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Frame-based Animated Mesh Compression and Optimized Mesh Traversal (PCA-Based) for 3D Animation Compression Media

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Abstract—The video compression efficiency for high technology application such as 3D animation can be increased by determining the suitable method in storing bits, transmitting and speeding up the rendering process. Good compression efficiency of polygon mesh-based application needs a method that can deal with 3D animation or dynamic 3D mesh complex properties. Due to the complexity of the application, several methods currently become center-focus by many researchers. Two of them are Frame-based Animated Mesh Compression (FAMC) and Optimized Mesh Traversal. Both methods are specially made for the 3D animation compression and have their own unique properties in increasing the compression efficiency. Thus, the best way to get a good speed in compression process can be achieved by comparing between FAMC and Optimized Mesh Traversal. It is found that implementation of the Optimized Meshes Traversal shows higher compression efficiency compare to FAMC approaches.

Index Terms— Mesh compression, video compression efficiency, animation compression, mesh traversal.

1 INTRODUCTION

IN this era of advanced technology, animated 3D meshes or 3D animation content is one of the applications that is required in many fields [1], [2]. Today, animated 3D mesh content is one of the fundamental contents in numerous general public entertainment, educational and professional applications especially in video games industries, CGI films, special effects or CAD systems. For distribution and exchange purposes, 3D animation is represented as 3D key-frames sequence [3].

The MPEG-4 standard was adopted for compression of dynamic 3D mesh called Framed-based Animated Mesh Compression (FAMC) [4]. This approach is based on the skinning motion representation strategy which involves an optimal motion based on segmentation approach and a skinning module which expresses the motion of each mesh vertex as a weighted combination of the clusters motions [5], [2]. This study will evaluate the efficiency compression of this method by comparing its result with Optimized Mesh Traversal (OMT), which is one of the Principle Components Analysis (PCA) algorithms.

OMT, known as traversal order optimization is one of the coding methods used for animated 3D mesh or triangle mesh compression [3], [6]. This is a PCA-based dynamic mesh compression by optimizing the order in which the mesh is traversed. Based on the recent research findings, OMT gives a better result than FAMC toward encoding the animated 3D meshes [6]. Maglo [3] had applied the traversal concept in his research for progressive compression of manifold polygon meshes. The result shows that the traversal order is more efficient for 3D animated meshes object.

The purpose of this study is to determine the most suitable method between FAMC and OMT in determining the higher compression efficiency of storing, transmitting, and rendering of animated 3D mesh, which made up of triangle meshes.

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2 MOTIVATION

2.1 3D Animation

3D animation is the representation of static meshes sequences sharing the same connectivity requires efficient compression [2]. Moreover, 3D animation is one of the applications with recent technology that includes complex models with thousands of vertices [2].

Animated 3D meshes are widely used in areas such as 3D television, interactive applications, video games, virtual reality, as well as in education and professional products [4], [2]. The 3D animation which utilized animated 3D meshes are also known as dynamic 3D meshes of 3D mesh sequences [2]. According to Vasa [7], dynamic meshes, made up of a series of static triangular meshes are convenient representation that shares a single connectivity where each frame of the animation has different vertex position. Generally, the model of 3D animation has a hierarchical structure which made up of a number of transformed nodes of geometry as well as an interpolator node for the timeline in contrast to a model of 3D polygon mesh [6]. With more complex 3D models, the efficiency of transmission will become poorer with the application of key frame representations [1], [4]. Mamou et al. [5] stated that these representations cause storing, transmitting and rendering processes to be very challenging [6], [1], [4].

Thus, determination of the most suitable method to compress the animated 3D representation is unavoidable.

2.2 Optimized Meshes Traversal (OMT)

The key-frame approaches clearly lead to highly complex representation during interpolation to ensure the desired video frame rates are achieved. This representation also causes storing, transmitting, and rendering processes to become a great challenge [1], [4].

Optimized traversal strategy is a method that appropriately optimized the mesh traversal for dynamic mesh compression, where the process includes specification of the traversal order needed by the overhead of information [6].

3 Problem Background

Compressions for animated 3D animation are highly demanding for both storage space and bandwidth and also for transmission purpose [6]. According to Sakuragi et al. [8], in order for 3D-content application to perform high quality expression, the amount of data required for data storage and / or transmission often becomes a heavy load. Thus, the efficient coding methods for dynamic 3-D polygon mesh also need to be considered in compression efficiency.

Lengyel in 1995 was the first researcher that considered the issue of compression dynamic 3D meshes with constant connectivity and time varying geometry [1], [4]. Some of the structure representations that were used are Local spatial-temporal predictive approaches, Principle Component Analysis (PCA), Wavelet-based methods, and Segmentation-based approaches [2], [4]. According to Bici [9], PCA method representation involves prediction at a stage for each group.

