# Chapter 13
# Digital Approaches to Visualization of Geometric Problems in Wooden *Sangaku* Tablets

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## ABSTRACT

*This chapter describes the digitalization process of 19th century scientific representations from the Japanese culture – a set of mathematical problems etched on wooden boards. The object of the demonstration is to apply computing techniques to the creation of artistic statements based on geometrical problems, highlight the dynamics of interaction between art and science, and examine how much both fields enrich the larger discourse and appreciation of Art. The following text describes the steps adopted in a visualization project. First, the data collection included selecting specific geometry problems from various Sangaku wooden tablets and converting them into digital information as a single black and white outline to define shapes, volumes, and textures. The vectorization of the underlying shapes transferred the exact mathematical information onto the virtual canvas. In the next step, the vector outlines were converted into bitmaps. Each individual plate was assigned a specific color scheme to enhance object size, positioning, and dynamic of the composition. At the last stage, vector-based sketches, colorizations, and the monochrome sketches were blended together to complete full color visualization. Finally, the step-by-step development of the creative process was recorded as a QuickTime movie, including an original soundtrack. Discussion refers to the dissemination of the project in art galleries and online, its potential instructional use, and it examines the audience responses.*

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## INTRODUCTION

The abstract beauty of *Sangaku* – Japanese temple geometry problems (2011) and the unusual medium on which they are presented provide a fertile ground to explore alternative means of effective scientific communication. The aesthetic quality of the *Sangaku* design as well as the exactitude of the scientific demonstration they convey provide an intriguing challenge from which to start an evaluation how objective science affects aesthetics and creativity.

*Sangaku* or San Gaku (算額), lit. mathematical tablets are geometric problems engraved on wooden tablets. They were very popular in Japan during the Edo period (1603-1867) where worshipers carved the likenesses of horses onto wooden tablets and used those tablets as offerings. They etched mathematical problems on wooden boards and dedicated them to a shrine or a temple. Japanese mathematicians and geometers followed the Shinto temples' carving tradition. Their geometric puzzles, or *Sangaku* were originally conceived as topological pursuits. Mathematicians, especially geometers followed this tradition. As Z.M. Ruttkay (2008) points out, most of such problems were of a geometric nature and the figures were often exquisite in style and color. From a larger perspective, *Sangaku* tablets can be seen as representations of the problems driven from biology because objects driven from nature are used as part of explanatory process.

*Sangaku* problems are problems in Euclidean geometry concerning area and volume, the number of units that cover a closed figure, and a set of points in space. Mathematicians and *Sangaku* experts Fukagawa Hidetoshi and Tony Rothman collaborated on the mapping and cataloguing this form of visualization and published a book titled "Japanese Temples Geometry" (Hidetoshi & Rothman, 2008), which includes over two hundred *Sangaku* mathematical problems. Insight, reasoning, and accurate information are essential elements of effective practices in all scientific fields and in the creative process as well. Science inspired computing techniques collect data to create models of natural systems that help artists create visual statements. The aim of this article is to engage readers to broaden their appreciation of abstract concepts, increase their awareness of multidisciplinary interaction, and encourage artists to apply an approach that blends technology and art, and use scientific knowledge and methodology as a source of inspiration and creativity.

Art provides a context in which artists express their individual perception of nature and may become an individual and subjective quest to represent and communicate emotion to others. It is also a tool of communication that conveys information. Artwork based on the understanding of how we are affected by shape, color, sound, and all the components that constitute a visual statement help artists create a more effective narrative and enrich the spectator's experience. Explorations that blend technology and art such as the electron microscope nano-landscapes of Cris Orfescu (NanoArt 21, 2011), the experiments performed in the Digital Art and Science Program at NUS (2011), as well as the works of many artists in the fractal environment (e.g., Fractal Foundation, 2011) stand as examples of this cross-interaction.

The following experiment incorporates elements of computing to create meaningful visualization. The project initially draws from the particular sequence of lines and shapes of well-known mathematical principles and integrates the visual components of geometrical figures into aesthetic statement. The specific framework of this demonstration is based on a series of artistic representations built around the data collected from the geometry problems carved on the *Sangaku* tablets. The reader is invited to follow the step-by-step progression of the art process from extracting an outline to create a multimedia product including sound. The resulting images were deployed to encourage the development of visually attractive propositions inspired by a rigorous