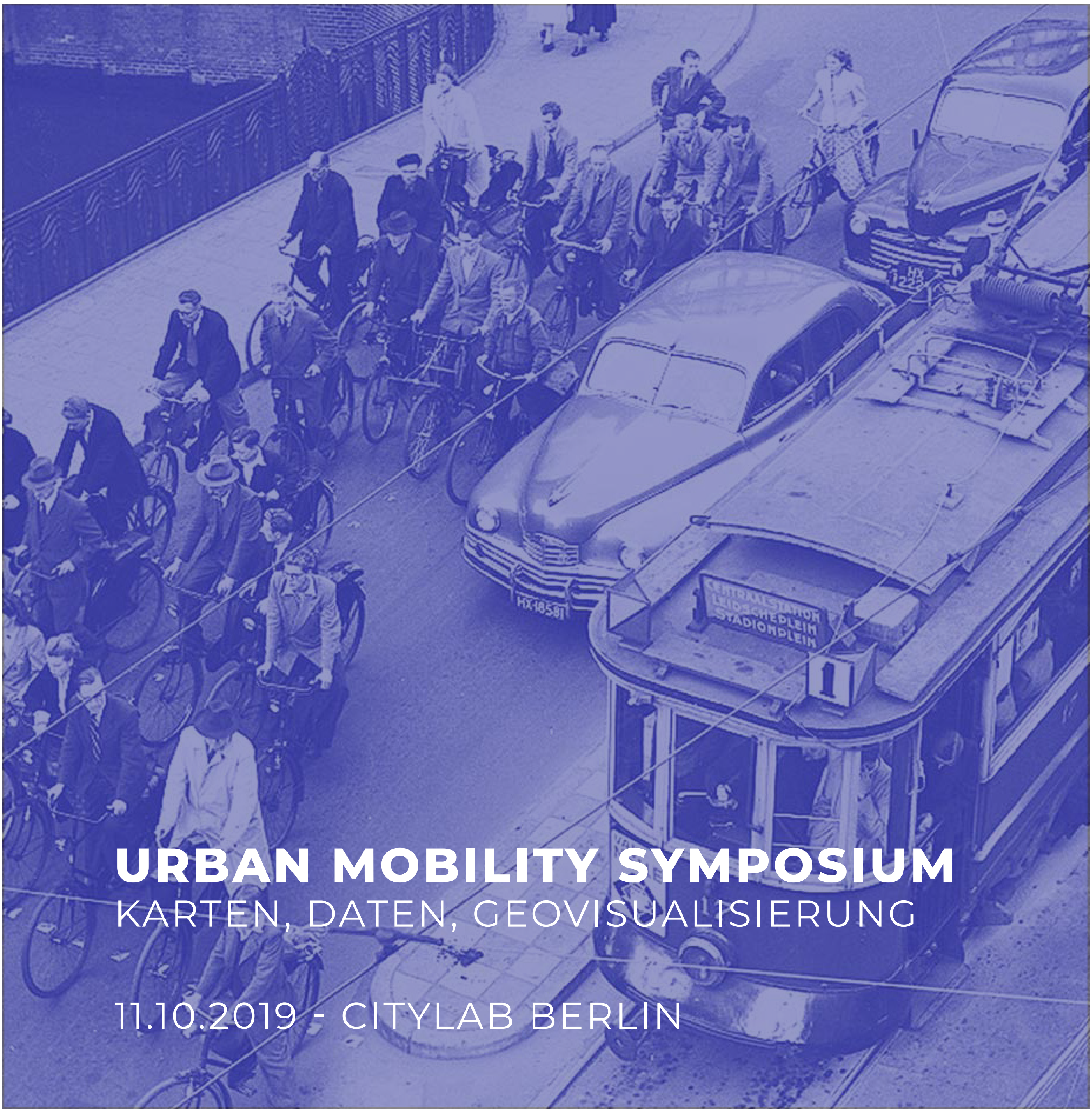


URBAN MOBILITY SYMPOSIUM

KARTEN, DATEN, GEOVISUALISIERUNG

11.10.2019 - CITYLAB BERLIN

Organisiert durch:

TECHNOLOGIE STIFTUNG BERLIN

HCU HafenCity Universität Hamburg

DGfK

Der Regierende Bürgermeister von Berlin Senatskanzlei | be Berlin

Die Veranstaltung wird finanziell unterstützt durch
den Regierenden Bürgermeister von Berlin — Senatskanzlei.

INHALT

PROGRAMMAUSSCHUSS

VORSITZ

Sebastian Meier, Technologiestiftung Berlin
Johannes Kröger, HafenCity University, Hamburg

MITGLIEDER

Sigrun Beige, Telefónica NEXT — Location & Mobility Analytics
Marian Dörk, Fachhochschule Potsdam
Julia Gonschorek, EASC eV.
Anita Graser, Austrian Institute of Technology, Wien
Katharina Jacob, Fachhochschule Potsdam
Alexandra Kapp, Technologiestiftung Berlin
Felix Kunde, Zalando
Nicolas Neubauer, HERE, Berlin
Charlotte Pusch, Technische Universität Hamburg
Raphael Reimann, Moovel
Jochen Schiewe, HafenCity University, Hamburg
Harald Schernthanner, Universität Potsdam
Lucia Tyrallova, Universität Potsdam

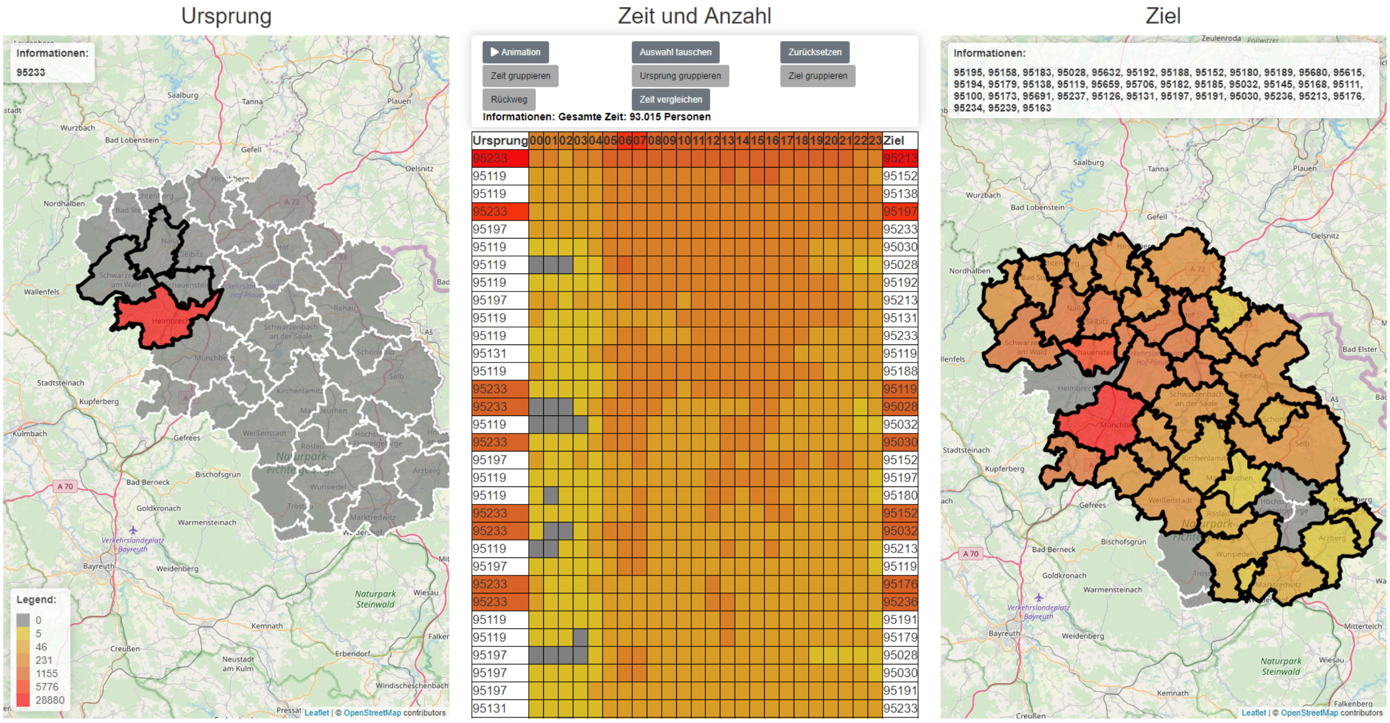


Abbildung 2. Betrachten einer Region auf der linken Karte.

Christoph Menzel (christoph.menzel.2@gmail.com)
Hochschule für Angewandte Wissenschaften Hof

VISUALISIERUNG DES BEWEGUNGS-VERHALTENS MIT EINER ERWEITERTEN FLOWSTRATES DARSTELLUNG ANHAND DER MODELLREGION HOCHFRANKEN

Keywords: Visual Analytics, Bewegungsdaten, Flowstrates

1. EINLEITUNG

Dieses Paper befasst sich mit der visuellen Unterstützung der Analyse des Bewegungsverhaltens in der Modellregion Hochfranken. Dazu sind die Veränderungen des Bewegungsverhaltens im Verlauf eines Tages zwischen Regionen relevant sowie Unterschiede zwischen Bewegungsdaten aus zwei verschiedenen Zeiträumen oder Quellen. Die Visualisierung des Bewegungsverhaltens ist ein wichtiges Hilfsmittel der Analyse. Aus den genannten Kriterien für die Analyse lassen sich folgende Fragestellungen für die Visualisierung ableiten, die in diesem Paper beantwortet werden:

- Wie kann der zeitliche Verlauf von Bewegungen veranschaulicht werden?
- Wie lässt sich ein Verhältnis zwischen aus- und eingehenden Bewegungen darstellen, wenn mehrere Regionen gegenübergestellt werden?
- Wie kann ein Vergleich zwischen zwei Datensätzen visualisiert werden?

Für die aufgeführten Fragestellungen werden in Kapitel 2 vorhandene Visualisierungen auf deren Eignung geprüft. Die ausgewählte Darstellung wird in Kapitel 3 beschrieben und es werden hinzugefügte Funktionalitäten aufgezeigt, die für die Beantwortung der aufgeführten Fragestellungen erforderlich sind. In Kapitel 4 wird anhand einer Fallstudie auf Basis der Region Hochfranken exemplarisch aufgezeigt, wie die Visualisierung zur Analyse des Bewegungsverhaltens genutzt werden kann. Abschließend werden die Ergebnisse zusammengefasst und ein Ausblick auf zukünftige Erweiterungen gegeben.

2. STAND DER WISSENSCHAFT

Die Herausforderung bei der Visualisierung von Bewegungen besteht darin, räumliche und zeitliche Informationen verständlich und übersichtlich abzubilden. Es existieren statische Darstellungen wie Flow Maps (Tobler, 1987) oder Edge Bundling (Holten et al., 2009), die keine zeitlichen Aspekte aufweisen. Mit animierten Darstellungen kann der zeitliche Verlauf aufgezeigt werden (Becker et al., 1995). Bei vielen Bewegungen und Regionen ist dies unübersichtlich und schwer nachverfolgbar. In einem interaktiven Ansatz wie MobilityGraphs (von Landesberger et al., 2016) mit separaten Darstellungen für die zeitliche und räumliche Komponente sind alle Informationen vorhanden. Dieser erfordert jedoch tiefere Einarbeitung durch den Anwender. Mit Flowstrates (Boyandin et al., 2011) existiert eine interaktive Darstellung, um Bewegungen anhand zeitlicher und räumlicher Kriterien übersichtlich und detailliert darzustellen.

3. FLOWSTRATES

3.1 Definitionen

Bevor die Anwendung im Detail betrachtet werden kann, ist die Definition folgender Begriffe erforderlich:

- Bewegung: Ortsveränderung von Personen zwischen zwei unterschiedlichen Regionen.
- Zeitabhängige Bewegung: In einem bestimmten Zeitintervall startende Bewegung.
- Bewegungsverhalten: Alle in einem Datensatz vorkommenden Bewegungen.
- Stärke einer Bewegung: Anzahl der sich bewegenden Personen.
- Auswählen: Temporäres Einschränken der Ursprungs- und/oder Zielregionen durch den Anwender.
- Betrachten: Untersuchen einer Region, eines Zeitintervalls oder einer Bewegung. Die tatsächliche Auswahl bleibt unverändert.

3.2 Aufbau der Darstellung

Flowstrates weist eine vertikal dreigeteilte Ansicht auf. Auf der linken und rechten Seite befindet sich je eine Karte. Die linke Karte ist für ausgehende, die rechte Karte für eingehende Bewegungen zuständig. Zwischen beiden Karten befindet sich eine Tabelle, deren Zeilen die Bewegungen von einer Ursprungs- in eine Zielregion repräsentieren. Durch die Spalten der Tabelle erfolgt eine Unterteilung in Zeitintervalle. Jede dabei entstehende Zelle stellt eine zeitabhängige Bewegung dar. Je nach deren Stärke wird eine farbliche Unterscheidung vorgenommen. Das Betrachten einer zeitabhängigen Bewegung in der Tabelle hat zur Folge, dass die beiden beteiligten Regionen der Bewegung auf der jeweiligen Karte anhand der Stärke der zeitabhängigen Bewegung eingefärbt werden, wie in Abbildung 1 dargestellt. Durch das Auswählen einer oder mehrerer Regionen auf den Karten ist es möglich, die Tabelle auf die jeweiligen Bewegungen zu beschränken. Bei jeder Auswahl des Anwenders wird die Tabelle erneut aufgebaut, wodurch die Farbwerte im Kontext der aktuellen Auswahl neu berechnet werden.

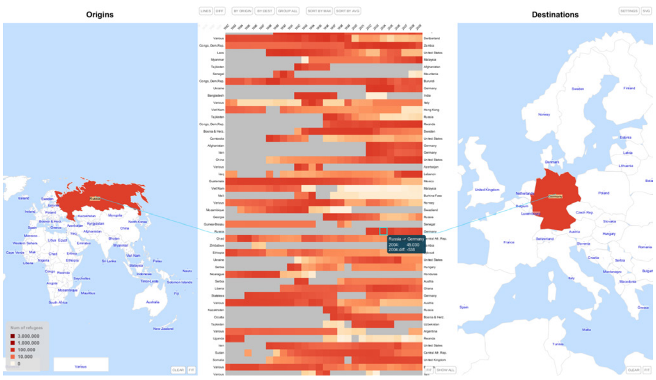


Abbildung 1. Ursprüngliche Flowstrates Visualisierung, in welcher die Ursprungsregion (links) und Zielregion (rechts) anhand der Stärke der betrachteten zeitabhängigen Bewegung eingefärbt werden. In der Tabelle (Mitte) befinden sich die Bewegungen untereinander, vertikal zeitlich unterteilt. (Boyandin et al., 2011)

3.3 Verbesserungen des ursprünglichen Ansatzes

Mit dem ursprünglichen Ansatz kann geklärt werden, ob und wie sich die Bewegungsstärke im zeitlichen Verlauf verändert. Mit veränderten Funktionalitäten kann dies detaillierter beantwortet werden. Um Datensätze miteinander zu vergleichen oder das Verhältnis zwischen aus- und eingehenden Bewegungen zu bestimmen, müssen neue Funktionalitäten ergänzt werden.

3.3.1 Gesamtstärke der Bewegungen

Im ursprünglichen Ansatz besteht keine Möglichkeit, die Stärke von Bewegungen, unabhängig des Zeitintervalls, anzuzeigen. Dies wurde ergänzt, da sich daran in einem ersten Schritt erkennen lässt, welche Regionen über den gesamten Zeitraum am häufigsten als Ursprung oder Ziel dienen.

3.3.2 Betrachten einer Region

Beim Betrachten einer Region auf der Karte werden die beteiligten Zeilen der Tabelle farblich anhand der Bewegungsstärke während des gesamten Zeitraums markiert. Außerdem werden alle betroffenen Regionen auf der entgegengesetzten Karte in denselben Farben eingefärbt. In der Kartenansicht der betrachteten Region wird diese farblich anhand der Gesamtstärke aller betroffenen Bewegungen gekennzeichnet, was in Abbildung 2 zu erkennen ist. Die drei weiteren schwarz umrahmten Regionen auf der linken Karte sind hervorgehoben, weil diese Teil der vom Anwender getroffenen Auswahl sind. Bei weiß umrahmten Regionen auf der rechten Karte existieren keine Bewegungen aus der Ursprungsregion. Des Weiteren besteht die Option, ein Zeitintervall festzulegen. Beim Betrachten einer Region erfolgt dann die Färbung der Regionen in beiden Karten ausschließlich anhand der Stärke der zeitabhängigen Bewegungen.

3.3.3 Animation

Obwohl in Kapitel 2 aufgeführt wird, dass Animationen als alleinige Visualisierung ungeeignet sein können, lässt sich Flowstrates um eine solche Option erweitern. Es wird eine Einfärbung der Regionen anhand der Stärke der Bewegungen im jeweiligen Zeitintervall vorgenommen. Die Animation der Bewegungen berücksichtigt die vom Anwender getroffene Auswahl. Da der Anwender einzelne Bewegungsinformationen interaktiv untersuchen kann, dient die Animation als unterstützende Komponente.