Another algorithm known as Frame-based Animated Mesh Compression (FAMC), which recently been promoted within the MPEG-4 standard is one of the new compression techniques especially for 3D dynamics mesh [5]. This algorithm combines model-based motion-compensation strategy with transform and predictive coding of residual errors [4], [5]. It is a version that based on a skinning approach with the main idea is to partition the vertices of the animated mesh into groups [2]. Besides supporting a rich set of functionalities including streaming, scalability and progressive transmission, FAMC encoder offers high compression performance with gains of 60% in terms of bit-rate savings compared to previous MPEG-4 technology [2], [5]. Fig. 1 shows the synopsis of the FAMC encoding algorithm. According to Vasa [7], this algorithm has a second amendment of the MPEG-4 part 16 that was published in 2009. Although this algorithm shows result that almost neglects the information about connectivity, it processes the data point as a cloud rather than as a connected mesh apart from clustering step where the properties of 3-D polygon mesh are not fully considered to get the result.

Therefore, the most suitable method needs to be applied in order to improve the performance in compression efficiency.

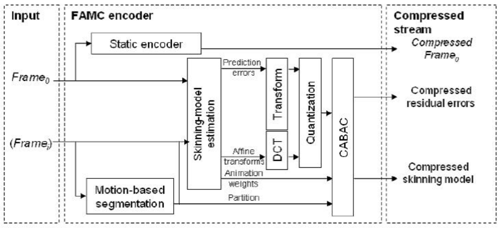

Fig.1. Synopsis of the FAMC encoding algorithm [4].

4 Methodology

4.1 Dynamic Meshes Compression using OMT

Compression for 3D animated meshes represented in series of static meshes with same connectivity has attracted many researchers [2]. Some other researches also focus on combination of PCA method with an Edge Breaker-Like mesh traversal and parallelogram prediction. A study conducted by Vasa [7] has suggested using vertex decimation as a part of the compression. This approach allows the encoder to partially steer the decimation process based on the used predictors [6].

Recently, Maglo et al. [3] has presented a new algorithm for the progressive compression of manifold polygon meshes. The research deals with the decimation of input surfaces by several traversals that generate successive levels of detail. The compression involves the specific path decimation operator, which combines vertex removal and local remeshing [3]. Wavelet formulation with a lifting scheme and an adaptive quantization technique were used to improve the rate-distortion performance [3]. Fig. 2 demonstrates the result of level of detail of quadrangle elephant model generated by the above compression algorithm.

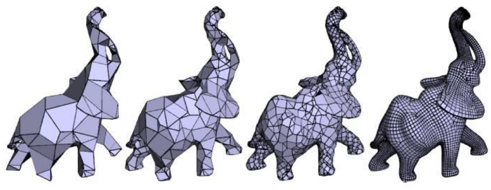

Fig. 2. Level of Detail of quadrangle elephant model generated using OMT [3].

4.2 FAMC and OMT in PCA Basis

With reference to FAMC encoder architecture as shown in Fig. 1, Mamou et al. [1], [4], suggested the first step is to optimally partition the mesh vertices into a set of cluster. A single 3D affine transform method can be used for this purpose. Then, the motion of each vertex is expressed as a weighted linear combination of the cluster motions by exploiting the skinning paradigm considered in animation techniques [1], [4]. The performance of the compression bit increases until 60% bit rate especially for 3D animation section in different components, which expresses similar movement, e.g. head and eyeball movements [10]. Besides, it neglects most of the connectivity problems [6]. However, there are some weaknesses in FAMC during its implementation especially in case of animation consisting of more connected components. Since FAMC applied the cluster approaches, it cannot give output for non-edge connecting components [4].

According to Vasa [7], the general idea of traversal meshes in compressing static meshes, is that the number of possible gates is about six times larger than the number of vertices. A large freedom in choosing a particular traversal order can be achieved by using traversal order when selecting one gate for prediction of each vertex [6]. The algorithm requires several steps in order to encode the final traversal order. First, assign cost to gates. The cost needs to be computed iteratively by using iterative algorithm. Then, gate selection strategy has to be applied. Finally, the traversal order description is transmitted to the decoder [6]. Based on several researches, the optimized traversal order produces more good performance of the algorithm of PCA where it out performs the FAMC standard [6]. Fig. 3 shows one of the results of a research based on optimized traversal order approaches against the FAMC.

Therefore, the implementation of the optimized traversal meshes shows more efficient in terms of compression efficiency against FAMC approaches.

5 CONCLUSION

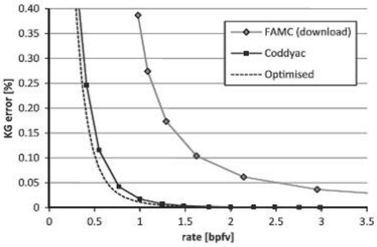

Fig. 3. Rate-distortion curves for the dance sequences [7].

The suggested method shows improvement in reducing the data rate and amount of data required to code feature vector [6]. The best result is obtained during irregular meshes processing. The method has achieved scalability from traversal order optimization and more focus on regularity of the triangle, which helps in defining vector for efficiency of the traversal order optimization. Although this method is, appropriate for 3D animation, further study on other methods that can improve the existing approaches in increasing the compression efficiency should be conducted.

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