodes and subsequently matching with LASeR 2D node. And, a conversion system was implemented to convert XMT-A files which are BISF text formats into LASeR-XML files.

Using Ko [9]'s method, a method is suggested that watermark is inserted in the conversion process of 3D graphic nodes in MPEG-4 BIFS into LASeR 2D graphic nodes in this paper. This method uses the procedures to process z-axis coordinate value in order to process 3D nodes in BIFS and to process 3D coordinate conversion like rotation, movement and expansion. And, 3D coordinate values in BIFS and transform nodes are processed and subsequently, Z-axis values are processed as 2D attribute values through projection transformation of calculated values.

Proposed watermarking algorithm uses vector information of polygon and original model is needed in extraction procedure. This proposed watermarking algorithm has good imperceptibility and robustness against the geometrical attacks such as noise addition, smoothing, mesh simplification and compression. And it is proved that this proposed algorithm is good for integrity authentication by the experiment.

Composition of this paper is as follows. In Chapter 2, explains a method to insert watermarks in the conversion process of 3D graphic node of MPEG-4 BIFS into LASeR 2D graphic node. In Chapter 3, implemented results of suggested algorithm are to be analyzed and compared with other similar research results. Finally in Chapter 4, future study subjects are to be described and conclusion is to be made.

2. Watermarking Algorithm of 3D Object based on LASeR

This chapter will explain the method that insert digital watermark in the procedure where 3D geometry objects of BIFS(Box, Cylinder, Cone, Sphere) and parent nodes(Transform node, Material node) are transformed into LASeR nodes.

2.1. Process to Represent BIFS 3D Objects to LASeR 2D

BIFS and LASeR have attributes including location, color, horizontal and vertical length and radius in order to represent the geometry object. Because BIFS and LASeR have different composing methods of these attribute information, conversion is required that LASeR node can be represented using extracted attribute information from BIFS.

Box which is 3D geometry object node and Cone, Cylinder, Sphere have individual object's size information properties including horizontal and vertical length, height and radius. And information about object coordinates and rotation and expansion are in transform node which is a higher level node and material node has color information.

On the other hand, LASeR defines just 2D geometry objects. Ellipse, circle, polyline and polygon which are LASeR 2D geometry objects include all size, coordinates and color information as object attributes. Therefore in order to represent BIFS 3D nodes into LASeR 2D nodes, transform node and material and the attributes of individual geometry objects in BIFS should be extracted first and converted as necessary information to represent these information as LASeR nodes [10].

The method of representing BIFS 3D nodes with LASeR 2D nodes is as follow.

1. Search for BIFS 3D node.
2. Extract the attribute of BIFS 3D geometric objects.
3. Calculate the reference coordinate using attribute of BIFS objects.
3. Transform operations on the reference coordinate.
4. Projection transformation from 3D coordinate system to 2D coordinate system.
5. Add attribute values in the 3D nodes.
6. Represent BIFS 3D nodes with LASeR 2D nodes.

2.2. Insertion and Extraction of Watermark in LASeR Conversion Procedure

This section will explain watermark insert algorithm in the conversion procedure that individual BIFS 3D geometry objects can be represented using LASeR.

2.2.1. Watermark Insertion Algorithm for Box Node: Kim and Cho [10] represented Box nodes in BIFS using polygon in LASeR. Figure 1 shows the procedures to represent Box node as polygon in LASeR.

Box node has size as attribute value and the size has size information of x, y and z-axis. Extract size information which is Box attribute at (1) in Figure 1. Calculate 8 reference coordinates, P_0 to P_7, using size information at (2) in Figure 1. Next, calculate 8 moved, rotated and expanded coordinates by applying transform node's location movement, rotation and expansion properties to reference coordinates, P_0~P_7. This procedure is shown at (3) in Figure 1. Project 8 reference coordinates to 2D coordinates and convert coordinate system.

