Re-Mapping the World's Population

Benjamin D Hennig[1], John Pritchard[1], Mark Ramsden[1], Danny Dorling[1],

[1]Department of Geography
The University of Sheffield
SHEFFIELD S10 2TN
United Kingdom
Tel. +44 114 222 7900 Fax +44 114 279 7912
b.hennig / j.pritchard / m.ramsden / danny.dorling [@sheffield.ac.uk]
http://www.sasi.group.shef.ac.uk/

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1. Introduction

The Worldmapper project has successfully produced a series of maps to visualize data, concerning a range of issues facing the modern world, based upon the idea of density-equalising maps. The Cartogram Geoprocessing Tool incorporating this density-equalising method has also recently been made available for ArcGIS. This presentation introduces and evaluates further new mapping approaches that move depictions beyond their simple descriptive form. It gives an insight into these new developments, focusing on sub-national level data which has until now been neglected. The world population cartogram demonstrates the first attempt to include sub-national density data. Within this approach, ArcGIS 9.3 plays a crucial role as an interface to convert suitable raster datasets and to produce updated cartograms. The data is converted using ArcMap's Toolbox, while the Cartograms were calculated using the ArcScript *Cartogram Geoprocessing Tool*. The final visualization has been conducted in ArcMap.

1.1 Worldmapper and its World Population Cartogram

In the first stage of the worldmapper project, a wide range of maps depicting various human dimension of the world have been published on the project's website (http://www.worldmapper.org). Since the publication of the first new world population cartogram in 2006 (Webb 2006) nearly 600 maps have been produced, going far beyond the depiction of the world's population but covering topics such as education, poverty, and pollution. Further methodological notions on the calculation and design of the existing worldmapper cartograms are given in Dorling, Barford & Newman 2006.
The worldmapper cartograms show the data for 200 territories, thus making this new view on the world to some extent an arbitrary view: territorial borders are artificial borders and are subject to change. Furthermore, the assignment of territories in worldmapper is arbitrary as different thoughts on these territories might exist (Dorling 2007). Therefore, the world population cartogram was taken as an example to test different ways to calculate these cartograms beyond the territorial borders.

2. Data and Cartogram Calculation

Data used in this work were derived from the Socioeconomic Data and Applications Center (SEDAC) of Columbia University, New York. The Gridded Population of the World (GPW) database contains the distribution of world's population on a gridded base (http://sedac.ciesin.columbia.edu/gpw/), including population data and estimates from 1990 to 2015. These data are available in resolutions of up to 2.5 arc minutes leading to a population grid of 8640x3432 pixels. Data from the year 2000 have been used to make results comparable to the original worldmapper population cartogram.
These raster format data were imported to ESRI's ArcGIS, converted to polygons and combined with further metadata (e.g. country labels) to match gridcells for further visualization tasks. The cartogram script (see below) uses a 4096x2048 pixel-sized lattice for its map results.
The cartogram itself is calculated by using the ArcScript *Cartogram Geoprocessing Tool* by Tom

Gross (http://arcscripts.esri.com/details.asp?dbid=15384) which uses Newman and Gastner's density-equalizing method methodology (Gastner & Newman 2004). Unlike the worldmapper cartograms that distort an initial projection of the boundaries of the territories, each population grid is treated as a separate part for the calculation, not taking any territorial information of borders into account. Thus each grid cell marks a border so that distinct shapes of countries are intentionally of no interest in the calculation.
Changes in the distortion of the resulting cartogram thus are only possible by adjusting the factor to smooth the original density. In addition, data from the USA have been extracted from the 2.5 arc minutes population grid and are calculated separately in the same way to produce a more detailed view of the resulting grid and its interval variation.

3. Results

The resulting cartograms require some final visualization steps to adapt them to appear similar to the original worldmapper cartograms. The polygons of the calculated world population cartogram are dissolved according to their affiliation to the worldmapper territories and coloured according to the distinctive worldmapper colour scheme. The gridlines in the USA cartogram are conserved to show the degree of distortion within the grid.

3.1 A redrawn World Population Cartogram

Compared to its predecessor (Figure 1), the redrawn World Population Cartogram (Figure 2) shows considerable differences. For example, in China the sparely populated Himalayan regions can be distinguished from the densely populated eastern coastal regions. Internal variation within the United States and Mexico can also be recognized. Somewhat harder to identify but still evident are North-South differences in Great Britain and West-East differences in Germany. Hence, our goal to take the varying distribution of population on a sub-national level and make them visible on a global view has been achieved. However, sub-national variation can be difficult to analyze in more detail because the gridcells are eliminated to sustain the view on the global scale. In addition, more distinctive national shapes are far more distorted than in the original cartogram, which for some users might appear odd when interpreting such maps.

