Studentská Vědecká Konference 2010

# RATE-DISTORTION OPTIMISATION IN DYNAMIC MESH COMPRESSION

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## 1 INTRODUCTION

In this article, we will be dealing with compression of dynamic 3D triangle meshes with constant connectivity. These can be viewed as animations consisting of frames with each frame being a triangle mesh. All the frame meshes in an animation have the same number of vertices and contain edges between the same vertices.

There are many algorithms for compressing such data. Most of them started out with a small number of compression parameters. Though, as the algorithms evolve to offer higher compression ratios and enhanced compression properies, the number of parameters usually grows along allowing better adaptation to different input and output conditions. Finding the optimal parameter configuration using a brute-force search needs to examine a number of configurations exponential to the number of parameters, and thus may become very time consuming. Moreover, brute-force approaches strongly trade off accuracy for computation time, which results in considerably inaccurate parameter configurations. We will show a solution, which can find near-optimal configurations in a significantly shorter time for compression algorithms with more than two parameters.

## 2 RD OPTIMISATION WITH PRINCIPLE OF EQUAL SLOPES

Rate-distortion (RD) optimisation is a technique that configures a compression algorithm for optimal performance. In most cases, this configuration depends on the input data, thus we have to perform it again for every new dataset. There is a set of many possible optimal configurations for each input data. RD optimisation is a process that finds a single configuration in this set that satisfies a specified constraint, e.g. a given bitrate.

The performance of a lossy dynamic mesh compression algorithm can be measured in terms of the distortion it introduces into the compressed data and the bitrate of the result. This pair of values can be plotted on a rate-distortion chart. A lower bound distortion exists for every bitrate, forming an envelope curve of the chart. This curve contains the configurations that result in the lowest distortion for a given bitrate. Experiments show, that for most dynamic mesh compression methods, this curve is decreasing and convex.

If we fix the values of all parameters but one in a single configuration, we will obtain a parameter RD curve, which we assume to also be decreasing and convex. As such curves are subsets of the complete RD chart, they all lie above the envelope curve and only touch it in the RD point of an optimal configuration. For each point of a parameter curve, we can calculate the slope value of the curve tangent in that point. Two parameter curves with a common point are intersecting, if their slopes differ in that point, or touching each other, if the slopes equal. A configuration, in which the curves are intersecting, cannot be optimal. Thus, we can say that a parameter configuration is optimal if and only if the slopes of all parameter curves in its result RD point are equal.

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## 3 ITERATIVE RD OPTIMISATION METHOD

Based on the Principle of Equal Slopes, we can iteratively refine a parameter configuration until it gets close enough to an optimum. In each iteration, the bitrate and the distortion are evaluated in the current configuration and several configurations around it, in order to approximate the local shape of the parameter curves. A new configuration is then determined from these values using linear or nonlinear extrapolation. This configuration is consecutively used as an input of the next iteration, and so on, until a stop-condition is met. For each new configuration, an overall deviation from optimality is calculated. Once this deviation falls under a specified threshold value, the optimisation ends.

The optimisation process needs to be constrained to exactly determine the resulting configuration. Therefore, we have considered and implemented four criteria specifying the overall deviation calculation and the calculation of the next configuration: target slope, target bitrate, target distortion, and fixed parameter.

## 4 RESULTS

We compared our algorithm to the commonly used brute-force approach on many different mesh animations with very similar results. Here, we show the results of finding the optimal envelope curve on the Cow animation using two compression algorithms: Coddyac by Váša and Skala (2007) and D3DMC by Müller et al. (2005). To measure the distortion, the KG error metric published by Karni and Gotsman (2004) was used, as it is the most commonly used metric in dynamic mesh compression. The comparison of the number of compressor invocations and the overall runtime is show in tab. 1.

| | **Coddyac** | | **D3DMC** | |
|---|---|---|---|---|
| | compressor runs | runtime | compressor runs | runtime |
| brute-force | 4500 | 36:06:35.4 | 969 | 9:44:33.5 |
| our method | 612 | 1:19:03.7 | 859 | 8:02:42.6 |
| **speedup** | **7.4** | **27.4** | **1.1** | **1.2** |

**Tab. 1:** Comparison of RD optimisation of the Coddyac and D3DMC algorithms.

## 5 CONCLUSION

We have developed a rate-distortion optimisation method for dynamic triangle mesh compressors based on the Principle of Equal Slopes. By using this approach, we can decrease the time needed to find an optimal configuration compared to the commonly used brute-force approach. Moreover, our method can also be constrained in four different ways, thus better fitting the current needs.

**Acknowledgement:** This work has been supported by the Ministry of Education, Youth and Sports of the Czech Republic under the research program LC-06008 (Center for Computer Graphics).

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