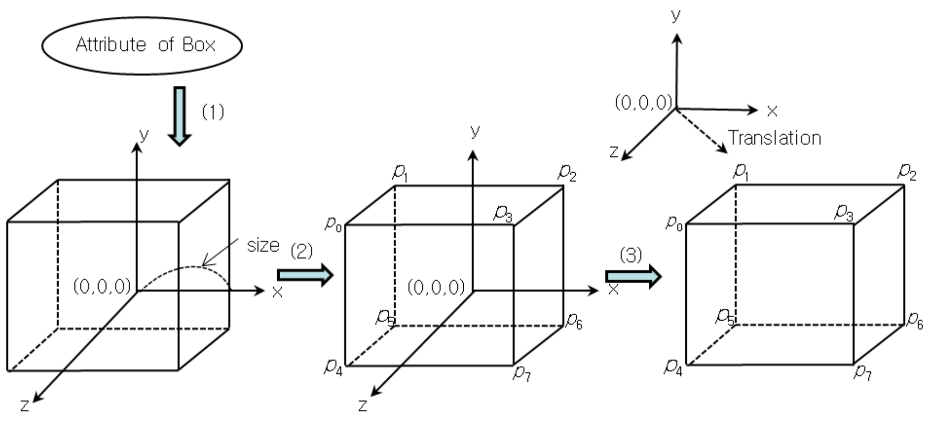


Figure 1. The Conversion Process of BIFS Box Node to LASeR Node

If it is projected as 2D coordinates at this moment, z-axis coordinates will disappear in original 3D coordinates. Figure 2 shows the procedures to project 3D coordinates to original 2D coordinates.

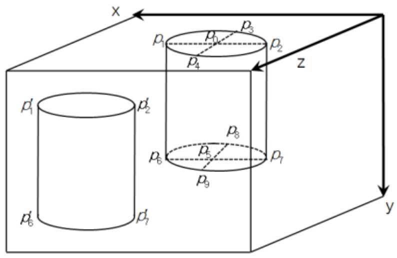


Figure 2. The Projection Conversion Process of 3D Coordinates to 2D Coordinates

In this paper, watermark is inserted using z-axis coordinates on the projection procedures of 3D coordinates to 2D coordinates. For example, if coordinate value of z-axis is negative, insert '1' as watermark and if it is positive, insert '0'.

Algorithm which inserts watermark in Box node is as follows.

Step 1: Extract size information which is an attribute of BIFS 3D geometry object.

Step 2: Calculate 8 references coordinates P_0~P_7 which compose Box using size attribute values of Box node.

Step 3: Calculate 8 moved, rotated and expanded coordinates by applying transform nodes' location movement, rotation and expansion properties to reference coordinates P_0~P_7. Calculate physically represented object locations by moving, rotating and expanding reference coordinates using location movement information, rotation information and expansion information which are in BIFS transform node.

Step 4: Project and convert 8 3D references coordinates to 2D coordinates and execute coordinate conversion with acquired 2D coordinates. Insert watermarks using used 3D reference coordinates like below.

if (3D reference coordinate value of z-axis < 0) then watermark=1

else watermark=0;

Step 5: Generate LASeR nodes with 2D coordinates and XSLT mapping which were converted at step 4. At this moment, BIFS Box nodes in LASeR scene technology are represented as 6 SVG: polygon.

2.2.2. Watermark Insertion Algorithm for Cone Node: Cone node has the attribute values of bottom radius and height. In Figure 3, there are attribute values of Cone node and 6 references coordinates which would be calculated using the properties of Cone node.

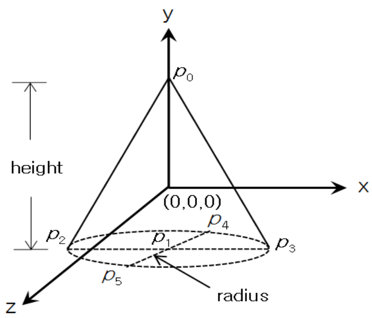


Figure 3. The Reference Coordinates of Cone Node

Algorithm to insert watermarks in Cone node is as follows.

Step 1: Extract the properties of 3D geometry objects in BIFS.

Step 2: Calculate 6 references coordinates which compose Cone using radius, height attribute values of Cone node.

Step 3: Calculate the locations where physical objects are represented through location movement, rotation and expansion using location movement information, rotation information and expansion information which are in BIFS transform node.

Step 4: Project and convert 3D coordinates to 2D coordinates and execute the conversion of coordinate system in acquired 2D coordinates. Insert watermarks as follows using 3D reference coordinates which were used at this moment.

if (3D reference coordinate value of z-axis < 0) then watermark=1

Else watermark=0;

Step 5: If (P5 < y-axis coordinate of reference coordinate P0 < P4) then represent as svg:ellipse

Else represent as svg:ellipse and svg:polygon;

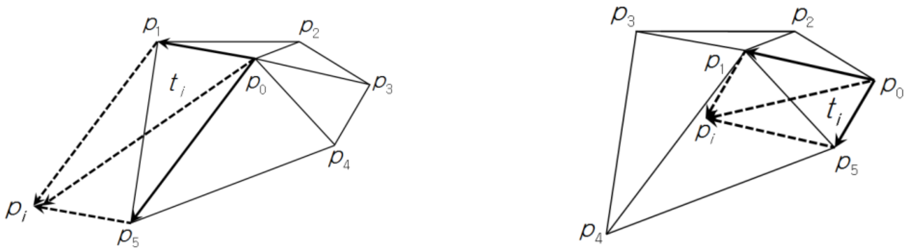
If (y-axis coordinate of P4 = y-axis coordinate of P5) then represent as polygon;

Step 6: Represent as LASeR node using converted 2D coordinates on step 4.

