Closing the Gap: Efficient Voxelization with Equidistant Scanlines and Gap Detection

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Abstract : This research introduces an approach to voxelizing the surfaces of triangular meshes with efficiency and accuracy. Our method leverages parallel equidistant scan-lines and introduces a Gap Detection technique to address the limitations of existing approaches. We present a comprehensive study showcasing the method's effectiveness, scalability, and versatility in different scenarios. Voxelization is a fundamental process in computer graphics and simulations, playing a pivotal role in applications ranging from scientific visualization to virtual reality. Our algorithm focuses on enhancing the voxelization process, especially for complex models and high resolutions. One of the major challenges in voxelization in the Graphics Processing Unit (GPU) is the high cost of discovering the same voxels multiple times. These repeated voxels incur in costly memory operations with no useful information. Our scan-line-based method ensures that each voxel is detected exactly once when processing the triangle, enhancing performance without compromising the quality of the voxelization. The heart of our approach lies in the use of parallel, equidistant scan-lines to traverse the interiors of triangles. This minimizes redundant memory operations and avoids revisiting the same voxels, resulting in a significant performance boost. Moreover, our method's computational efficiency is complemented by its simplicity and portability. Written as a single compute shader in Graphics Library Shader Language (GLSL), it is highly adaptable to various rendering pipelines and hardware configurations. To validate our method, we conducted extensive experiments on a diverse set of models from the Stanford repository. Our results demonstrate not only the algorithm's efficiency, but also its ability to produce 26 tunnel free accurate voxelizations. The Gap Detection technique successfully identifies and addresses gaps, ensuring consistent and visually pleasing voxelized surfaces. Furthermore, we introduce the Slope Consistency Value metric, quantifying the alignment of each triangle with its primary axis. This metric provides insights into the impact of triangle orientation on scan-line based voxelization methods. It also aids in understanding how the Gap Detection technique effectively improves results by targeting specific areas where simple scan-line-based methods might fail. Our research contributes to the field of voxelization by offering a robust and efficient approach that overcomes the limitations of existing methods. The Gap Detection technique fills a critical gap in the voxelization process. By addressing these gaps, our algorithm enhances the visual quality and accuracy of voxelized models, making it valuable for a wide range of applications. In conclusion, "Closing the Gap: Efficient Voxelization with Equidistant Scan-lines and Gap Detection" presents an effective solution to the challenges of voxelization. Our research combines computational efficiency, accuracy, and innovative techniques to elevate the quality of voxelized surfaces. With its adaptable nature and valuable innovations, this technique could have a positive influence on computer graphics and visualization.

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