Enhancement of the Refinement Process for Surface of 3D Object

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Abstract: The most challenging task in developing surface modelling is to make the look of 3D object surface realistic such as a real object. To achieve this objective, three main issues that must be considered are the number of polygon, quality of the surface and time. A smooth surface is a key factor to make realistic look of 3D object in the virtual environment. Therefore, the main motive of the previous surface modelling methods is to produce a smooth and a good quality of object surface but it mostly incurred high generation cost .Thus, this paper will focus on developing a technique to obtain a smooth object surface at less cost without reducing the quality of the surface.

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1. Introduction

Object modelling is a way to design and create a 3D model in virtual environment [1,2]. Virtual environment is an application that provides an opportunity to the users to interact with the environment [3,4] and to feel as they are in the real world. Realistic is the most important property to make the environment looks like as a real environment. To achieve this objective, a 3D object surface has to be smooth. A method that can be used to make 3D object surfaces look smooth is to perform surface modelling [5,6].

A subdivision surface is the technique to make a good and smooth surface. For a realistic and smooth application of subdivision surfaces, surface modelling is used to represent 3D objects. Smoothness and regularity is criteria to generate a good quality surface in surface modelling. Furthermore, shading issue is also an important in subdivision surface. Shading process should be fast enough to reduce the production cost. Therefore, the number of polygon should also be minimized. Subdivision surfaces reach the optimum level if the surface has all this criteria. However, many researchers still have difficulty in dealing with these issues while producing a 3D object surface that suitable for a virtual environment [7].

1.1 Related Works

In order to make 3D object looks real in the virtual environment, many researchers are involved in modelling field to improve the quality of a surface. A good surface depends on the number of polygon, time and the smoothness of the surface. To achieve this objective, Healay et al., [8] has proposed a method for reducing the number of parallel polygon surfaces that can help to reduce the processing time and decrease the amount of memory needed by each process. This method is suitable for objects that have a huge number of polygons. Kammoun and Payan et al [9] use simplification in order to transform an unstructured surface into the structured and smooth surface.

In the refinement of 3D objects, parameterization is used to transform unstructured surface to the structural surface. Gu et al [10] use grid sampling with the basic flat square and Guskov et al [11] apply subdivision on the simple domain surface. To generate a high quality triangle, Desbrun et al [12] has produced a same size of polygon on a flat surface by using a Delaunay triangular with intention to maintain the quality of the surface. However, discontinuity occurs along the cuts if this method is used. Surazhsky and Gotsman [13] solve the problem of global production of the polygons by using a localization of the same size polygon method which transfer vertex and make it as a part of the clear reconstruction scheme. Ray [14] also uses this method to generate a global constant square polygon on the 3D surfaces.

A subdivision surface is a technique that can produce a smooth surface and commonly used in the object modelling, animation [15] and computer games. Repetition is the sub process for repairing a control point to reach a surface that is limited in the subdivision surfaces. The advantage of subdivision surfaces is its ability to cope with the extraordinary surfaces which enable it to interpret with two random forms. Kammoun and Payyan [9] also use this technique in their research to overcome the inequality surfaces problem. They have produced a refinement scheme for unstructured 3D surfaces.

The process of the previous techniques can be improved by reorganizing the process well. In this thesis, three times repetition of the process for smoothing surfaces or trifine is proposed. This proposed technique involves three main processes, which are reducing the number of polygons, the creation of the same size of polygon and subdivision surface process.

1.3. Surface Refinement Process

This section will explain the detail process of generating a smooth surface. The framework is created to develop the process of smooth surface and also a method of surface refinement will be explained that is used in this work.