2.2.3. Watermark Insertion Algorithm for Polygon Nodes: Method to insert watermarks in Polygon node was used by correcting cho's method[11] and the algorithm is as follows.

Step 1: Like in Figure 4, calculate the vector value($\overline{p_0p_5}$) of the longest side, and the vector value ($\overline{p_0p_1}$) of the shortest side, for Polygon t_i and calculate the sum ($\overline{p_\iota} = \overline{p_0p_1} + \overline{p_0p_5}$).

Step 2: If calculated value $\overline{p_\iota}$, is located in mesh model like (a) in Figure 4, insert watermark '0', and if it is located outside of mesh model like (b) in Figure 4, insert watermark '1'.



(a) Insertion of Watermark '0' (b) Insertion of Watermark '1'

Figure 4. Insertion Watermark for Polygon Node

When extracting watermarks, original image is required. In the projection and conversion process from 3D model to 2D model, reference coordinates on z-axis disappear. When extracting watermarks, restore disappeared reference coordinates on z-axis using original image. Extract watermarks from restored original 3D model with the same method as watermark insert procedure. And, judge the attacks by comparing with extracted watermarks which were extracted from transformed 3D model and find transformed or distorted polygon caused by the attacks.

3. Experimental Results

All the tests were carried out on the P.C. equipped with an Intel core2 2.3 GHz processor and 4GB memory. The proposed method is implemented in C++, and has been tested on several 3D models. Figure 5 shows six of them: Box, Cone, Cylinder, Pawn, Cat and Dolphin.

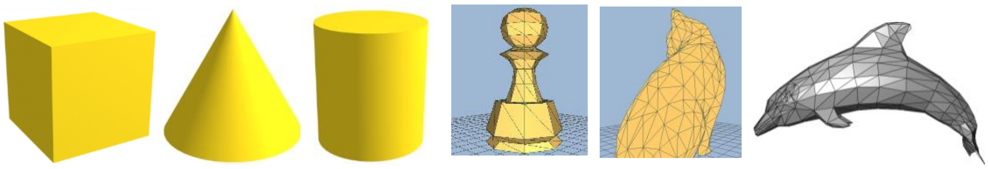


Figure 5. Original 3D Models: Box, Cone, Cylinder, Pawn, Cat, Dolphin

In this paper, proposed method was verified by distortion and robustness evaluation. The robustness indicates how resistant the watermark is against various routine operations on the watermarked content. The robustness is evaluated in terms of the BER (bit error rate) of the extracted watermark bit sequence.

Noise addition attack aims to simulate the artifacts introduced during 3D mesh generation and the errors induced during data transmission. In this experiment, pseudo-random noises added. Figure 6 shows experimental results after various noise addition attacks.

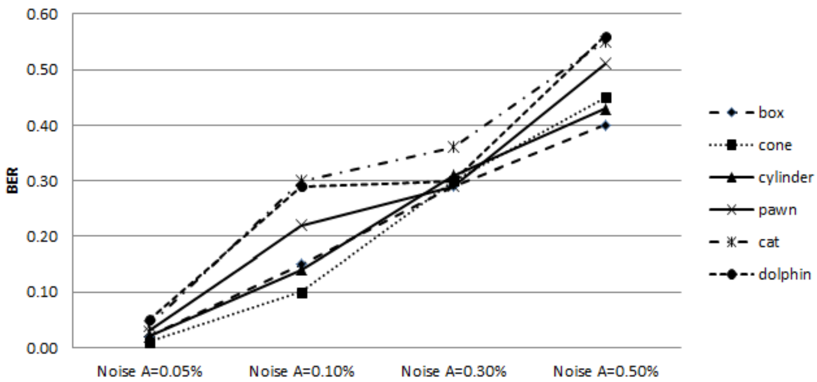


Figure 6. Experimental Results after Various Noise Addition Attacks

Smoothing attack is a common operation used to remove the noise introduced during the mesh generation process through 3D scanning. For experiment, this paper chooses to carry out Laplacian smoothing [12] on watermarked meshes, with different iteration numbers *itr*. Figure 7 shows experimental results after various smoothing attacks.

