sDNA project

Release of Cardiff cycling models

June 2016
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Date: 6 June 2016

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Introduction
sDNA is freely available urban network analysis software produced by Cardiff University, and funded by a mixture of sources including the ESRC Impact Accelerator scheme. Among other tasks, sDNA allows the quick construction of high resolution, spatial network based transport models suitable for the planning of active travel. The software is available at www.cardiff.ac.uk/sdna. The models shown in this publication are produced using sDNA+, a commercial extension to sDNA available from the same URL.

Coinciding with the implementation of the Wales Active Travel Act (2013), Cardiff has been our research test case for the developing models of cyclist behaviour in cities. These models can visualise current flows, predict flows in the presence of infrastructure change, visualise accessibility issues and the cause of barriers to uptake of active travel (Figure 1).

This document aims to put our Cardiff models into the public domain to contribute to an ongoing public debate on the future of Cardiff’s cycling infrastructure. The document is accompanied by GIS shape files which can be downloaded and used without restriction except where otherwise noted.

The reader is reminded that all models rely on assumptions (in this case documented in the technical appendix) and that no model gives a complete representation of real life. The models presented are intended to complement, not replace, existing decision making processes.

![Figure 1 Typology of models which can be produced with sDNA](image)

Data sources
Road network data is based on OpenStreetMap. OpenStreetMap is a free, editable map of the whole world that is being built by volunteers largely from scratch and released with an open-content license. It was chosen for this study as at time of writing it contains more information on traffic free cycle routes than any other publicly available map (including commercial offerings). The network data is prepared according to the instructions in the sDNA user manual, including planarization and use of a high cluster tolerance to correct errors: [http://www.cardiff.ac.uk/sdna/wp-content/downloads/documentation/manual/sDNA_manual_v3_4_beta2/network_preparation.html](http://www.cardiff.ac.uk/sdna/wp-content/downloads/documentation/manual/sDNA_manual_v3_4_beta2/network_preparation.html)

Models are calibrated to measurements of cycle flows released by the Department for Transport (on roads) and Cardiff Council (off roads).

OpenStreetMap License details: [http://www.openstreetmap.org/copyright](http://www.openstreetmap.org/copyright)
DTF data and license terms: [https://data.gov.uk/dataset/gb-road-traffic-counts](https://data.gov.uk/dataset/gb-road-traffic-counts)
Background mapping uses Ordnance Survey OpenData.
sDNA model outputs are released to the public domain under the terms given on the contents page.
Current flows

Figure 2 can be used to identify currently popular routes, but caution should be taken in assuming these will stay the same in the face of behaviour or infrastructure change.

The same model can be applied to new layouts and behaviour if recalibrated.

The current model is calibrated to DfT and Cardiff Council counts of cyclists at 121 locations (cross-validated fit 78%).
Current Accessibility

High numbers indicate higher quantity of destinations accessible within a fixed distance adjusted for barriers (slope and motor vehicle traffic).

Accessibility is directly correlated with increase in propensity to cycle. For example, 43% of variability in the decision to cycle to work is explained by cycling accessibility.

The city centre exhibits higher accessibility not because it lacks barriers but because of the higher number of destinations accessible from a short trip.

Figure 3 Current accessibility for cyclists
Conflicts

Figure 4 dates from a previous study of risk. The model is simpler, with cyclist behaviour assumed to be limited to trips of 3km or less (not adjusted), taking routes to avoid traffic and slope.

Black dots indicate all incidents reported to the police 2005-2012 involving at least one cyclist and at least one motor vehicle.

Conflict score indicates roads the model predicts are popular for both motor vehicles and cyclists. The cutoff for determining a risky (pink) road is chosen manually to identify 75% of dangerous sites and 73% of safe sites within the study area.

Cycle flow numbers are not calibrated hence show relative, not absolute flow predictions.
Cycle trip origins worst affected by motor vehicle traffic

Figure 5 is derived by comparing current accessibility (as shown in Figure 3) with accessibility as it would be without motor traffic.

Higher numbers (pink) indicate a greater increase in accessibility for trip origins, i.e. these are the areas in which cycling accessibility is currently worst affected by traffic.

The key areas affected are Ely, Fairwater, Whitchurch, Heath, Llanishen and Rumney. These areas are affected more than the city centre not because the centre lacks barriers, but because trips from outlying areas tend to be longer so any barriers along the route will have a greater effect on behaviour.
Figure 6 shows the bottlenecks, or pinch points, which are causing poor accessibility for the trip endpoints shown in Figure 5.

The figure is derived by simulating which links would experience the greatest increase in cycling if motor vehicles were absent. A cutoff is manually chosen to show outliers. This method is not precise, hence short links identified in purple which do not form part of a longer route are not likely to be significant.

Some existing traffic-free routes show an increase in use under the 'no vehicle' scenario, this is because the longer routes connecting to them are adversely affected by traffic at present.
Appendix: Technical Model Descriptions

Flow models
The models presented are based on a multivariate Betweenness centrality analysis with a hybrid distance metric and banded hybrid radius. See: http://www.cardiff.ac.uk/sdna/wp-content/downloads/documentation/manual/sDNA_manual_v3_4_beta2/analysis-spec.html
This is best conceptualised as being a combination of multiple agent models, representing the following trip types:

- Trips from everywhere to everywhere
- Trips from/to the densest quintile of network, e.g. the city centre (defined for modelling purposes as densest Link count within 2km on network)
- Trips from/to and along the Taff Trail (in Cardiff this represents a significant recreational destination in its own right)

Each trip type is itself represented by multiple agent models to account for different types of cyclist

- Light aversion to vehicle traffic (t=0.04 for sDNA cycle roundtrip metric)
- Medium aversion to vehicle traffic (t=0.06 for sDNA cycle roundtrip metric)
- Heavy aversion to vehicle traffic (t=0.08 for sDNA cycle roundtrip metric)

Each of the above is also represented by multiple models representing trips in different distance bands

- 0-3km adjusted round trip distance
- 3-5km adjusted round trip distance
- 5-8km adjusted round trip distance
- 8-11km adjusted round trip distance
- 11-15km adjusted round trip distance
- 15-20km adjusted round trip distance

Round trip distances are adjusted to account for the presence of slope, vehicle traffic and angularity as described for the CYCLE_ROUNDTRIP metric in the sDNA user manual. Trips are weighted by opportunity (inferred from network link density) hence this is an elastic demand model.

The models are calibrated to match available flow data using cross-validated ridge regression techniques. The combination of agent models explains 78% (cross-validated r2 weighted as GEH) of variation in link level cyclist flows.

Mode choice/Accessibility models
The mode choice/accessibility models are based on a simplified agent model of links accessible within a fixed, adjusted network radius from each origin. This is also an elastic demand model. The round trip distance is 13km adjusted for traffic, slope and angularity. Traffic aversion is light (t=0.04). This model explains 43% of variation in the decision to cycle to work based on Output Areas in the 2011 Census. Note that the journey to work accounts for a small fraction of cycling trip purposes, the remainder of which are not measured, but combined will represent more of the overall cycling volume than journeys to work. It is for this reason that a simplified model is employed so as not to over-represent the journey to work in the models.

Vehicle models
The vehicle model underlies the cyclist model and can be conceived of as a single agent model based on Angular betweenness in a Euclidean radius for a range of one-directional trip distances up to 28km. 81% of variability in link level vehicle flows is explained by this model.