A MATSim model for a low carbon future mobility in the UK context

The UK faces a considerable challenge in decarbonising transport. At Newcastle University, we are exploring the use of MATSim to meet that challenge and deliver a net zero transport future. In this abstract, we describe an ongoing PhD research project exploring the role of infrastructure interventions and behavioural changes to enable the use of sustainable transport modes in the Tyne and Wear region (North East of England). This PhD research project proposes four novel innovations to simulate transport scenarios with MATSim in the UK context: 1) a new, open-access and very detailed synthetic population methodology for any region in the UK; 2) a new network attribute ("quietness") inclusion ranking links for cycling based on their built characteristics; 3) a bicycle contribution code update to consider the "quietness" attribute; and 4) tailored "stick" and "carrot" scenarios to test urban mobility policies to enable the agents to use active travel modes (walking and cycling) instead of private motor vehicles in the area of study.

The fundamental underpinning of transport Agent-Based Models (ABMs) is a synthetic population of agents that represent transport demand in the model region, with individual socio-demographic characteristics and activity plans. Socio-demographic attributes were generated combining two open-source tools: SPENSER (Lomax et. al, 202) and synthetic_population_dev (Alvarez, 2023). The first generates a synthetic population with four attributes (age, sex, ethnicity group and household ID), using 2011 UK census data that can be projected up to the year 2040 (in our case, 2019). The latter, allows generating eight additional attributes to define family dependencies (marital status, children dependency), spending power (economic activity, occupation, annual gross income) and mobility access (driving license, car access and bicycle access), based on 2011 UK census and 2019 statistical data. The implementation of these eight attributes is a fundamental task to represent individuals more accurately and to assign them activity plans based on their characteristics. The activity plans were obtained from the National Travel Surveys (NTS), the primary source of data on personal travel patterns by residents of England, providing information on how, why, when and where people travel, factors affecting travel, and individual socio-demographic characteristics. Individuals from the synthetic population were matched with NTS individuals based on similar socio-demographic characteristics. The assumption was that individuals with similar socio-demographic attributes perform similar activities during a typical working day. Additionally, individuals from the same household in the synthetic population were matched, whenever possible, with NTS individuals sharing the same household to allow interactions between individuals from the same dwelling (e.g. a parent accompanying a child to school). This provides a more realistic representation of the population during their daily activities. Geospatial locations were assigned applying Spatial Interactions Modelling (SIM) techniques, where competitiveness, attractiveness and distances between previous and following activities were considered, using OpenStreetMap (OSM) buildings classified with OSMOX (Arup, 2021) in different categories, based on their tags. Additionally, individuals from the same household and sharing activities (e.g., a child going to school and an adult accompanying the child) were set to go to the same location.

Once the synthetic population was generated, a combination between the road network used by the agents and the public transport information of the area of study was required. Roads were extracted from OSM, while public transport information was obtained from UK GTFS datasets. Elevation data was incorporated to nodes and gradient to links, using a 10-meter resolution Digital Elevation Model (DEM). Additionally, a new "quietness" attribute (Cyclestreets, 2023) was added to the network. It ranks each link for cycling purposes depending on its characteristics (e.g., road type, cycle infrastructure, path width, barriers, surface type and quality, kerbs). The values are ranked between 0.0 to 1.0, being 0.0 very bad conditions for cycling (e.g., motorway) and 1.0 excellent (e.g., dedicated cycle path). To include this information in the model, MATSim's bicycle contribution code (Ziemke, 2019) was updated during a research stay at Technical University of Dresden (TUD).

Once synthetic population and network were generated, a MATSim scenario with a 20% sample population (around 200,000 agents) was set up. Public transport modes were simulated based on their schedules (i.e., deterministic), allowing walking access and egress to all transit stops, and also cycling to railway stations. The updated bicycle contribution code was enabled, with the new "quietness" and the existing "gradient" values used. Their values were calibrated until results showed that agents were choosing smooth (based on the gradient) and safe (based on the quietness) routes, being validated against real bicycle counts in specific links in the area of study.

The base-case scenario was calibrated and validated against external statistical datasets (e.g., transport split modes; average trip time and distance by transport mode; transport split modes when commuting to work only; percentage of commuting trips per range of distance; average trip time and distance for educational purpose; vehicle counts per hour in different roads; and percentage of vehicles en-route per hour) from different sources (DfT, TADU, NTS). Currently, the project is at this stage. The model will be considered validated and ready to test different urban mobility policies when differences between simulated results and statistical data are minimum.

The tailored urban mobility policies to simulate have been classified in two categories: "stick" and "carrot". The first are those where the agents are penalised when using private motor vehicles, while the latter are those where the agents are rewarded or offered new alternatives to use active modes. On the one hand, "stick" policies are two: the definition of Low Traffic Neighbourhoods (LTNs), where access restrictions in residential areas will apply to those agents using cars; and distance-based tolling or "pay-as-you drive", where the agents will pay a monetary penalty per kilometre driven. On the other hand, "carrot" policies are three: the implementation of fully segregated and safe cycle paths in the area of study, reducing the capacity of each link proportionally; a monetary reward per kilometre walked or cycled; and the implementation of secure cycle hubs next to Metro stations to allow the use of bike and metro combined in trips. Results from each scenario will be compared against the base-case scenario to identify differences in agents' behaviour and explore shifts towards sustainable modes of transport. Criteria to assess the success or failure of the simulated policies could include the reduction in the number of vehicles on the roads, the reduction of carbon emissions generated, or the change in the number of kilometres walked/cycled by agents and their impact in the economy and health.

References

Alvarez, David. "synthetic_population_dev" tool. https://github.com/DACNC/synthetic_population_dev. Accessed on 14/06/2023

Arup, 2021. Osmox tool. https://github.com/arup-group/osmox/tree/main. Accessed on 14/06/2023

Cyclestreet, 2023. https://www.cyclestreets.net/ Accessed on 14/06/2023

Lomax, Nik, et al. "An Open-Source Model for Projecting Small Area Demographic and Land-Use Change." Geographical Analysis 54.3 (2022): 599-622. https://doi.org/10.1111/gean.12320

Ziemke, Dominik, Simon Metzler, and Kai Nagel. "Bicycle traffic and its interaction with motorized traffic in an agent-based transport simulation framework." Future Generation Computer Systems 97 (2019): 30-40. https://doi.org/10.1016/j.future.2018.11.005