3.3.4 Rückweg

Mit entgegengesetzten Bewegungen lassen sich Regionen in ein Verhältnis stellen. Für jedes Zeitintervall wird anhand der ausgewählten Regionen die Differenz zwischen aus- und eingehenden Bewegungen berechnet. Ist die berechnete Bewegungsstärke negativ erfolgt das Einfärben in Komplementärfarben, siehe Abbildung 3.

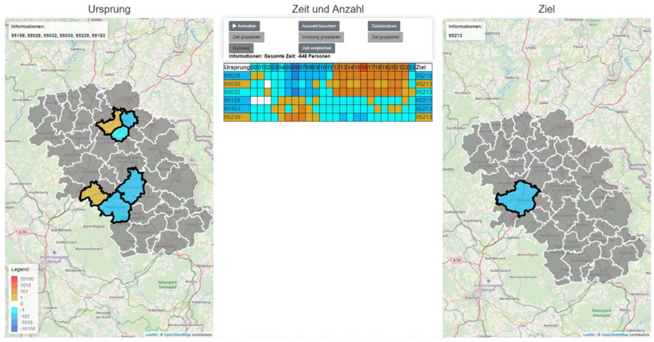


Abbildung 3. Vergleich zwischen Hinweg und Rückweg ausgewählter Bewegungen über den gesamten Zeitraum. Ist die Stärke der ausgehenden Bewegung größer als die der eingehenden, wird dies in Orangetönen dargestellt, andernfalls in Blautönen.

3.3.5 Vergleich zweier Datensätze

Um Unterschiede im Bewegungsverhalten zwischen zwei Datensätzen aufzuzeigen, wird die Anwendung um eine Vergleichsfunktionalität ergänzt. Voraussetzung dafür ist, dass beide Datensätze ein einheitliches Datenschema nutzen, was verwendete Zonierung und Zeitintervalle betrifft. Differenzen in der Bewegungsstärke zwischen beiden Datensätzen werden farblich dargestellt. Erhöht sich die Bewegungsstärke werden Orangetöne verwendet, verringert sich die Bewegungsstärke Blautöne.

4. Auswertung der Ergebnisse anhand der Fallstudie Hochfranken

4.1 Datenbasis

Die Arbeiten dieses Papers sind im Rahmen des Forschungsprojektes Mobilität Digital Hochfranken entstanden, in welchem das Bewegungsverhalten in der Modellregion Hochfranken analysiert wird. Als Datenbasis dienen Bewegungsdaten von Mobiltelefonen eines Telekommunikationsunternehmens, welche aus einem Analysezeitraum vom 01. bis 29. März 2017 stammen. Es sind ausschließlich stündliche Bewegungen für die Wochentage Montag bis Donnerstag aufgeführt. Die Bewegungen wurden auf Ebene der Postleitzahlengebiete erfasst. Bewegungen, die nur eines der beiden Gebiete als Ursprungs- bzw. Zielregion aufweisen, sind ebenso wie Durchgangsverkehr nicht enthalten. Mit Erkenntnissen aus dem Projekt sollen Simulationen erstellt werden, bei denen das tatsächliche Bewegungsverhalten nachempfunden wird.

4.2 Veränderung der Bewegungsstärke

Mit der Darstellung kann festgestellt werden, dass sich die Bewegungsstärke im Verlauf eines Tages deutlich ändert. Besonders morgens und zwischen Mittag und Nachmittag sind gesamtheitlich die meisten Bewegungen vorzufinden. Die in Abbildung 2 getroffene Auswahl deutet diese Verhaltensweise an. Da die Daten für Wochentage ermittelt wurden, könnte dies auf Bewegungen zu Schulen oder Arbeitsplätzen zurückzuführen sein. Vormittags, abends und nachts finden vergleichsweise weniger Bewegungen statt. Außerdem weisen städtische Gebiete mehr Bewegungen auf als ländliche. Die hinzugefügten Funktionalitäten aus Abschnitt 3.3.1 bis 3.3.3 unterstützen den Anwender bei der Analyse des Bewegungsverhaltens.

4.3 Rückweg

Die beschriebene Ansicht des Rückweges gibt das Verhältnis aus- und eingehender Bewegungen zwischen Regionen an. In Abbildung 3 ist erkennbar, dass sich die oberen drei Bewegungen im zeitlichen Verlauf deutlich von den unteren drei unterscheiden. Die oberen drei zeigen Bewegungen zwischen Münchberg und den drei Postleitzahlengebieten der Stadt Hof, die unteren drei zwischen Münchberg und peripehereren Regionen. Morgens finden von Münchberg in die Stadt Hof mehr Bewegungen statt als entgegengesetzt. Ab Mittag kehrt sich dieses Verhältnis um. Bei den anderen drei Bewegungen zeichnet sich ein gegensätzliches Bild ab. Das vermehrte Aufkommen von Schulen und Arbeitsplätzen in Hof im Vergleich zu Münchberg, aber wiederum im Vergleich von Münchberg zu den peripheren Regionen, könnte eine Ursache dessen sein.

4.4 Vergleich zweier Datensätze

Der Vergleich zweier Datensätze soll im Projekt dafür genutzt werden, das Bewegungsverhalten beispielsweise zu unterschiedlichen Jahreszeiten oder im Vergleich zwischen Wochentagen und Wochenende zu analysieren. Die im Rahmen des Projektes erstellten Simulationen können mit den tatsächlichen Bewegungen verglichen werden. Mit der Darstellung besteht die Möglichkeit, die Ergebnisse der Simulation zu verifizieren, da stark abweichende Ergebnisse deutlich auffallen.

5. Fazit

Durch die dreigeteilte Darstellung besteht eine anschauliche und strukturierte Übersicht, um Bewegungen über einen zeitlichen Verlauf zu analysieren. Die anfangs aufgeführten Fragestellungen lassen sich mit den ergänzten Funktionalitäten beantworten. Das Betrachten einer Region auf der Karte ermöglicht es, die zugehörigen Zielregionen auf der entgegengesetzten Karte anhand der entsprechenden Bewegungsstärke hervorzuheben. Durch das Animieren der Bewegungen werden Veränderungen der Bewegungsstärke im zeitlichen Verlauf zusätzlich herausgestellt. Mit der Rückwegsansicht können Regionen in Relation zueinander gestellt werden. Damit wird das Verhältnis von aus- und eingehenden Bewegungen deutlich, wodurch sich Rückschlüsse auf die Infrastruktur einer Region ziehen lassen. Es ist möglich, Datensätze zu vergleichen, wodurch starke Abweichungen in komplementären Farben ersichtlich werden. Dies kann bei der Analyse des Bewegungsverhaltens zu unterschiedlichen Zeiträumen, aus verschiedenen Datenquellen oder zum Vergleich mit Simulationsergebnissen genutzt werden. Erkenntnisse, die aus der Darstellung hervorgehen, lassen sich beispielsweise für den öffentlichen Personennahverkehr nutzen, um zu verifizieren, ob sich deren Routen mit häufig aufgesuchten Bewegungen decken bzw. ob angebotene Abfahrtszeiten während Intervallen mit hoher Bewegungsstärke stattfinden. Weiterführend wäre eine offene Frage, wie eine dynamische Zonierung der Regionen erreicht werden kann, um fein- und grobgranularere Analysen durchzuführen.

6. Referenzen

Becker, R. A., Eick, S. G., & Wilks, A. R. (1995). Visualizing network data. IEEE Transactions on Visualization and Computer Graphics, 1(1), 16–28.

Boyandin, I., Bertini, E., Bak, P., & Lalanne, D. (2011). Flowstrates: An Approach for Visual Exploration of Temporal Origin-Destination Data. Computer Graphics Forum, 30(3), 971–980.

Holten, D., & van Wijk, J. J. (2009). Force-Directed Edge Bundling for Graph Visualization. Computer Graphics Forum, 28(3), 983–990.

von Landesberger, T., Brodkorb, F., Roskosch, P., Andrienko, N., Andrienko, G., & Kerren, A. (2016). MobilityGraphs: Visual Analysis of Mass Mobility Dynamics via Spatio-Temporal Graphs and Clustering. IEEE Transactions on Visualization and Computer Graphics, 22(1), 11–20.

Tobler, W. R. (1987). Experiments In Migration Mapping By Computer. The American Cartographer, 14(2), 155–163.

[33] World Air Map by Plume Labs. Available: https://air.plumelabs.com/en/. [Accessed 23-Aug-2019]

[34] N. Yau, "Visualizing Incomplete and Missing Data", FlowingData, 30-Jan-2018. Available: https://flowingdata.com/2018/01/30/visualizing-incomplete-and-missing-data/. [Accessed: 20-Jun-2019]

[35] Yellow Dust. Available: http://yellowdust.intheair.es/. [Accessed 21-Jun-2019]

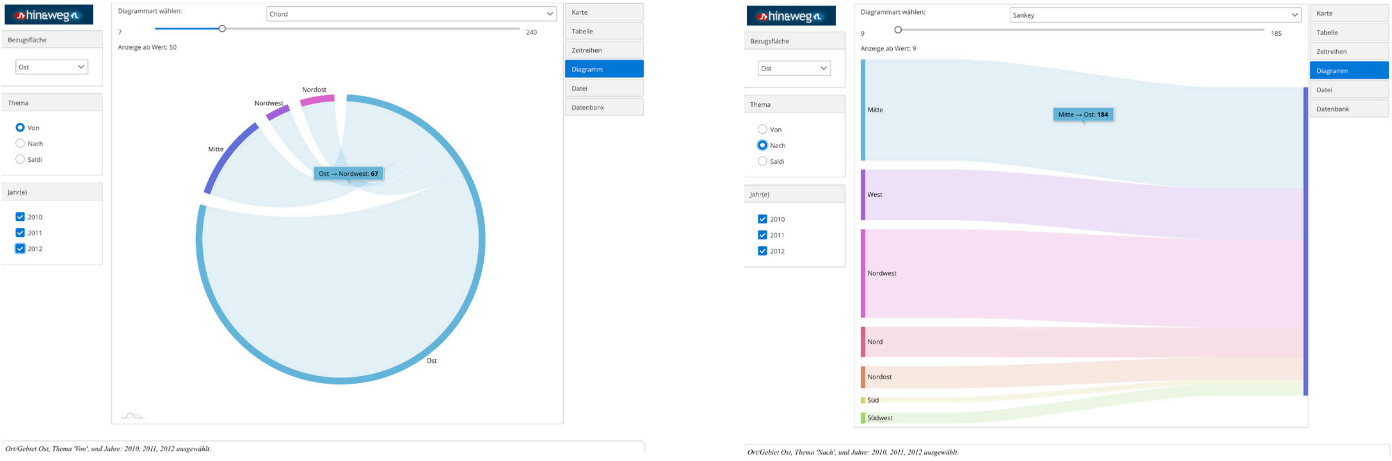


Figure 4. Chord and sankey diagrams in the alpha version of hin&weg software.

Maria Turchenko (m_turchenko@ifl-leipzig.de) & Francis Harvey (f_harvey@ifl-leipzig.de)
Leibniz Institute for Regional Geography

HIN&WEG — ANALYSIS AND VISUALISATION TOOLS FOR THE STUDY OF URBAN AND REGIONAL MIGRATION DATA

Keywords: analysis tools, visualisation tools, statistical migration data, origin-destination, participatory design

1. INTRODUCTION

The digitalisation of public administrations opens up many intriguing possibilities for improving the use of demographic data. The complexity of this data means visualisation tools are frequently required and ideally coupled with analysis functionality to support analysis. In the hin&weg project we are developing an innovative and integrated analysis and visualisation application (also called hin&weg) for administrative work with urban and suburban migration information from official registry data. The analysis and visualisation of the administrative statistical records on migration, inner-city movements and commuting can help reveal changes and help develop valuable insights into transformations and the processes, such as of neighbourhood gentrification and up- and downgrading. This tool is also helpful for understanding demographic changes and their impacts, e.g., changing demands of the transportation networks (Andrienko et al., 2017). While technologically the challenges in this application are (at the moment) not ground-breaking nor cutting edge developments, the application address the almost complete absence of any software to support time/space analysis integrated with visualisation of official demographic data. Following a participative design approach that aims to assure the basic suite of analysis and visualisation tools is useful for administrative staff, the data architecture we develop in the first phase can support further extensions and technological developments that support new modes of use among staff, and ideally, the general public. Due to the protected nature of official registry data, the software we develop currently can be deployed also on individual and isolated computers, e.g., in a statistical office. Often municipalities lack the tools to visualise and analyse such complex data. This suggests that having an application like hin&weg alone will be innovative for most cities. We describe in this paper and presentation the software architecture and preliminary functionality, which we will developing in the coming 18 months with cities participating in the hin&weg project.

2. BACKGROUND

The project hin&weg in Leibniz Institute for Regional Geography (IfL) involves the development of tools for the analysis and visualisation of this administrative data. It is an ongoing research project (2019-2021). It will produce in a cross-platform software package. The development cooperates with participants from ten German cities, the German Institute of Urban Affairs (Difu) in Berlin and software development company Delphi IMM from Potsdam.

Visualisations help city statisticians, city planners and other expert municipal actors identify patterns and flows to support decision-making processes (Ding et al., 2018). Such visualisations can also reach political decision makers and the interested public to help them gain insight into recent and even ongoing processes. Coupling analysis with visualisations has been very successful (Rudwick, 1976; Ware, 2008; Börner, 2015; Tversky, 2019)

Precursors of the current hin&weg project can be traced back to 2004. It went through several versions with different architectures and functionalities, but all of them were built around the concept of data visualisation combined with analytical functionality (figure 1). The data was added manually by the professional staff at IFL and users were not able to perform import by themselves.

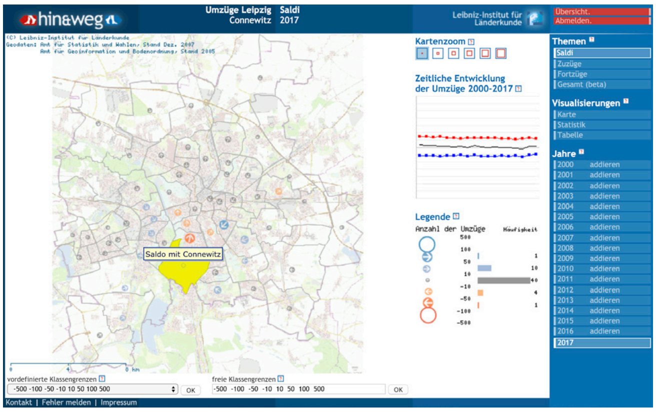


Figure 1. A previous version of the hin&weg from 2017.

The current version, under development, integrates analysis and visualisation tools from the previous versions. They should be simple enough for elementary uses and help facilitate the visualisation of diverse urban and regional registry data to help with analysis and development of policy. It uses a very different software architecture and implementation.

3. CURRENT HIN&WEG SOFTWARE ARCHITECTURE

The software development follows the principles of modularity and uses node.js modules (nodejs.org) and JavaScript libraries. It is built with the Electron framework (electronjs.org). The development follows a model-view controller pattern, which facilitates the separation of data handling from data representation. This pattern allows us to produce several different front-end outputs from the OLAP data cube (npmjs, 2018). The software includes models of geodata, table attributive data, a combiner and a time-related aggregation model. Data representations are provided through several views (map, table, line graph, diagrams and database), described in detail later.

The generic space/time representation of the hin&weg data follows the geo-relational model (De Paoli and Miscione, 2011; Chrisman, 2006) extended through the data cube to support time series analysis. Following this model, hin&weg data consists of geographic data linked to attribute data based on the shared id of the administrative areas. The current import format for the geodata is shapefile (geojson remains a possibility) and the attributive data must be provided as a csv-file with header information for future meta-data fields (e.g., attribute names, time periods, etc).

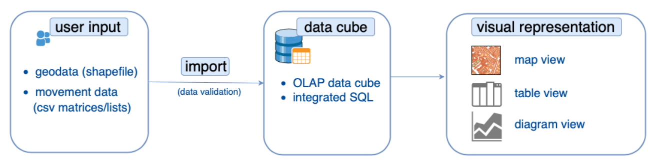


Figure 2. Simplified overview of hin&weg data processing.

To provide not only a visual representation of the data, but to support its exploration and knowledge discovery interactive visualisations are combined with an analytical functionality in the hin&weg interface (figure 3). It is built with d3.js in combination with react.js and ramda.js.

4. PROJECT DEVELOPMENT CYCLE

The project development cycle for this version of hin&weg commences in August 2018 and will last three years. It includes three stages of software development: alpha, beta and release versions. Each version will be developed in a one-year period.

