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Colored words

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Colored words

David Dureisseix

This is an English version of an article published as: David Dureisseix, Des mots en couleur, *Le Pli* 161:8-12, 2021, the journal of the *Mouvement Français des Plieurs de Papier* (MFPP), the French paperfolding association.

Using two-color paper

Many origami models take advantage of using two-colored paper (one color per side), to get some more or less geometrical patterns using the color-changing technique. John Smith [1] considered the use of two-colored paper as an extension of pure origami (a single square single-colored paper, no cut, no glue), but the inverse situation could also be considered!

Among the flat-folded models, there is also the folding of letters and numerals. A non-exhaustive list, without even looking to pop-ups, quilling, nor 3D folding [14], will contain different designs of LCD displays for digits:

- *7-segment display* of Mi Wu [5],
- *Digital 7-segment* of Ichiro Kinoshita [6] (but with 2 paper squares),
- *Seven-segment display* of Hadi Tahir¹.

Concerning letters, one can find:

- *Typeset* of Jason Ku [8],
- *All letters and ciphers* of Andrey Lukyanov [12],
- The amazing minimalist alphabet of Jeannine Mosely [13] (*4-folds alphabet* and *2-folds alphabet*),
- *Crease typeface* of Amilia Ramirez [7] with a completely different technique (creases are marked and a grazing light allows to have a difference in brightness on the same side of the paper).

In these latter examples, a paper sheet is used for each symbol. The present question therefore concerns the possibility to fold not letters, but words, with a single sheet (or even a sentence). A possibly hard challenge, if using a single square sheet... The pressure is then a bit relaxed: using a single rectangular sheet is allowed in the following.

Underlying principle

As a starting point, a design principle may be useful. If it happens to be prolific enough, it may become a style, otherwise, it will evolve... Let us try first to settle some constraints: start with a strip of paper, proceed to a book-folding that reduces the useful surface by half, but allows to gather the paper edges in the center, that will be helpful for the color-change, Figure 1.

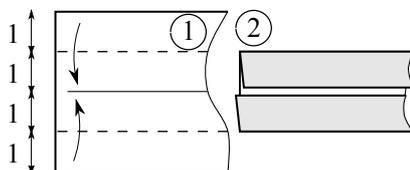


Figure 1. Book-fold the paper strip (whose height is 4) in half.

The aim is therefore to use these long strip edges to change the color in a “modular” fashion to make symbols appear, not as for the classical modular technique, i.e. by connecting different blocks, but as a junction as for tessellations [4]. Each symbol will therefore be independent and will be able to plug itself horizontally with the next one. We can also add the objective to optimize the paper usage.

Herein, we will not design every alphabet letter, but exemplify some design principles, letting the reader try by himself. The edge diagrams of several letters are depicted in Figure 2.



Figure 2. Examples of edge diagrams.

¹ <https://haditahir.wordpress.com/2017/10/23/tutorial-origami-layar-tujuh-segmen/>
<http://www.haditahir.com/2017/10/tutorial-origami-layar-tujuh-segmen.html>

The simplest case to start with: "I" letter on Figure 3; we can note the small shift at step 2 to get a thickness 2ϵ for the vertical bar. Neglecting this last one, the paper consumption is of a length 2 for this letter.

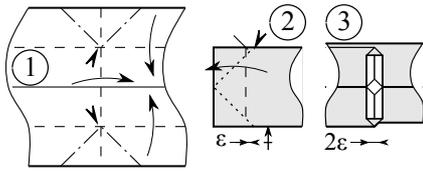


Figure 3. Letter "I" (or number "1").

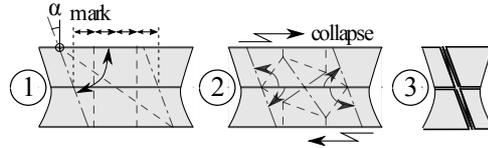


Figure 4. A reclining bar (for an angle α between -30° and 30° ; for a null angle, we recover a letter "I"). Start with the folded strip.

