Representing Realistic Pavement Blocks

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Abstract. The depiction of the irregularity in nature is crucial for the realistic representation of the real world. For example, real pavement blocks are not always paved evenly, but partially sink over time. Many games or virtual reality systems however represent the pavement too neatly with perfectly flattened surface and clean texture images. In this paper, we suggest a method for representing realistic pavement blocks by adding irregularity to blocks. We create uneven surfaces by placing pavement blocks on the randomly generated terrain. Our method is applicable to real-time rendering systems such as games and virtual reality systems.

Keywords: Pavement, Perlin noise, Irregularity, Terrain, Height map

1 Introduction

One of the main purposes in computer graphics is to represent highly realistic scenes. The unreality in the computer graphics mostly comes from the clean and regular models. There has been a significant progress in realistic rendering, but many of models shown in games or virtual reality systems are still too clean and regularly modeled. For example, the pavement blocks are generally rendered with two large triangles textured with neat block images. The real life pavement blocks are uneven, soiled, and weathered. Representing the irregularity in nature is crucial for realistic representation of the real world such as the pavement blocks. Since manually representing the irregularity is tedious and time-consuming, there has been some research creating irregular natural phenomena. For representing pavement, techniques for generating pavement textures have been proposed including Miyata *et al.*[3] and Legakis *et al* .[5] Also others suggested methods for representing weathering effects such as scratches or cracks [7,8]. Most of the methods expressing weathering effects simulate physical phenomena, and are limited to quickly represent those effects in real-time rendering systems.

In this paper, we propose a method that models and renders weathered pavement blocks representing the irregularity in the nature. Our method is useful for real-time rendering systems such as games and virtual reality systems.

2 Related works

Generally, we create a terrain by using a height map. To make an arbitrary random height map, we use the K. Perlin's method [2] that manipulates the frequency and the amplitude for generating a noise.

K. Miyata *et al.* [3] addressed a method that generates a pavement shape texture by packing basic patterns in a square. The packed square having patterns formed that applied by particle simulation. Cellular pattern based system has been suggested by J. Legakis [5]. This method shows a result form geometric information that an object adapted by cells. Another approach by C. I. Yession **[**4] proposed an algorithm which produces graphical materials like wood patterns, stones, and ground materials. By using this solution, it is possible to generate disturbance on a target which initialed regular patterns randomly. S. Gobron *et al*. [8] proposed a technique to simulate the crack propagation on 3-dimensional surfaces. Given technique is offered to generate easily with manipulation.

3 Representing Uneven Pavement

For generating a naturally curved terrain, we generate a random noise by using Perlin's method [2] for generating gradient noise. Based on the underneath ground properties and oldness of the pavement, level of terrain unevenness would be various. The terrain underneath an older pavement on the softer ground would be more highly curved, and the terrain underneath a newer pavement on the firmer ground would be less curved. To express the level of terrain unevenness, we generate a two dimensional noise in various frequencies and amplitudes by adjusting the frequency and the amplitude of the noise function. The generated noise is stored in a two dimensional array and used as a height map representing the terrain underneath of the pavement blocks. After generating a height map representing the underneath terrain, we place pavement blocks on the curved terrain. This procedure resembles the real world procedure to pave blocks. First, we uniformly pack the pavement blocks in the rectangle containing the height map which is the horizontal bounding box of the terrain. Then, we vertically reposition the blocks so that they lie at the same height with the underlying terrain. Finally, we rotate each block so that it is aligned with the orientation of the underlying terrain area covered by it.

To compute the orientation of the underlying terrain, we crop the height map covered by each block, and generate a point set by converting pixels of the cropped height map into points, and compute three orthogonal directions by using principal component analysis (PCA)[13]. The PCA is done by computing the eigenvectors of a covariance matrix of the data points on the underlying terrain. Figure 1 (a) shows an axis-aligned pavement block, and Figure 1 (b) shows a set of points on the underlying terrain and the pavement block aligned with it.

