Chapter 5

Epilogue

In this dissertation, we have developed a solid platform for using convolution surfaces for computer graphics purposes. Specifically, we addressed three major aspects of the problem: how to describe convolution surfaces mathematically, how to employ them for design of complex shapes and how to render objects modeled with convolution surfaces. We hope that methods and algorithms discussed on these pages will find their users among computer graphics community, both researchers and practitioners.

There are certain areas in our *Formulation – Modeling – Rendering* framework that still can be improved. For instance, an implicit cubic curve, produced via convolution with a polynomial kernel, may be a valuable addition to the arsenal of implicit primitives (*Formulation*). Modifying an object's blobbiness along the surface of the object was mentioned but never actually used, although it could help reducing unwanted blending (*Modeling*)[1]. Volumetric wrinkles and other high-frequency details could have been explored more (*Modeling*). Finally, the mapping of flat textures onto convolution surfaces is a topic of great importance (*Rendering*), which is at present undergoing major developments [53, 81].

As far as implementation is concerned, a graphics user interface for the modeling part of the *RATS* system could facilitate the design process. However, speaking in terms of a software production cycle, we strongly believe that the core of the *RATS* system is already wide and stable enough to be passed to the development stage.

What's next? Although the mathematical and rendering aspects of using convolution surfaces merit additional research, we believe that modeling with convolution surfaces should take precedence and guide the process of their development. So far, we have considered only a limited range of modeling situations where convolution surfaces can be applied. The topics of further research, that may benefit from the results presented in this thesis, are truly inviting.

Several areas of possible application of convolution surfaces were briefly mentioned in the introduction. They concern modeling and animating situations where objects behave essentially as rigid bodies, moving in some unusual force fields (recall an example with the gravity field of a donut-shaped planet or a journey to the center of a Gaussian blob).

Another large set of interesting problems is related to modeling interactions between objects represented with implicit surfaces. This territory seems more exciting and much more challenging. Objects may collide, deform and undergo topological changes. Objects also may react to external forces as elastic and non-elastic bodies. In general, the behavior of interacting solids is very complex and often deceptive.

To illustrate, consider a bubble floating in a lava lamp. At a glance, it may seem as a perfect example of the original Blinn's blob, i.e. a subject for straightforward implicit representation. In fact, on its way *up* along the lamp, such a bubble *does* look like a blob, as it separates from the lava substance and forms an isolated spherical shape. The situation changes drastically when the bubble cools down, descends and starts to merge with the lava mass. Before the actual merger happens, both the bubble and the rest of the lava mass participate in the following processes: collision, mutual deformation (squeezing and bulging), growing tension on the contact surface (double membrane), formation of a puncture in the contact membrane. During the explosive growth of the puncture, the actual merger happens. None of this occurs during the separation phase.

Naturally, it is very desirable to be able to describe the motion and appearance of a 'simple' bubble in some unified consistent way, regardless of direction of its movements and topological changes it undergoes.

Physically-based animation of implicit surfaces is currently a focus of intensive research [18, 21, 28]. To what extent convolution surfaces may help in modeling interactions between implicit surfaces, is sub-

[1] Such blending occurs, for instance, in animating human lips that are modeled with implicit arcs, one arc per lip. The upper and lower arcs must always blend in the corners, thus blendability in these regions must be high. The middle regions should never blend with each other.

ject for further investigation. However, it seems very likely that the closed form implicit functions, developed in this dissertation, may assist in accurate simulations of such subtle phenomena as the building of tension in membrane structures, which are needed to model merger under pressure correctly. Similarly, the gridless (i.e., contiguous) volumetric representation may help to ensure that the contact between colliding bodies and the consequent merger are detected and described accurately.

It also seems clear that a more general modeling paradigm is needed to incorporate various types of interactions between implicit surfaces. Every change in the appearance and topology of the object should be governed by a single set of rules and corresponding algorithms. The Unified Implicit Shape Equation that will incorporate the appearance, motion and deformation of complex interacting systems, is still to be written.