Towards Expressive 3D Modeling: new challenges for geometric computing

[Invited talk]

Marie-Paule Cani
Grenoble University & Inria
655 avenue de l'Europe
38330 Montbonnot, France
Marie-Paule.Cani@inria.fr

ABSTRACT

In this talk, I will review the recent advances in Computer Graphics towards more expressive modeling techniques. Based on a new methodology that combines knowledge-based models with expressive user controls, these methods are making 3D modeling and animation faster and easier for artists, and should soon put them at the reach of the general public. I will also identify a number of new challenges this research brings for geometric computing.

Keywords

Computer graphics, geometric modeling, 3D animation.

1. INTRODUCTION

Despite our great expressive skills, we humans lack an easy way of conveying the 3D content we imagine. Over centuries we relied on drawing and sculpture to convey shapes, and even, shapes in motion. However, these tools require significant expertise and time investment, especially when one aims to describe complex or dynamic shapes. With the advent of virtual environments, one would expect digital modeling to replace these traditional tools. Unfortunately, conventional techniques in the area have failed, since even trained computer artists still create with traditional media and mostly use the computer to reproduce already designed content.

Could digital media be turned into a tool, even more expressive and simpler to use than a pen, to convey 3D content? This would make design directly possible in a virtual form, from early drafting to progressive refinement and finalization of an idea. To this end, models for shape and motion need to be redefined from a user-centered perspective, i.e. they should incorporate enough knowledge to take form, refine, and deform as the user would expect under design gestures. This talk presents our recent work towards such knowledge-based models. It covers three paradigms: the use of 2D sketching to ease initial creation, shape refinement using sculpting metaphors, and the ability to re-use complex models by transferring them to another context.

SoCG'14, June 8–11, 2014, Kyoto, Japan.

2. CREATION: 2D SKETCHING

Even in the real world, sketching is faster and more natural for beginners than directly sculpting a 3D shape. Therefore, sketch-based modeling has become a very popular modeling technique in the past decade. Perceptual studies show that when we, humans, see a 2D sketch, we either use some pre-exisiting knowledge to infer a 3D representation, or, in case of unknown shapes, imagine the simplest shape - i.e.the most symmetric one - that matches the sketch. Both strategies can be used for inferring 3D models from sketches:

We first present a general approach enabling the progressive creation of arbitrary, smooth volumetric shapes using the maximal symmetry hypothesis. Our solution involves medial axes, convolution, and advanced implicit blending operators [2, 1, 11].

We then discuss specific sketching interface, relying on stronger a priori knowledge, dedicated to specific categories of shapes, such as garments and hair [10], and show how character poses can be specified using a single, expressive stroke [5].

3. EDITING: SCULPTING METAPHORS

While digital sculpting techniques were developed for many years in Computer Graphics and recently made available in commercial modeling packages, these methods have typically been restricted to the sculpting of simple, homogeneous material, according to a "'virtual clay" metaphor [8].

This part of the talk focuses on the recent advances towards interactive sculpting of more complex, structured 3D content: we first present an approach for sculpting nested manifolds of different dimensions [9], and structured shapes following precise design rules [7], such as architectural models. We finally show that interactive sculpting can even be applied to animated content, which we illustrate with a method for interactively sculpting crowd animations [6].

4. RE-USE: TRANSFER METHODS

Lastly, being able to re-use exiting 3D content is mandatory to accelerate the creation of complex scenes. Intuitively, the user would like to copy model components and re-use

them elsewhere. Such transfer operations typically requires knowledge-based models, able to maintain their main features while self-adapting to the new context.

We illustrate this through two examples: transferring garments [3] and transferring the internal anatomy [4] of a character to characters of different morphologies. Both techniques output models that can be directly used for animation.

