DemoGraphic

Visualising population distribution in Australia over time using rapid 3D web graphics libraries

AUSTRALIAN POPULATION STUDIES

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This paper presents an interactive 3D visualisation tool and workflow for exploring current and past population data in Australia. The visualisation of small-area population data enables the exploration of population dynamics, such as scale, density, movement, age and sociodemographic information. Such information is becoming increasingly accessible with the advent of open government data (Jetzek et al. 2013), sensor data (Sagl et al. 2012), and more sophisticated computational and visualisation tools (Kashnitsky and Schöley 2018; O'Brien and Cheshire 2016; Pettit et al. 2012; Pettit et al. 2017). Such tools enable planners, geographers, demographers to understand the current structure of cities and how they are changing over time.

There are a number of challenges in representing small-area population geographies in a user-friendly way at a large national (or, indeed, international) scale. These geographies consist of statistical boundaries which can vary significantly in area. The rendering of density and colour breaks can further be difficult, and often can skew the visibility of interconnecting regional cities and centres. Due to the complexity of boundary geometries, it can be computationally slow to show national datasets in standard GIS applications, and even in web applications they are particularly difficult to interpret when zoomed out as a consequence of preserving the legibility of these boundaries.

Several systems have been developed to address the visualisation of detailed population data at a large scale by using methods which ameliorate effects of administrative population boundaries. For example, work by Smith (2016) discusses this, and creates an interactive 2D population explorer using the open release of the European Commission (2019) Global Human Settlement Layer. To overcome these challenges this DemoGraphic presents a novel approach (Figure 1) using rapid, open source 3D web visualisation libraries to explore how this can be achieved with national-level population data in Australia.