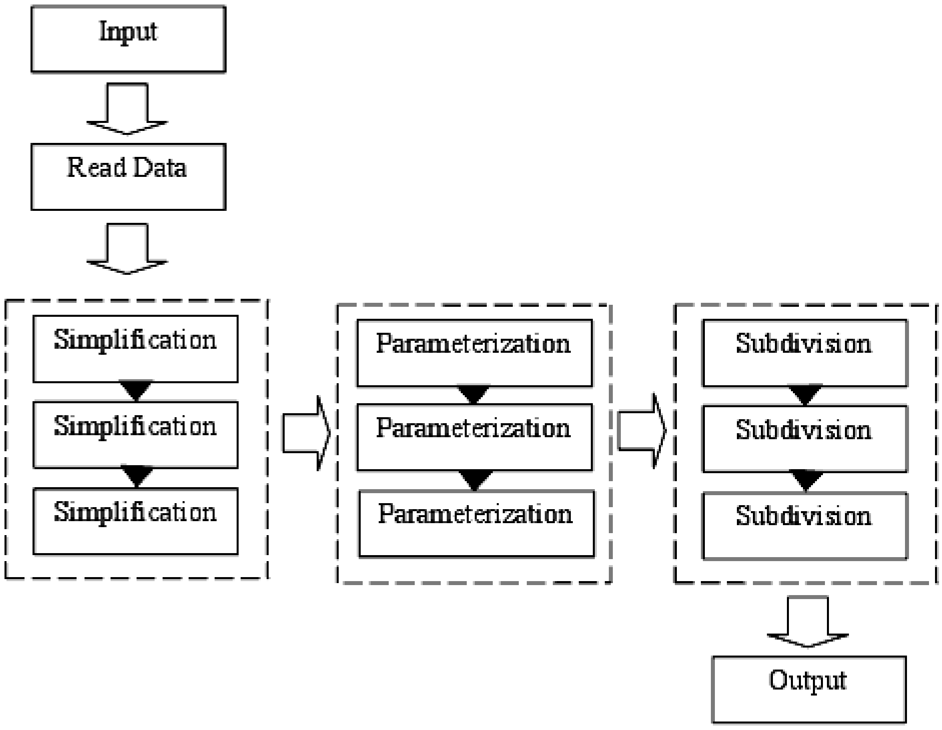


Figure 1. An implementation of three times reiteration for the refinement process.

1.3.1. Implementation

In this research, the enhancement of the refinement process is made that based on Kammoun and Payan et al [9] surface refinement method. The combination of three main processes which are simplification, parameterization and subdivision surfaces has to be evaluated to produce a smooth and uniform surface while preserving the features and quality of a surface.

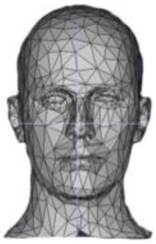
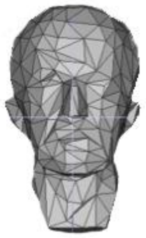
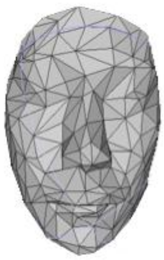
There are three main processes used to obtain a smooth surface in this research which are the reduction of the number of polygon, the creation of the same size of polygon and finally the process of subdivision surfaces. The process for reducing the number of polygon also known as simplification process and it has a capability to transform a three dimensional polygons to the simple polygon. This process reduces the number of polygons by combining a particular point to illustrate an object while maintaining the original form of the object. A kd-tree method is used in this process because a kd-tree is capable to support a fast query for vertex and triangle. This process will be done recursively to increase the combination of the vertex and triangular, and as well reduce the number of polygon vertex.

When the simplification process is completed, the next step is to create a same size of polygon. The parameterization process is implemented to structure the polygon. This process is needed because it gives a representation to the mapping of polygon textured. In this research, mean curvature flow is used in this process to mitigate crinkle on the surface and thus to obtain a uniform surface. A polygon surface generates by this method will be more uniform and regular form if this be done recursively. Therefore, the repetition of this process will be applied in this proposed technique.