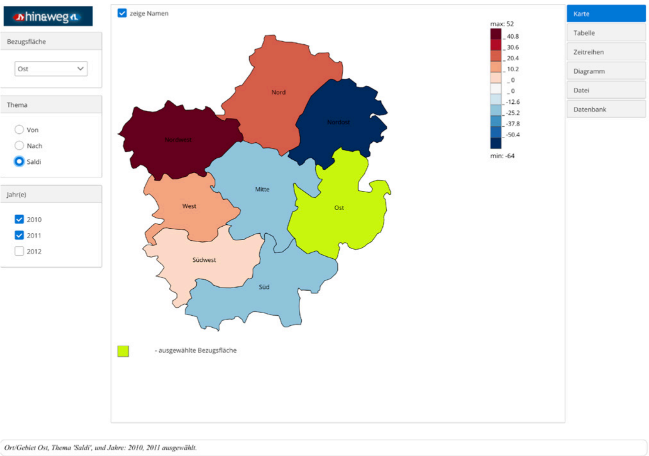


Figure 3. hin&weg alpha version interface.

The focus of the Alpha-Version is the development of the stable data import and its storage and retrieval. Currently the Alpha-Version is with participating cities for testing. At this point we can only provide more details about the Alpha-Version and our first ideas for the Beta-Version. During the Alpha-Version development we resolved some important challenges for data import. Administrative registry data comes in the form either of lists or matrices with numerical values for demographic characteristics according to origin/destination or cumulative values. It can include several attributes, such as gender, age, marital status, etc. Some matrices indicate calculations of changes between specific data collection time points. Others record just the observations and the calculations remain to be done. Both involve different data-handling, even though the analysis and visualisations are in the end identical. These involve issues to resolve as well in the future.
The import function is designed to be easy and understandable for the administrative workers. Thus, the system will alert error messages with explanations if ids are not identical in both data sources, or if the formatting of the data does not correspond to the established format. It is possible to upload more than one tabular data file, each representing one year time interval. Map view represents data as choropleth map visualisation of the incoming and outgoing flows. The current Alpha-Version only supports an equal intervals classification. For analysis, the user chooses the administrative area by clicking on the map or from the dropdown list. He should also choose the representation mode: outgoing/incoming flow or differences. Additionally, he should choose the years for analysis. The data for the chosen years will be aggregated for each administrative unit.
There are three diagram types built-in the Alpha-Version. These are bar chart, sankey diagram and chord diagram (figure 4). The diagrams have mouseover information windows and can be filtered with a slider showing only the highest values of the flows. The table view represents data in form of table with three columns: origin, destination and value. The data here can be re-ordered and filtered. All the diagrams and table are responsive for the user's selection of administrative area, representation mode and years.
A line graph covers the whole time period of the imported data and has mouseover functionality, showing exact values for incoming, outgoing flows and their difference. Database view include basic SQL-query functionality.
The Beta-Version will focus on improving import process, developing export functionality and additional visualisations and analytical functions. Also, the future development includes creating a windowing system for user interface allowing users to decide how many different visualisations they want to have at the screen at the same time and realign them. The second cycle of development begins after a workshop with the participating cities in November 2019 to prioritise and fine-tune functionality. These developments are at first glance technologically modest, but have vast innovative potential in city/communal administrations. In this context, data protection and its implementation are important to mention. Reflecting the high emphasis placed in city administrations on data security, hin&weg is a stand-alone software with an internalised data store that does not require an internet connection. The software is available for Mac, PC and Linux (Ubuntu) operating systems.

5.PARTICIPATORY DEVELOPMENT OF HIN&WEG

The meaningful representation of this data to politicians or public is a way to support the productive dialog between all participating parties (Boyandin et al., 2011; Contreras-Ochando et al., 2018). This theory has been demonstrated many times by academics (Jankowski and Nyerges, 2003). It is the innovative emphasis of the hin&weg software. Because of city/communal control of data and stringent legal requirements, the project stakes out no specific public access ambitions beyond developing a publicly available version of hin&weg. The specifics of the public version will be discussed and determined in the coming two years with the project advisory board. The cities and communes have completely flexibility in this regard. The software could be provided online, installed on public kiosks, etc. Data access can also be handled flexibly. Currently, we need to strive to develop needed functionality for the cities and communes. It is important to take a piece of humble pie and recognise we know little how cities carry out the analytical and related visual work required and desired using information technology. Hence, the participatory process emphasises the involvement of practitioners who determine how to best support planning processes, consider which visualisation types and types of user interactions are preferable (Spinuzzi, 2005; Sanders & Brandt, 2010). For example, we face questions that include: do city staff tend to analyse the data in tables, visualisations, work with both, or develop feedback loops among analysis processes and visualisation processes? Or, is there no clear and dominant approach, but the actual choice is dominated by other parameters (experience, work culture, IT-skills, etc)? How much variation do we find? The participation of city administration staff will shed light on this in the coming months.

The common method of a participatory design is a whole day workshops with the stakeholders and other interested parties of the future software. The first hin&weg workshop took place in March 2019 as a focus group discussion and was focused on defining data formats, basic preferable visualisation types and analytical functions. The next 'user-workshop' for Alpha-Version users will held in November 2019. In the following 18 months we will be using established usability testing formats including focus groups, in-situ software walk-throughs, A/B questions, questionnaires and telephone interviews. Usage of several different methods has been proven to provide a better overview and more insights. (Kuniavsky, 2003).

The final version of the software will be distributed at the concluding workshop in mid-2021. Software and data license arrangements, or their absence (open), will be determined in the project advisory group by this point.

6. RESULTS AND OUTLOOK

At this stage in the project, this paper and corresponding presentation provide basic information about software aspects of the ongoing hin&weg project. The participatory approach emphasises the innovative potential of this software to support analysis and formulation of policy in completely new ways, which can help guide a more liveable and innovative city planning.

The final product of the project is a multi-purpose hin&-weg application. This presentation describes the principles and the concepts behind the development of the hin&weg analysis and visualisation tools and explains the participatory process. By helping create a useful analysis and visualisation tool, we believe hin&weg will contribute to the digitalisation of German city administration and open up new possibilities for participation. We look forward to sharing more information about hin&weg in the coming years.

7. REFERENCES

Andrienko, G., Andrienko, N., Chen, W., Maciejewski, R., & Zhao, Y. (2017). Visual analytics of mobility and transportation: State of the art and further research directions. IEEE Transactions on Intelligent Transportation Systems, 18(8), 2232-2249.

Börner, K. (2015). Atlas of knowledge : anyone can map. Cambridge, Massachusetts: The MIT Press.

Boyandin, I., Bertini, E., Bak, P., & Lalanne, D. (2011, June). Flowstrates: An approach for visual exploration of temporal origin-destination data. In Computer Graphics Forum (Vol. 30, No. 3, pp. 971-980). Oxford, UK: Blackwell Publishing Ltd.

Chrisman, N. R. (2006). Charting the unknown. Esri Press.

Contreras-Ochando, L., Font-Julián, C. I., Nieves, D., & Martínez-Plumed, F. (2018). How Data Science helps to build Smart Cities: Valencia as a use case. In Conference on Small and Medium Smart Cities (pp. 14-15).

De Paoli, S., & Miscione, G. (2011). Relationality in geoIT software development: How data structures and organization perform together. Computers, Environment and Urban Systems, 35(2), 173-182.

Ding, L., Meng, L., Yang, J., & Krisp, J. M. (2018). Interactive visual exploration and analysis of origin-destination data. Proceedings of the ICA.

Jankowski, P., & Nyerges, T. (2003). GIS for group decision making. Boca Raton, FL: CRC Press.

Kuniavsky, M. (2003). Observing the user experience: a practitioner's guide to user research. Elsevier.

Rudwick, M. J. (1976). The emergence of a visual language for geological science 1760—1840. History of science, 14(3), 149-195.

Sanders, E. B. N., Brandt, E., & Binder, T. (2010, November). A framework for organizing the tools and techniques of participatory design. In Proceedings of the 11th biennial participatory design conference (pp. 195-198). ACM.

Spinuzzi, C. (2005). The methodology of participatory design. Technical communication, 52(2), 163-174.

Tversky, B. (2019). What Makes a Map Good. Medium Retrieved 22Jul2019, 2019, from https://modus.medium.com/what-makes-a-map-good-4db0de3b2cec.

Ware, C. (2008). Visual thinking for design. New York City: Morgen Kaufmann.

npmjs. 2018. cubus. [ONLINE] Available at: https://www.npmjs.com/package/cubus. [Accessed 4 September 2019].

electronjs. Electron. [ONLINE] Available at: https://electronjs.org/. [Accessed 4 September 2019].

nodejs. Node.js. [ONLINE] Available at: https://nodejs.org/en/. [Accessed 4 September 2019].

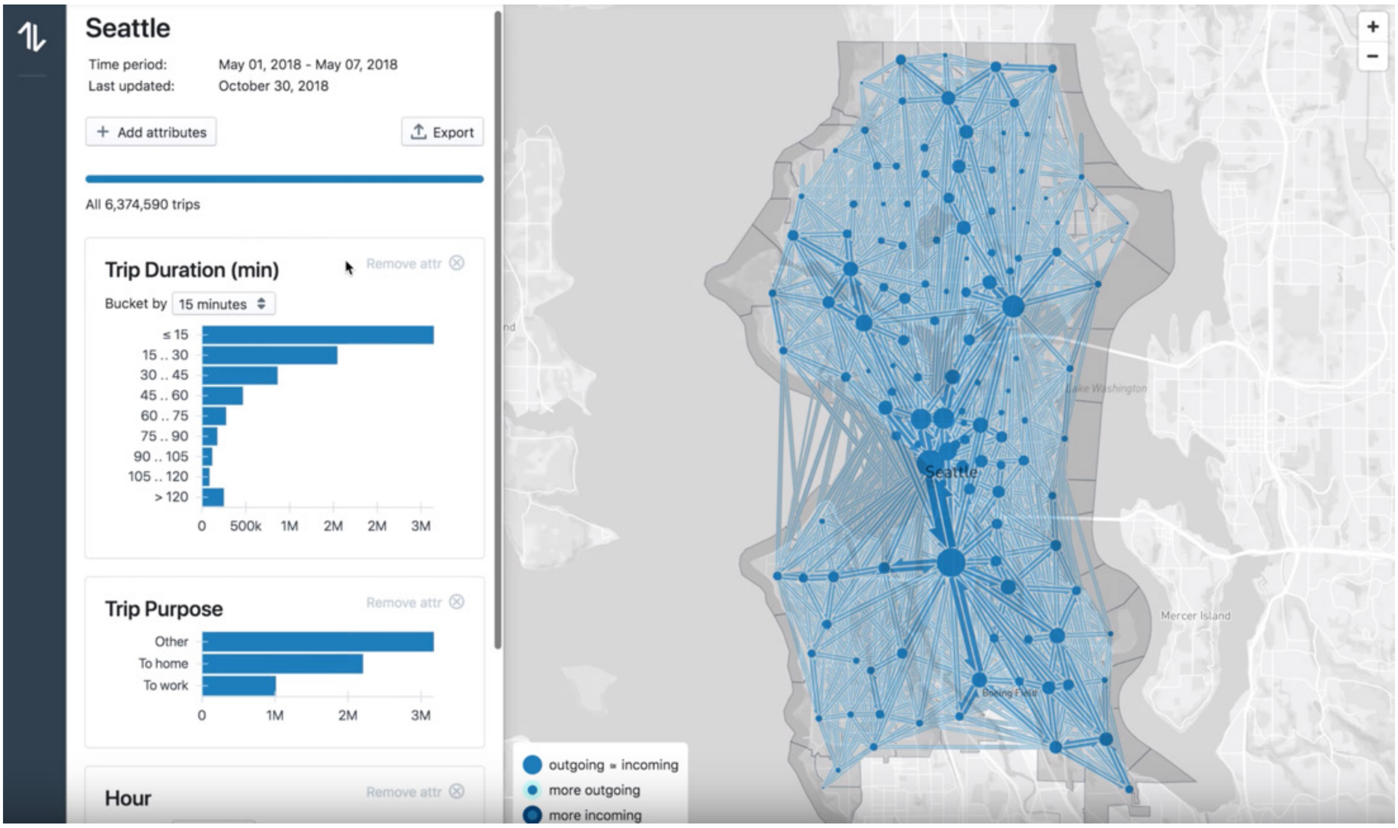


Figure 3. Flowmap.query, an exploratory visualization tool for the analysis of OD-data with attributes backed by an efficient database.

Ilya Boyandin (ilya@boyandin.me)
Teralytics

SCALABILITY OF OD-DATA VISUALIZATIONS

Keywords: geographic data visualization, movement of people, mobility, transportation, flow maps, scalability

1. INTRODUCTION

Understanding mobility patterns is important for fields like migration studies, urban and transportation planning, epidemiology, ecology, and disaster response. Origin-destination data (OD-data) are often used in this context for analysing numbers of movements between geographic locations. We believe that many OD-datasets remain under-analysed. The reason for that is that not many analysis tools are available today that are designed specifically for this kind of data and that are, at the same time, easy to use.
To improve this situation we published and open-sourced Flowmap.blue[1], an online tool which makes it very easy to create interactive geographic flow maps from datasets uploaded to Google spreadsheets. Since it was published few months ago, hundreds of datasets from all around the world have been visualized with it.
This simple tool, however, only works well for relatively small datasets (tens of thousands rows). The size of OD-data depends quadratically on the number of locations involved. It can quickly grow to hundreds of millions of rows when flow attributes like time, mode of transport, duration are added to the dataset. Such large datasets cannot be entirely visualized in one image. Their analysis requires the use of summarization and interactive exploration techniques. Moreover, ensuring smooth interactivity and short query response times necessary for such interactive analysis requires using an efficient database for executing the queries.

At the company Teralytics we are building exploratory tools for the analysis of aggregated data on movement of people in cities and countries with the purpose of improving transportation and mobility services. Scalability to the growing data sizes is an important challenge we are facing. In this article we discuss some of the technological solutions we have been working on to address this challenge and the tools we have published and open-sourced to make these solutions available to the broad public.

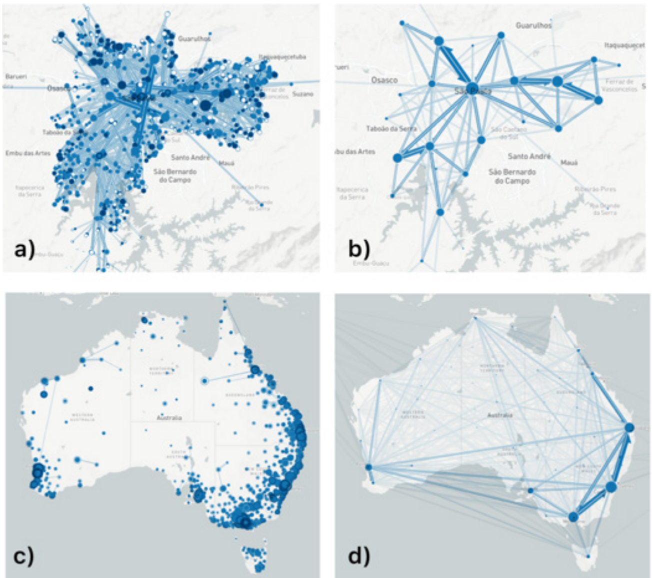


Figure 1. Bus rides in São Paulo. a) The original "messy" version with too many overlapping locations and flows. b) A clustered version of the same dataset showing high-level patterns. Relocations in Australia c) The original version with the most important flows being too short to be visible. d) Clustered version making high-level patterns visible. The circle sizes show the locations' in-/out totals and include internal flows.

2. SCALABILITY OF FLOW MAPS

In our tools we use flow maps as the main geographic representation of OD-data. They represent numbers of movements between locations as lines of varying thickness drawn on a geographic map. Flow map is the most straightforward and often used representation of OD-data, but it has limitations.

One important problem with flow maps is that, depending on the nature of the dataset and the number of lines drawn, there can be a significant overlap caused by the line crossings (Figure 1a). This problem is sometimes addressed by applying edge bundling techniques (Lhuillier et al, 2017, Graser et al, 2017).

Another problem is that short flows (which are often also the largest ones, because close-by regions are often more connected than those which are far apart) can be difficult to see (Figure 1c). Both these problems are more likely to arise, the more locations and flows are in the dataset.

To address these two problems we implemented an adaptive clustering approach. Locations within a certain distance from each other (the distance depends on the current map zoom level) are clustered together (Figure 1b, d). The clusters are positioned in the centers of masses of the locations constituting them (the locations are weighted by their total in-/out flows). After the location clusters are formed, flows are aggregated by summing up the magnitudes of the flows connecting the constituents of the clusters.

We are using a simple and very efficient density-based clustering algorithm implemented in the Supercluster[2] library. Instead of the automated clustering approach, taking an existing administrative area hierarchy may result in more meaningful and familiar clusters. However, with the former it is possible to produce a separate clustering for each map zoom level providing for a smoother user experience. In any case, the flow aggregation step doesn't depend on any particular algorithm and can be applied to any clustering.

