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Peer-reviewed author version

WENIG, Dirk & SCHOENING, Johannes (2016) The Aesthetics of StripeMaps: Being Small and Beautiful. In: Adjunct Proceedings of the International Conference on Human-Computer Interaction with Mobile Devices and Service Workshop on Mobile Aesthetics, (2016), p. In Press.

DOI: 10.1145/2957265.2965021
Handle: http://hdl.handle.net/1942/21792

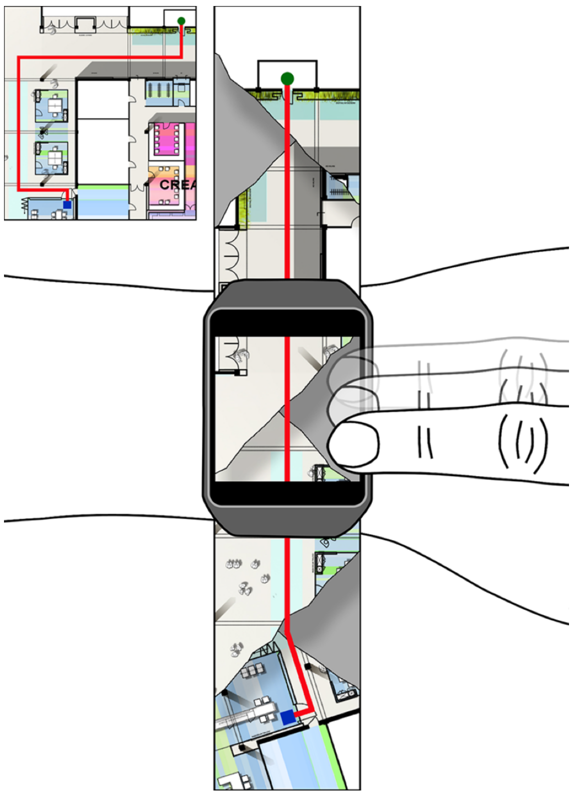

Figure 1: StripeMaps converts a 2D map to a 1D stripe (the original path in 2D is shown on the mini-map).

# The Aesthetics of StripeMaps: Being Small and Beautiful

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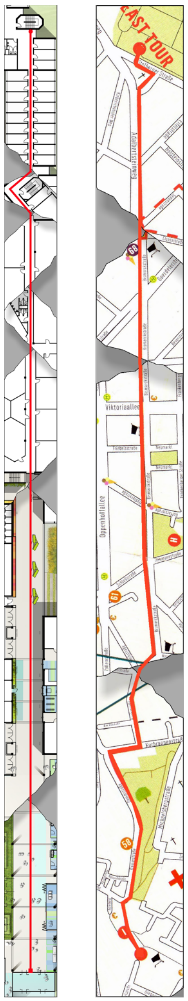
## Abstract
Maps are a very powerful form of information visualization. Beside their main purpose to communicate often very complex relationships between elements of some space, “good” maps are often perceived as aesthetically pleasing and beautiful. Maps are collected for those reasons; since centuries and ages they are “beautiful” – over all trends. Cartography, the study and practice of making maps, has long tradition. Even today, most of the maps, e.g., road maps and public you-are-here maps, are still crafted by professional cartographers. However, maps do require space to be displayed while mobile and wearable devices are getting smaller and smaller. This presents new challenges in cartography, as designing aesthetic user interfaces is an important aspect in the area of HCI. With StripeMaps we present a technique to bring maps to very small displays without destroying their utility and beauty. In this workshop paper we discuss our design considerations in depth and open up the discussion for alternative approaches.

## Author Keywords
smartwatches; cartography; mobile maps; stripe maps

## ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: *User Interfaces — input devices and strategies, interaction styles*


MobileHCI '16 Adjunct, September 06-09, 2016, Florence, Italy
ACM 978-1-4503-4413-5/16/09.
http://dx.doi.org/10.1145/2957265.2965021



(a) (b)

Figure 2: StripeMaps of routes in a Hasselt University building (a) and in the city of Aachen (b)

## Introduction

While map apps belong to the most often used apps on smartphones [2], maps are also expected to play an important role in the day-to-day use of smartwatches. Map apps are included by default with the Apple Watch and with Google's Android Wear platform. However, before smartwatch map apps can meet their potential, important cartographic challenges must be addressed. These challenges arise from the very small smartwatch screen sizes of typically 4 to 9 $cm^2$.