After the application of simplification and parameterization processes on the polygonal surface, a polygonal surface appears to be more simple and organized. However, these two processes have no effect to smooth the surface. Loops subdivision surfaces process is used to solve this problem [16]. Loops subdivision techniques are the fastest and easier division techniques to produce a smooth surface. In this approach, a polygonal surface is divided until the surface becomes smooth. Triangular polygonal surface is divided into four parts and a new vertex will be generated on the middle of each triangle edge. Then each side of triangle will be connected by the new vertex. After that, Loop mask is used to improve the refinement of 3D object surfaces. This process involves the repetition for each stage of subdivision so that the process can generate a smoother surface [17].

In this study, the algorithm involves three times reiteration for each process is represented in the figure 1 below. Reiteration can be defined as a process, method or manufacturing that should be done repetitively. In this paper, the concept of three times reiteration for the refinement process is the concept of repetition for an existing method. This concept is applied to produce a better result. The more repetitions are performed, the better quality of results may also produce [18].

Table 1. Specification of the 3D objects data.

Objects	**The Number of Vertex**	**The Number of Triangle Surfaces**
Head 	689	1355
Max-Planck 	249	487
Face-MH 	146	264

2. Experiment

Testing, comparison and evaluation phase of proposed method is the last phase in this research. This phase is conducted in order to be used as a standard to ensure that the rules meet the requirements of virtual environment applications. Testing is done by performing experiments on head, max-planck and face-MH objects which are specified in Table 1. The objective of this research is to reduce rendering time, thus the resulting time and the number of polygon for each object are recorded to determine the performance and the capabilities of the proposed method in this experiment. After that, the changes and the improvements that have been made by the proposed method are identified by performing a comparison with the Kammoun and Payyan [9] method.

2.1. Testing Platform

In this experiment, the specification of device that was used to conduct the experiment process is specified in Table 2. The results from this experiment are discussed based on Frame per Second (FPS) and the number of polygon.

Table 2. Specification of the device to render 3D object

Processor	Intel® Core™ i3 CPU M350 @ 2.27GHz
Memory (RAM)	4.00GB
Graphics Card	AMD Radeon HD 6470M
Operating System	Microsoft Window 7 Ultimate

3. Results

This section will discuss the result from the experiment of the refinement 3D surface. Developing a smooth surface for 3D object is important to produce a realistic virtual environment. In this experiment, three sample of 3D object are used and every sample is measured in term of their performance based on FPS and the number of polygon used in this system.

Based on this experiment, the total number of triangles generated by the 3D objects which are using trifine process in the subdivision surfaces is less than the total number of triangles generated without trifine process. The number of FPS produced by the object using the trifine process is high compare to the amount of SPF. To develop an effective and powerful system, the total of FPS must be high and the number of SPF is low. This experiment proved that the trifine process can produce a smooth surface with speeding up the rendering time.

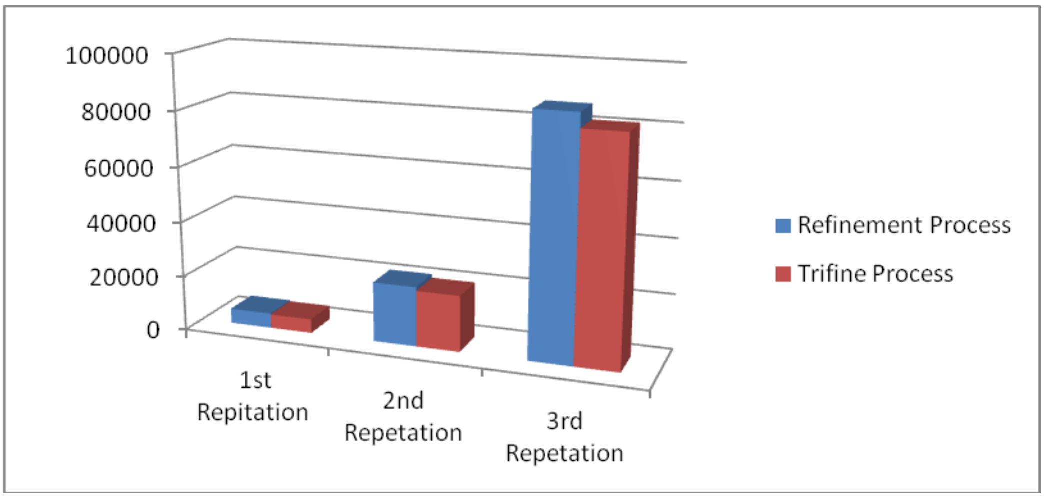


Figure 2. The comparison of the total number of head object triangles between the with trifine process and regular subdivision process.

