Designing Origami Polar Bear by Using Software Algorithms: Implications for Future Industrial Applications

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Introduction

Origami is the paper folding art that originated from Japan in the 1700s. The early models of Origami were simple and similar to each other (Fig. 2). However, in the last 50 years of Origami evolution in many countries, the figures of Origami have become more complicated in shape with exquisite details that contain thousands of steps to fold in an on-going subject (Fig. 3) (Lang, 2012).

Objective

The purpose of this project is to apply origami algorithm in designing a complex model such as a polar bear (Fig. 1). The origami polar bear was designed by using stick figures, circle packing, and Tree Maker. These origami algorithms can be applied to various subjects.

Crease pattern (Flaps) : Mountain and Valley fold

The basic Origami design is represented by dotted and dashed lines (Fig. 5). The arrows show the direction of folds. The dotted lines are called valleys, which folds >0 to 180, and dashed lines are called mountain, which folds <0 to -180 (Fig. 4) (Lang, 2008). These angles tell the direction of where those patterns are to be folded. These patterns are the basic folding methods of Origami algorithms and they require step-by-step folding instructions to illustrate the designs. Crease patterns can be generated easier and faster by using the program called Tree Maker. To determine crease patterns before the Tree Maker was invented, it required many complex calculations using algorithms. Fig. 5 is one of the examples of the complicated crease patterns that was created by using Tree Maker. However, before using Tree Maker, it requires understanding some of the main algorithms to generate the inputs for the program.

Main Algorithms

Stick Figure

- Determines the symmetry of symmetry of the body and the scale of the individual parts that are proportionate to the overall object

Main Algorithms can’t

Pre-circle packing steps

Before Tree Maker was used, circle packing was applied to optimize packing circles into a square shaped paper. Circle packing requires 6 major steps.
1. Count up the number of the parts in the object and scale each of the lengths that represent the flaps
2. Mark each of the flaps which represent the radius of each circle
3. Locate the circle on a square that the center of the circle lies in a square
4. Identify tiles from the connected circles in the axial polygons
5. Fill in the axial polygons with tile creases
6. Tree Maker builds crease patterns from the calculation of the circle packing.

Origami Polar Bear

To determine the most efficient Origami polar bear, stick figures was first used in order to be used for Tree Maker program. The first model of the polar bear was simple. It had less crease patterns compared to later versions and it did not allow building additional details for claws and textures (Fig. 7). Fig. 8 represents crease patterns of the polar bear with a tail. This crease pattern was designed to give extra detail for the back portion of the polar bear but it was not the most efficient design. This model however gave more texture for the back legs. This second model showed the need for additional space for some body parts to in order to add detail and texture. Figure 9 and 10 below show the modified designs incorporating improvements. Figure 9 shows a book symmetry crease patterns and figure 10 shows a diagonal symmetry. Both models were folded and the most efficient Origami design was determined to be figure 9. This design gave spaces for additional details but it was limited to the back legs. Finally, this design provided equally distributed spaces for both front and back portions of the bear. The completed Origami structure is shown on figure 1 and 6.

Applications of Origami Algorithms

Air bag for vehicles

- Designing air bags needs to be precise because it accounts for a variety of conditions of accidents; such as distribution of passengers, speeds, angles, and the endurance of the airbag (Lang, 2012). In addition, it needs to be compressed in a limited space. Designing new air bags requires precise calculations to fulfill these conditions. As the air bag is a 3-D polyhedron (piecewise linear shape) flat shape, the crease pattern of the model can be designed by using an origami algorithm which can be a quite challenging origami design (Fig. 11).

Space Telescopes

- The use of origami algorithms in space telescopes is to amplify the sensitivity and the resolution of the data from satellites (LLNL, 2003).
- Origami algorithms helps to minimize the size allowing it to fit into the satellite (Fig. 17)

Building Construction and TV Commercials

- Origami algorithms can be applied for designing building construction and TV commercials (Fig. 14)

Conclusion

The Origami algorithms have been tested in this project in building the most efficient polar bear model. By using stick figures, circle packing, and Tree Maker, it created a model without any cuts on the paper. It also demonstrates that it can be used for building any other objects that require testable prototypes for safety and minimizing the surface area. Many examples listed above have already been tested by other professional Origami designers.

References