Much of the art and science of reference map cartography (the type of cartography used in online and mobile maps [6]) involves simplifying a large, complex world for display on a much smaller canvas [3]. In general, the smaller the canvas, the harder the simplification – regardless of whether the canvas is digital or paper. Since maps on smartwatches are likely to be the smallest maps that have ever come into common use, existing simplification approaches may not work well and new cartographic techniques and principles need to be developed.

At last year's MobileHCI, we introduced one such technique: *StripeMaps* [7], a novel cartographic approach for smartwatch maps targeted at pedestrian navigation. StripeMaps adapts the mobile web design technique of linearization for displaying maps on the small screens of smartwatches. Just as web designers simplify multiple column desktop websites into a single column for easier navigation, StripeMaps transforms any two-dimensional route maps into a one-dimensional "stripe". These "stripes" can be easily browsed on a smartwatch by scrolling in only one direction (as one does with a well-designed mobile website).

The linearization approach taken by StripeMaps is motivated by a small family of traditional paper-based cartographic products used for long overland trips (e.g. via car or motorcycle). These products take a route which zigzags in two-dimensions and carve the route into segments such that each segment of the route can be rotated and displayed roughly horizontally or vertically for printing on a piece of paper. These sheets of paper are then arranged in a booklet. Probably the most well-known application of these days of this approach is the American Automobile Association's (AAA) TripTik map booklet. These route-customized booklets were commonly used on long road trips in the United States prior to GPS and smartphone navigation.

StripeMaps adapts this TripTik-style approach to linearize route maps into stripes. By reducing a route from two-dimensions to one-dimension, StripeMaps simplifies the world into a single linear stripe, centered on the route of interest. The main challenge of this approach is selecting a visualization strategy to have StripeMaps being small and beautiful. In the later section we discuss different alternatives (see Figure 3) and we hope to use the workshop to get inspirations for novel approaches.

## StripeMaps Visualizations

A number of dimension reduction strategies are available in the cartography literature and in cartography practice. The most well-known come from map projections, in which the goal is to minimize high-cost distortion when representing the earth's three-dimensional shape on a two-dimensional paper or digital surface. For example, the often used Mercator projection offers conformality (same angles in the real world and on the map) at the cost of area distortion.

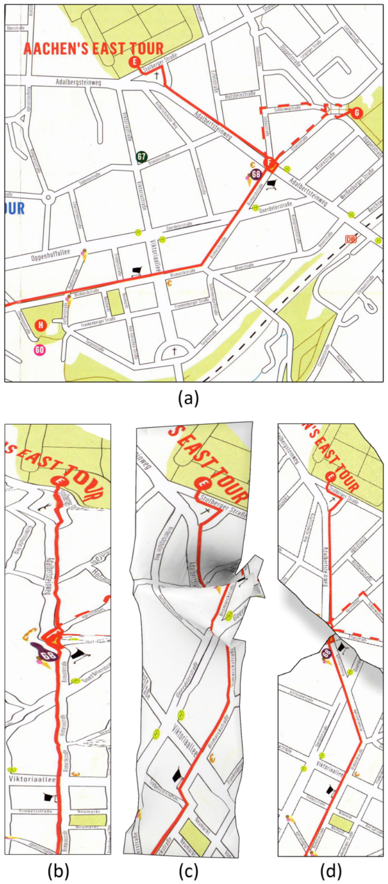



Figure 3: The same route (a) was linearized with the transmogrification tool [1] (b), an approach where we simulate that the map was printed on a piece of fabric and then was transformed into a stripe (c) and an approach in which we simulate that the map was printed on paper and then cut and reassembled (d).

Linear stripe maps do have a long history. One famous example is the 350 years old John Ogilby's 1675 Britannia Atlas (see Figure 4), which is considered to be the first road atlas of Britain. The atlas contains a series of scrolls. Each scroll shows just one journey: from one British town to another town. Similar maps were also produced by August II the Strong, the Elector of Saxony, in the $16^{th}$ century. One of them was nearly 14 m long. More recent examples are map books for inland waterway navigation, which only show the relevant parts for a specific river or canal.

*Transmogrification by Brosz [1]*

The first visualization strategy we tested for StripeMaps was to transform the area along a route using an adaptation of the transmogrification approach by Brosz [1]. The transmogrification tool was developed for quick graphic transformations; it allows to transform images, e.g. along a path defined by the user through touch. However, as can be seen in Figure 3b, these transformations are very difficult to interpret because it is hard to identify the decision points. In addition, labels and the environment at decision points can be heavily distorted. We also added a regular grid to the original map to overcome these effects, but the complex transformation model was still hard to grasp for the users.