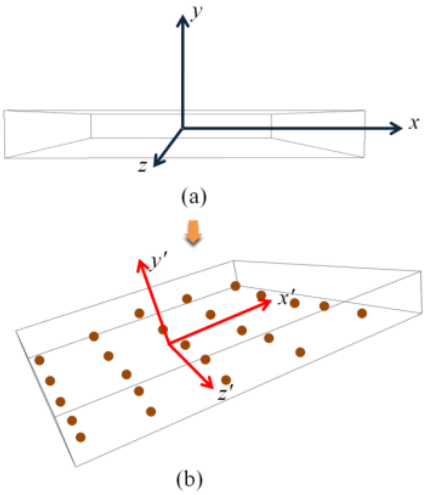

Fig. 1. Aligning a block along with the underlying terrain orientation. (a) The axis-aligned pavement block is vertically positioned on the terrain. (b) The block is rotated so that it is aligned with the underlying terrain orientation computed by the principle component analysis.

In this paper, we create a pavement realistically by addressing an irregularity of unevenness. Representing uneven pavement blocks which are partially raised or sunk is crucial for modeling the irregularity in the paved block. Figure 2 shows the resulting uneven pavement blocks and Figure 3 represents final images of textured uneven pavement blocks with various frequencies.

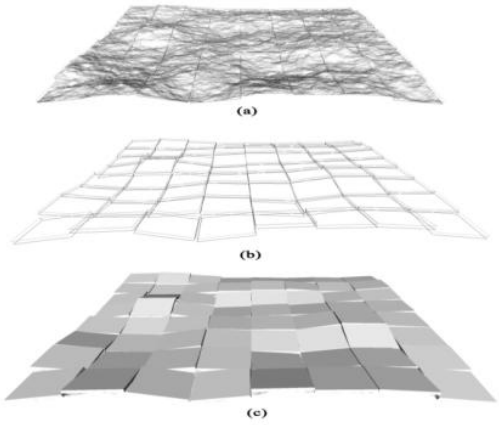

Fig. 2. (a) The underlying terrain generated by a Perlin noise. (b) The pavement blocks placed on the curved terrain in wire frames. (c) The blocks paved on the curved terrain in solid rendering.

4 Conclusion

In this paper, we propose a method for creating a realistic pavement on the terrain by representing the irregularity. Our method is intuitive and easily applicable to most of

arbitrary random terrains in games, virtual reality systems, or other interactive graphics systems. In this paper, we generate randomly curved terrains for representing uneven pavements. In addition, our suggestion for representing uneven pavements actually transform the object's geometry, so it has a potential to represent physical phenomena such as puddles, wet or soiled surfaces, snow on the pavement, and mosses or grasses between bricks. For real-time systems, generating uneven surfaces and synthesizing textures on the GPU would be also worth to try for the future works