The clustering level adapts to the map zoom making sure that not too many flows need to be drawn and that all the drawn flows are not too short. Flow lines which are too short are summarized as cluster-internal flows and are represented as part of the location totals by the circles of varying sizes. When zooming in, the clusters will gradually expand, so the level of summarization will automatically adapt to the map viewport.

This approach makes it possible to visualize and explore very large OD-datasets providing a useful summary at first and allowing the users to zoom in to see detailed flows within specific regions of interest. For an efficient implementation the approach can be combined with map tiling[3], so that only the data for the visible map tiles of the current summarization level needs to be fetched.

3. SCALABILITY OF THE DATA BACKEND

Often flows in OD-datasets have additional attributes, e.g. time or mode of transport. This is useful for exploring differences between various types of flows or for comparing the movement patterns emerging at different times. Hence, an OD-dataset is a list of tuples (*origin, destination, magnitude, …attributes*). To support the exploration of such data we developed a system allowing the users to cross-filter flow data by the attributes or by selecting locations and then to visualize the resulting flows as a flow map.

In our first implementation we loaded the entire dataset

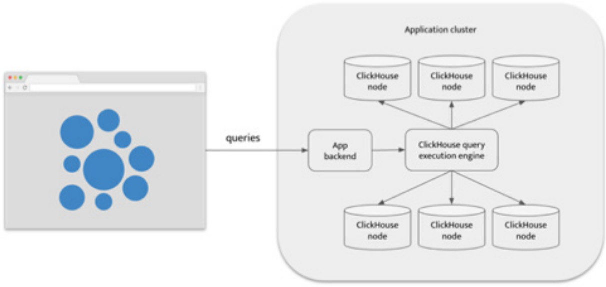


Figure 2. The system architecture of our scalable OD-data exploration application.

in browser and did the cross-filtering there. However, we quickly realized that it was only fast enough for small datasets. We looked for a database solution to support large OD-datasets (~1 billion of rows) such that it would also be possible to scale it horizontally if a dataset was growing. Initially we used Postgres, but it didn't perform well enough to support interactive analysis.

We evaluated several scalable database solutions and found that Google BigQuery and ClickHouse fulfilled our response time requirements (queries shouldn't take more than a few seconds). Both support SQL and are designed with scalability in mind. They are also both column-oriented. This means that the actual data is stored on disk column-by-column, not row-by-row like in traditional relational databases. Hence, only the data for the columns referred to in the queries need to be read from disk, not all of the columns. In our queries we either refer to two (*attribute, magnitude*) or three columns (*origin, destination, magnitude*), whereas the total number of columns can be much larger. Reading data from disk is often the most time consuming step of the query execution, so reducing it to the bare minimum has a significant positive effect on the performance.

Both BigQuery and ClickHouse scale horizontally, so dealing with larger datasets is a matter of adding more machines for query execution. However, BigQuery only offers a managed solution hosted in the cloud by Google. ClickHouse is an open-source database which we can host in our own data centers. Some of the data we work with at Teralytics is sensitive and cannot be uploaded to the cloud. For this reason, we decided to go with ClickHouse, and it has worked out very well for us.

The system architecture of our OD-data exploration tool backed by ClickHouse is shown in Figure 2. First, the API queries from the application front-end running in the browser arrive to the application back-end. There, SQL queries are formed and are sent to ClickHouse.

The ClickHouse query execution engine splits the work into multiple jobs and executes them in parallel on all the available machines so that the query results can be delivered as fast as possible with the available resources. The query performance for our OD-datasets has been very pleasing with the described set up.

We are open-sourcing a demonstration version of this solution as Flowmap.query[4] (Figure 3). Currently, it only supports ClickHouse as its backend, but we plan to add BigQuery support soon.

4. CONCLUSION

In this paper we discussed two particular solutions for enabling scalability in OD-data exploration tools. One is the adaptive zoom-dependent location clustering for flow maps. Another is employing a scalable database backend for interactive querying. When used in combination, these two techniques make it possible to explore and analyse very large OD-datasets. We are open-sourcing parts of these technological solutions. Our goal is to make it easier for the large public to produce flow maps from OD-datasets of any size and to interactively explore them.

5. REFERENCES

Lhuillier, Hurter, C., Telea, A. (2017) State of the art in edge and trail bundling techniques, Computer Graphics Forum

Graser, A., Schmidt, J., Roth, F., & Brändle, N. (2017) Untangling Origin-Destination Flows in Geographic Information Systems. Information Visualization 1-20

6. FOOTNOTES

1. https://flowmap.blue
2. https://github.com/mapbox/supercluster
3. https://en.wikipedia.org/wiki/Tiled_web_map
4. https://github.com/teralytics/flowmap.query

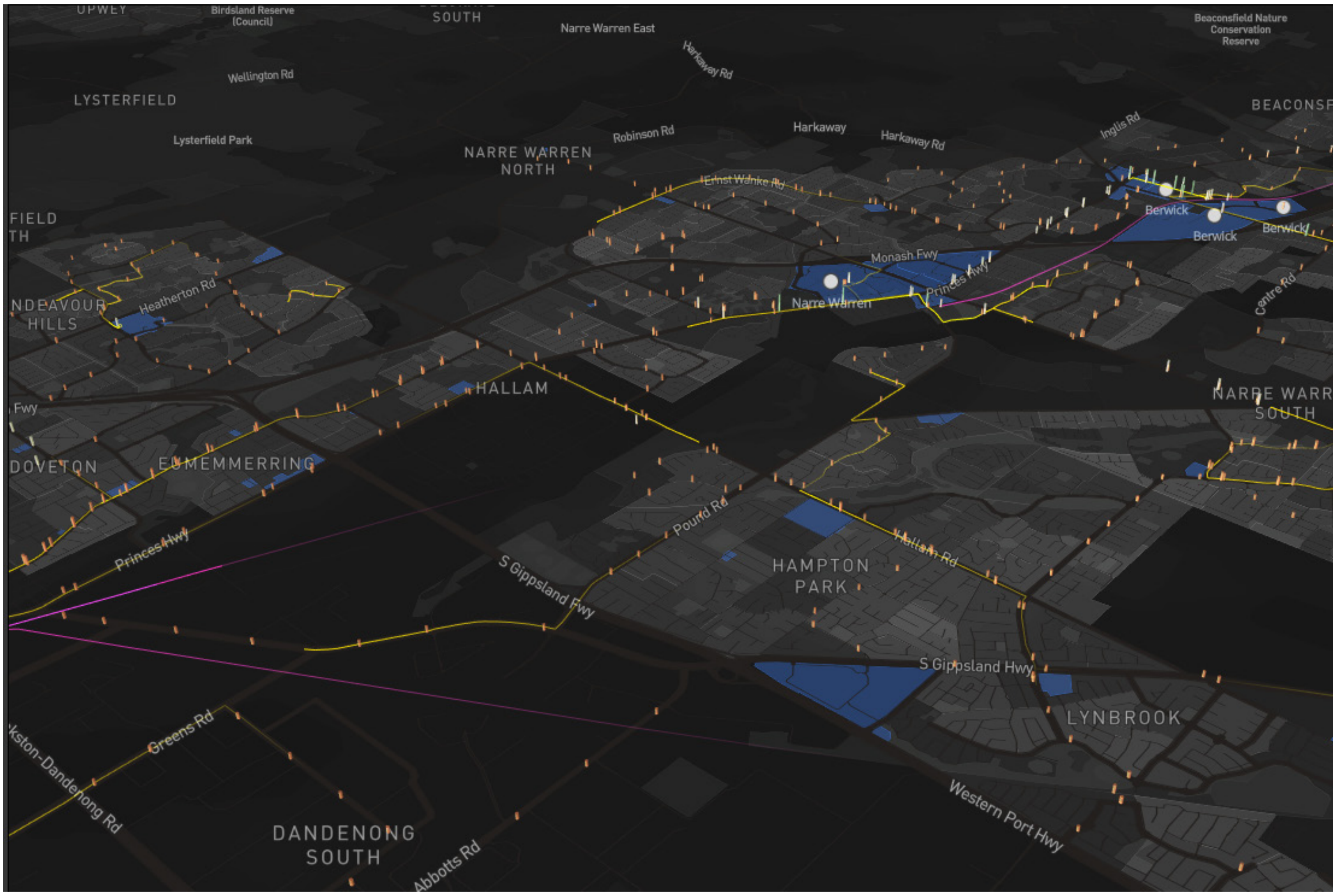


Figure 1: https://ptadvocacy.casey.vic.gov.au/ - coloured dots represent bus and train stops

William Jones (will@orbica.world), Orbica UG

TRANSPORT ADVOCACY USING CATCHMENT AREAS AND FREQUENCY VISUALISATION

Keywords: transport, advocacy, GeoServer, DeckGL, Melbourne

1. INTRODUCTION

A significant challenge that cities face is how to visualise the accessibility and frequency of public transport in a way that policy-oriented decision makers can understand. Melbourne, Australia, metropolitan area has experienced significant population growth in recent years, which has placed enormous pressure on the city's public transport infrastructure. One major growth area absorbing residential expansion is the City of Casey, which is located 40km south-east of Melbourne's Central Business District. Its population has doubled in the past 10-years and is expected to exceed 500,000 people by 2041. This has put pressure on its public transport infrastructure, meaning that services can't keep pace with population growth and the City of Casey is heavily reliant on cars.
Consequently, the City of Casey Council decided to advocate for adequate planning and investment into public transport. The advocacy campaign's aim was to achieve the local and state government goal to ensure that residents

can access essential services (such as hospitals, schools, community centres and areas of employment) within 20 minutes by sustainable transport modes.
To achieve the 20-minute neighbourhood goal, cognise the advocacy requirements and understand the current service provided, it was necessary to visualise the current state of public transport accessibility and frequency. Traditional accessibility modelling in GIS results in catchment maps that show the geographic coverage of public transport; however, coverage alone does not illustrate whether there is good public transport service as frequency is a significant component. A public transport service may have a large geographic coverage, however, a low frequency and especially a frequency that does not match demand, has a major impact on patronage.

2. TOOLS/TECHNOLOGY STACK

This paper illustrates the process by which we can use publicly available datasets such as General Transit Feed Specification (GTFS) feeds of public transport, census data and Vic Roads centreline datasets, in conjunction with open-source tools such as PostgreSQL, Geoserver, React MapGL and DeckGL to achieve this understanding.
First, all the publicly available datasets were sourced from:

1. GTFS feeds: https://transitfeeds.com/p/ptv/497
2. 2016 census data: https://www.abs.gov.au/
3. Road network: https://www.data.vic.gov.au/data/dataset/road-network-vicmap-transport
4. Key services: City of Casey

3. PROCESS

GTFS feeds come in the form of eight text files. These were imported into a PostgreSQL table. Details of the schema setup can be found at: https://github.com/tyleragreen/gtfs-schema. This provides us with the geometries and attributes of all the routes for all buses and their respective stops and stop times. Subsequently, 2016 census data at the ward level, road network for the Melbourne area and key services (provided by City of Casey) were downloaded as shapefiles and imported into the PostgreSQL database.

The road network was converted into a routable network. Using this routable network, a 400m[1] walking buffer along the roads was created for each of the key services. This provided a catchment of walking distance to the key services. These catchments were overlaid with all bus and train stops, thus producing a set of stops for each key service that was accessible by walking distance.

The analysis then selected all the bus/train routes from GTFS that intersected the stops found to be accessible by walking distance. Because of the intersect, the output illustrated all the bus and train routes that passed through those stops at different times. These routes were then able to be separated for each key service.

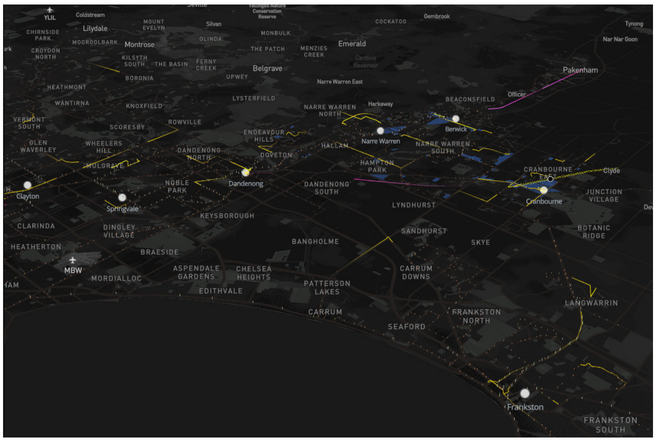


Figure 2: https://ptadvocacy.casey.vic.gov.au/ - Moving lines represents a public transport routes that service key areas.

As an output of the analysis, all the unique routes to a key service were identified. These routes were then intersected with the stops to understand which of the public transport stops serviced a key service (and associated walking buffer) at different times. As the study looked at understanding the current levels of public transport accessibility, the selection of an appropriate time period in which people would use public transport was essential. Therefore, in consultation with City of Casey council, the morning peak time period of 7–9 am was selected. This also restricted the time period available to calculate frequency.

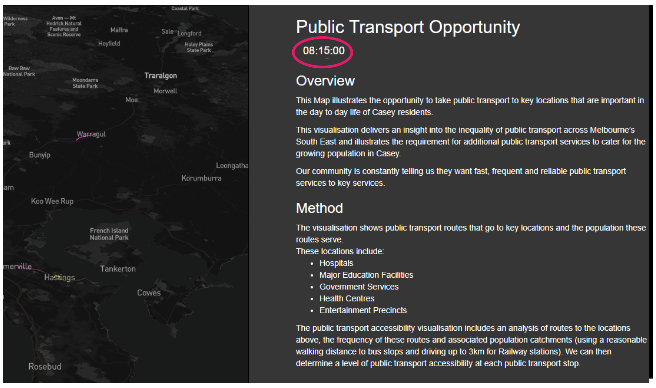


Figure 3: https://ptadvocacy.casey.vic.gov.au/ - Time period. A public transport service is visualised in highlighted form as it moves on its route over time.

Following the analysis above, it is understood which routes intersected which stops, and from GTFS feeds' stop times dataset, what time each route serviced a stop. Using this information, the next step calculated how many times a route (that services a key service) passed a stop in a given time period. Therefore, stops that had multiple routes passing through them, which serviced a key service, would have a higher frequency, attracting the public to use public transport at that stop. This process categorised all the bus stops as high or low frequency and all train stops as a separate category.

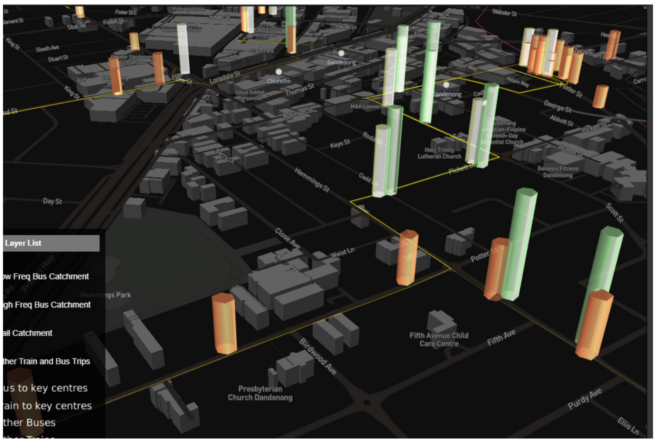


Figure 4: https://ptadvocacy.casey.vic.gov.au/ - Height represents frequency of public transport that services a key area. Tall represents high frequency.

Based on the frequency, a service area was generated for each stop:

- High frequency: 800m catchment
- Low frequency: 400m catchment
- Train stops: 3km catchment

The rationale that if a stop had a high frequency of buses, then people were willing to walk a bit further than a stop with low frequency, was behind creating such catchments. Additionally, since trains are a faster public transport service covering a greater distance, people are willing to drive to a train station and take the train to get to their destination.
At this point of the analysis, it is understood which public transport stops are serviced, their frequencies and the catchments they serve. The next step involves calculating the population served by each stop to a key service area. To do this, the population information from census was transferred to the road centreline. Public transport serves bus stops that are on streets rather than houses, therefore the population information was transferred to the street centre lines and then aggregated to the catchment level per stop.

Figure 5: https://ptadvocacy.casey.vic.gov.au/ - A low-frequency catchment area is highlighted by clicking on a layer.

Finally, to infer the distance between each stop and the time at each stop, the routes were intersected with stops. Using the stop times information provided the time and distance on each route.
The above process produced the following datasets:

1. A service area catchment with population for every stop that served a key service – served as a polygon through Geoserver
2. Routes that served each key service
3. A frequency value on each bus stop per key service – served as a point layer
4. A point layer with distance along the route – stored as a JSON file

The above datasets were then applied to a web application to illustrate this data in a user-friendly interface. The following functionality was implemented (see Figure 1):

1. Key service areas were grouped into various suburbs
2. Bus stops were symbolised based on frequency
3. Time ticker to show elapsed time 7–9 am
4. Within a suburb, clicking a bus stop would highlight the service area covered by that bus stop, which serviced the key services in that suburb
5. Turn on high frequency, low frequency and train catchments to illustrate overall coverage of public transport accessibility to key services in a suburb
6. Visualise the movement of public transport only between 7-9am to show the reach of public transport at any given time

7. Ability to show all buses and trains in all of Melbourne area between 7-9am
8. Ability to show population catchment for each bus stop for a key service
9. Show overall accessibility coverage by high, low frequency and train stops.