*Fabric*

The underlying idea of the second approach, inspired by the work of Sarkar [4], was that the map could be “virtually printed” on a highly deformable material (such as fabric or cloth) and then deformed into a stripe. An example visualized with the help of Blender can be seen in Figure 3c. This approach resulted in the less information loss along the way, but again the information density at decision points was very high.

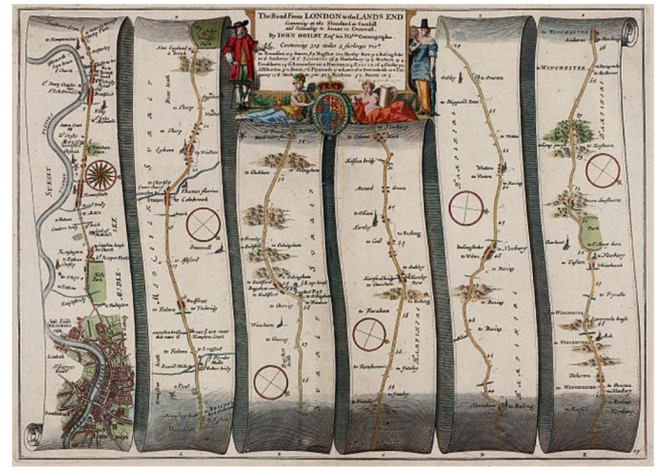


Figure 4: The road from London to the Lands End in John Ogilby's 1675 Britannia Atlas (Wikimedia Commons, public domain)

*Paper*

Another alternative approach occasionally taken in cartography practice involves the “straightening” of mostly-linear features. For instance, this is done in the New York Times visualization of the Tigris and Euphrates rivers[1]. However, this approach only works well when the 2D feature being visualized has only soft curves and no sharp angles, something that is not the case for most pedestrian navigation routes. A similar approach is also employed in the TripTik maps discussed above. However, because each “slide” of the map appears on its own piece of paper, this approach does not address the important issue of how to integrate “slices” of the map into a single, continuous visualization.

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[1] http://nyti.ms/1mNQTKx

Therefore, our third design adapted the core idea of the second approach, but instead of taking fabric, we used paper. As analog maps are usually printed on paper, cutting a digital map into pieces and then rearranging the pieces into a stripe should be an easy to understand transformation model for the users. Furthermore, as can be seen in Figure 2 and Figure 3d, it results in less information loss at decision points. A side effect was also that the cuts provide excellent information on how to turn at the decision points. The cuts do not only show the coarse direction but also the exact turning angle.

### Benefits & Limitations

With StripeMaps we present a technique to bring maps to very small displays without destroying their utility and beauty. In the user studies, we received comments that StripeMaps is simple, nice and fun to use [7]. Nevertheless, we think that the list of possible strategies to linearize maps we have presented in this paper is not complete. Therefore, we hope to get feedback from the workshop participants and explore with them further ideas for map linearization.

The current version of the StripeMaps application turns rasterized images into stripes. While pixel-based maps are widespread and simple to use, this also allows us to paper maps or public you-are-here maps. For example, the stripe map shown in Figure 2b was created using an image scan of an official tourist paper map. For the future, following the PhotoMap [5] approach this also allows to convert spontaneously taken images of public maps, e.g., maps in parks or near hiking trails, into stripes. Public maps offer advantages compared to mobile maps from services such as Google Maps as they often show local landmarks that are not shown on standard digital maps. Often these you-are-here maps are adapted to a special use case, e.g., a zoo map or a hiking map of a certain area. Being designed for a fashioned purpose, these maps are often aesthetically well designed and their usage is therefore more pleasant.

Unfortunately, a serious drawback of pixel-based maps are rotated labels (e.g., street names or symbols of landmarks), which can become unreadable or unrecognizable. In the future we are planning to develop a system providing vector-based maps. Furthermore, while the reality-based transformation used by StripeMaps was very well received, a drawback of this approach is, that it cuts the routes at decision points, resulting in information loss due to the cuts at the most important parts of the map. For the future, we would like to explore alternative approaches, e.g. folding the map. Furthermore, the StripeMaps transformation works best with straight route segments between the turning points while long curves, as they often do occur in the nature world, are still an unsolved problem.

Another limitation is, that StripeMaps is explicitly dedicated to map *navigation* rather than *orientation* (i.e. “getting one’s bearing”), which is the other primary use case for reference maps (the family of maps to which mobile maps belong). There is a long tradition of developing technologies specifically for navigation (e.g. print directions) as we did for StripeMaps, and new techniques will have to be developed to aid in smartwatch map orientation. This is a subject of future work for us, and it is likely that similarly non-traditional approaches will be necessary, as we assume that orientation is also quite dependent on screen size.

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