Slightly more difficult: the letter "C" (for a paper consumption 3) Figure 5. The bar in step 2 is now of length 4.

A small modification for the letter "E" (or number "3, without additional consumption) is to add a horizontal bar (last step of Figure 5).

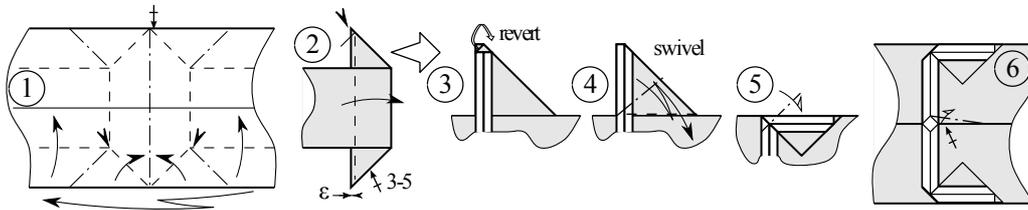


Figure 5. Letter "C" (up to step 5), and letter "E" (with the last step 6).

One step beyond: try letter "S" (or number "2" with a consumption 5) Figure 6. The model is anti-symmetrical (with a central symmetry).

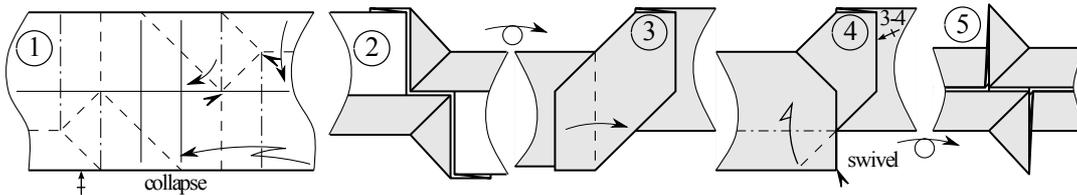


Figure 6. Letter "S"; continue after step 5 as for the letter "E".

Let's move to the letter "O" (or number "0"). A first version is anti-symmetrical and use a twist at step 1, Figure 7 (with a consumption 6). If we break this symmetry, we get a second version, without any twist, with the same consumption, Figure 8.

A small modification for the letter "D": we round only 2 corners, and for letter "B" (or number "8"): we add the horizontal central bar, as for letter "H" for which we start with 2 "I" easily linked by an horizontal bar (with a consumption 4).

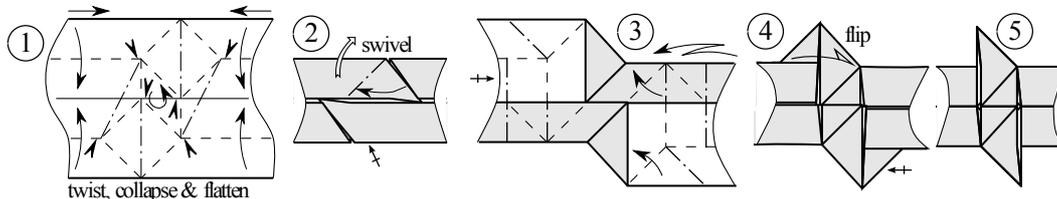


Figure 7. Letter "O"; continue after step 5 as for letter "C".

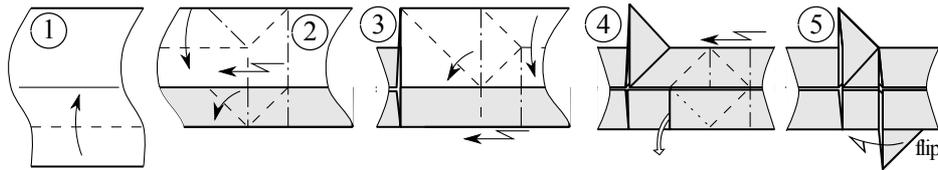


Figure 8. Second version of letter “O”: loss of symmetry and no twist.