4. DELIVERY/RESULTS

The City of Casey was able to use this application as an advocacy tool to illustrate current levels of public transport throughout the city and where additional public transport service was required.
The tool found that some parts of the City of Casey were close to experiencing a "20-minute" neighbourhood. Nevertheless, many parts of the City of Casey - such as the greenfield growth areas had poor public transport services, which meant that new residents could not access essential day-to-day services such as education, medical and community facilities by public transport.
The tool provides a multi-faceted analysis of public transport accessibility with spatial and temporal analysis, coupled with the population aspect. City of Casey was able to demonstrate in its advocacy that there was a significant resident population that required additional public transport services. The tool contributed to the 2018 City of Casey advocacy to the state government, which was its most successful campaign to date.

ACKNOWLEDGEMENTS

Solution was developed in consultancy with City of Casey, Melbourne

FOOTNOTE

1: Catchments/walking buffer was as per requirements set by City of Casey, based on its data.

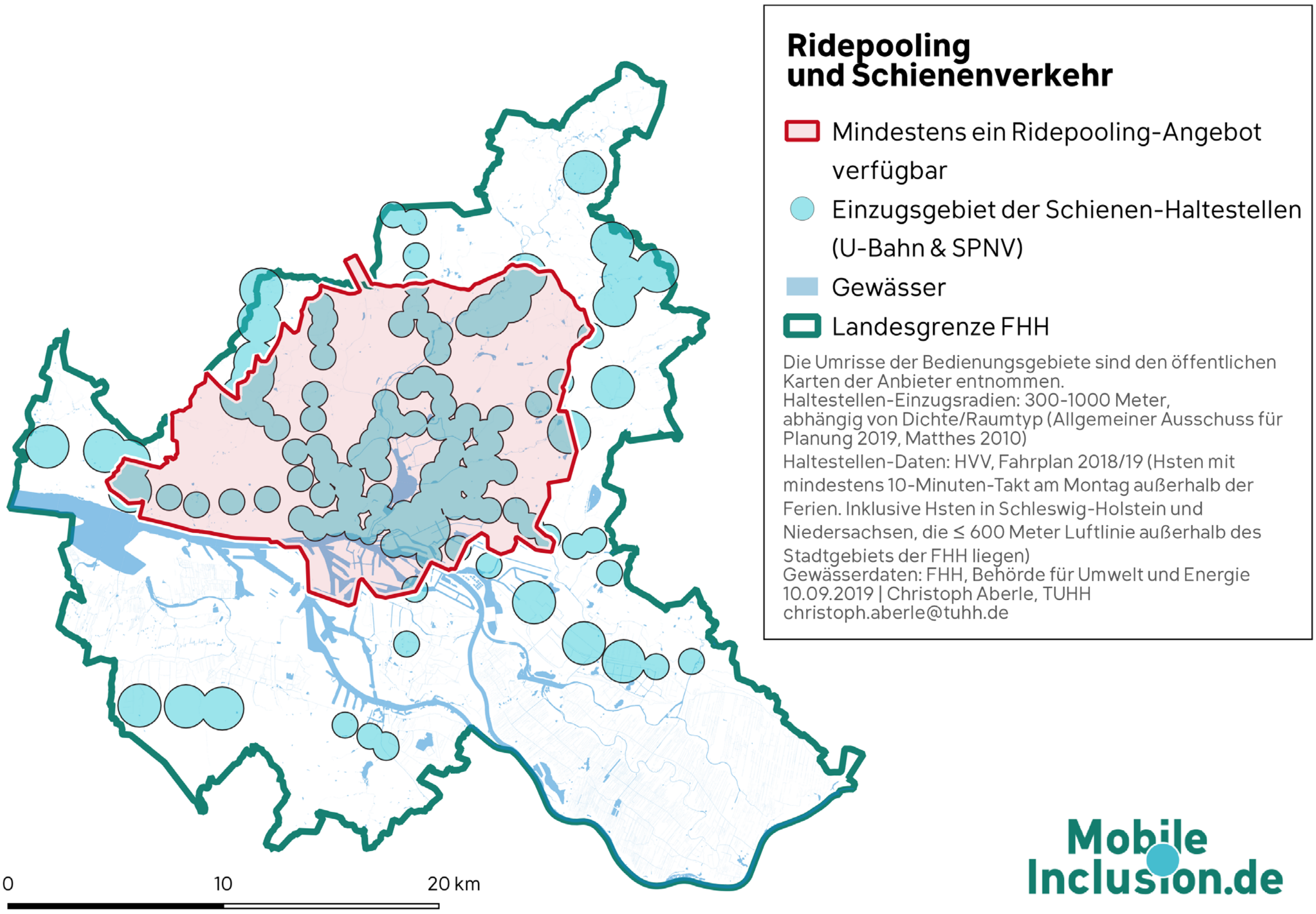


Abbildung 3: Vergleich der Fläche, die durch Ridepooling bzw. durch den Schienenverkehr erschlossen wird. Die Haltestellen-Radien betragen zwischen 300 und 1000m, abhängig von der Nutzungsdichte bzw. vom Raumtyp (nach Allgemeiner Ausschuss für Planung 2019; Matthes 2010).

Christoph Aberle (christoph.aberle@tuhh.de)
Technische Universität Hamburg (TUHH), Institut für Verkehrsplanung und Logistik (W-8)

MOBILITY AS A SERVICE: EIN ANGEBOT AUCH FÜR EINKOMMENSARME? GIS-BASIERTE BETRACHTUNG VIERER RIDEPOOLING-ANGEBOTE IN HAMBURG

Keywords: Mobility as a Service; Städtische Armut; Digitalisierung; Hamburg; Räumliche Analyse

1. Einleitung

Digitale Ridepooling-Angebote versprechen eine Innovation des Öffentlichen Nahverkehrs. Die Anbieter annoncieren eine Beförderung, die flexibler ist als klassische ÖPNV-Angebote und dabei günstiger ist als das Taxi. In Vorbereitung auf den Weltkongress für Intelligente Verkehrssysteme (ITS) im Oktober 2021 hat die Stadt Hamburg drei Ridepooling-Angebote genehmigt, die unter den Bezeichnungen MOIA, CleverShuttle und ioki betrieben werden (BWVI 2019). Ein viertes genehmigtes Angebot ist mytaxi match bzw. FREE NOW, das aus Fahr-

gastsicht die gleiche Leistung bietet[1].
Eine Ridepooling-Fahrt wird üblicherweise via Smartphone-App gebucht und abgerechnet. Im Gegensatz zur herkömmlichen Taxifahrt dürfen unterwegs andere Fahrgäste eingesammelt und abgesetzt werden. Das Ridepooling-Fahrzeug folgt nicht zwangsläufig der kürzesten Route, sondern wird als Kompromiss der Start- und Zielpunkte aller Passagiere geführt. Während das Ridepooling zurzeit experimentell betrieben wird, ist mittelfristig eine Integration in den Hamburger Verkehrsverbund (HVV) angedacht (Aigner 2019).
Dieser Beitrag stellt die potenzielle Nutzbarkeit des Ridepoolings für Menschen in Einkommensarmut in den Mittelpunkt. Anhand einer GIS-basierten Methode werden vier Ridepooling-Angebote hinsichtlich der Armutsquote und der Altersquote der Population untersucht, die potenziell bedient wird. Als einkommensarm werden Personen betrachtet, die in einer SGBII-Bedarfsgemeinschaft leben, d.h. erwerbsfähig und seit mindestens 365 Tagen arbeitslos sind. Ihr Anteil an der Hamburger Gesamtbevölkerung beträgt 9,7 Prozent (Stand 2016). Dahinter steht die Annahme, dass die hinreichend untersuchte räumliche Verteilung urbaner Ungleichheit (z.B. Marcinczak et al. 2016; Nightingale 2012) sich in der räumlichen Erreichbarkeit des Verkehrsangebots niederschlägt.
Gemeinhin weisen Personen mit geringem Einkommen ein unterdurchschnittlich ausgeprägtes Verkehrsverhalten auf, wobei sie einen größeren Anteil ihres verfügbaren Budgets dafür aufwenden müssen (Altenburg et al. 2009). In Hamburg legen Menschen aus ökonomisch schwachen Haushalten im Alltag kürzere Wege zurück als Personen mit größerem Einkommen, sowohl auf die Tagesstrecke als auch auf die Unterwegszeit bezogen. Öffentliche Verkehrsangebote werden von Geringverdienenden anteilig stärker genutzt (infas 2019).

2. METHODE

Um den Anteil der Hamburger*innen zu quantifizieren, der potenziell vom Ridepooling bedient wird, wurden die Bedienungsgebiete der Anbieter mittels eines Spatial Joins mit Meldedaten verschnitten. Die Meldedaten stammen aus dem Zensus 2011 und liegen in einer Auflösung von 100x100 Metern vor. Der Spatial Join ist eine etablierte Methode, um räumliche Daten aus verschiedenen Quellen miteinander in Beziehung zu setzen (bspw. Wang 2006). Um die Langzeitarbeitslosen-Quote zu gewinnen (Empfänger*innen nach SGBII / ugs. „Hartz IV“), wurden Daten des städtischen Sozialmonitorings genutzt (BSW 2017). Diese sind für 893 von 941 Statistischen Gebieten verfügbar, die nicht deckungsgleich mit den Bedienungsgebieten der Ridepooling-Angebote sind. Um die Sozialdaten für jedes Bedienungsgebiet abzuschätzen, wurden sie zunächst mittels eines Spatial Join disaggregiert, um sie anschließend auf die Bedienungs-gebiete zu re-aggregieren. Um Personen zu berücksichtigen, die nicht im Bedienungsgebiet, aber in der Nähe wohnen, wurde ein Buffer von 300 Metern ergänzt. Diese Distanz entspricht der Empfehlung des Verbandes Deutscher Verkehrsunternehmen für städtische Haltestellen-Einzugsradien (Allgemeiner Ausschuss für Planung 2019, S. 15).

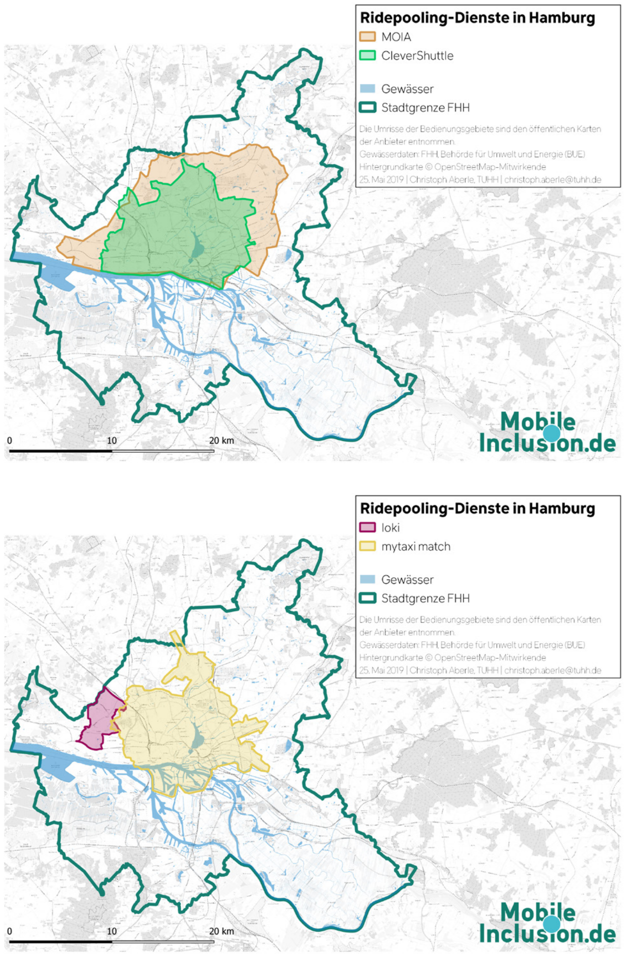


Abbildung 1:
a) Bedienungsgebiete von MOIA und CleverShuttle;
b) Bedienungsgebiete von ioki und mytaxi match
Für die GIS-basierte Berechnung wurde ein Buffer von 300 Metern hinzugefügt, der hier nicht abgebildet ist.

3. ERGEBNISSE

3.1 Ridepooling-Angebote konzentrieren sich auf nicht-arme Gebiete, die bereits erschlossen sind

Potenziell haben 1,1 Millionen Einwohner*innen Zugang zu mindestens einem Ridepooling-Angebot, was etwa

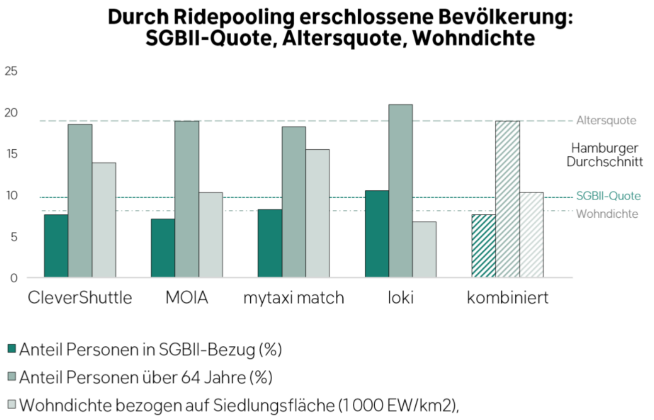


Abbildung 2: Vergleich zweier Sozial-Kennzahlen und der Wohndichte in den Einzugsgebieten der vier Ridepooling-Angebote

62,5% der Hamburger Bevölkerung entspricht. Kenngrößen der vier Angebote sind in Tabelle 1 zusammengefasst.

Es fällt auf, dass die Bedienungsgebiete sich auf Hamburgs Agglomeration nördlich der Elbe beschränken und zumeist das innere Stadtgebiet abdecken. Eine Ausnahme stellt diesbezüglich das Angebot ioki dar. Das Bedienungsgebiet liegt am westlichen Stadtrand und hat eine deutlich kleinere Fläche als die anderen (Tabelle 1). Neben dem durch Einfamilienhäuser geprägten Lurup umfasst ioki die in den 1960er-Jahren angelegte Großwohnsiedlung Osdorfer Born, die seit Jahrzehnten ein Schwerpunkt städtischer Armut ist. Diese Erschließung peripherer Wohnlagen mit neuen Mobilitätsdienstleistungen war eine Bedingung seitens der Stadt, um das Angebot zu genehmigen (Aigner 2019). Darüber hinaus war ioki zu Beginn vollständig in den HVV-Tarif integriert, sodass alle Fahrausweise gültig waren. Seit April 2019 erhebt ioki einen Komfortzuschlag von 1 EUR pro Fahrt, um „Spaßfahrten" v.a. jugendlicher Fahrgäste zu unterbinden (ebd.; VHH 2019; Mehlert 2001, S. 133).

Abbildung 3 zeigt die Fläche, in der mindestens ein Ridepooling-Angebot genutzt werden kann, entsprechend 32% der Hamburger Gesamtfläche bzw. 49% der Siedlungsfläche (Tabelle 1). Im Vergleich zum Einzug des Schienenverkehrs (SPNV und U-Bahn) sind größere Lücken zwischen den Schienen-Achsen auszumachen, die das Ridepooling schließt. Diese sind allerdings nahezu vollständig durch Bushaltestellen mit mindestens zehnminütiger Bedienung in der Nebenverkehrszeit erschlossen (nicht abgebildet).

3.2 Menschen in Einkommensarmut sind unterrepräsentiert

Bei Betrachtung der drei großen Ridepooling-Angebote sind Menschen in Einkommensarmut unterrepräsentiert: In den Bedienungsgebieten von CleverShuttle, MOIA und mytaxi match ist die SGBII-Quote geringer als im Hamburger Durchschnitt. Einzig im Bedienungsgebiet von ioki ist die SGBII-Quote überdurchschnittlich (Tabelle 1, Abbildung 2). Das gleiche gilt für die Quote an Personen über 64 Jahren: Allein ioki erschließt einen größeren Anteil älterer Menschen als der Hamburger Durchschnitt.

Auch in der Betrachtung der Wohndichte fällt ioki ein Sonderstatus zu: Entgegen den drei anderen Ridepooling-Diensten erschließt das Angebot ein Gebiet, das mit 6 708 Einwohner*innen/km2 um 17 Prozent dünner besiedelt ist als das städtische Siedlungsgebiet (8 069 EW/km2, bei einer Hamburgischen Siedlungsfläche von 220,71 km2 nach Daten der BSW, Stand 2018). Die größeren Angebote dagegen erschließen Räume, die deutlich dichter bewohnt sind (Tabelle 1).

