# Map Folding Techniques in the Digital Age

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**Abstract.** This paper expands and illuminates a little studied aspect of map design; folding techniques for paper maps. It addresses which kind of map folds are used today and which could be applied in future folding devices and displays as technologies evolve and mature.

**Keywords:** map folding techniques, folding displays

## 1. Introduction

Since the advent of the digital age it has often been stated that paper - including paper maps - will be substituted by other materials or electronic devices. But although paper maps are on the decline, they still exist for various reasons. Folding techniques are an inherent aspect of most paper maps. Interestingly enough, this topic was only marginally treated in the past (see e.g. Stams 1983 or Witt 1979 for German examples) and seems to be hardly ever to be focus in recent cartographic literature. This stands in sharp contrast ironically, given the newly developed and applied folding techniques emerging during the digital age.

One reason why paper maps still retain their attractiveness to users is their foldability. This is an advantage over small scale displays. But on the other hand, this advantage is also a liability as we have to fold paper maps to overcome their disadvantage of being too big to be handled easily in plain form. Despite the ease when shifting between scales in electronic devices, these devices usually fail to provide an overview at a conveniently large scale. With new technological developments like e-paper or OLED (organic light emitting diode) displays, it might be possible to overcome this

problem - but then again, map folding could also become a more important topic for digital device interfaces in the future.

## 2.   Folding Paper Maps

In Figure 1 and Figure 2 several folding schemes and examples for paper maps are shown. Basic folds only consist of vertical and/or horizontal folding lines. Folds with vertical folding lines are called horizontal folds, while those with horizontal folding lines are called vertical folds. Besides the cross fold, which combines a vertical and a horizontal half fold, all shown basic folds are horizontal folds. Most of these are applied as vertical folds as well.

### 2.1.  Traditional Solutions

Besides well known folding techniques like the accordion fold, many other techniques and even their names are sometimes quite unfamiliar. The Turkish fold or the Miura fold (although the last one has been described by its inventor Koryo Miura at the ICC (2001)) are such examples. The Turkish fold is maybe better known as pop-out fold (Figure 1 and 2). Both folds were invented before the digital age but are still used today. Therefore they can be seen as traditional solutions.

For large format maps usually two or three different kinds of folds are combined (e.g. it is very common to combine an accordion fold with a half or tri fold). The Miura fold can be seen as a sophisticated combination of two accordion folds (Figure 1 and 2). The decisive factor is the slight inclination of the vertical or horizontal folding lines. Miura recommends 2-6 degrees as the appropriate angle (2001). Another interesting technique is the Falk fold, invented more than 60 years ago (named after the inventor Gerhard Ernst Albrecht Falk; Figure 1). Its decisive property are slits that allow certain parts of a map to fold independently from neighboring parts (Falk 1951).

