Redefining Great Britain

This new research describes a clever way to redefine and redraw geographical areas using telephone communication networks.

Let's pretend that you have been given the task of redrawing the county boundaries for Great Britain; how would you do it? Would you rely on natural geographic features, like hills, rivers and topology to suggest regional boundaries? Perhaps it makes more sense to use man-made features like cities, canals and motorways as boundaries? But what about using population distribution? Counties are all about defining groups of people, after all. But when considering political issues such as voting and government funding, you might instead decide to draw boundaries so all counties have roughly the same number of people, or include people with the same political affiliations, socio-economic class or religions. Or maybe you would delineate boundaries so as to disrupt particular groups? If so, which ones, and why? The more one thinks about it, the more complex it becomes to redraw regional boundaries.

Recently, an Anglo-American research group wanted to learn whether existing government-defined regional boundaries respect the natural ways that people interact across space.

"We are particularly interested in how rich data at the individual level can promote a better understanding of our society," wrote Carlo Ratti in an email. Dr Ratti is the lead author on this newly published paper and he is the director of the SENSEable City Laboratory, a research initiative at the Massachusetts Institute of Technology (MIT) in Boston, USA.

Using Great Britain as their study subject, Dr Ratti and his colleagues designed a novel
paradigm to redraw regional boundaries by examining human connections: the team looked at their telephone calls.

British Telecom provided the researchers a 2005 data set containing 12 billion telephone calls made in Great Britain over a one-month time period. This data set, collected for the BBC series, "Britain from above", were anonymised by British Telecom before being shared with a number of research universities, including MIT. It contains information from more than 95% of Great Britain's residential and business telephone landlines.

Dr Ratti and his colleagues aggregated these data into a grid of 3,042 squares, each roughly 100 square kilometres in size, and that grid was superimposed upon a map of Great Britain. All telephone calls going into or out of each individual square were counted, and the "strength" of each connection was determined by the total call time -- a reflection of the local population density. These numbers formed a matrix containing the total telephone traffic between each pair of squares within Great Britain (Figure 1):

The above figure shows the strongest 80% of all links, as measured by total talk time, between and within each 100 km-square region in Britain. Darker squares and links indicate longer talk times. Each region was identified with a different colour based on connection richness -- the time spent talking to people within the region contrasted to the time spent talking to people outside of the region.

Dr Ratti's team checked their findings by lumping Great Britain into just three regions and statistically analysing those data, which gave them fairly good network partitioning (Figure 2a). Fine-tuning these regions to more accurately reflect their findings provided even greater statistical support (Figure 2b & c):

The researchers then combined the results from several different analytic methods to generate the map that you see below (Figure 3):

In the above map, the thick black lines are the official borders for counties within England, Scotland and Wales, and the black dots mark Britain's towns and cities.

As you can easily see, even though there was some variation along official boundaries, the researchers' analytic methods found that officially-defined regions were generally preserved. Dr Ratti and his colleagues also found 11 stable densely populated "core areas" separated from each other by "peripheral regions" that lie at boundaries that have somewhat ambiguous associations. This is not surprising, considering that these core areas contain 85% of Great Britain's population.

"We began by looking at the human network as a topological entity with no geographical constraints, but uncovered clear regions in space that respect spatial
adjacency," wrote Dr Ratti in an email. "Apparently the telecommunication links between individuals -- and the interpersonal transactions that they capture -- are so intertwined with geographical space that partitioning at a network-topological level produces a very accurate partitioning of geographic space."

The research team also found that Wales, and to a lesser extent, Yorkshire, are well incorporated into regions dominated by the major cities of the West and East Midlands regions, respectively. These findings agree with detailed commuting data gathered by the 2001 census.

"The difference between Scotland and Wales is striking," wrote Dr Ratti. "Based on our landline data, Scotland is very separated from the rest of Great Britain: just 23.3% of all call time placed or received there goes to or comes from another part of the country. Conversely, Wales, in spite of its unique cultural and linguistic heritage, is well integrated with its English neighbors to the East."

Surprising to me as an outsider looking in was the researchers' suggestion that if Wales seceded from Great Britain, this would be twice as disruptive to the human network than if Scotland seceded. I wonder what effect geographic location has on Britain's social network development?

The team's data also substantiate earlier research suggesting that a new 'Western Crescent' region of high-tech activity is developing just to the west of London in Berkshire, Buckinghamshire, and Oxfordshire. This makes me wonder if those regions might provide different data if internet-based communications (Skype, for example) are analysed instead of landline telephone calls -- what percentage of these residents even own a landline?