Figure 2 above represented the comparison between the quantities of triangular head meshes with the trifine process and the quantities of head triangular meshes of regular refinement process. Based on this figure, the total number of triangles for head object without trifine process is more than the head object with trifine process. Subdivision process performed to the object surface with the trifine process shows that the total number of triangles is less than the regular subdivisions process.

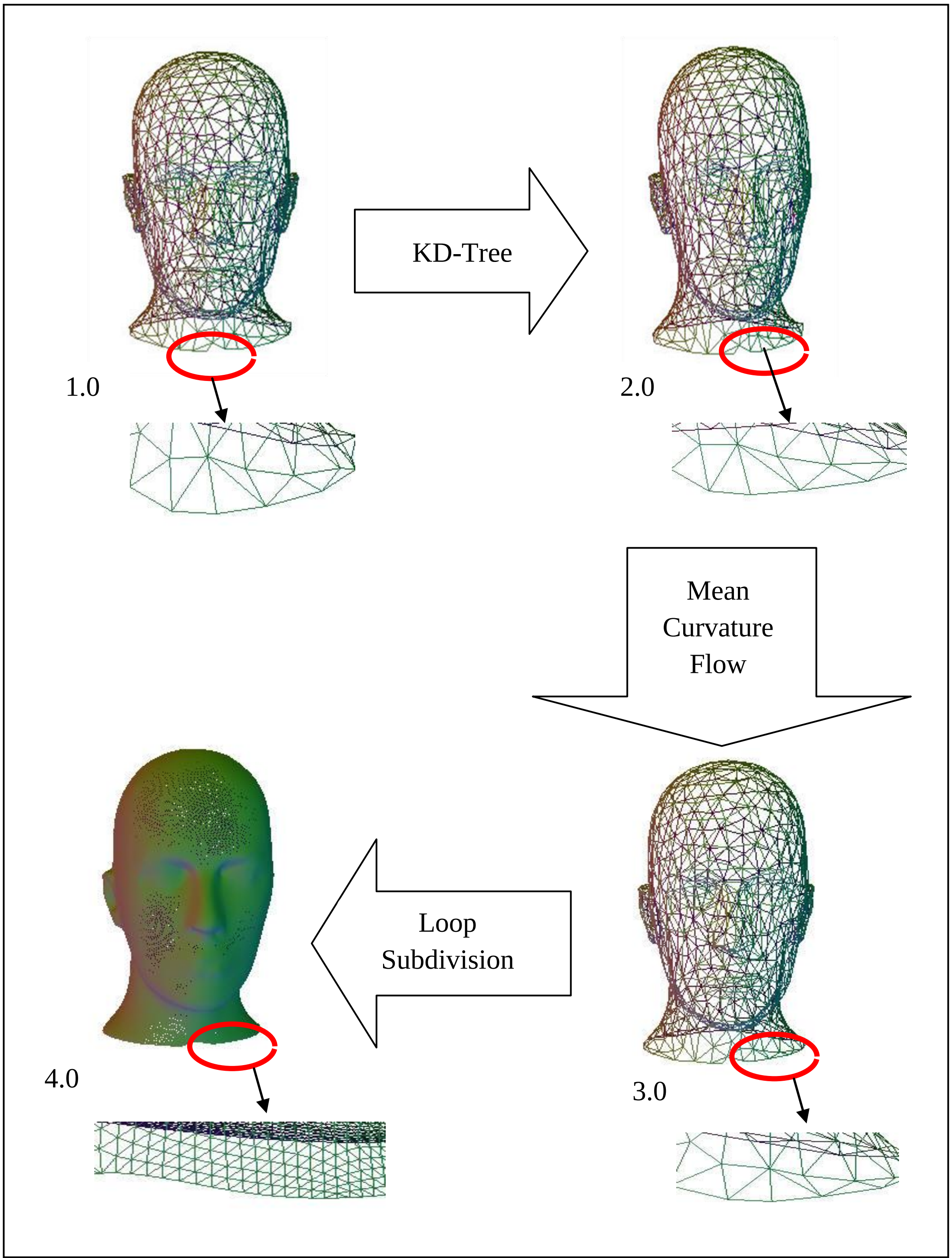


Figure 3. The object after the refinement process.

Figure 3 shows the resulting object from the refinement of smooth surface. By doing the repetitions on the simplification process, the quantity of the resulting meshes decreases and these processes also reduce the rendering time. A repetition for the parameterization and the subdivision surfaces