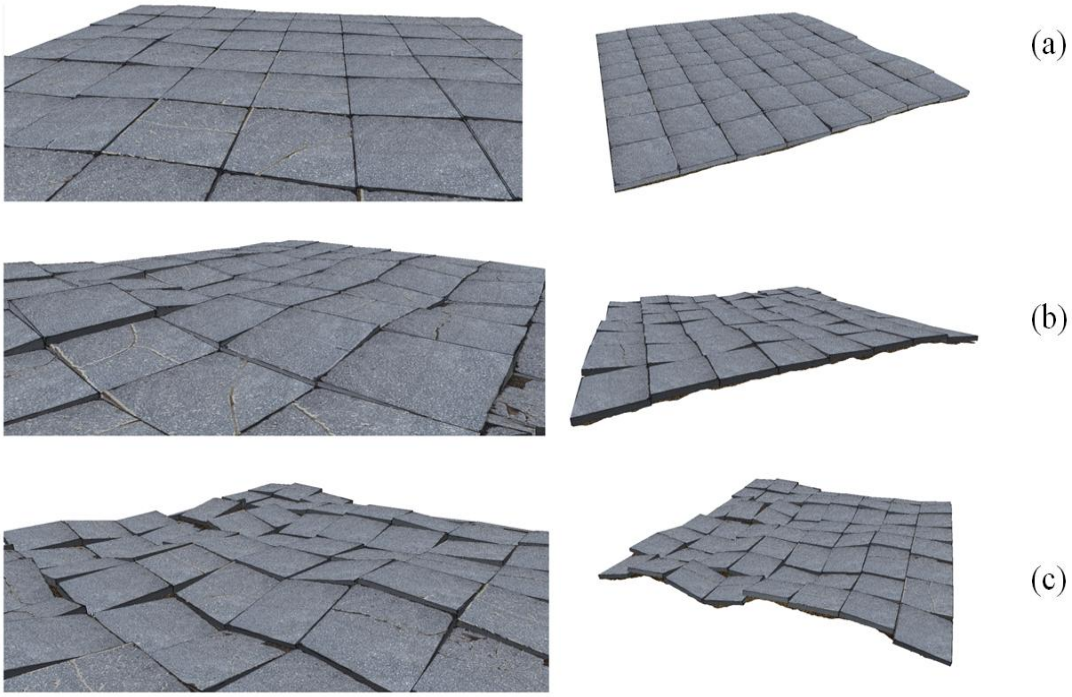

Fig. 3. Uneven pavement blocks generated by our method (a) on a terrain by a low frequency height map, (b) on a terrain by a mid frequency height map, and (c) on a terrain by a high frequency height map

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References

1. Perlin, K.: An Image Synthesizer. In Computer Graphics. Proceedings of ACM SIGGRAPH 85, 19(3), 287-296.
2. Perlin, K.: Improving noise. In SIGGRAPH `02. Proceedings of the 29th annual conference on Computer Graphics and interactive techniques. ACM Press, New York, NY, USA, 681-682
3. Miyata, K. Itoh, T. Shimada, K.: 2001. A method for generating pavement textures using the square packing technique. The Visual Computer`00, 16:371 - 378.
4. Yessios, C I. 1979.: Computer drafting of stones, wood, plant and ground materials. SIGGRAPH`79. ACM SIGGRAPH Computer Graphics. Vol 13.
5. Legakis, J. Dorsey, J. Gortler, S. 2001. Feature-based cellular texturing for architectural models. SIGGRAPH`01. Proceedings of the 28th annual conference on Computer graphics and interactive techniques.
6. Worley, S. 1996.: A cellular texture basis function. SIGGRAPH`96. Proceedings of the 23rd annual conference on Computer graphics and interactive techniques.
7. Merillou,S. Ghazanfarpour, D.: 2008. A survey of aging and weathering phenomena in computer graphics. Computers & Graphics 32 (2008) 159–174.
8. Gobron, S. Chiba, N. 2001.: Crack pattern simulation based on 3D surface cellular automata. The Visual Computer (2001) 17:287–309.
9. Brachmann,C. Walther-Franks,B. Loviscach,J.: 2007. Exemplar-based Worn Edges. In Eurographics 2002 Short- Presentations
10. Xuey, S. Wang, J. Tong, X. Dail, Q . Guo,B.: 2008. Image-based Material Weathering. EUROGRAPHICS 2008. Vol 27.
11. Iben, H N. O'brien, J F.: 2006. Generating Surface Crack Patterns. In Eurographics ACM SIGGRAPH Symposium on Computer Animation.
12. Desbenoit, B. Galin, E. Akkouche, S.: 2005. Modeling cracks and fractures. Visual Comput (2005) 21: 717–726.
13. Rao, C R. 1964. The Use and Interpretation of Principal Component Analysis in Applied Research. Sankhya A 26, 329 -358.
14. PRESS, W. H., TEUKOLSKY, S. A., VETTERLING, W. T., AND FLANNERY, B. P. 1992. Numerical Recipes in C: The Art of Scientific Computing. Cambridge University Press, New York, NY, USA, ch. 19.6, 871–888.
15. Youn-Ok Park, Jong-Won Park.: 2010. A Study on the 3 Dimension Graphics Accelerator for Phong Shading Algorithm. The Journal of IWIT. VOL. 10 No. 5, October 2010
16. In-Kyoo Park, Gyoo-Seok Choi.: 2010. Modeling of Fine Cracks using Fuzzy Mathematical Morphology. The Journal of IWIT . VOL. 10 No. 5, October 2010