Origami:

History, Folds, Bases and Napkins in The Art of Folding

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Abstract: Origami is an ancient art of paper folding, existing since the invention of paper. Pure traditional origami consists on performing a series of folding operations on a square sheet of paper to assemble a final paper model. This paper is basically an introduction to origami and it is composed of a brief introduction and history of this ancient art followed by three essentially demonstrative sections. The first of these sections shows the basic folds, which are the essential steps used in origami making: the valley/mountain, pleat, crimp, reverse, sink, squash, swivel, rabbit ear and petal folds are shown. The second section shows some of the standard bases. Bases are essentially incomplete origami models, used as halfway baselines to produce different finished models: the kite, fish, bird, frog, cupboard, windmill, water bomb, square and blintz bases are shown. Finally, there is a third section showing some popular napkin origami models. A final conclusion with our intentions for future work will terminate the paper.

***Keywords**: Origami history; Origami folds; Origami bases; Napkin origami.*

1. Introduction

Origami is an ancient art of paper folding. Pure traditional origami is based on assembling a bi or tri-dimensional static paper model, by performing a series of folding operations on a unique square sheet of paper.

There are variants of this pure art form. Different shapes of the initial sheet, like rectangular or other can be used. Different foldable materials, like cloth, metallic sheet, or other can be used. Cutting operations can be included, and can be dominant, this is known as *kirigami*. Multiple initial sheets can be folded, made to fit and assembled in one model, which is known as modular origami. The final goal can also be models that can move, fly or go through some kind of transformation, which is known as dynamic, or action, origami. Different fastening methods, like gluing, staples, *etc*., can be used to assemble a complex sculpture (Temko, 2006).

Aesthetically speaking, models can either be authentic pieces of art, ranging from the figurative (flowers, animals, people, everyday objects) to the abstract (geometric objects, patterns, tessellations, *etc*.) or functional, useful, objects like boxes, cups, ash trays, structures, folded maps, *etc*.

2. A Brief History of Origami

Origami is an ancient art of paper folding which is believed to exist since the invention of paper. Paper was invented in 105 A.D. by a Chinese court official and was taken to Korea and

Japan in the sixth century by Buddhist monks. Arabs have taken contact with paper fabrication in Uzbekistan in the seventh century and brought it to West when they invaded Spain. Until the thirteenth century paper fabrication and use was progressively spread through European countries like Italy, France, England.

Apparently, there are two independent origami origins until the middle of the XIX century: one in Japan since the VII century and another in the Iberian Peninsula since the VIII century.

5.1 Classic Japanese origami

Origami is part of the Japanese culture and from the eighth century to the twelfth century (during the Heian period) was already taking significant part in ceremonies of the nobility. Origami was often a form of wrapping for ceremonies (Beech, 2005; Cantz, 2005). For example, there was a custom of the samurai warriors of exchanging wrapped gifts of good fortune, called *noshi*. Diplomas of Tea ceremony masters were closed by folding them in a manner as to remain secret and, once unfolded, they could not be folded again without leaving additional creases, *i.e.*, traces revealing the opening. There was also a kind of wrapping for bottles of sake. Also, in the celebrations of noble Shinto weddings, glass cups decorated with paper female and male butterflies, representing the bride and groom, were used.

From the fourteenth century to the sixteenth century (during the Muromachi period), with the popularization of paper, origami takes another ceremonial aspect in Japan, with different styles of origami used to distinguish different classes of samurai aristocrats. Later, during the centuries XVII to XIX (the Tokugawa period), which involved a flowering of Japanese culture and art, origami had a great diffusion. In this period a new type of origami appeared: the figurative, or recreational origami, which includes several known origami models, such as the bird, or grou (in Japanese, Orizuru) and what is now called the bird base (Beech, 2005; Cantz, 2005). Many representations of those origami can be seen engraved in wood or drawn in books since the eighteenth century. There was then already quite sophisticated origami, whose complexity made adults fascinated, more than children.

5.2 Classic European origami

In the eighth century the Moors invaded the Iberian Peninsula and brought paper and paper folding to Spain with them. Those people were excellent with mathematics and astronomy and, possibly, the theory behind folding paper was used as a support to the teaching of geometry principles. Although the Moors were later expelled from the Iberian Peninsula, the tradition of paper folding kept up to date and was notably practiced and documented (under the name of *coctología*) by the Spanish philosopher and poet Miguel Unamuno (XX century).

Traditional European classics are, for example, the *pajarita* (parrot) in Spain, the *cocotte* (chicken) in France and origami horses and riders of the nineteenth century kept today in German museums (in Nuremberg and Dresden). The German baptismal certificate of the sixteenth and seventeenth centuries is another example, which corresponds to what is now called the blintz base (Cantz, 2005).