According to Dr Ratti, this research shows that analyzing information flow could be a useful tool in the drawing of political boundaries and "could lead to more democratic, bottom-up structures of governance."

And, he wrote, it will only become more useful as data from other networks -- the Internet, Internet telephone networks, instant-messaging networks -- become available for analysis.

As an early-adopter, I am astonished to learn that almost no research has been done using the wealth of data represented by human communication networks in geographical space, particularly in view of the fact that the internet is so vital for connecting people around the world, people who would never have met in real life without the internet.

"This is part of an emerging field that has recently been known as 'computational social
sciences' -- *i.e.* the ability to address social sciences research questions using huge datasets that have emerged over the past decades as a result of digitalization," wrote Dr Ratti.

This little paper is, in my opinion, a defining piece of research because it provides both an intellectual advance in *how* we think about networks, and because it suggests a practical methodology for pursuing these types of questions. As more scientists use human networking data to explore social evolution, the methods will only get better and we, as people, will come to see ourselves, and society, in sharper detail.

**Sources:**


Francesco Calabrese [email; 9 December 2010]

Carlo Ratti [emails; 10 & 11 December 2010]

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LarryJayCee

13 December 2010 2:45PM

This research is all based on landline data. It would be interesting to see if mobile phone data gave the same or a different pattern.

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pseudosp1n

13 December 2010 2:49PM

People who talk the most often have the least to say.

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GrrlScientist

13 December 2010 2:56PM

@LarryJayCee indeed. i asked them the same question and Dr Ratti says they have not looked at those data. i also was interested to know if the data provided by calls placed at different times of day/week/year, and Dr Ratti said they are looking at those data in another project.
Thanks GrrlScientist, a really interesting article. If they find it, no doubt people will come on and complain about invasion of their privacy. Though they miss the point, their phone call, just one of these data points is uninteresting. The whole set of data is what is interesting. It provides all sorts of interesting results and if this leads to better local services, more synchronisation in public transport, health and education, all the better.

Very interesting. How much of this integration is due to relatively recent infrastructure developments? I mean recent compared with the original county boundaries, such as canals, railways, major trunk roads and motorways.

Reinforces some of my own observations; that North Wales looks to Merseyside and beyond for trade and transport for instance. This could prompt a whole tirade of Welsh objections but there is a real problem with political structures that follow the ancient boundaries like the Welsh Assembly. They are trying to resurrect affiliations that have been disappearing for 300 or more years. I have heard it said in North Wales is that the political system is trying to replace colonisation from England with colonisation from the South.
@childonfire thank you, i really enjoyed reading and writing it (i did have extraordinary trouble finding anyone to talk to about this: astonishingly, press agents at the universities and at PLoS never responded to me, so i then hunted down the paper's authors). so sadly, this write-up was published almost one week after embargo because it took me until saturday to get an email interview with the authors. by that time, i decided to wait until monday to publish so more people would/could read it.

i know, TMI. but i am pleased that the piece finally came together and that you are enjoying it. it's a sweet little paper.

@leadballoon i love your questions, partially because these are things i wondered also. :) i was hoping that my readers might share your insights into this issue, especially those of you who have lived in great britain for generations. i think the research is rally fun and wanted to share it with you for that reason, but i am really interested to learn what you know about the evolution of britain, how the history, geography, terrain and other factors all interact.
What did that massive great picture at the top of the counties as they aready are add to the article?

@GrahamRounce

What did that massive great picture at the top of the counties as they aready are add to the article?

What does this comment add to the discussion?

the evolution of britain, how the history, geography, terrain and other factors all interact.

There are several lifetimes work there.
What we have with the telecom data is deriving the links from the detailed data. This would be in contrast with how it's usually done, the top down approach of government, church diocese, feudal nobility or modern planning authorities.

Areas of study that might reveal something interesting along the 'bottom up' lines of the telecom data probably start with place names, linguistic evidence of influence when they were founded. There are some established studies, the broad swathes of Saxon and Norse ending are distinct but there are plenty of other influences there from Roman, Norman and elsewhere. Another source is going to be dialect, potentially harder to quantize and fast disappearing but it is there. A more recent source would be the census, there are some studies of surname distribution. There is the census category of 'where born' that as far as I know has been mostly used to highlight immigration from abroad but should contain a wealth of information about internal migration patterns.

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15 December 2010 1:48AM

Interesting but confounded by the fact that many telephone calls are dictated directly or indirectly by established civic boundaries.

For example if I want to complain about rubbish collection I have no choice of which council to phone.
Less directly, my kids (who probably account for the majority of phone use) call their school friends, who met because they live in the same catchment.

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