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Mapping London using cartograms

The Londonmapper project funded by the Trust for London is an attempt to create a new social atlas of London using cartograms instead of conventional mapping approaches. This paper gives an introduction into the techniques and methods that were deployed for creating cartograms from the British capital.
The area of Greater London covers the area of the 33 London Boroughs that are under the administration of the Greater London Authority(GLA 2011b).
London covers an area of 1,572 km2 and has a population of approximately 7.7 million. It is the largest city of the United Kingdom (and Europe) and situated in the densely populated southeast of the country. London and its surrounding region is the economic centre of the country and as such it is a highly disparate city with large socio-economic differences. This makes the population of London a highly polarised society, which finds a geographic manifestation in the emerging social patterns there (Dorling 2008, Zehner 2010, Zehner & Wood 2010).
The population grid covering the extent of London consists of 151 grid cells in the 2.5 arc minute resolution. As a base for a refinement of the grid this resolution and the underlying data was regarded as less suitable because it was assumed that a city level population grid requires more detail but also more accurate redistribution than the method that was used to create the refined grid for the Middle East. A city-level map should be able to show a more accurate variation not only between populated and less populated areas. With an urban area generally being densely populated, the redistribution of population onto an equally distributed grid should take significant differences in these overall high densities into account without being based upon a rough estimate. A larger scale map is generally expected to bear more detail, and the more detail is displayed, the more accurate it needs to be.
London was chosen for testing an urban area gridded population cartogram because of its distinct social geography. This makes it not only worth looking at the patterns of population distribution themselves, but also to use these to analyse and visualise the existing social polarisation in novel ways. In addition, the methodology benefited from higher resolution population data that is available from official resources and can be used for a more accurate generation of a population grid. The generation of a higher resolution population grid was realised without using the GPWv3 data.
Used as a base for the generation of a high-resolution population grid for London was data from the Office for National Statistics (ONS) in the United Kingdom. The ONS provides population figures on a yearly basis as mid-year estimates projected from the last census counts. The latest available 2009 estimates were selected for this work .

FIGURE 59: POPULATION DISTRIBUTION IN THE LSOA AREAS OF LONDON

The graphs show the total occurrences of population values in the Lower Layer Super Output Areas (LSOA) within the urban boundaries of London
(own depiction by the author using data from ONS 2009a)

The population data is based on so called Output Areas, which are the base units used in the Census counts. The Lower Layer Super Output Areas (LSOA) are oriented on ward units, which as a key administrative geographic unit of the United Kingdom cover an average population of 5500, with huge variations between the urban and rural areas. The statistical wards used by the ONS are also modified to reduce the impact of electoral ward boundary changes. London is covered by 4765 LSOA units, which for the 2009 population estimates have a total population of 7,753,555 people (Figure 59). The mean population per LSOA unit thus is 1627 people, with a standard deviation of 257 (ONS 2009a, ONS 2010, ONS 2011).

The generation of a gridded population dataset for London was based on the approach that has also been used in the creation of the GPW global population database (see section 9). The redistribution undertaken here did not consider advanced modelling approaches because these reached beyond the scope of the research to test the general applicability of gridded population cartograms for an urban area. Modelling approaches based on additional information about land use patterns may be valuable for future studies on the creation for an even more accurate population grid than the present one.

The methodology used to create the gridded population data for London based on the LSOA units included the following work steps: firstly, the grid size was defined with a 100 x 100 m resolution to potentially cover enough detail for an urban area. The grid was generated over the area of London and clipped by the outer administrative boundaries, resulting in a grid containing 161,052 grid cells. Secondly, the LSOA level population data was converted to a raster layer with the same resolution, in which all LSOA-level population counts were equally redistributed over their areal extent. Thirdly, the population values of the LSOA population raster were then joined with the raw population raster, resulting in a vectorised 100 m resolution population raster for London.

15 Warping countries and cities

The different level population data ranging from the GPWv3 2.5 arc minute population grid for all countries of the world down to the newly generated 100 m population grid for London are the basis for the creation of a series of new population maps based on the gridded cartogram technique. The following section explains the main processing steps in which the different levels of detail are tested for their applicability of the gridded cartogram technique. Thereafter, the newly created maps are explained and discussed in their cartographic value.

15.1 Methods

The method of creating gridded cartograms followed the methodological approach elaborated and outlined in the previous chapter (see section 10.4). The additional work stages in this part included the reduction of the population grids to the different administrative areas of interest and the use of the corresponding grid resolution that has been prepared for the respective scale. All works have been performed in ArcGIS and with the XTools extension and the Cartogram Processing Tool.

The countries of the world were extracted from the worldmapper geometry and saved as separate polygons. For each country then a 2.5 arc minute grid was

generated and combined with the GPWv3 population data, so that separate population grids were created for each of the countries. To reduce processing time and the manual effort that went into the creation of the country grids, a faster approach was used for the creation of the population grids. The simplified approach converts the raster data directly into polygons instead of creating a point layer and merging this with a polygon grid. This approach reduces the manual effort that is needed to create the population grid, but results in some grid cells being merged with others to simplify the polygon structure where duplicate values exist in neighbouring grid cells. This has no effect on the overall map transformation because the overall population values for each polygon are still correct after the transformation, but can in some cases lead to a different appearance of the grid. This restriction was accepted to allow the creation of a series of gridded population cartograms for all countries within a reasonable time .

A coherent population grid using the 2.5 arc minute resolution has also been created for the African continent and Europe. Here the full manual approach has been used to create the grid, so that no automated simplification of the resulting grid cells could happen.

For every country a separate gridded population cartogram based on the 2.5 arc minute resolution was calculated. The transformation was performed using a density blurring factor of 1 (resulting in the highest possible transformation) and a maximum analysis mesh of 2048 (depending on the overall extent of each individual country grid). Some smaller countries with only very few grid cells were transformed together with one of their larger neighbouring country. This was e.g. the case for Vatican City, which is only covered by one fraction of a grid cell in the 2.5 arc minute resolution and was thus included in the population grid of Italy.

The final gridded country cartograms were visualised in different ways. For the creation of a worldmapper-project related online world population atlas, one set of cartograms was visualised using the worldmapper colour scheme for each country. Additional elements for guiding the map reader through the interpretation of the maps included a background display of the original country shape. It also included the visualisation of an overlaid raster that emulates the transformation and shows the areas of largest and smallest distortion in relation to that raster. Furthermore, the final map included city labels for the largest urban areas or most distinct features in each country cartogram. These were derived from a manual examination of each individual map. From the unique identifiers of each grid cell, the location of the transformed areas could be related to their original geographic position and so be combined with the information about the location of the major cities. The city labels and additional design elements for the online maps were created using Adobe Photoshop. A total number of 172 maps were created for the world population atlas (including a version of the gridded world population cartogram).

The gridded country population cartograms included a 2.5 arc minute resolution version of Israel and the Occupied Palestinian Territories. The refined grid with higher resolutions for the Occupied Palestinian Territories and parts of Israel was used for two additional cartograms of the region, one with the grid containing the varying grid sizes, and a second version with the consistent 2.5 arc minute grid superimposed onto the more detailed grid.

The gridded population data of London was analysed in more detail to compare the different cartogram techniques on city level and their visual appearance. Therefore, several cartograms based on the population values for different geographic units were created: A cartogram based on the main borough-level population figures (similar to a world population cartogram based on national-level population data, data for London obtained from GLA 2011a), a cartogram based on the LSOA-level population data (using the best available official data set), and a gridded population cartograms based on the 100 m population grid. A polygon feature showing the River Thames was also included as a guiding visual element in the gridded cartogram transformation.

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