### 2.2.  New Developments

One consequence of the changing conditions for mapmaking in the digital age is a rise in individualism. As digital technologies diffused throughout society, correspondingly it became easier for creative people to start their own business and sell new kinds of maps. In addition to the great number of newly developed solutions for ephemeral media, also some interesting map folding ideas have reached the market. Not all of them use paper, as new synthetic materials enable other ways of folding.
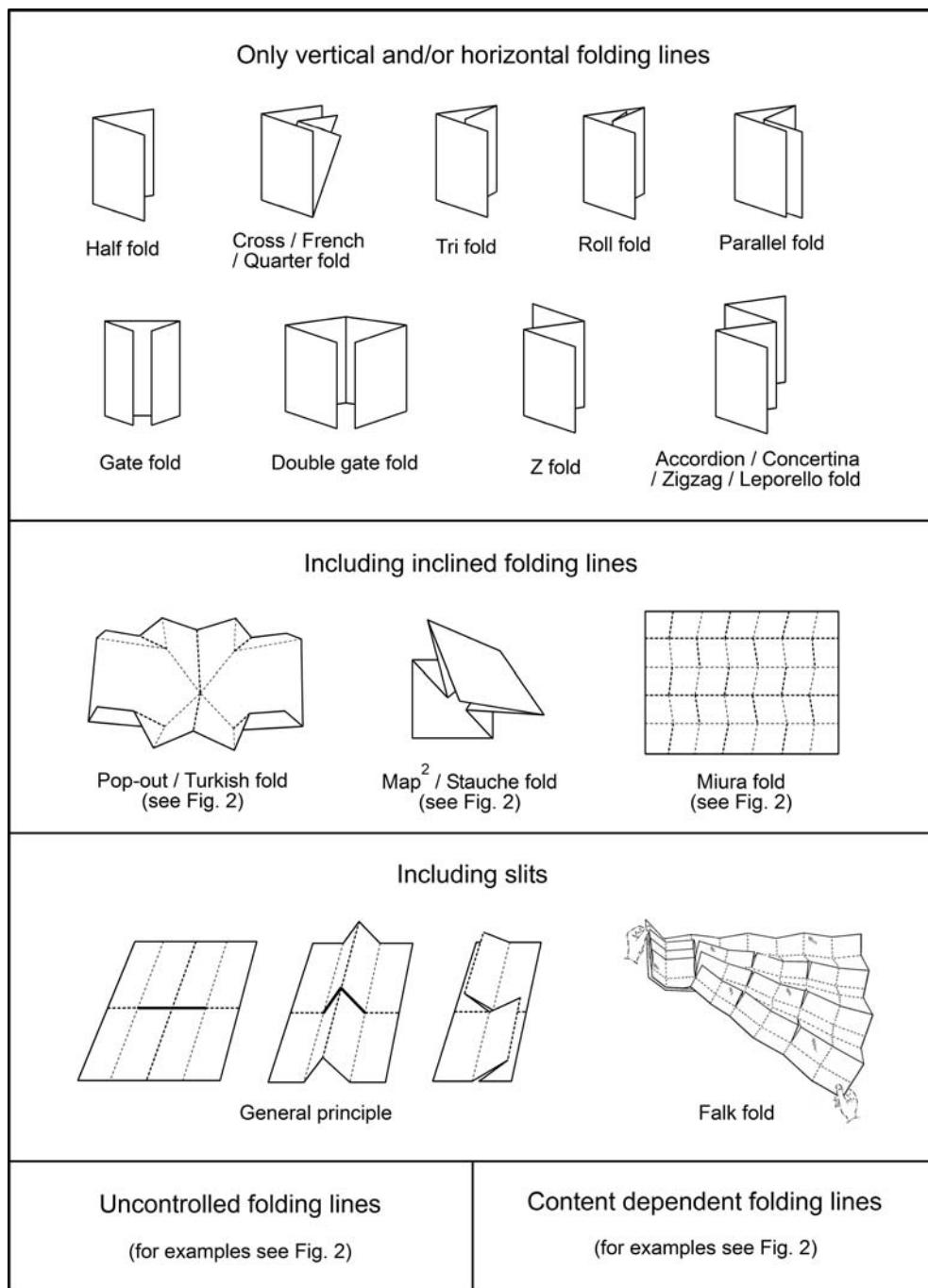
**Figure 1.** Schemes of map folding techniques (sources see appendix).

**Figure 2.** Examples for map folding techniques (sources see appendix).

Around 2005 Stephen Brittan and Fletcher Morgan started to produce the first MountMaps (Gizmodo 2005). They represent the mountainous landscape of ski resorts as a 3D model which are built every time the map is unfolded (Figure 2). Resulting folding lines are content dependent like the ones involved in Jamshid Kooros' pop-up maps (Figure 2). Here they enable important features like famous buildings to pop-up whenever the map is unfolded. In 2004, Anne Stauche filed her patent application for a fold that enables zoomable maps - an idea which is obviously inspired by zooming techniques in digital media (Stauche 2012; Figure 1 and 2). Her final zoomable map combines four such folds (I call them Map² or Stauche folds), one at each corner. No predefined folding lines structure Emanuele Pizzolorusso's crumpled maps (Figure 2). They reached the market 2010 (Pizzolorusso 2010) shortly after a similar concept developed by Rand McNally (called fabMAP; Figure 2).

## 3. Folding Digital Devices

As design concepts, several devices with foldable OLED displays have been developed (Figure 3). But none of them have achieved market readiness as it is not possible to fold displays in ways similar to a sheet of paper so far. Recent prototypes (e.g. Samsung's "Youm") only show bendable or flexible displays. Nonetheless  it seems only to be a question of time before the first products are delivered. Will the ongoing developments lead to new folding techniques as well? Such predictions are of course difficult. Design concepts for phones, tablets, and notebooks typically use simple basic folding techniques like half, tri, or Z folds. Only one older idea (from 2006) tried to combine a mobile phone with a pop-out fold variant (Figure 3:8). Because of its successful application for different purposes, the Miura fold is a promising candidate for foldable devices or displays. But so far, a survey of the available sources failed to yield a related design concept.

Taking into consideration the differences in material properties, new developments seem to be more likely, qualitatively different than merely just a kind of modernization of paper folding schemes. Experiments with programmable self-folding sheets explicitly express the assumption that future displays might be unfold and fold automatically (Hawkes et al. 2010).

1 — Half fold

2 — Half fold

3 — Half fold

4 — Half fold

5a 5b 5c — Tri fold

6 — Tri fold

7 — Z fold

8 — Pop-out / Turkish fold (variant)

**Figure 3.** Examples for possible display folding techniques (sources see appendix).
Please note: these are visualizations of design concepts; none of these devices exists (so far)

## 4.  Conclusion

Map folding techniques in the digital age concern paper (and similar materials) as well as displays (or at least devices). While it is not surprising that designs for possible future devices are heavily influenced by traditional paper folding techniques, it is interesting to see that there exists at least one paper fold that is influenced by zooming techniques in ephemeral media. It will be exciting to see how newly invented and developed materials will influence future devices and folding techniques.