Now move to letter “N”: we then need an inclined bar with an angle $\alpha = 30^\circ$, completed with two vertical bars like “I”.

Concerning letter “A”, we need two inclined bars with a smaller angle, completed by a horizontal central bar as for “H”. This reclining bar can be designed with the crease pattern (CP) of another version of the letter “I”, deformed as in Figure 4 (with a consumption $2 / \cos \alpha$).

When we face a lack of symmetry, we may try to couple several letters. For the single letter “L”, we can reuse letter “C” and a bit of a paper waste. Or, we can recycle the extra edge in the following letter, for instance for the couple “LY”, Figure 9. If the letters are separated by a larger distance, can we still couple them? Indeed, this is not impossible, as shown for “L Y” on Figure 10.

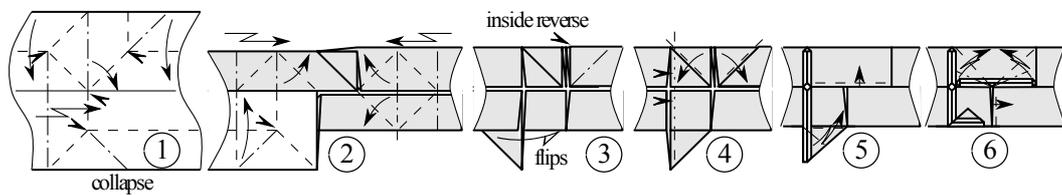


Figure 9. Coupling “LY”: end with bar thickening as previously.

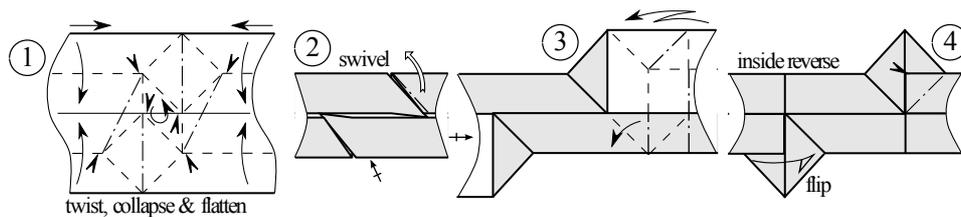


Figure 10. Long distance coupling “L Y”: start as for letter “O”; end as for the previous “LY” coupling.

Concerning letter “Z”, a higher complexity level arises; due to the design principle, this cannot be deduced from letter “N” with a simple 90° rotation. Its CP is depicted in Figure 11.

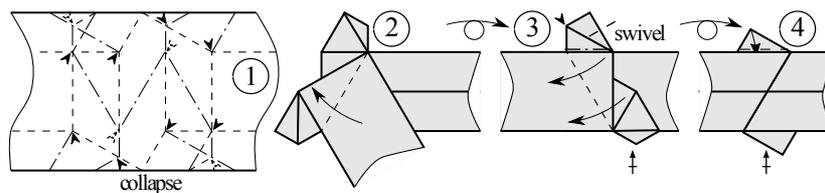


Figure 11. Letter “Z” (all angles are $\pm 30^\circ$); end with bar thickening as previously.

What about books?

Do not forget the historical literature support: books. Herein, we will not try to fold with the pages of a book² but to fold a book with its pages (do you follow?) and, obviously, with a single sheet (till non-modular approach here). The color-change is then used to differentiate the book cover and its pages.

There also exist several famous models, from a square of paper:

- *Book* of David Brill (6 or 8 pages) [2],
- *Book* of Martin Wall (8 pages) [9],
- *Book* of Kunihiro Kasahara (10 or 16 pages) [3].

²<http://web.archive.org/web/20201126034949/https://www.origami-resource-center.com/folded-books.html>

One design with a large number of pages is the one of Hans Birkeland (36 pages³!).

Now, let's try to invoke the previous principle (the rectangular strip) to design more easily a book with a potentially large number of pages.

