Aesthetic Beauty of Rotation

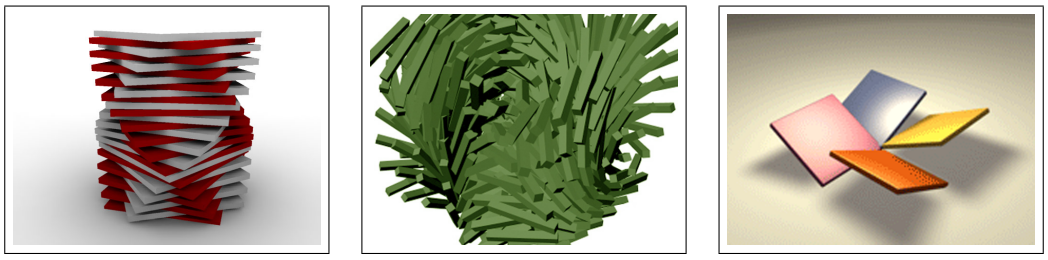
Ergun Akleman
Visualization Department
Texas A&M University

Vinod Srinivasan
Visualization Department
Texas A&M University

Abstract

In this paper, we present the rotation project in our introductory animation class. During lectures we cover the mathematical aesthetics of rotations by comparing the advantages and disadvantages of using vector, matrix and quaternion algebras to create rotations. Students create animated virtual sculptures using only combinations of periodic functions. The abstract moving sculptures that are produced reveal that unusual and interesting aesthetics can be created using simple rotation.

The first animation course in M.S. Visualization Sciences program, *3D Modeling and Animation*, provides an introduction to the mathematical, aesthetic and programmable aspects of computer graphics and visualization [1]. In this paper, we describe how we teach these different aspects using one of the class projects as an example. Figure 1 shows a set of example frames from student animations.



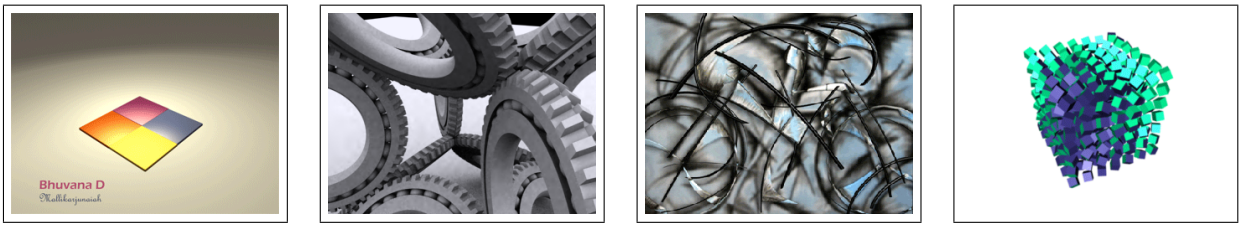
(a) (b) (c)

Figure 1: *Example frames from rotation animation projects created by our students. The images were created by (a) Don Fong, (b) Landon Gray, and (c) Bhuvana Mallikarjunaiah*

The M.S. program in Visualization Sciences is designed to prepare students who are talented both in science and art for a range of long-term careers in visualization. Our graduates often find jobs that require writing code to simplify modeling and animation processes. Developing a good understanding of the mathematical and programmable aspects of computer graphics, thus becomes very important. However, most students entering our program usually do not have a good grasp of linear algebra concepts. The challenge for instructors is to motivate all students to learn some basic concepts for preparing them for future careers.

Rotation is one of the basic concepts that can help motivate students. There are three reasons behind our choice of rotation as one of the first animation assignments.

1. *Rotation is important:* Rotation is one of the preliminary elements of both mathematics and programming aspects of computer graphics. It is used in both animation and modeling. Therefore, our student must develop a good understanding of rotation and how to make rotations.
2. *Teaching rotation is fun:* The mathematics behind rotation is beautiful. There is no one algebra that is best for rotation. With rotation, it is possible to introduce vector, matrix and quaternion algebras and compare their advantages and disadvantages to represent free-form rotations. We should note that, except for one book by Watt & Watt [2], computer graphics books usually start with matrix rotation [3, 4]. In our course, we start with vector algebra, which is intuitively easier to understand and proceed to matrix and quaternion formulations. We also cover the history of mathematics as it relates to rotations, which makes the subject more interesting for students.



(a) (b) (c) (d)

Figure 2: *Student animation project examples. (a) Representational sculpture and abstract motion (Bhuvana Mallikarjunaiah), (b) Representational sculpture and realistic motion (Cem Yuksel), (c) Abstract sculpture and realistic motion (Brooke Beane), (d) Abstract sculpture and abstract motion (Landon Gray)*

3. *Using rotation is fun:* With rotation students can create simple animated virtual sculptures with simple programming, which teaches them programming can be fun and allows them to create interesting motions and images.

We strongly believe that students learn better if they apply what they have been taught in lectures. The rotation assignment provides an opportunity to students to implement the mathematics they learned in class to create animation art. Students write short programs to create animated virtual sculptures, which also teaches them programming can be fun and allows them to create interesting motions and images. Students come up a wide variety of ideas that result in interesting visual effects. We can classify student works in four categories:

1. *Representational Sculptures and Abstract Motion:*In this case, shapes look familiar but the motions are not representative of any real-world motion.
2. *Representational Sculptures and Realistic Motion:* In this case, both shapes and motions look familiar.
3. *Abstract Sculptures and Realistic Motion:* These are abstract shapes that go through realistic motion.
4. *Abstract Sculptures and Abstract Motion:* These are abstract non-existing shapes that go through abstract, non-physical motion (e.g. objects passing through one another).

Figure 2 shows frames from animations illustrative of each of the above categories. More animations can be found on the course website [1].

We believe that mathematics and art are closely related. Not only can art be used to teach mathematics, but also mathematics can be used to teach art. We also believe that it is important to go beyond mathematical ideas and explain how these ideas were created. Once the students realize that there is a strong relationship between art and math by observing that both mathematicians and painters create beauty, they will be more open to learning math. Rotation is an ideal subject to teach mathematical beauty and show close correlation between art and math.

References

[1] Akleman, E. and Srinivasan, V., VIZA 613: 3D Modeling & Animation, Course Website, URL: http://www-viz.tamu.edu/courses/viza613

[2] Watt, A.H. and Watt, M. *Advanced Animation and Rendering Techniques: Theory and Practice*. Addison-Wesley, Reading, MA, 1992.

[3] Foley, J., van Dam, A., Feiner, S. and Hughes, J. *Interactive Computer Graphics: Principles and Practice*. Addison-Wesley, Reading, MA, 1990.

[4] Rogers, D.F. and Adams, J.A. *Mathematical elements for computer graphics*. McGraw-Hill, New York, NY, 1989.