The European classic origami is well documented in the context of children's education also. This was due to Friedrich Fröebel, a German educator who established the first kindergarten in the middle of the nineteenth century and included paper folding in the children's educational program (Cantz, 2005). Perhaps for this reason, in the modern West folding paper has been for long seen as little more than a hobby for school children, who amused themselves with birds, frogs, hats, water pumps, boats and darts (later planes) made of paper. However, more recently, many paper folding enthusiasts recognize the practice of origami as an intellectual challenge and an exercise in creativity.

5.3 Traditional and modern origami

According Koshiro Hatori, see (Cantz, 2005), Japanese and European paper folding remained independent until the middle of the nineteenth century, being quite different (*e.g.*, the classical European origami is based on creases angled mostly at 45 degrees, while the Japanese is typically at 22.5 degrees). Then, there was an interchange movement giving birth to a mixture between European and Japanese origami, yielding a repertoire that evolved and formed the core of traditional origami.

Also according Hatori, from the middle of the twentieth century there occurred a second interchange movement that popularized the art of origami and gave rise to the so-called Modern origami. This is characterized by authoring, *i.e.*, recognizing the intellectual property of origami creators (this did not happen with traditional origami, were the author is anonymous), by viewing origami as an intellectual challenge, by the publication of origami works of European, American and Japanese in English and Japanese, by the foundation of organizations focused on origami (for example, the British Origami Society, founded in 1967) and by the standardization of notation used in origami representation diagrams (created by Japanese engineer Akira Yoshizawa, one of the leaders of the modern creative origami, in the 1950s and 1960s and the introducer of curved folds using damp paper).

5.4 Mathematic and computational origami

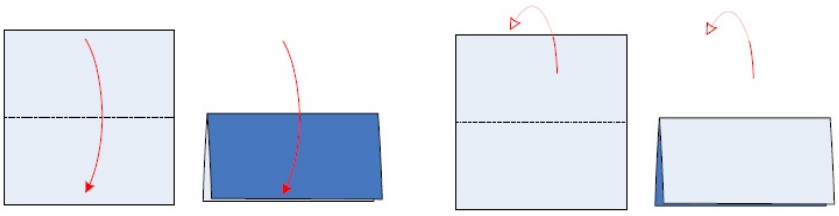
The modern design method of origami depended on some existing origami bases. A base (*e.g.*, the bird base, the frog base, the blintz base) is an origami an intermediate phase of the folding sequence that can serve as a starting point to produce certain finished origami models.

From the 1980s on, starting with independent work of Jun Maekawa and Peter Engel, who studied the geometric aspects of the foundations, a process of inventing new bases was discovered, paving the way for the composition of complex origami models. Essentially, the method consists in the rearrangement of crease patterns (triangles, rectangles) on the sheet of a disassembled existing base to obtain a new base, which can yield different origami models. This led to an engineering-like process, in which new models can be designed before performing the folds that produce them. The mathematical methods behind the process have been further developed and resulted in computational algorithms which allow automation of the process (an example of this is the program TreeMaker, of Robert Lang, one of the scientists involved in the

mathematical origami trend) (Cantz, 2005; Lang, 2003; Demaine and O'Rourke, 2007). The practical application of folding principles opened the door to the engineering of many kinds of self-assembly, self-transforming artifacts, not just decorative but useful and functional ones as well (Lang, 2003; Hull, 2002).

3. Basic Folds

A fold is the basic step used in origami making. In Figure 3 we represent the basic rectilinear fold, called valley or mountain fold depending on the result being hiding or showing the initially observable paper face.



a) b)

Figure 3 – Valley (a) and mountain (b) folds.

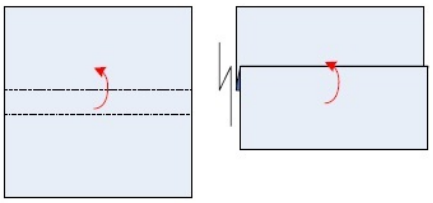


Figure 5- Pleat fold.

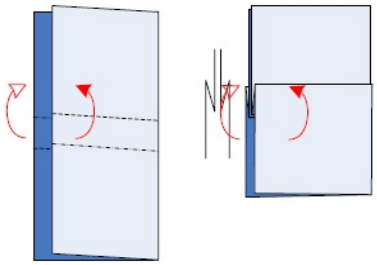
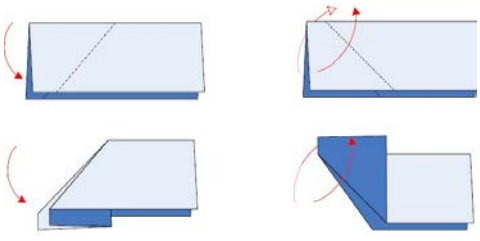


Figure 4- A crimp fold.



a) b)

Figure 6- Inside (a) and outside (b) reverse folds

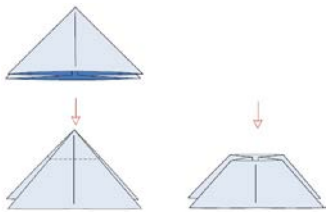


Figure 8- Sink fold.