A first design starts from the folded strip of Figure 1. Pages are somehow thick, so we have to take into account the thickness e of the spine of the book, Figure 12. It is obviously a source of limitation to the number n of pages, Figure 14 (left). If the n internal pages have for size $b \times h$, with ϵ the extension of the cover dimension with respect to the pages, the required length for the strip is $l = 2nb + 2h + 5(b + \epsilon) + e$.

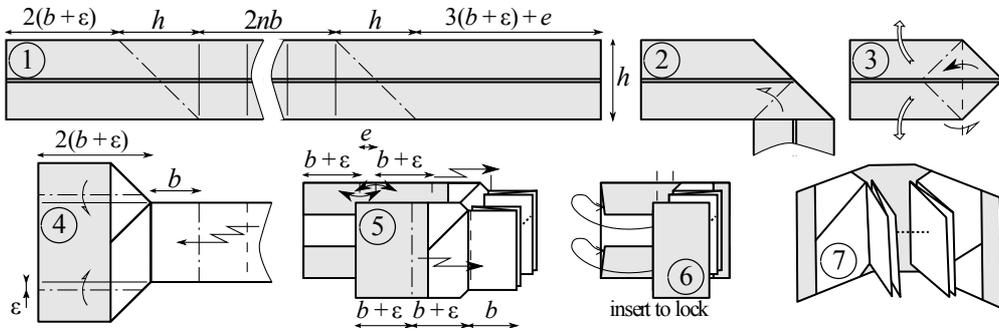


Figure 12. A first version for a book. The two ends of the strip are of different lengths (step 1); steps 2 and 4 must be repeated on both ends.

Do you want to save some length of the paper strip? Then let's start from an unfolded strip; the issue is then to color-change the cover and to lock the model. If the n internal pages have for size $b \times h$, it is enough to start with a $h \times l$ strip, with $l = 2(nb + 3h + 5\epsilon + e)$, Figure 13, but one cannot choose b and h completely independent: $b < h - e - \epsilon$.

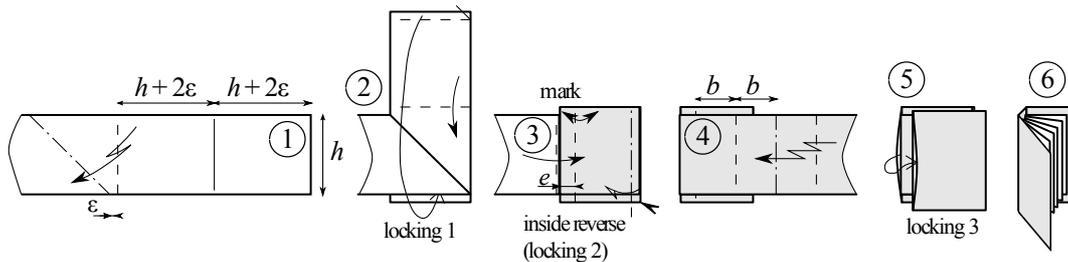


Figure 13. An economical version of the book. The two ends of the strip are identical. Step 5 is the most difficult: insert one cover into the pocket of the other one and mark the creases for the spine.

We can note that allowing the use of a strip in place of a square relaxes the constraints; it is much easier to get a book with 56 pages, Figure 14 (right).

And what about the bookcase?

To store these books, we need shelters in a bookcase. Fortunately, there exists some models, for instance:

- *Bookcase* of Kunihiko Kasahara [3],
- *Origami Mini Library* of Katrin and Yuri Shumakov [10],
- *Bookcase* of Mark Bolitho [11].

And finally, the reader and its chair...

Of course, we can try *The reader* of Kunihiko Kasahara [3], Figure 15 (folded for the 10 year birthday of the INSA Lyon library Marie Curie, on 2019).

