

Swirling-Swepers: Constant Volume Modelling

Alexis Angelidis, Marie-Paule Cani, Geoff Wyvill, Scott King

▶ **To cite this version:**

Alexis Angelidis, Marie-Paule Cani, Geoff Wyvill, Scott King. Swirling-Swepers: Constant Volume Modelling. Siggraph Technical Sketches and Applications, 2004, Los Angeles, United States. 10.1145/1186223.1186273 . inria-00537465

HAL Id: inria-00537465

https://inria.hal.science/inria-00537465

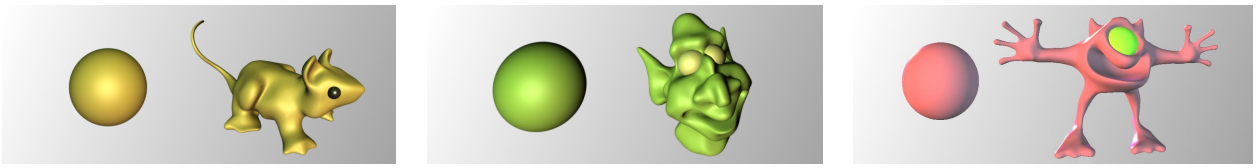
Submitted on 18 Nov 2010

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Swirling-Sweepers: Constant Volume Modeling

Alexis Angelidis* University of Otago
Marie-Paule Cani† Laboratoire GRAVIR‡
Geoff Wyvill§ University of Otago
Scott King¶ University of Otago



Swirling-sweepers is a new method for modeling shapes while preserving volume. The artist describes a deformation by dragging a point along a path. The method is independent of the geometric representation of the shape. It preserves volume and avoids self-intersections, both local and global. It is capable of unlimited stretching and the deformation can be controlled to affect only a part of the model.

1 Motivation

In a virtual modeling context, there is no material. A challenge for computer graphics is to provide a modeling tool that convinces the artist that there is a material. Volume is one of the most important factors influencing the way an artist models with real materials.

The limitation of existing volume-preserving methods is either that they only apply to a specific type of geometric representation, or they only apply to shapes whose volume can be computed, with the exception of [Decaudin 1996]. His technique does not always preserve volume, and is discontinuous at one point.

2 Principle of Swirling-Sweepers

A Swirling-Sweeper is a new space deformation based on our framework called Sweepers [Angelidis et al. 2004b]. It is a blend of simpler deformations that we call *swirls*. In Figure 1, we show that a swirl is a rotation whose magnitude decreases away from its center, c. We represent the magnitude of rotation by a C^2 monotonic scalar function, ϕ, which vanishes outside a neighborhood of radius λ around c. More formally, a swirl is a rotation matrix raised to the power ϕ

$$f(p) = \exp\left(\phi(||p-c||)\log M\right)p \quad (1)$$

A swirl preserves volume since the determinant of its Jacobian is always equal to 1. There is a convenient way of blending n swirls to produce a more complex deformation

$$f_n(p) = \exp\left(\sum_{i=1}^{n}\phi(||p-c_i||)\log M_i\right)p \quad (2)$$

See [Angelidis et al. 2004a] for computing exp and log.

From Swirls to Swirling-Sweepers: By specifying a single translation $\vec{t}$, an artist can input n swirls. As shown in Figure 2, we place n swirl centers, c_i, on the circle of center h, and radius r lying in a plane perpendicular to $\vec{t}$. These points correspond to n consistently-oriented unit tangent vectors $\vec{v}_i$. Each pair, $(c_i, \vec{v}_i)$, together with an angle, θ, define a rotation. Along with radii of neighborhood $\lambda = 2r$, we define n swirls. The radius of the circle, r, is left to the user to choose. The following value for θ will transform h exactly into $h + \vec{t}$, and preserves volume for sufficiently small $\vec{t}$:

$$\theta = \frac{2||\vec{t}\,||}{nr} \quad (3)$$

*email:alexis@cs.otago.ac.nz
†email:Marie-Paule.Cani@imag.fr
‡GRAVIR is a joint lab of CNRS, INRIA, Institut National Polytechnique de Grenoble and Université Joseph Fourier.
§email:geoff@cs.otago.ac.nz
¶email:scott@cs.otago.ac.nz

Preserving coherency and volume: To preserve coherency and volume, it is necessary to subdivide input vector $\vec{t}$ into a series of smaller vectors. We use $s = \max(1, \lceil -4||\vec{t}\,||/r \rceil)$ sub-vectors. This decomposition is shown in Figure 3.

Achieving Real-Time: We have a closed-form for the logarithm of a rotation matrix and also for computing $(\exp N)p$, when N is the logarithm of an unknown rotation matrix. These formulas, together with a more complete discussion can be found in [Angelidis et al. 2004a]. They save otherwise expensive numerical approximations.

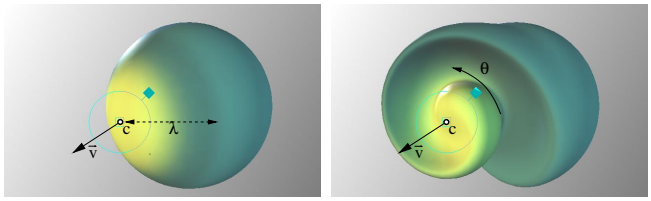


Figure 1: Swirl of center c, rotation angle θ around $\vec{v}$.

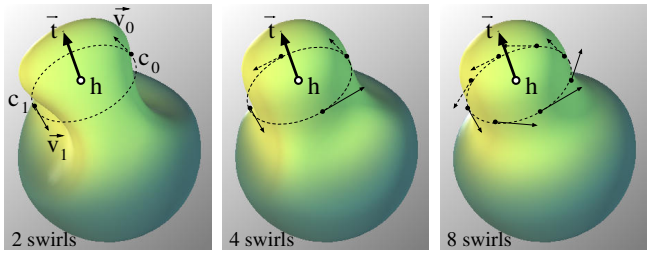


Figure 2: n swirls arranged in a ring creates more complex deformations. There are no visible artifacts with 8 swirls.

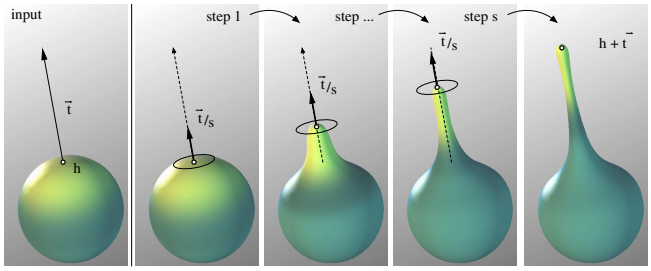


Figure 3: Volume preservation is obtained by composing rings of swirls. The selected point is precisely controlled.

References

Angelidis, A., Cani, M.-P., Wyvill, G., and King, S. 2004. Swirling-sweepers: Constant volume modeling. Tech. rep., University of Otago.

Angelidis, A., Wyvill, G., and Cani, M.-P. 2004. Sweepers: Swept user-defined tools for modeling by deformation. In *Shape Modeling International*.

Decaudin, P. 1996. Geometric deformation by merging a 3d object with a simple shape. In *Graphics Interface*, 55–60.