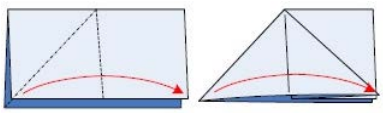


Figure 7- Squash fold.

Figure 9- Swivel fold.

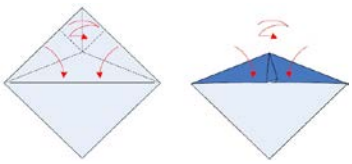


Figure 10- Rabbit ear fold.

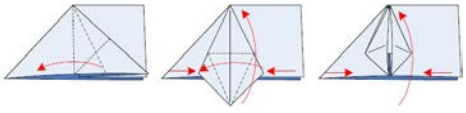


Figure 11- Petal fold.

From

Figure 5 to Figure 10 we show how to obtain instances of other typical folds. These are used extensively as basic steps in many origami bases and finished models, see (Lang, 2003). Examples of the pleat, the crimp, the reverse, the sink, the squash, the swivel, the rabbit ear and the petal folds are shown. Animations of these will be shown in the paper presentation.

4. Some Standard Origami Bases

Bases are essentially incomplete origami models, used as halfway baselines to produce different finished models. In this section we show some of the standard bases.

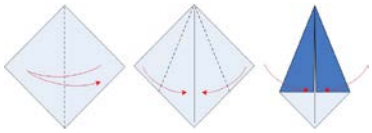


Figure 12- The kite base.

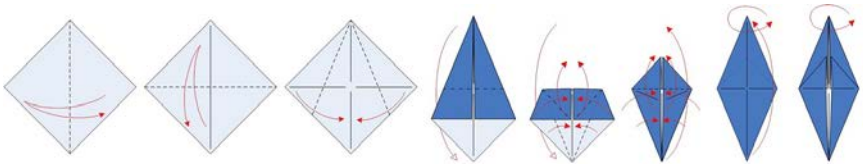


Figure 13- The fish base.

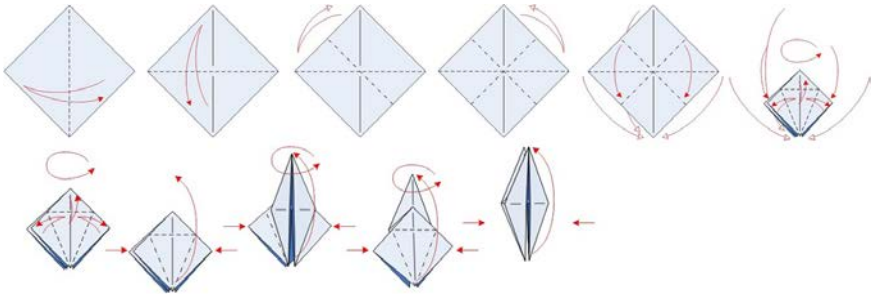


Figure 14- The bird base.

From Figure 12 to Figure 20 we show how to obtain the kite, the fish, the bird, the frog, the cupboard, the windmill, the water bomb, the square and the blintz bases. Animations of these will be shown in the paper presentation.

As pointed in (Lang, 2003), there is an hierarchy in the bases presented. For instance, the fish base includes the kite base at its beginning; the windmill base also includes the cupboard base.

