§50. Virtual Laboratory by Immersive Projection Display

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The goal of our study is to develop a method that enables us to construct 3D detailed shape models suitable for immersive virtual systems and to carry out psychological experiments on the system. We call it virtual laboratory. In the system, an effective and efficient way of the shape representation has been required in order to establish experiments using photorealistic objects such as face model reconstructed from 3D point measurements. The shape modeling method based on implicit surface representation has become an indispensable technique yielding fast and accurate modeling from massive amount of points on a surface. The modeling technique has meant that surfaces of real objects can effectively be modeled using 3D scanning systems. Color information of the measurements can also be acquired with specific device and it enables surface modeling of human faces with textures.

We suppose here that surface of a 3D object is represented as an implicit function as follows:

$$f(\boldsymbol{x}) = 0, \quad \boldsymbol{x} = [x, y, z]^{\mathrm{T}} \in \mathbb{R}^3,$$

where f is a field function whose value is positive inside the surface and negative outside the surface. Several techniques have been developed for creating field function interpolating measured point data $\boldsymbol{x}_1, \ldots, \boldsymbol{x}_n$. The recently introduced multi-level partition of unity (MPU) method[1] provides high accurate implicit surface from large number of points with small computational cost. The corresponding color field functions:

$$\left[f^{(\mathrm{R})}(\boldsymbol{x}), f^{(\mathrm{G})}(\boldsymbol{x}), f^{(\mathrm{B})}(\boldsymbol{x})\right], \quad \boldsymbol{x} \in \mathbb{R}^3$$

can also be constructed from color information defined on the points

$$\boldsymbol{c}_1, \ldots, \boldsymbol{c}_n \quad (\boldsymbol{c}_i = [r_i, g_i, b_i]^{\mathrm{T}})$$

in the same way as the surface reconstruction process[2].

Another method, called sparse low-degree implicit surface (SLIM) [3], also enables us to generate a surface interpolating a set of points automatically. In the present work we developed a method imposing continuous color distribution to the SLIM surface. The color distribution is defined as a set of localized color functions that is independent of the localized functions representing the surface.

It is required to choose appropriate parameters for accurate generation of surfaces and their color distributions. The parameters for convergence criteria, which determine the accuracy of the reconstruction, are particularly important since CPU time and memory requirement depend strongly on these values. Fig. 1 shows an example of the surface reconstruction interpolating a set of points with colors. The surface is represented as a set of local implicit functions using SLIM model and the colors are also constructed as a set of local color distribution functions. Since the local color functions are generated independently of the surface model, it is possible to use different accuracy criteria for the shape and the color.

Fig. 1. Example of SLIM surface with colors. Top-left: input point data with colors (860k points), Top-right: SLIM surface model, Bottom: SLIM surface model with local color distribution

1) Ohtake, Y. et al.: ACM Trans. Graph., **22**, (2003) 463
3) Itoh, T. et al.: ICNAAM 2005 proc., WILEY (2005) 263
2) Ohtake, Y. et al.: Eurographics Symposium on Geometry Processing (2005) 149