4. DISKUSSION

Die Ergebnisse spiegeln den vielfach empirisch dargestellten Befund wider, dass die Verteilung sozioökonomischer Kennzahlen räumlich strukturell ungleich verteilt ist (Nightingale 2012; Florida 2017, 2015). Insbesondere periphere Großwohnsiedlungen sind durch über Jahrzehnte hinweg beständig hohe Armutsquoten geprägt (Runge 2005).

Für Ridepooling-Anbieter sind diese Gebiete anscheinend nicht hinreichend attraktiv, um einen befriedigenden Deckungsbeitrag zu erwirtschaften. ‚Arme' Nachbarschaften werden weniger oder nicht bedient, was sich in den Kennzahlen in Tabelle 1 niederschlägt: Die Bevölkerung, die von den drei großen Angeboten erschlossen wird, ist weniger einkommensarm und weniger alt als der Hamburger Durchschnitt. Die Ausnahme stellt das Angebot ioki dar, das von der Stadt Hamburg dazu verpflichtet wurde, ein mutmaßlich unprofitables Quartier zu bedienen.

Ob die Angebote profitabel betrieben werden, ist derweil fraglich[2]. Aus einer verkehrswirtschaftlichen Perspektive darf ein kostendeckender Betrieb für iokis Tarif von 1 EUR / Fahrt / Person als unmöglich bewertet werden, wobei die Kostendeckung durch die Betreiber nie als Ziel formuliert wurde. Der Tarif dient demnach nicht der Einnahmensicherung, sondern der Nachfragelenkung.

	Betriebliche Kennzahlen der Ridepooling-Angebote					**Soziodemografische Kennzahlen der Bevölkerung, die potenziell bedient wird**			
Ridepooling-Angebot	Fläche Bedienungsgebiet +300 m Buffer, km²	Anteil Siedlungsfläche, %	Wohndichte gemessen an Siedlungsfläche (für Bed.-Gebiete +300 m Buffer), Einw./km²	Fahrpreis für 5 km, EUR/Fahrt[1]	Art der Konzession, § PBefG	Anzahl erschlossener Einwohner*innen, Personen	Anteil erschlossener Einwohner*innen, %	SGBII-Quote, %	Anteil Personen älter als 64, %
ioki	20	5	6 708	1	42 und 2(6)	75 664	4,2	10,5	20,9
CleverShuttle	134	26	13 845	5-6	2(7)	785 405	44,1	7,6	18,5
mytaxi match	141	22	15 467	9-12	51[2]	756 816	42,5	8,2	18,2
MOIA	211	46	10 294	5-8	2(7)	1 054 140	59,2	7,1	18,9
kombiniert	240	49	10 299	n/n	n/n	1 112 897	62,5	7,6	18,9
Hamburg	n/n	n/n	8 069	n/n	n/n	1 780 828	100	9,7	19,1
Datenbezug	*2019*	*2018*	*2011 / 2018*	*2019*	*2019*	*2011*	*2011*	*2016*	*2011*
Datenquelle	*Karten der Ridepooling-Anbieter (selbst georeferenziert)*	*Behörde für Stadtentwicklung und Wohnen (BSW)*	*Zensus / BSW*	*Eigene Buchungs-anfragen*	*Auskunft der Genehmigungs-behörde (BWVI)*	*Zensus*	*Zensus*	*Statistisches Landesamt*	*Zensus*

Tabelle 1: Betriebliche und soziodemografische Kennzahlen der vier untersuchten Ridepooling-Angebote

Generell ist anzumerken, dass die 2011 erhobenen Zensusdaten, die dieser Untersuchung teilweise zugrunde liegen, nicht die jüngsten Entwicklungen hinsichtlich des Wohnungsbaus und Zuzugs widerspiegeln, die in Hamburg stattfinden. Es handelt sich allerdings um den jüngsten Datensatz, der öffentlich in dieser feinen Auflösung zugänglich ist.

Im Hinblick auf die Methodik wird darauf hingewiesen, dass die räumliche Verschneidung der Armutsindikatoren (disaggregieren und re-aggregieren) unter der Annahme geschieht, dass die SGBII-Quote innerhalb der Statistischen Gebiete gleichmäßig verteilt ist. Das ist nicht der Fall, kann aber angesichts der großräumigen Untersuchungsdimension akzeptiert werden. Das zugrunde liegende Phänomen – die Fläche und Form der Untersuchungseinheiten beeinflusst das Untersuchungs-ergebnis – wird seit Jahrzehnten als Modifiable Areal Unit Problem / MAUP diskutiert (Wong 2009).

Insbesondere die hohe SGBII-Quote in iokis Bedienungsgebiet hängt mutmaßlich mit der kleinen Fläche und der räumlichen Lage zusammen. Während ioki mit dem Osdorfer Born ein peripheres Wohngebiet erschließt, erstreckt sich sein Bedienungsgebiet nicht auf Hamburgs City, die eine geringere SGBII-Quote aufweist. MOIA, CleverShuttle und mytaxi match hingegen bedienen eine große Fläche, die sich über sowohl über die City als auch über einige ‚arme' Quartiere erstreckt. Die sozio-ökonomischen Kennzahlen der drei ‚großen' Angebote nähern sich dem Hamburger Mittel also mutmaßlich weniger aufgrund einer fehlenden Agenda zur Inklusion einkommensarmer bzw. älterer Menschen als aufgrund ihrer räumlichen Eigenschaften. Mit anderen Worten: MOIA, CleverShuttle und mytaxi match sind für die Zielgruppe vermutlich per se nicht weniger erreichbar als ioki. Es ist möglicherweise schlichtweg ihre räumliche Ausdehnung, die ihre SGBII-Quote drücken. Entsprechend kann iokis starke Anbindung von Menschen in Einkommensarmut als intendiertes Ergebnis des räumlichen Zuschnittes gelesen werden.

5. FAZIT

Digitale Ridepooling-Angebote können den konventionellen ÖPNV flexibel ergänzen, während sie günstiger sind als herkömmliche Taxidienstleistungen. Zurzeit erschließen drei der vier untersuchten Ridepooling-Angebote in Hamburg eine Population, die weniger einkommensarm und weniger alt ist als die Gesamtbevölkerung. Sie konzentrieren sich auf dicht besiedelte Quartiere, die bereits weitgehend durch den ÖPNV erschlossen sind. Die Ausnahme stellt das Angebot ioki dar, das durch eine Steuerung seitens des Aufgabenträgers in allen untersuchten Kriterien gegensätzliche Ausprägungen aufweist. Dieser Beitrag wirft ein erstes Schlaglicht auf den Zusammenhang zwischen neuen Formen urbaner Mobilität und den Zugangsmöglichkeiten für Menschen, die von einem geringen Einkommen leben. Aufschlussreich kann eine

Erweiterung der Betrachtung um weitere Indikatoren für Exklusion sein, bspw. die räumliche Einkommensverteilung. Durch eine methodische Weiterentwicklung hin zur räumlichen Statistik kann die Debatte an Qualität gewinnen, wie neue Bedienformen im Sinne einer inklusiven öffentlichen Mobilität eingesetzt werden. Auch ein Abgleich mit der tatsächlichen Nutzung des Ridepoolings, die zurzeit bei mehreren Angeboten forscherisch ausgewertet wird, wird erkenntnisbringend sein.
Ob und unter welchen Bedingungen das Ridepooling ein integraler Bestandteil des Hamburger Nahverkehrs werden wird, bleibt über den ITS-Kongress hinaus abzuwarten. Als Erfolgskriterium ist nicht nur die technisch anspruchsvolle Abwicklung digital mitgeteilter Fahrt-wünsche zu bewerten – sondern auch die Frage, wer alles an der neuen Mobilität teilhaben kann.

Die Geodaten zu diesem Beitrag können im Repositorium TUHH Open Research heruntergeladen werden: https://doi.org/10.15480/336.2396

Dieser Beitrag ist im Rahmen des DFG-Projekts MobileInclusion entstanden, das den Zusammenhang von urbaner Mobilität und sozialer Exklusion in Hamburg und Berlin untersucht (www.mobileinclusion.de).
DFG-Projektnummer: 382428751

6. LITERATURVERZEICHNIS

Aigner, Lutz (2019): Der HVV – Vom Verkehrs- zum Mobilitätsverbund? Vortrag bei der DVWG Hamburg e.V. Hamburg, 09.05.2019.

Allgemeiner Ausschuss für Planung (2019): VDV-Schrift 4: Verkehrserschließung, Verkehrsangebot und Netzqualität im ÖPNV. Köln.

Altenburg, Sven; Gaffron, Philine; Gertz, Carsten (2009): Teilhabe zu ermöglichen bedeutet Mobilität zu ermöglichen. Diskussionspapier des Arbeitskreises Innovative Verkehrspolitik der Friedrich Ebert Stiftung. Hg. v. Friedrich-Ebert-Stiftung (Wiso-Diskurs. Expertisen und Dokumentationen zur Wirtschafts- und Sozialpolitik).

BSW (2017): Sozialmonitoring Integrierte Stadtteilentwicklung. Bericht 2017 (Langfassung). Unter Mitarbeit von Jannis von Lüde.

BWVI (2019): DIGITALISIERUNG DES VERKEHRS. Hamburgs ITS-Strategie: Lösungen für die urbane Mobilität und Logistik von morgen.

Florida, Richard (2015): Inequality and Economic Segregation Are on the Rise in European Cities, Too. CityLab (16.11.2015).

Florida, Richard (2017): The new urban crisis. How our cities are increasing inequality, deepening segregation, and failing the middle class - and what we can do about it. New York, NY: Basic Books.

infas (2019): Ergebnisse der Studie Mobilität in Deutschland (MiD) – Stadt Hamburg. Präsentation für die Metropolregion Hamburg.

Marcinczak, Szymon; Musterd, Sako; van Ham, Maarten; Tammaru, Tiit (2016): Inequality and rising levels of socio-economic segregation. Lessons from a pan-European comparative study. In: Tiit Tammaru, Szymon Marcinczak, Maarten van Ham und Sako Musterd (Hg.): Socio-Economic Segregation in European Capital Cities. East Meets West, Bd. 89: Routledge, S. 358–382.

Matthes, Gesa (2010): Reurbanisierung in Hamburg und ihre Auswirkungen auf die Verkehrsentwicklung. ECTL Working Paper 43. Diplomarbeit. Technische Universität Hamburg-Harburg, Hamburg. Institut für Verkehrsplanung und Logistik.

Mehlert, Christian (2001): Die Einführung des AnrufBus im ÖPNV. Praxiserfahrungen und Handlungsempfehlungen. In: Schriftenreihe für Verkehr und Technik (91).

mytaxi (2019): Allgemeine Geschäftsbedingungen für mytaxi sharing service Festpreis (derzeit angeboten unter der Bezeichnung „match Festpreis“) für Fahrgäste.

Nightingale, Carl H. (2012): Segregation. A Global History of Divided Cities. Chicago: University of Chicago Press (Historical studies of urban America).

Runge, Diana (2005): Mobilitätsarmut in Deutschland? Berlin: TU Berlin, Fachgebiet Integrierte Verkehrsplanung (IVP-Schriften, 06).

VHH (2019): VHH und ioki bauen Angebot in Hamburg weiter aus.

Wang, Fahui (2006): Quantitative methods and applications in GIS. Boca Raton/FL: CRC Press.

Wong, David (2009): The Modifiable Areal Unit Problem (MAUP). In: The SAGE handbook of spatial analysis, S. 105–124.

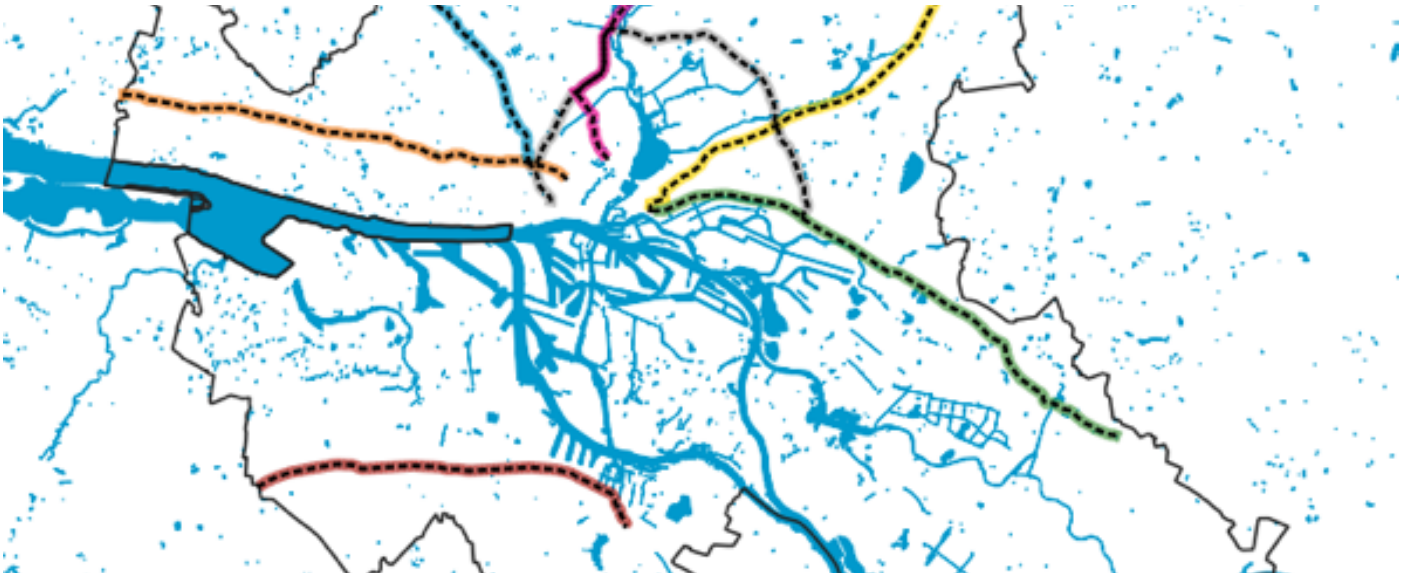
6. FOOTNOTES

1. Anfang Juli 2019 wurde mytaxi zu FREE NOW umbenannt. Die Datenerhebung fiel vor diesen Zeitpunkt, daher wird im Folgenden der alte Name mytaxi genutzt.
Formell handelt es sich bei mytaxi match um eine Taxifahrt. Die Buchung erfolgt als Taxibuchung nach Sonderregelung gemäß §51PBefG bzw. §2(10) Taxenordnung (mytaxi 2019), während die anderen Angebote nach §2(7) bzw. nach §§42 und 2(6) PBefG genehmigt sind. Aus Fahrgastsicht sind diese Unterschiede allerdings vernachlässigbar.

2. Wie Mehlert (2001) für einen ländlichen Raum in Brandenburg darstellt, hätte 1998 ein Fahrpreis von knapp 12 DM pro Person und Fahrt aufgerufen werden müssen, um kostendeckend zu fahren. Inflationsbereinigt entspricht das einer heutigen Kaufkraft von 8,21 EUR und ist damit nicht weit entfernt von Preisen der drei großen Anbieter für eine 5-km-Fahrt (vgl. Tabelle 2; Kaufkraftbereinigung mithilfe des Online-Rechners Finanzen-Rechner.net). Angesichts einer deutlich größeren Akzeptanzrate und zu erwartenden Auslastung im verdichteten Stadtgebiet scheint ein kostendeckender Betrieb in Hamburg nach oberflächlicher Betrachtung zumindest nicht ausgeschlossen.

3. Der Fahrpreis wurde anhand mehrerer Buchungsanfragen aus dem Hamburger Zentrum (Große Theaterstraße 1A) in ein 5 Kilometer entferntes Wohngebiet (Lortzingstraße 8) ermittelt. Die Buchungsanfragen wurden jeweils drei Mal zu unterschiedlichen Tageszeiten gestellt. Pauschale Einführungspreise wurden nicht berücksichtigt.
Alle Angebote außer ioki erheben variable Preise, die von der Relation, der Tageszeit und den Fahrtwünschen anderer Fahrgäste abhängig sind. Darüber hinaus bietet ioki nur ein räumlich stark begrenztes Angebot (vgl. Abb. 1) und ermöglicht keine Fahrten durch das Stadtgebiet. Für die Kombination mit dem herkömmlichen HVV-Verkehrsmitteln fallen zusätzlich zum Komfortzuschlag die üblichen Fahrpreise an. Dieser wesentliche tarifliche Unterschied erlaubt an dieser Stelle nur einen schematischen Vergleich.

4. Konzessionierung als Taxifahrt in Verbindung mit einer Sondergenehmigung nach Hamburger Taxenverordnung



See figure 1.

Klein, Timotheus (t.klein@argus-hh.de) & Clausen, Sebastian (s.clausen@argus-hh.de)
ARGUS Stadt und Verkehr

URBAN TRANSECTS AND TRUNK ROADS - OBSERVATIONS IN HAMBURG

Keywords: Town Planning, Transport Planning, Bauforum, New Urbanism.