## References

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Hawkes E, An B, Benbernou NM, Tanaka H, Kim S, Demaine ED, Rus D, Wood RJ (2010) Programmable matter by folding. PNAS 107(28): doi: 10.1073/pnas.0914069107

Miura K (2001) Folded map and atlas design based on the geometric principle. Proceedings of the 20th International Cartographic Conference, Beijing.

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Stauche A (2012) Improvements relating to foldable publications. European Patent EP1615776, Filing date: 2004-04-14, Publication date: 2012-08-29

Witt W (1979) Lexikon der Kartographie. Deuticke Verlag, Wien (= Arnberger E (Hrsg.): Die Kartographie und ihre Randgebiete, Band B)

# Appendix

## Figure 1

> Only vertical and/or horizontal folding lines

http://www.foldfactory.com/Online_offerings.pdf; Accessed 28 March 2013
http://www.foldfactory.com/Picker_sample.pdf; Accessed 28 March 2013
http://www.handwerker-druckservice.de/Bilder/Falzarten.jpg; Accessed 22 March 2013
http://www.wood-mitchell.co.uk/2012/01/24/binding-and-folding-illustrations/;
Accessed 28 March 2013
http://www.bookprintingcn.com/bookprint-images/folding_styles.gif; Accessed 22 March 2013
http://www.abcoffice.com/images/cross-fold.jpg; Accessed 01 April 2013

> Including inclined folding lines

Pop-out / Turkish fold
http://www.greenchairpress.com/blog/?page_id=2083; Accessed 21 October 2012

Map² / Stauche fold
http://www.freepatentsonline.com/EP1615776.html; Accessed 15 April 2013

Miura fold
http://library.thinkquest.org/28923/miuraori.html; Accessed 15 April 2013

> Including slits

General principle
http://www.map-reading.com/appendb.php; Accessed 13 October 2012

Falk fold
http://www.google.com/patents/US2572460; Accessed 24 April 2013

## Figure 2

> Including inclined folding lines

Pop-out / Turkish fold - New York City Unfolds Map
http://www.moma.org/collection_images/resized/761/w500h420/CRI_160761.jpg;
Accessed 23 April 2013

Map² / Stauche fold - London - the zoomable map
http://www.thezoomablemap.com/templates/sta_map/images/homepic.jpg; Accessed 23 April 2013

Miura fold - San Francisco Map
http://uponafold.com.au/static/files/assets/776311f5/opc_opc_sfm_1_large.jpg;
Accessed 17 April 2013
http://uponafold.com.au/static/files/assets/5ed5a0b7/opc_opc_sfm_2_large.jpg;
Accessed 17 April 2013

> Uncontrolled folding lines

Crumpled City map London
http://www.pizzolorusso.com/index.php?/project/crumpled-city/; Accessed 24 October 2012

fabMAP Washington DC
http://gearjunkie.com/rand-mcnally-fabmap; Accessed 06 November 2012

> Content dependent folding lines

Mountmap Les Trois Vallées
http://www.snowgo.com/images/mountmap.jpg; Accessed 21 October 2012

Paris Pop-Up Map
http://koorosmaps.com/popup_paris.htm; Accessed 22 April 2013


## Figure 3

1: nVue Phone (concept Dragan Trenchevski 2010)
http://www.spicytec.com/2010/11/nvue-mobile-phone.html; Accessed 04 November 2012

2: A3 Tablet (concept Phil Pauley 2011)
http://www.unp.me/f140/stunning-a3-foldable-tablet-concept-designing-by-phil-pauley-161841/; Accessed 23 April 2013

3: "Concept 9" Phone (concept Max Borhof 2012)
http://www.coroflot.com/maxborhof/Foldable-mobilephone; Accessed 24 April 2013

4: Samsung YOUM Phone (concept 2013)
http://www.eweek.com/mobile/slideshows/samsung-youm-brand-dreams-up-ideas-for-bendable-displays/; Accessed 23 April 2013
http://ibnlive.in.com/photogallery/8281.html; Accessed 23 April 2013

5a-c: Feno Notebook (concept Niels Van Hoof 2011)
http://www.gadgetlite.com/2011/05/08/feno-foldable-laptop-concept/; Accessed 18 April 2013

6: Kyocera EOS Phone (concept Susan McKinney 2009)
http://www.core77.com/blog/object_culture/kyoceras_flexible_folding_phone_concept_13184.asp; Accessed 18 April 2013

7: "Wallet" (multifunctional) (concept Claudia Copersito 2012)
http://www.yankodesign.com/2012/11/22/move-over-tablet/; Accessed 24 April 2013

8: Origami Cell Phone (concept 2006)
http://www.textually.org/textually/archives/2006/05/012452.htm; Accessed 06 November 2012