Transparent Visualization for Implicit Surface considered Texture

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1 Introduction

In the field of computer graphics, implicit surface techniques have been developing to visualize smooth surfaces precisely. Recent development of reconstructing an implicit surface from 3D point cloud also makes the techniques to grow importance [1].

On the other hand, in medical, scientific and other fields, precise and comprehensible transparent visualization is required to investigate complex inner structures and positional relation of 3D objects. The particle-based surface rendering (PBSR) [2] has been developed so satisfy such requirements. The PBSR is a method for transparent rendering using opaque particles and probabilistic determination of surface opacity. So far, rendering colors used in the PBSR has been determined by hand or with a color transfer function. For realistic visualization, however, texture mapping should also be useful. The target of this paper is to develop a particle-based texture mapping technique in the framework of the PBSR.

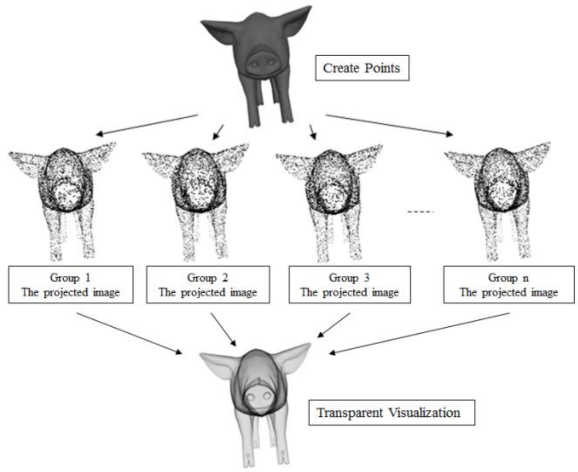

Fig.1. The process of the particle-base surface rendering.

2 Particle-Based Surface Rendering (PBSR) of Implicit Surfaces

2.1 Implicit Surface

Implicit surfaces enable compact expression of complex 3D objects. An implicit surface is defined as a zero isosurface of a proper scalar filed $F(x,y,z)$. A usual way to execute its transparent rendering is to decompose it into many small polygons, e.g., triangles. The polygons are sorted along the line of sight and dawn one by one, beginning from the farthest one from the eye position. This rendering scheme, however, requires computing time proportional to $n \log n$ with n the number of polygons. Besides rendering artifact often appears because of sorting errors coming from finiteness of polygon widths.

2.2 Particle Base Surface Rendering

In our approach, we use the PBSR to visualize implicit surface transparently. The PBSR is a kind of point rendering using opaque particles and probabilistic determination of surface opacity. It enables high-quality transparent rendering and flexible fused visualization of different types of objects, e.g., surface-volume fusion.

The PBSR is executed, following the three steps below: 1. particle generation, 2. particle projection, and 3. determination of pixel values as averages of created multiple statistically independent images. In the particle generation, opaque particles are generated on curved surface uniformly. In the particle projection, first, the generated particles are randomly divided into L_R groups. (Below we call L_R "repeat level".) Then the Z-buffer algorithm is executed to create a single image for each particle group. Finally, in the determination of pixel values, images of all the particle groups are averaged to calculate the final pixel values. Fig.1 illustrates the process of the PBSR explained here.

3 Mapping Texture to the Curve Surface

The target of this paper is to propose texture mapping within the framework of the PBSR. The ordinary texture mapping is executed in units of polygons. In the PBSR, since its rendering primitives are particles, the texture mapping should also be done in units of particles. Then particles become colored. Applying the colored particles to the PBSR algorithm realizes transparent rendering of implicit surfaces.

The way to map image colors to particles is illustrated in Fig.2. Fig.2a is the case of the orthogonal projection, and Fig.2b the perspective projection. In any case, we consider a straight line starting from each particle. An image color at an intersection point between the line and the texture image is assigned to the particle.

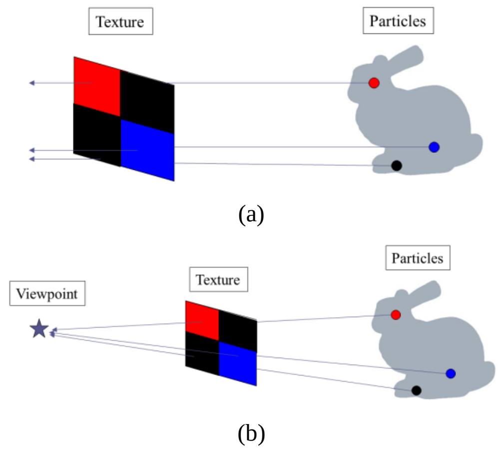

Fig.2. (a) Texture mapping by parallel projection, (b) texture mapping by perspective projection.

4 Experiments

Fig.3 is a simple example of our particle-based transparent texture mapping. A transparent giraffe pattern is mapped to a lemon shape using the parallel projection. A transparent section image, which is also visualized with the PBSR, is fused with the boundary surface of the lemon. We can see that the proposed texture mapping method works well, enabling us to see inside the boundary surface to which a texture image is mapped. Fig.4 is a more complex example. The transparent texture of a human face is mapped to a human-head surface. A transparent skull volume, which is visualized with the particle-based volume rendering (PBVR) [3], is fused with the face. We can see positional relations of eyes, a mouth, etc. on the face surface with those in the skull volume.

(a) (b) (c)

(d)

Fig. 3. Transparent visualization of a lemon shape to which a giraffe pattern is mapped by the parallel projection. A transparent section image is also fused. (a) Surface. (b) A giraffe pattern. (c) Section image. (d) Fused image.

(a) (b) (c)

(d)

Fig.4. Transparent visualization of a human head surface to which a facial image is mapped by the perspective projection. A transparent skull volume is also fused. (a) Surface. (b) A facial image. (c) Skull volume. (d) Fused image.

5 Conclusion

In this paper we have proposed s particle-based transparent texture mapping method for precise transparent rendering of implicit surfaces. We have demonstrated the method using parallel and perspective projections of a texture image to the particles. We have also demonstrated mixed use of our texture mapping with the fused visualization, which is a unique feature of the PBSR.

Our method proposed here is applicable to polygon models as well as the implicit surface model. Once particles are generated on each polygon, our method becomes executable. We plan to apply our method to digital archiving of cultural heritages for which polygon models exist. For example, we are going to visualize complex 3D inner structures of Funeboko float for the Gion Festival in Kyoto, Japan. Many high-quality photographs taken during the real festival are available as texture images. Created contents should be suitable for, e.g., a digital museum in a virtual space of the Internet.

References

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