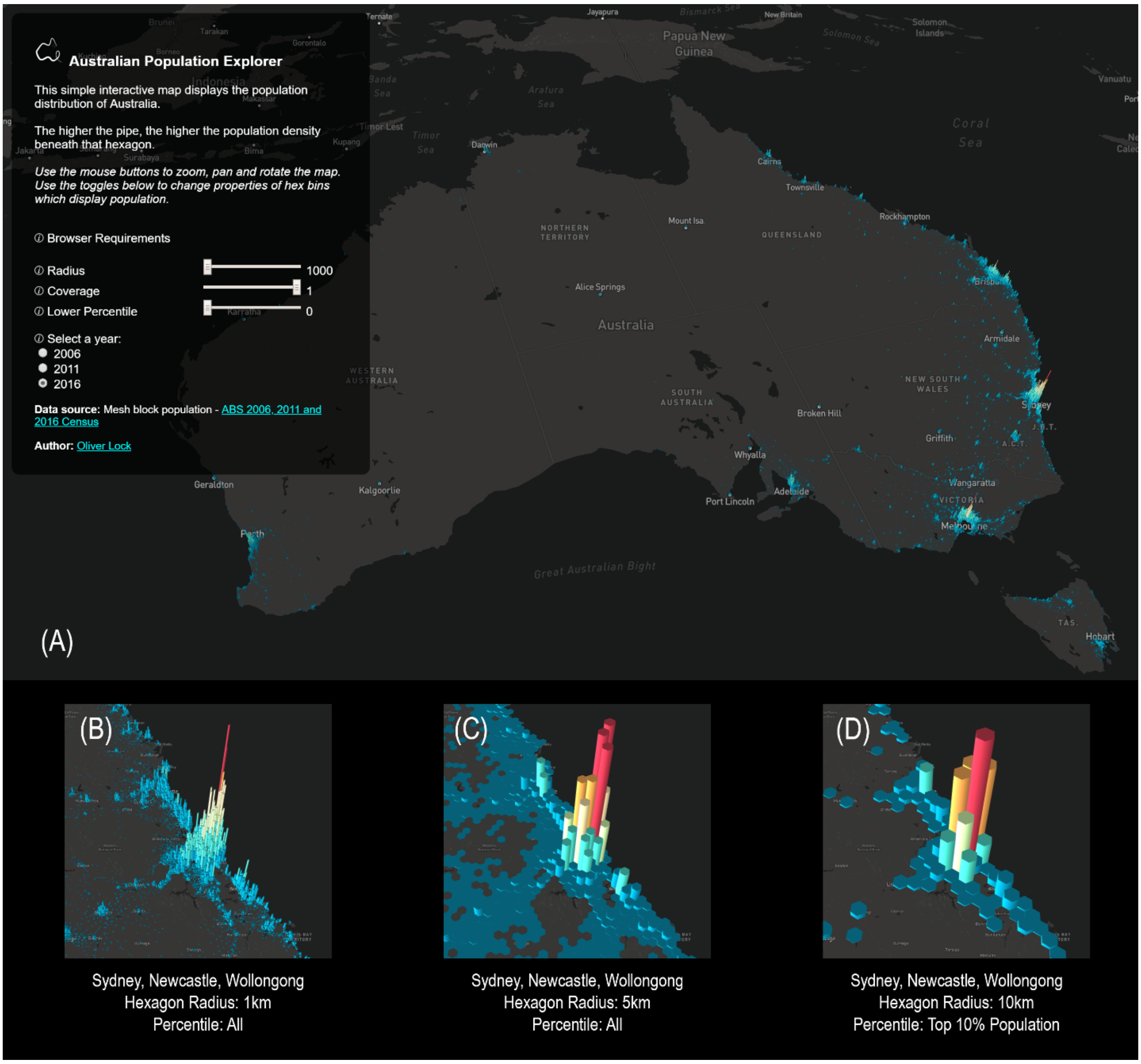

Figure 1: Australian Population Explorer

Note: Access the interactive version via https://aus3dpop.city-informatics.com

WebGL operates across multiple supported browsers (Chrome, Firefox, Safari) with a royalty-free API (Application Programming Interface), and creates fast, hardware accelerated 3D graphics (Khronos Group 2019). The open-source WebGL-based library DeckGL (Uber 2019) was used due to its specialisation in processing very large geographic data sets and rendering them in three dimensions. Three dimensional techniques are a sensible choice for displaying population density, which has a natural perceptual association with its impact on the height and size of the built environment to support that density.

The method used in this visualisation is known as 'hexagon binning'. A hexagon bin is a form of bivariate histogram which considers both its location and a frequency of values underneath it. The process of generating a hexagon bin is as follows:

- geographic space is transformed into a regular grid of hexagons;

- the number of points (in this instance, population) falling into each hexagon is counted;
- hexagons with a count above 0 are plotted, with their colour and height varying with the density of points underneath.

There are several reasons why hexagons are useful (Lewin-koh 2011). Hexagons are more efficient than covering a plane with squares. They are also visually less biased for displaying densities than other regular tessellations with fewer edges (and thus an implied visual directionality). As such, they provide a sound medium for communicating population and related urban densities.

For this visualisation, usual residence census data from the smallest geographic unit for population data within the ABS Census data was used, mesh blocks. According to the ABS (2016), mesh blocks contain around 30-60 dwellings, the smallest number of dwellings that can be communicated without potentially revealing sensitive information. The amount and geometry of mesh blocks has changed over time, from the 2006 Census (when originally conceived) when there were approximately 314,000 to approximately 347,000 in 2011 and 358,000 in 2016. A challenge lies in their evolving geometries as their visual comparison is unclear over time. Another challenge, as discussed, is in computing the complex, detailed geometries and trying to represent such granular polygons at national scale.

The resulting visualisation is available through Australian Population Explorer (Lock 2019). The tool is rapid and exploratory. Users can toggle between alternate years of the census and see changes in population distribution. Further, changes can be made in the coverage of the hexagon to explore more densely populated areas. The Lower Percentile toggle can be used to see which areas fall in the highest densities of all hexagons generated across the country.

It can be seen that Australia's major cities continue to operate as primate cities within their respective States/Territories, however, such visualisation also highlights the country's vast network of regional cities and the interconnectedness of urban regions such as in South-East Queensland. By increasing the radius of the hexagon to 10km, and around the 95th percentile, users can begin to see Australia's network of smaller cities and how they may connect to one another, which could, for example, be useful in considering future, major infrastructure projects.

With a smaller hex bin it is clearly visible that 2006 and 2011 have greater similarity in population structure and pattern than in 2016. This is likely due to a combination of factors related to the new digital version of the Census in 2016, including changes in response rates, imputation challenges and new address-matching systems (the Address Register), documented by Census Independent Assurance Panel (Harding et al. 2017). This representation difference was mitigated by increasing the hexagon sizes. By changing size dynamically, it is easier to compare cities over time and highlight overarching structures – see for example components B, C and D of Figure 1.

In summary, the Australian Population Explorer presented here permits the interactive investigation of population distribution and trends over time. This contributes to our understanding of effective methods to represent detailed small-area information, which can be useful across multiple domains. Such applications include planning and delivering of government services, transportation planning, estimating vulnerable communities in disaster situations, understanding communities for election preparation, estimation of population at risk for spread of diseases (Wardrop et al. 2018).

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