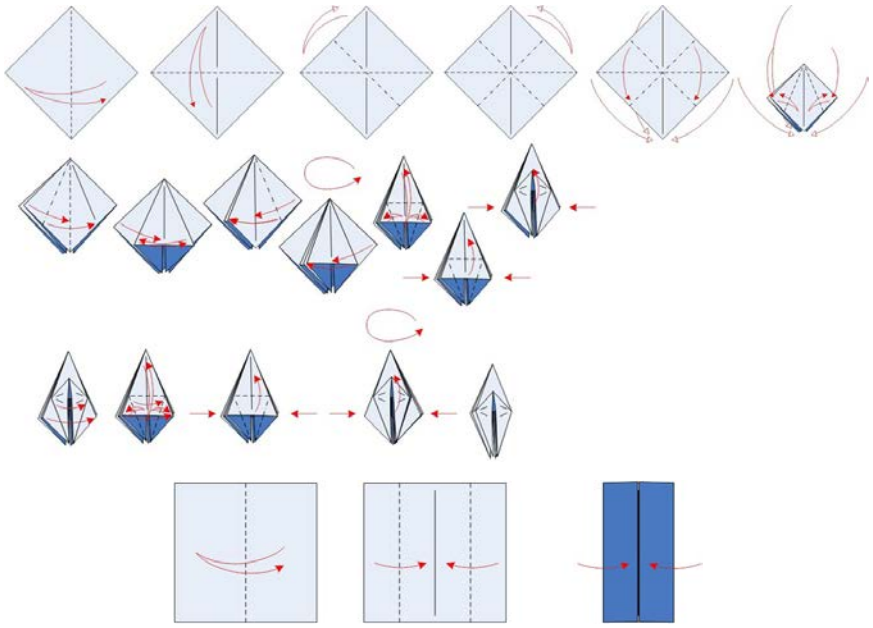


Figure 16- The cupboard base.

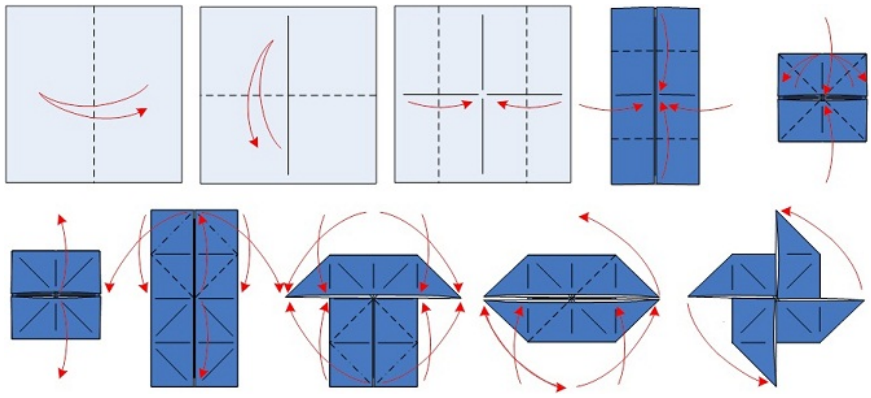


Figure 17- The windmill base.

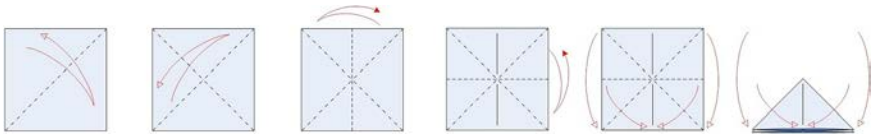


Figure 18- The water bomb base.

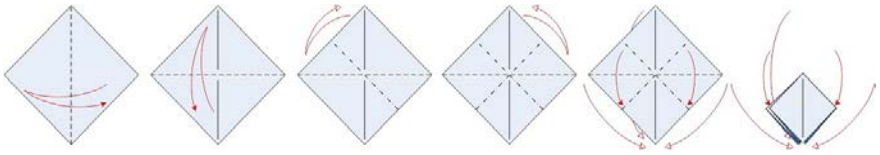


Figure 19- The square base.

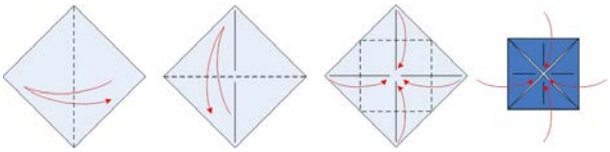


Figure 20- The blintz base.

5. Some Popular Napkin Origami Models

In this section we show some napkin origami models (both cloth and paper napkin).

Figure 21- Some napkin origami models (from left to right and top to bottom): a candle, a flame, a shell, a fan, a Japanese folding, a leaf, a boot, a rose (paper), the bishop's hat, fire in a glass and an Easter bunny.

These models were produced according to (Beech, 2005). Videos will be shown in the paper presentation.

Napkin origami is a popular origami variant not rarely seen on hotel and restaurant dining tables. Exotic models (*e.g.*, giraffes, palm trees) can also be seen on top of hotel beds made with towels or linen sheets.

6. Conclusion and Future Work

In this paper we gave a brief introduction to origami and its history, presented the basic folds and some of the standard bases and showed some popular napkin origami models.

Our goals for future work are to study and explore origami using a more scientific approach, with the formalization of folding mathematics and the computational representation and modeling of origami (including the challenge of the flexible material origami, *e.g.*, cloth, napkin), following work being done in the scientific community, see for instance (Hull, 2002; Lang, 2003; Demaine and O'Rourke, 2007; Ida and Takahashi, 2009).

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