³<http://web.archive.org/web/20170620044005/https://www.origami-resource-center.com/36-page-book.html>
<https://web.archive.org/web/20170620081303/https://www.origami-resource-center.com/26-page-book.html>

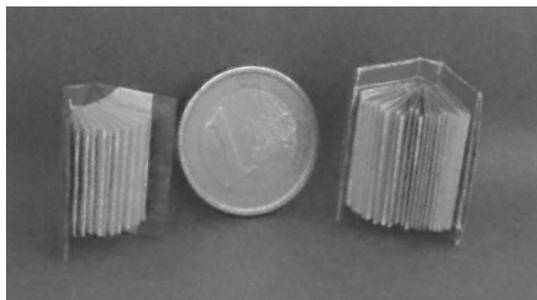


Figure 14. Folded models of the proposed book designs. Left: 22 pages from the folded strip version; right: economic version with 56 pages; center: won't you say that it worth 1 Euro?



Figure 15. The reader, the chair and the bookcase [3], almost full of books (models of K. Kasahara, D. Brill, and one proposed in the present article – the thick book on the top, and the bottom-right one).

You wish to fold a bookcase, chair and reader with the rectangular strip as well? Are you a bit crazy? But why not? It's up to you...

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Addendum: add-on to the original article

In the same issue of the journal *Le Pli* that this article appeared, there are some astonishing coincidences: the diagram of a wish card model of Jacques Justin that uses also the folded strip of two-colored paper (but not with the use of the edge for the color-change) [16]. Moreover, for a book, the same issue also provides a page bookmark [17] of Michel Grand. Is that all? Not yet: you can also find an article of Aurèle Duda [18], reporting for a recently published amazing article concerning historical letterlockings [19]!

We can also complete the bibliographic references with an additional one for the “7-segment display” of Mi Wu [15].

Symbol: an arrow.

Other symbols can obviously take advantage of the same design principle. For instance, a big arrow is proposed in Figure 16.

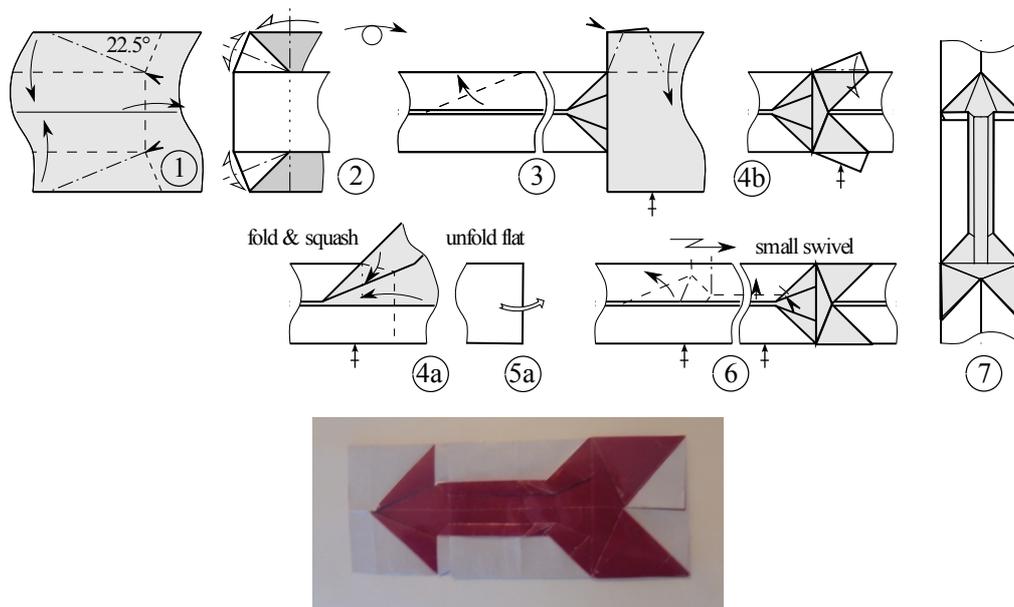


Figure 16. A big horizontal arrow.

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