5. DISCUSSION AND CONCLUSION

The new direction towards expressive modeling we presented brings a number of new challenges for geometric computing: First, expressive creation methods such as sketch-based modeling need to be generalized to handle the arbitrary models needed in Computer Graphics, namely non-manifold graphs and/or distributions of 1D, 2D or 3D elements. For instance, such models are useful to represent a full character model with clothes and hair, or a tree with bark, branches and foliage. Secondly, generalizing intuitive sculpting or transfer to these complex shapes will require robust methods for automatically deciding which shapes features or which properties of detail distributions need to be preserved throughout interaction.

This research opens a number of new challenges for geometric computing: in particular, it involves automatically extracting sub-shapes (for instance from a skeletal or medial axis representation), local symmetries, and distributions of self-similar features from a given model. Moreover, Voronoi diagrams will need to be extended to cells around arbitrary shapes, possibly distributed onto complex manifolds, which may involve complex geodesic distances. Lastly providing real-time expressive interaction is mandatory for making seamless digital design possible. Therefore, more methods enabling incremental and local re-computations when a structure is progressively edited should be developed.

By reaching these goals, the modeling system of the future should enable users to be, as much as possible, unaware of the underlying mathematical models and algorithms, and only focus on their design.

6. ACKNOWLEDGMENTS

The work has been supported by the ERC advanced grant *Expressive*. I would like to thank all my students and collaborators on this project.

7. REFERENCES

[1] A. Bernhardt, L. Barthe, M.-P. Cani, and B. Wyvill. Implicit Blending Revisited. *Computer Graphics Forum*, 29(2):367–375, May 2010.

[2] A. Bernhardt, A. Pihuit, M.-P. Cani, and L. Barthe. Matisse : Painting 2D regions for Modeling Free-Form Shapes. In C. Alvarado and M.-P. Cani, editors, *SBM'08 - Eurographics Workshop on Sketch-Based Interfaces and Modeling*, pages 57–64, Annecy, France, June 2008. Eurographics Association.

[3] R. Brouet, A. Sheffer, L. Boissieux, and M.-P. Cani. Design Preserving Garment Transfer. *ACM Transactions on Graphics*, 31(4):Article No. 36, July 2012.

[4] A. H. Dicko, T. Liu, B. Gilles, L. Kavan, F. Faure, O. Palombi, and M.-P. Cani. Anatomy Transfer. *ACM Transactions on Graphics*, 32(6):Article No. 188, Nov. 2013.

[5] M. Guay, M.-P. Cani, and R. Ronfard. The Line of Action: an Intuitive Interface for Expressive Character Posing. *ACM Transactions on Graphics*, 32(6):Article No. 205, Nov. 2013.

[6] K. Jordao, J. Pettré, M. Christie, and M.-P. Cani. Crowd Sculpting: A space-time sculpting method for populating virtual environments. *Computer Graphics Forum*, 33(2), Apr. 2014.

[7] A. Milliez, M. Wand, M.-P. Cani, and H.-P. Seidel. Mutable elastic models for sculpting structured shapes. *Computer Graphics Forum*, 32(2pt1):21–30, 2013. Special Issue: Proc. Eurographics, May 2013, Girona, Spain.

[8] L. Stanculescu, R. Chaine, and M.-P. Cani. Freestyle: Sculpting meshes with self-adaptive topology. *Computers and Graphics*, 35(3):614–622, June 2011.

[9] L. Stanculescu, R. Chaine, M.-P. Cani, and K. Singh. Sculpting multi-dimensional nested structures. *Computers and Graphics*, 37(6):753–763, Oct. 2013. Special Issue: Shape Modeling International (SMI) Conference 2013.

[10] J. Wither and M.-P. Cani. Dressing and hair-styling virtual characters from a sketch. In J. A. Jorge and F. Samavati, editors, *Sketch-Based Interfaces and Modeling*, Advances in Pattern Recognition, pages 369–395. Springer, 2011.

[11] C. Zanni, A. Bernhardt, M. Quiblier, and M.-P. Cani. SCALe-invariant Integral Surfaces. *Computer Graphics Forum*, 32(8):219–232, Dec. 2013.