add the realistic features for 3D objects rendered in virtual environment and also look more real than the original object. Overall, the developing of the refinement of an object surface generates a smooth surface at a less cost without reducing the quality of the surfaces.

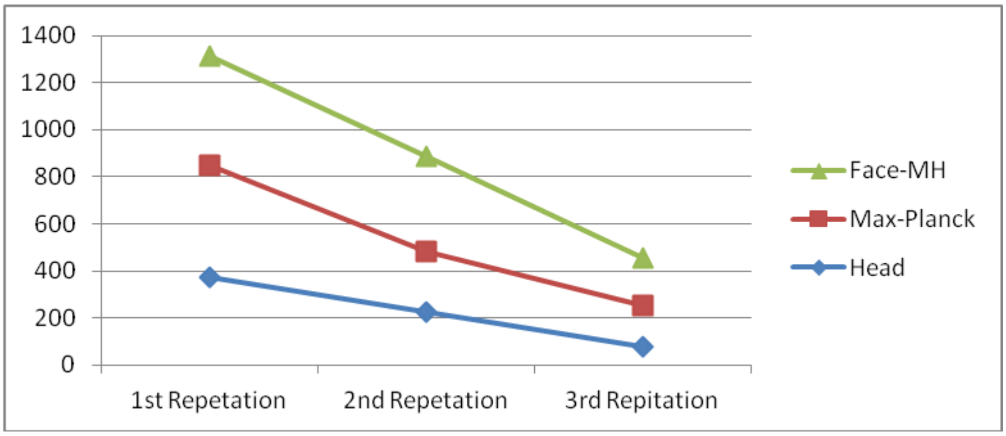
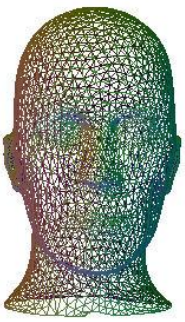
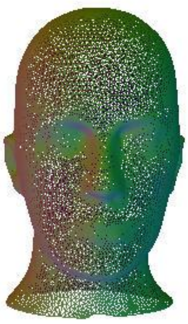
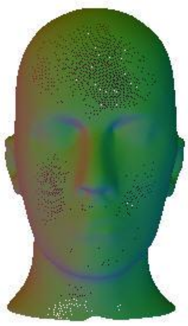


Figure 4. Line charts of the total number of FPS (Frame per Second) after trifine process.

Figure 4 above shows the total number of FPS produced by the trifine process. Total frame generated in every second decreasing when more repetition of the subdivision surfaces is produced. The experiment results show that the FPS will decrease when more triangle surface is generated. A time for generated an object also decrease when more repetitions is done.