3.2 Down to Earth: A Population Cartogram of the United States

To counter the loss of familiar national boundary shapes a separate population cartogram is produced for the contiguous United States (Figure 3) and several other countries. The shape of the cartogram has more detail compared to the shape of the USA on the world population cartogram. This is because more gridcells are used in the calculation of the cartogram and no other polygons (e.g. from the European continent) influence the calculation. The different scale also allows the visualization of each gridcell so that sub-national variation can be recognized. An "original" map of the USA with its familiar shape is shaded-in underneath the grid to aid interpretation.
This visualization on a different scale is an improvement in the visualization that goes far beyond the current capabilities of the worldmapper project by using gridded base data to allow not only a different view on population distribution worldwide but also within separate regions. By using cartogram techniques, a different view on the regional variations of the human geography is created which can hardly be achieved with traditional mapping techniques.

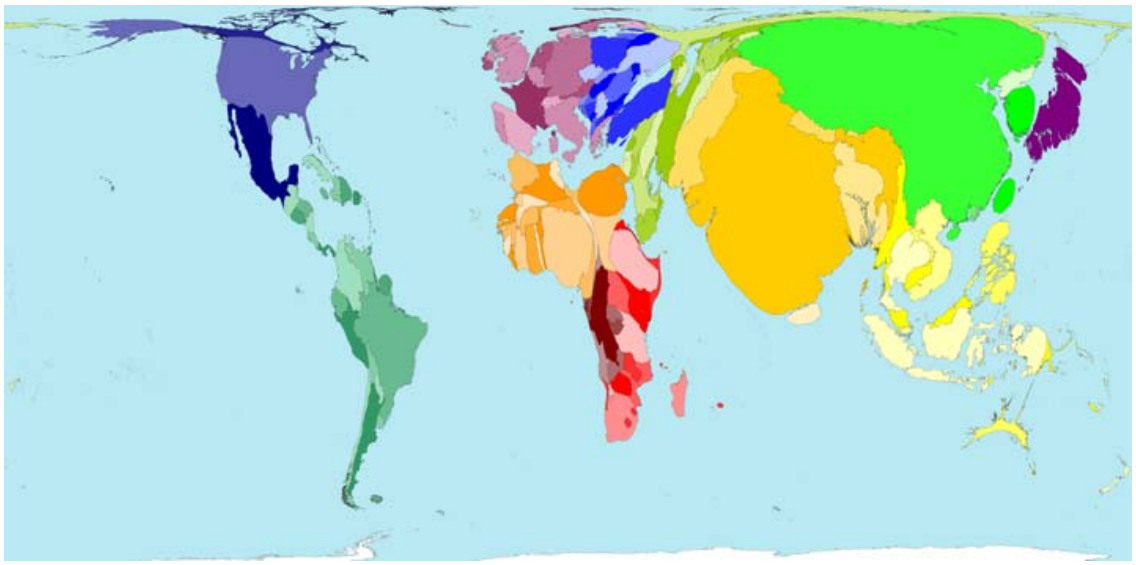

Figure 1. Worldmapper Population Cartogram
(Source: http://www.worldmapper.org/images/largepng/2.png)

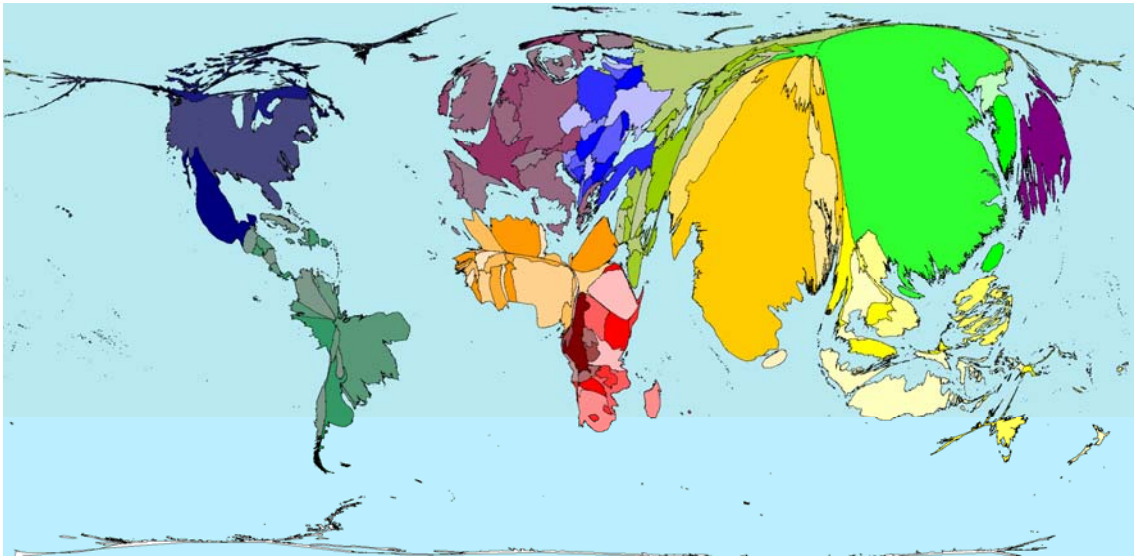

Figure 2. Grid-based World Population Cartogram (2000)