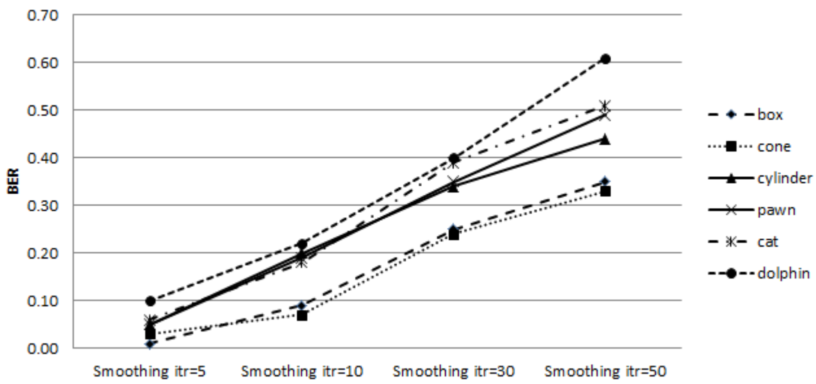


Figure 7. Experimental Results after Various Smoothing Attacks

Vertex coordinates quantization is largely used in 3D mesh compression. Figure 8 shows experimental results after various quantization attacks.

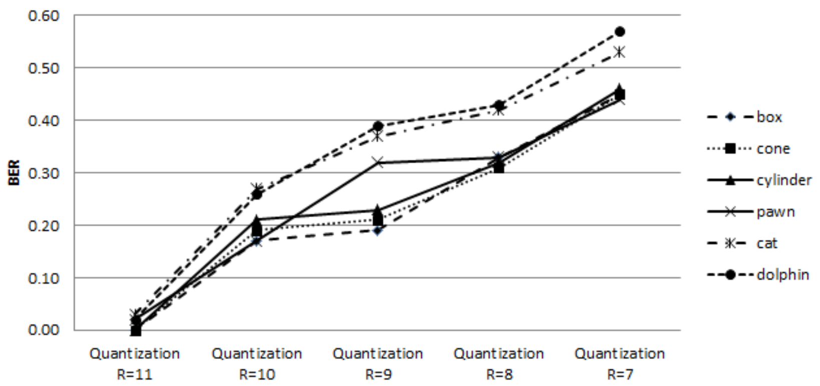


Figure 8. Experimental Results after Various Quantization Attacks

The watermark is often embedded in the original complex model, and then the 3D mesh is simplified so as to adapt to the capacity of the available resources. This simplification operation is the most important one of various connectivity attacks. Figure 9 shows experimental results after various simplification attacks.

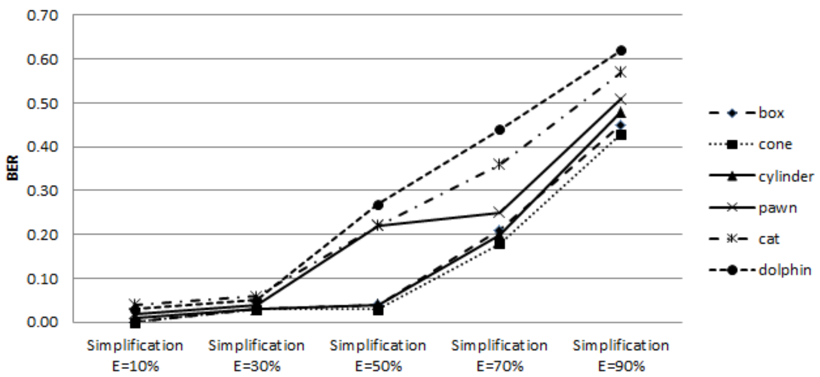


Figure 9. Experimental Results after Various Simplification Attacks

4. Conclusion

MPEG-4 BIFS is targeting P.C. environments, but its specifications are complicated even though it can represent 2D and 3D scenes based on VRML. On the other hand, LASeR is targeting mobile environments, and can represent only 2D graphic based on SVG, and has simple specifications. Using Ko's method [9], a method is suggested that watermark is inserted in the conversion process of 3D graphic nodes in MPEG-4 BIFS into LASeR 2D graphic nodes in this paper. This method uses the procedures to process z-axis coordinate value in order to process 3D nodes in BIFS and to process 3D coordinate conversion like rotation, movement and expansion. And, 3D coordinate values in BIFS and transform nodes are processed and subsequently, Z-axis values are processed as 2D attribute values through projection and conversion of calculated values.

Proposed watermarking algorithm uses vector information of polygon and original model is needed in extraction procedure. This proposed watermarking algorithm has good imperceptibility and robustness against the geometrical attacks such as noise addition, smoothing, mesh simplification. And it is proved that this proposed algorithm is good for integrity authentication by the experiment. The future research is to develop the algorithm for embedding and extracting a watermark in the rendering information, when rendering 3D mesh models.

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