Object	**With Trifine Process**	**1st Repetition**	**2nd Repetition**	**3rd Repetition**
Head	No			
	Yes			

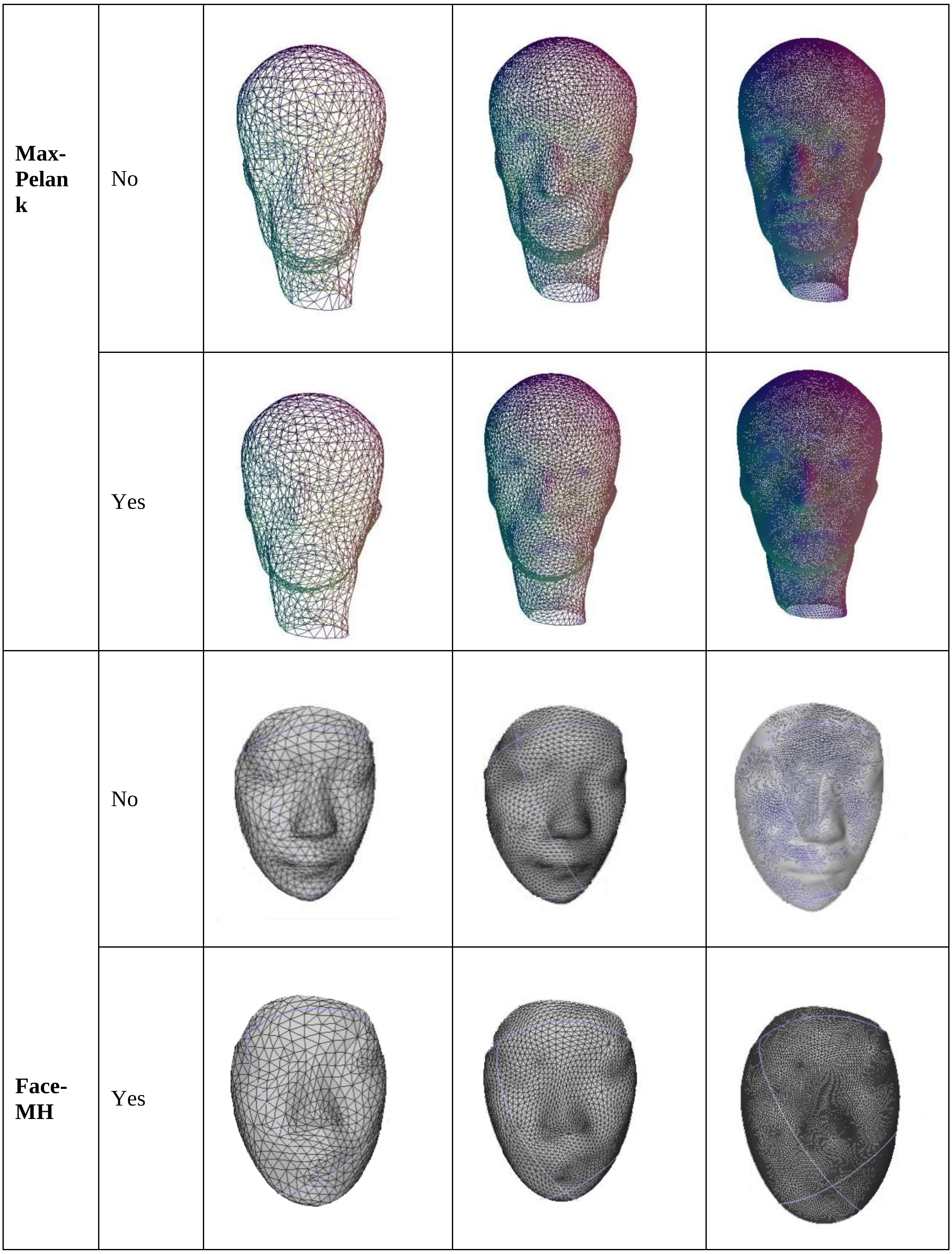


Figure 5. Comparison 3D object refinement between trifine technique and without trifine technique

4. Conclusion and Future Work

In this study, the trifine process has been developed to refine and generate a smooth surface as a real object. A method for reducing the number of polygons, parameterization of the same size of polygons and the subdivision surfaces have been combined and repeated to produce a trifine technique. The trifine process can reduce costs by reducing the processing time of generating a 3D objects. Various of an enhancement can be made to improve the quality of the 3D surface in addition to looks smooth, realistic and high quality for the virtual environments.

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