Chapter 9
An Assistant Interface to Design and Produce a Pop-Up Card

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ABSTRACT

This article describes an assistant interface to design and produce pop-up cards. A pop-up card is a piece of folded paper from which a three-dimensional structure pops up when opened. The authors propose an interface to assist the user in the design and production of a pop-up card. During the design process, the system examines whether the parts protrude from the card or whether the parts collide with one another when the card is closed. The user can concentrate on the design activity because the error occurrence and the error resolution are continuously fed to the user in real time. The authors demonstrate the features of their system by creating two pop-up card examples and perform an informal preliminary user study, showing that automatic protrusion and collision detection are effective in the design process.

INTRODUCTION

A pop-up card is a piece of folded paper from which three-dimensional (3D) paper structures pop up when it is opened. The card can be folded flat again afterward. Pop-up cards, also called Origamic Architectures, find their origin in Japan (Chatani, 1985). People enjoy this interesting paper craft through the realization of pop-up books

(e.g. Baum, 2000; Sabuda & Carroll, 2003; Sabuda & Reinhart, 2005) and greeting cards. Figure 1 shows an example of pop-up books.

Constructing a pop-up card is relatively easier than designing one; anyone can simply cut out and fold the pieces and glue them together if a template, which is printed parts, is available. However, it is unfortunately much more difficult for nonprofessionals to design a pop-up card and make its templates from scratch. There are two reasons to this difficulty. The first difficulty is

Figure 1. "Alice's Adventures in Wonderland", a typical pop-up book (Sabuda & Carroll, 2003)

correctly understanding and designing the pop-up mechanisms. The book (Carter & Diaz, 1999) helps to understand mechanisms, but does not tell how to combine them to design a desired look. The second difficulty is determining the positions of pop-up parts so that they do not collide with each other. Professionals usually solve these problems through repetitive trial and error by drawing on their experience during design: cutting component parts out of paper, pasting them on the card, and checking whether they collide. If an error is found, they re-think the design and start over from the beginning. This process requires a lot of time, energy, and paper. Design and simulation in a computer help both nonprofessionals and professionals to design a pop-up card, eliminate the boring repetition, and save time.

Glassner (1998, 2002) proposed methods for designing a pop-up card on a computer. He introduced several simple pop-up mechanisms and described how to use these mechanisms, how to simulate the position of vertices as an intersecting point of three spheres, how to check whether the structure sticks out beyond the cover or if a collision occurs during opening, and how to generate templates. His work is quite useful in designing simple pop-up cards.

In this article, we build on Glassner's pioneering work and introduce several innovative aspects. We add two new mechanisms based on the V-fold: the box and the cube. We present a detailed description of the interface for design, which Glassner did not describe in any detail. In addition, our system provides real-time error detection feedback during editing operations by examining whether parts protrude from the card when closed or whether they collide with one another during opening and closing. Finally, we report on an informal preliminary user study of our system involving four inexperienced users.

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