1. INTRODUCTION

Transects have been used to describe the variation of geographic features along a section of landscape since Ferdinand von Humboldt in the late 18th century (von Humboldt, et al., 1807). The "new urbanism" movement originating in the USA in the late 20th century applied them to the study of the urban fabric. An example is the prototypical rural-to-urban transect described in the "SmartCode" (Center for Applied Transect Studies) that differentiates six transect zones of varying density and recommends corresponding design elements.

Trunk Roads often geometrically represent a transect and have been subject to town planners' scrutiny in Hamburg, where the "Internationales Bauforum 2019" features seven selected trunk roads as "Magistralen" with the aim of improving their contribution to the urban structure (hamburg.de GmbH & Co. KG, 2019; Figure 1). The radial are the most important type among metropolitan trunk roads,

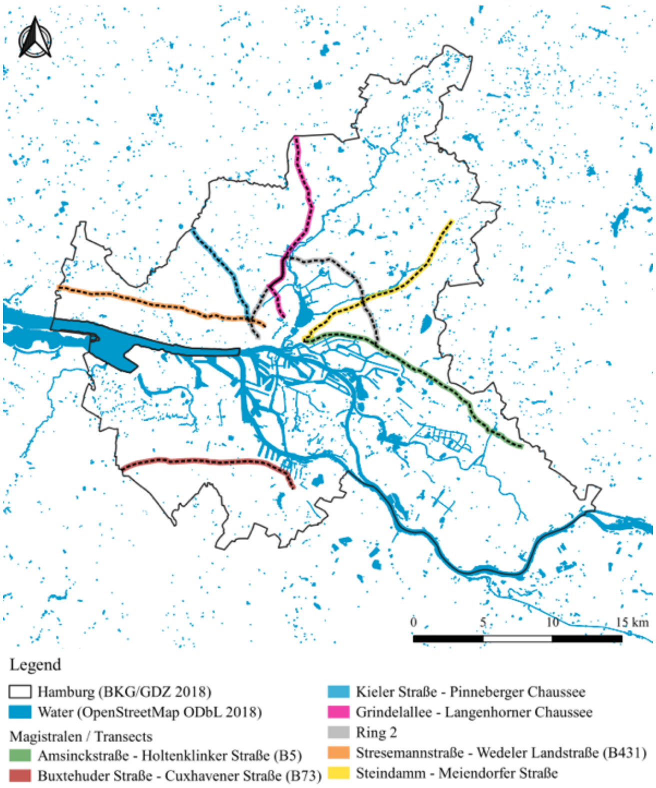


Figure 1. Axes of the seven trunk roads, resp. "Magistralen" featured in the "Internationales Bauforum 2019" in Hambur

they structure the city and provide orientation, forming the backbone of polycentric structures (Hofmann, et al., 2013). Often enough, radial trunk roads, connecting major cities, constituted the raison d'être of adjacent towns. Recent studies of the complex interactions between urban fabric and road transportation infrastructure testify to their importance in town planning (e.g. Dutkowski (2012) or Bohmann & Siegmund, (2013)).

In this paper we analysed land use, demographics and traffic volumes along these trunk roads as a quantitative approach to the transect concept and discuss its usefulness.

Description	**Source**
actual land use, (17 categories), maximum number of storeys above ground	ALKIS: LGV[1], 2018
share of foreign residents, household size, share of households with children, share of households on social support, motorization	statistical zones: LGV, 2018; Statistisches Amt für Hamburg und Schleswig-Holstein 2018
living space per resident	district profiles: FHH, 2018; Statistisches Amt für Hamburg und Schleswig-Holstein 2018
public transport stops (rail)	HVV[2]
vehicle kilometers travelled	Transport Model of Hamburg (ARGUS)
distance to town centre	Measured

Table 1. Datasets intersected with trunk road transects

2. METHODOLOGY AND DATA

The axes of the seven trunk roads were split into segments of 100m length, which in turn where offset 200m to each side of the axis to build altogether 400 x 100m² sized rectangles. These rectangles were intersected with an array of georeferenced land use, demographic and traffic data (Table 1).

The resulting values for each transect segment were then exported to a table and visually analysed with a normalized diagram. To improve readability and to more closely represent a pedestrians' perception of the urban space, we also made diagrams representing a moving average of altogether five segments' values. Correlation coefficients were calculated for every parameter combination.

3. RESULTS

3.1 Land Use

The ALKIS dataset differentiates 17 actual land use categories, which we classified as traffic, leisure, business or residential space. To illustrate the results, we chose the Transect from Steindamm to Meiendorfer Straße with altogether 148 segments, running from the central train station into the suburbs (Figure 2). The composition of land uses in these segments is displayed in the following figures (3 and 4), sorted from town centre (left) to suburb (right).

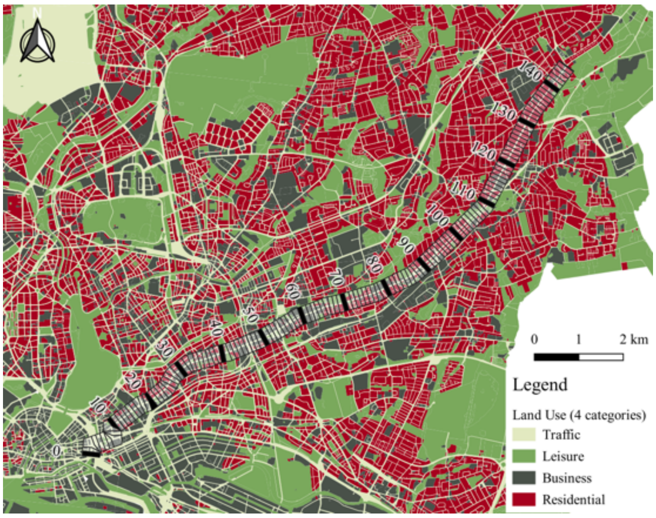


Figure 2. Transect of Trunk Road Steindamm-Meiendorfer Straße

The moving averages of land uses (Figure 4) show a rhythmic variation of dominating land use: traffic and business in the centre with increasing waves of residential areas and insertions of leisure areas. The latter reflect the Wandse, a creek running parallel in varying distance to the road and before crossing it approximately 10km from the town centre. Residential dominance appears in aggregations of approximately 0.5 to 2kms.

Correlation coefficients between different values are generally low and the underlying causal relations seem trivial, as most of the parameters are either competing in space or mutually reinforcing. Of particular interest is the correlation with distance from town centre as a genuinely locational factor that could support the continuous development of certain features and parameters as suggested by the "Smart Code". However, the only quantifiable parameters with a noteworthy (|R| > 0.5) correlation found for the seven transects analysed in Hamburg were children, motorization and density (Table 2).

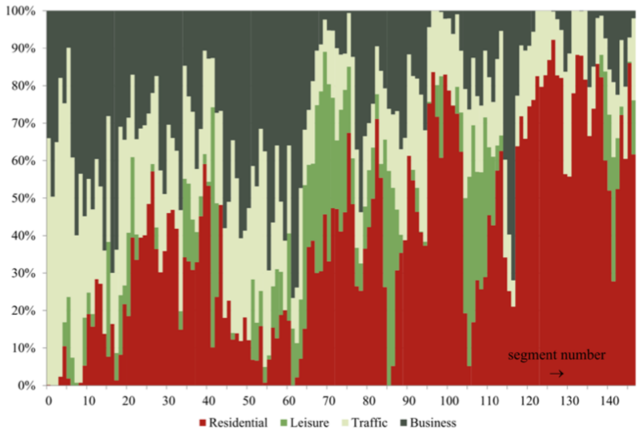


Figure 3. Transect Diagram for Steindamm-Meiendorfer Straße with share of aggregated land uses, sorted from town center (number 0, left) to suburb (number 147, right)

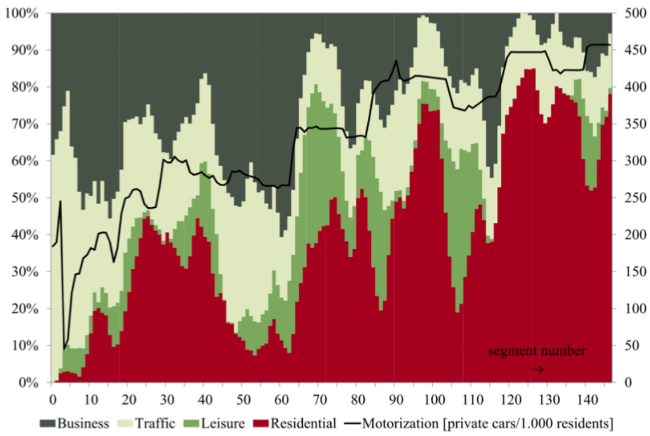


Figure 4. Transect Diagram for Steindamm-Meiendorfer Straße with moving averages of aggregated land uses. The black line indicates motorization, sorted from town center (number 0, left) to suburb (number 147, right)

Values	**R**
% Households with Children	+0.521
Motorization	+0.517
Total gross floor area (all buildings)	-0.544

Table 2. Correlation Coefficients for Distance from Centre and different Values, absolute above 0.5, 7 Transects

4. DISCUSSION

The transect method has been found useful in other, e.g. anthropological contexts (Krebs & Pilz, 2013). The analysis of road space frequently uses two-dimensional representations (e.g. Dutkowski (2012)), addressing a huge variety of issues around trunk roads. The prototypical rural-to-urban transect, however, appears to lack detail and complex variation along roads or transport infrastructure in general and radial trunk roads in particular. In a similar vein, (Tagliaventi, 2016) suggests several amendments to the Transect concept in order to use in Europe. He found, for instance, "the need to introduce an intermediate category to the transect classification to identify a common level of European urban settlement with neither the strength, size, nor mixed-use complexity of the neighbourhood" as defined in the Charter of the New Urbanism (Congress for the New Urbanism). Still, "neighbourhood"-like structures are clearly visible in our transect diagrams. Also identifiable are problematic locations: detailed analysis reveals spaces that call for intervention, e.g. strong variation in demographics along the transect and questionable combinations like a high share of residential land use around high traffic volumes. Bohmann & Siegmund (2013) provide a useful influence matrix to identify critical factors for the development of selected sections. Such issues, however, could also be studied on a grid or zoning basis.

As (Tagliaventi, 2016) suggests to distinguish between different building types within the urban Transect Zones, it might be recommendable from a geographers point of view to analyse the urban morphology along a transect, classified by building, composition and neighbourhood typologies as documented in (Schirmer & Axhausen, 2015). We conclude that transect style, 2-dimensional analyses of roads and their surroundings in general are compelling where larger stretches of roads and their interaction with the surroundings are examined. They can help to illustrate historic and contemporary developments and to identify spaces worth closer examination. It should be noted that a 2-dimensional approach cannot analyse or resolve issues arising from the larger urban environment.

5. REFERENCES

Bohmann, A., & Siegmund, Y. (2013). Wohnen an der Magistrale - Auf der Suche nach Potentialräumen. Urban Design 3 Project, Urban Design (Master), Hamburg.

Center for Applied Transect Studies. (kein Datum). codes & manuals. Abgerufen am 12. Februar 2019 von https://transect.org/codes.html
Congress for the New Urbanism. (kein Datum). The Charter of the New Urbanism. Abgerufen am 28. Juni 2019 von https://www.cnu.org/who-we-are/charter-new-urbanism

Dutkowski, D. (2012). Urbane Transformation. Die Triester Straße im Wandel. Diplomarbeit, Vienna University of Technology, Wien.
hamburg.de GmbH & Co. KG. (1. Mai 2019). Warum ein Bauforum Magistralen? Abgerufen am 25. Juni 2019 von https://www.hamburg.de/bauforum/12457720/warum-ein-bauforum-magistralen/

Hofmann, A., Polinna, C., Richter, J., Schlaack, J., Bodenschatz, H., & Machleidt, H. (2013). Hauptstraßen der Großstadt: Vom Verkehrsraum zum Stadtraum. In H. Bodenschatz, A. Hofmann, & C. Polinna (Hrsg.), Radialer Städtebau (S. 13-25). Berlin: DOM publishers.

Krebs, M., & Pilz, M. (2013). Anthropological Urban Transect: A Methodology to Study Urban Environment. Working Papers des Sonderforschungsbereiches 640, Nr. 1/2013, Humboldt-Universität zu Berlin, Berlin. Von https://edoc.hu-berlin.de/handle/18452/3902 abgerufen

Schirmer, P. M., & Axhausen, K. W. (2015). A multiscale classification of urban morphology. (University of Minnesota Center for Transportation Studies, Hrsg.) The Journal of Transport and Land Use(9 (1)), S. 101-130.

Tagliaventi, G. (2016). The European Transect: An Organic Way for Architecture to Develop Towns, Cities, and Metropolises. Places, 18(1), S. 46-52.

von Humboldt, A., Bonpland, A., Schönberger, L. A., Turpin, F., Bouquet, & Aubert, L. (1807). Geographie der Pflanzen in den Tropen-Ländern : ein Naturgemälde der Anden : gegründet auf Beobachtungen und Messungen, welche vom 10ten Grade nördlicher bis zum 10ten Grade südlicher Breite angestellt worden sind, in den Jahren 1799 bis 1803. Tübingen: F.C. Cotta

FOOTNOTES

1. Landesbetrieb Geoinformation und Vermessung (LGV) Hamburg, authority for geoinformation and survey

2. Hamburger Verkehrsverbund, Hamburg traffic association

Heike Marquarta[1] (heike.marquart@dlr.de) & Uwe Schlink[2] (uwe.schlink@ufz.de)
[1]Institute for Transport Research, German Aerospace Center (DLR), Berlin, Germany
[2]Helmholtz Centre for Environmental Research (UFZ), Leipzig, Germany

PERSONAL EXPOSURE TO ENVIRONMENTAL STRESSORS WHILE COMMUTING: EXPLORING ON-SITE EXPERIENCES USING WALKING INTERVIEWS AND QUALITATIVE GIS

Keywords: Perceived environment, Personal exposure, Walking Interviews, Qualitative GIS

1. INTRODUCTION

The promotion of health and wellbeing in cities is a key goal for urban development (UN General Assembly, 2015). A close relation exists between health and urban transport (van Wee & Ettema, 2016). While citizens are moving in the city, they take part in the often congested and stressful urban transport system (Evans et al., 2002). Meanwhile, they are exposed to environmental hazards and urban stressors, being reported to have severe health effects (Nieuwenhuijsen, 2016). Upon them, bad air quality and noise are considered as crucial (Kassomenos et al., 2014, Reardon and Abdallah, 2013). A high level of congestion, environmental effects, e.g. heat, and a lack of safety are additionally impacting health and wellbeing (Nieuwenhuijsen, 2016; Reardon and Abdallah, 2013).

Evaluating environmental stressors and its impact on commuters often refers to measurements (Okokon et al., 2017, Chaney et al., 2017); it is only recently that individual experiences and perceptions come into consideration (Gössling et al., 2019, Ueberham et al., 2019, Gany et al., 2017). How an environment is perceived, affects route- and mode-choices (Golledge, 1995; Böcker et al. 2016). Research focuses on measured and reported health-impacts of stressors and related behavior, measured with quantitative methods such as closed questionnaires or sensors. Yet, research is lacking with a focus on commuter's on-site experiences of the environment and perceived stressors, providing in-depth insights into commuters' related behavior. Firstly, our research aims at investigating different methods for researching commuters' perceptions and experiences regarding their exposure to stressors. Secondly, we introduce a methodological approach for researching and visualizing commuters' perceived exposure and related behavior, using Walking Interviews and qualitative GIS approaches. We argue that for researching perceptions and experiences of commuters and their spatial context, qualitative methods can be particularly supportive.

2. METHODS FOR RESEARCHING PERSONAL EXPOSURE

2.1 Quantitative methods and Wearable Sensors

Research exists on measuring urban stressors with stationary measurement devices. Yet, researching how commuters are impacted by environmental stressors requires a more flexible approach due to varying exposure situations while moving. Wearable sensors are a good solution, enabling participants to measure while being mobile (Ueberham et al., 2019, Nieuwenhuijsen, 2016). Carrying sensors on the body while moving is highly beneficial for identifying individual route- and mode-specific exposure to environmental stressors. Yet, the measured exposure might not be equal to the perceived exposure (Ueberham, Schlink, Dijst, & Weiland, 2019) and the way urban stressors are experienced can have an impact on mobility behaviour, which cannot be revealed by solely using measurements.

2.2 COMBINING QUESTIONNAIRES WITH SENSORS

A solution might be to additionally use survey methods, to investigate how people experience stressors. This has been applied in recent transport related studies: Gany et al. (2017) compared New York City taxi-drivers' exposure (stationary and mobile in-vehicle) with their knowledge, attitudes and beliefs about air pollution. Camusso and Pronello (2016) measured noise emissions and traffic density in relation to people's disturbance and noise perception using an epidemiological survey, while Böcker et al. (2016) used a travel diary on weather perception, emotional experiences and travel behavior, linking it to meteorological data. Simultaneously measuring noise, air pollution and temperature and comparing it with the perceived exposure using a smartphone-based survey, was conducted by Ueberham et al. (2019). However, quantitative surveys are insufficient to explore experiences and perceptions in-depth. Unconscious behaviour and perceived exposure on-site with regard to spatial conditions cannot be revealed. Still, most studies use quantitative surveys due to easier comparison; qualitative methods have rarely been applied.