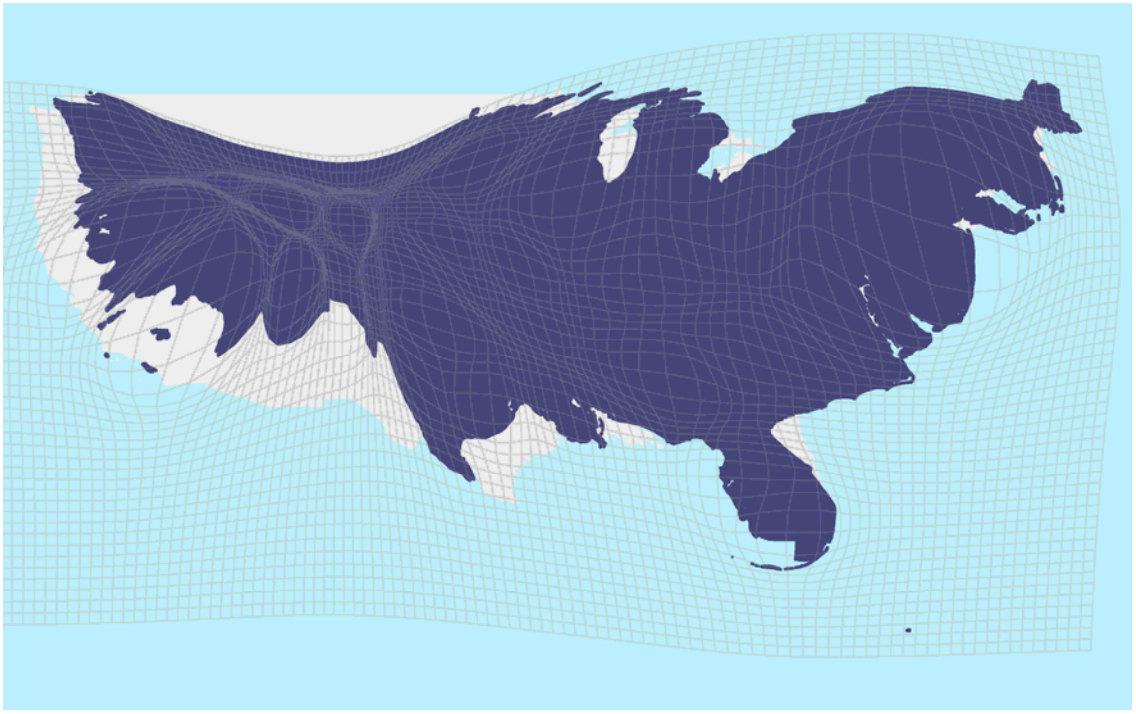

Figure 3. Grid-based Population Cartogram of the contiguous United States (2000)

4. Outlook

The most significant obstacle to the realization of gridded depiction for worldmapper will be the vast quantity of the different topics covered and availability and reliability of data. Reliable gridded social and economic data for the whole world is rarely available and rarely of such good quality as the population data. The estimation of missing national data for some topics has already been a serious matter in the existing worldmapper cartograms (Dorling, Barford & Newman 2006). Such estimations will not meet the demands of gridded datasets, so new ways of data estimation are needed. Current approaches to estimate data commonly use the GWP data and these have the potential to be adapted to worldmapper's requirements (e.g. Gaffin et al 2004; Hay, Graham & Rogers 2006).

Revised gridded cartograms offer great potential to enhance the variety of worldmapper's visualization capabilities. A different view of the "real" location of the depicted topic can present a better understanding of human action and human patterns on the globe. However, distortions associated by the gridded method are a disadvantage and undermine the purpose of Newman and Gastner's algorithm to preserve the familiar shapes of countries. The potential of the gridded approach and the desire to preserve familiar shapes must therefore be carefully balanced. Nevertheless, much potential lies in adding more user-interactivity and detail to worldmapper. Grid-based cartograms have the advantage of allowing a user to zoom in to view national and regional details, within a global context. As Dorling comments, "*Our maps could be made more interactive, certainly, and there are probably many other features that could be added.*" (Dorling, Barford & Newman 2006)

GIS technology is a key tool to make this happen. A GIS environment not only facilitates data conversion and calculation of cartograms but Geographical Information Systems allow different geographical scales to be brought together under one map. An easy transfer to popular digital globes can thus easily be realized, allowing viewers to identify the regional dimension of a subject. Separate regional editions of gridded population cartograms can be generated to visualize the regional variation of population distribution.

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