2.3 QUALITATIVE METHODS: INTERVIEWS

For researching subjective experiences and how the environment is perceived, qualitative interviews give space to discuss experiences, beliefs, values, opinions and practices in an explorative way (Pink, 2015). Narratively talking about experiences and what is sensed (noise, smell, heat) or felt (stress), enhances the understanding of commuters' situation more openly than narrowing it down by closed questions. Transport research displays an increasing usage of qualitative methods (Mars et al., 2016). Yet, using stationary qualitative interviews does not give insights into site-specific perceptions and actions, because interviewees are answering out of their remembrance, and it holds the difficulties of the subjective nature of qualitative data. Distorted memories of the actual experience could affect respondent's responses, as any post-hoc qualitative approach.

3. WALKING INTERVIEWS FOR EXPOSURE RESEARCH

The methodological approach of Walking Interviews addresses the spatial limits of stationary interviews. It is used for researching attitudes, knowledge and experiences about the surrounding environment on-site (Evans and Jones, 2011). Walking Interviews help to understand how people sense their environment (Lenzholzer et al., 2018, Pink, 2015). Additionally, identifying mobility behavior through static surveys is limited to the remembered situation, thus, unconscious, habit-related behavior may not be captured. Accompanying the respondent holds the opportunity to call attention to that and puts the interview in a spatial context (Kusenbach 2003). However, Walking Interviews are prone to disturbances from the outside, since they do not have a controlled interview situation and are challenging to compare due to the varying environmental conditions. Mostly used in ethnographic and urban design research, Walking Interviews use qualitative interview structures with open questions, promoting discussions right at place. This is more than a closed questionnaire is able to capture, considering the multi-sensory experiences while being in a city (Kelly et al., 2011). Combined with GPS-data, the qualitative data can be analysed using qualitative GIS methods (Jones and Evans, 2012). Weighted against the obstacles, the strong advantage of exploring spatial perception on-site while moving becomes evident. Yet, Walking Interviews are rarely applied in transport research.

3.1 EXAMPLE OF DATA PROCESSING AND VISUALISATION

For investigating the possibilities of Walking Interviews and qualitative GIS for researching perceived exposure and related behaviour of commuters, we tested a methodological approach using a small sample in a city with high air and noise pollution, traffic density and temperature. Starting with a semi-structured problem-centred interview (Witzel 2012) on health perception, perceived exposure to stressors and mobility behaviour while commuting, we could create baseline data on how commuters describe their daily commute. Directly following this stationary interview, we investigated the same questions on-site with the respondents using Walking Interviews and GPS-tracking. In this second phase, the respondents were accompanied by the interviewer on their daily way to work/from work to home. The interviewer tracked the route with a GPS and discussed at specific spots (noting the respective minute to attach it later to the GPS-coordinate) how the environment is perceived, how the respondents perceive their health and talked about specific behavioural patterns using semi-structured interviews. Simultaneously, air pollution (particle number count) and noise (dB) were measured with wearable sensors. The answers were noted down and later translated in a GIS, attached to the minute/GPS-coordinate the answer was given while moving. Based on methodological approaches of qualitative GIS (Jung & Elwood, 2016), the Walking Interview answers and measured data were combined and visualized (Fig. 1). The stationary interviews were analysed using a qualitative content analysis and comparisons of the stationary interview answers and Walking Interview answers were made case-specifically.

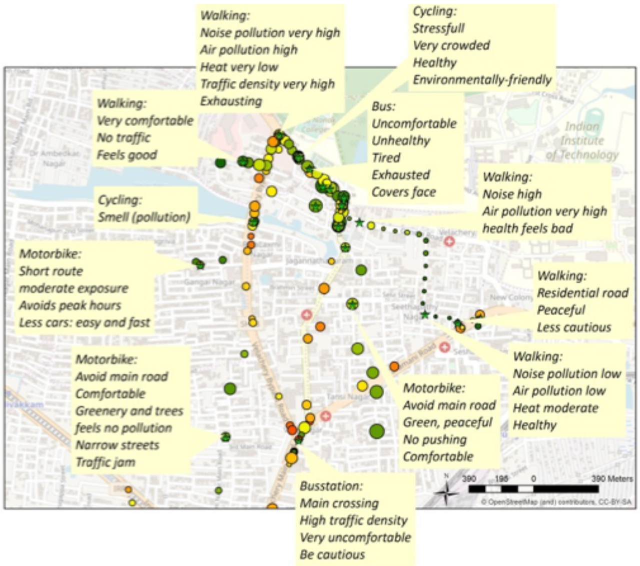


Figure 1: Example for visualizing Walking Interview answers (attached to GPS-coordinate) and measured data. The colour of the dots represents measured noise level (from green (low) to red (high)), the size particle number count (0.5-2.5μm/m³).

4. DISCUSSION OF METHODOLOGICAL APPROACH

Commuters report negative health and wellbeing impacts due to urban stressors, influencing their route-choices and leading to avoidance strategies. They change their routes by using side-roads with greenery, avoiding negatively perceived main roads. That was rarely stated during the stationary interviews. Our methodological approach was beneficial for researching perceptions of commuters on-site. We could highlight that Walking Interviews provide in-depth insights into commuter's perception, experience and behavior, which could not be revealed by solely conducting measurements or stationary interviews. While accompanying the participant, we could directly point at behavior patterns and reveal habitual, unconscious actions – addressing how exposure perception affects mobility behavior. Our methodological approach holds the possibility to spatialize qualitative data and visualize the answers in a GIS. Contrasting data from stationary interviews and Walking Interviews, the latter increases the ecological validity. This calls for a stronger focus in health-mobility-research on observing participants' behavior and perceptions while taking part in their everyday mobility. By using GPS-devices for tracking the route combined with wearable sensors, we could attach the interview-answers to a specific spatial situation and integrate pictures added to the respective GPS-coordinate. Qualitative GIS is highly beneficial for visualizing and communicating qualitative data spatially (Jung & Elwood, 2010).

5. CONCLUSION

In order to research perceived exposure while commuting and related behaviour, a novel methodological approach is necessary. Concepts such as "citizens as sensors" and "citizen sciences" can contribute to a comprehensive understanding of health-impacts and related behaviour of commuters. Results can easily be integrated in maps and communicated to decision-makers, researchers and the citizens themselves. Qualitative GIS approaches can support a better understanding of commuting in cities and should be used additionally to quantitative surveys and measurements. Future research should investigate the possibilities of wearable sensors and smart-devices, while considering Walking Interview approaches. Thus, further understanding about how environmental stressors are perceived and how they impact mobility behaviour can be achieved.

6. ACKNOWLEDGEMENT

We thank Prof. S.M.Shiva Nagendra and the colleagues from the Indian Institute of Technology Madras (IIT), Chennai, India, for their hospitality and great support with carrying out the field research.

7. REFERENCES

Böcker, L., Dijst, M., & Faber, J. (2016). Weather, transport mode choices and emotional travel experiences. Transportation Research Part A: Policy and Practice, 94, 360-373.

Camusso, C., & Pronello, C. (2016). A study of relationships between traffic noise and annoyance for different urban site typologies. Transportation Research Part D: Transport and Environment, 44, 122-133.

Chaney, R., Sloan, C., Cooper, V., Robinson, D., Hendrickson, N., McCord, T. , & Johnston, J. (2017). Personal exposure to fine particulate air pollution while commuting: An examination of six transport modes on an urban arterial roadway. PLoS One, 12(11).

Evans, G. W., Wener, R. E., & Phillips, D. (2002). The Morning Rush Hour: Predictability and Commuter Stress. Environment and Behavior, 34(4), 521-530.

Evans, J., & Jones, P. (2011). The walking interview: Methodology, mobility and place. Applied Geography, 31(2), 849-858.

Gany, F., Bari, S., Prasad, L., Leng, J., Lee, T., Thurston, G. D., . . . Zelikoff, J. T. (2017). Perception and reality of particulate matter exposure in New York City taxi drivers. J Expo Sci Environ Epidemiol, 27(2), 221-226.
Golledge, R. (1995). Defining the criteria used in path selection, Technical Report UCTC No. 78. University of California Transportation Center, Berkely.

Gössling, S., Humpe, A., Litman, T., & Metzler, D. (2019). Effects of Perceived Traffic Risks, Noise, and Exhaust Smells on Bicyclist Behaviour: An Economic Evaluation. Sustain-ability, 11(2), 408.

Jones, P., & Evans, J. (2012). The spatial transcript: analysing mobilities through qualitative GIS. Area, 44(1), 92-99.

Jung, J.-K., & Elwood, S. (2010). Extending the Qualitative Capabilities of GIS: Computer-Aided Qualitative GIS. Transactions in GIS, 14(1), 63-87.

Kassomenos, P., Vogiatzis, K., & Coelho, J. L. (2014). Critical issues on environmental noise: Editorial. Science of the Total Environment, 482-483.

Kelly, C., Tight, M., Hodgson, F., & Page, M. (2011). A comparison of three methods for assessing the walkability of the pedestrian environment. Journal of Transport Geography, 19(6), 1500-1508.

Kusenbach, M., (2003). Street phenomenology: the go-along as ethnographic research tool Ethnography, 4, 455-485.

Lenzholzer, S., Klemm, W., & Vasilikou, C. (2018). Qualitative methods to explore thermo-spatial perception in outdoor urban spaces. Urban Climate, 23, 231-249.

Mars, L., Arroyo, R., & Ruiz, T. (2016). Qualitative Research in Travel Behavior Studies. Transportation Research Procedia, 18, 434-445.

Nieuwenhuijsen, M. J. (2016). Urban and transport planning, environmental exposures and health-new concepts, methods and tools to improve health in cities. Environ Health, 15(1), 38.

Okokon, E. O., Yli-Tuomi, T., Turunen, A. W., Taimisto, P., . . . Lanki, T. (2017). Particulates and noise exposure during bicycle, bus and car commuting: A study in three European cities. Environ Res, 154, 181-189.

Pink, S. (2015). Doing sensory ethnography (S. Pink, ed), Sage Publ., Los Angeles.

Reardon, L., & Abdallah, S. (2013). Well-being and Transport: Taking Stock and Looking Forward, Transport Reviews, 33, 634-657.

Ueberham, M., Schlink, U., Dijst, M., & Weiland, U. (2019). Cyclists' Multiple Environmental Urban Exposures - Comparing Subjective and Objective Measurements. Sustainability, 11(5), 1-12.

UN General Assembly. (2015). Transforming our world: the 2030 Agenda for Sustainable Development. Retrieved from: http://www.refworld.org/docid/57b6e3e44.html [03.04.19]

van Wee, B., & Ettema, D. (2016). Travel behaviour and health: A conceptual model and research agenda. Journal of Transport & Health, 3(3), 240-248.

Witzel, A. (2012). The problem-centred interview: principles and practice (A. Witzel & H. Reiter (ed.). Sage, Los Angeles.

Fig 1. Aggregated surface of parking (orange) overlaid on NY

Fabio Galicia (fabio.galicia@woodsbagot.com), Dr. Lucy Helme (lucy.helme@woodsbagot.com),
Dave Towey (dave.towey@woodsbagot.com), Dr. Christian Derix (christian.derix@woodsbagot.com)
SUPERSPACE, Woods Bagot. www.superspace.agency

MORE LA: TRANSFORMING PARKING TO PLACES IN LOS ANGELES

Keywords: parking, housing, affordability, sprawl, autonomous vehicles

1. INTRODUCTION

This abstract describes a major research and design study into novel densification strategies for Los Angeles. The project analyses the surface dedicated to grade parking in the city of Los Angeles and proposes ways of repurposing these spaces to allocate new residential density without disturbing the image of the city or the community profiles.

2. BACKGROUND

2.1 Changing Travel Patterns

With improvements in public transport, as well as increased uptake of car-sharing platforms and even automated vehicles on the horizon, there is a real possibility that private car-use in LA could sharply decline, especially given the advent of increased multi-modal transportation choice. Access to the metro and larger infrastructure is greatly improved if we can assume a 'last-mile' service with either automated vehicles or car-sharing services. We imagine a future where car use is declining, and the need for all that parking is drastically reduced. This opens the door to potential repurposing scenarios that could alleviate the pressure on housing that this area suffers from. This project intends to present ways of doing so that take into account the built environment context and the different sensitivities present in the varied community of LA.

2.2 Commuting times

In Los Angeles, almost 80% of workers commute to work by car, and only 10% use public transport. The LA commute is one of the worst in the US, each person averaging 30 minutes daily commute and a total of 104 hours spent in traffic jams per year, much longer than New York (89 hours), Washington (6 hours), Boston (58 hours), or San Francisco (83 hours). This dependency on private cars necessitates a huge amount of parking.

2.3 Parking surface

LA's design revolves around private car usage. This has historically defined its streets and building typologies, and has drastic effects in sprawl and parking provision. Using an open-access dataset on surface-level parking lots [3], we calculated that the area of land dedicated to parking in LA county is 4.4 times the size of Manhattan (101 square miles), and just within the LA City boundary is larger than the area of Pasadena (27 square miles).

2.4 Redevelopment Potential

Taking this large area, we propose that the city could make use of some of its development potential and we set out to test its capacity under different scenarios.

3. APPROACH & METHODOLOGY

In order to identify areas best suited to benefit from densification, we analysed the grade-parking data in relation to different topics: Land use, built mass, commute patterns, jobs' quality and socioeconomic profiles. We mapped data on a 250x250m grid, and on a later stage we aggregated it using the LA Times neighbourhoods dataset. The undertaken analysis could be divided in two tasks:

1. Characterisation of the parking lots
2. Analysis of the local character of the neighbourhood where each lot is placed in.

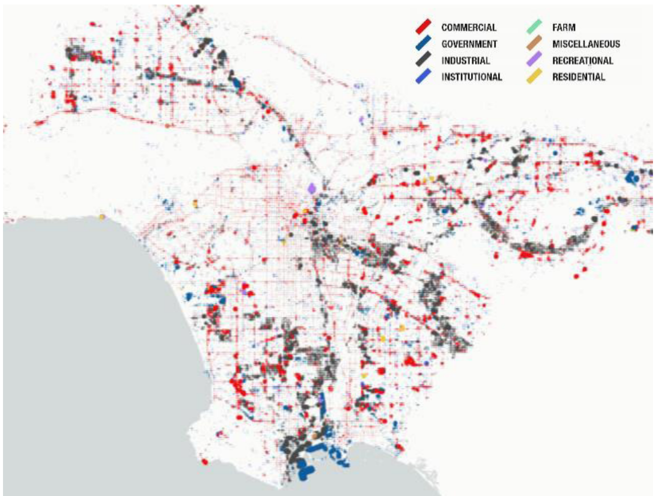


Fig 2. Distribution of grade parking area per land use

3.1 Land Use

Commercial and Industrial corridors were first identified: Industrial belts are well interweaved in the city fabric – the study would leave these areas out of future proposals. It was also observed that the greatest amount of grade parking serves commercial and public/institutional uses. In the case of commercial, it tends to concentrate around main streets and boulevards.

3.2 Built Mass

While the amount of grade parking seems to follow the Gross Floor Area for Industrial uses, this is not always true for commercial and residential uses. Highly built areas around the Boulevards west from Downtown have smaller, but more frequent pockets of parking. While looking at density (FSR), the trend seems much clearer, and again, west from Downtown we can see dense areas with relatively low provision of grade-parking.

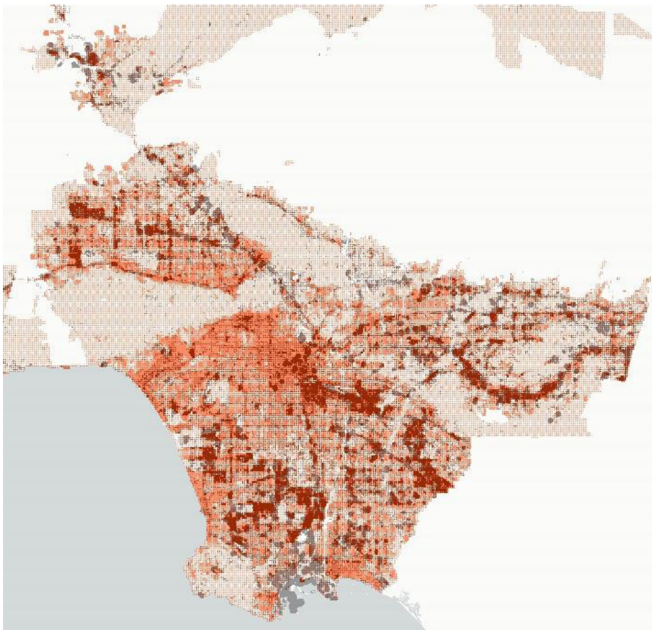


Fig 3. Distribution of grade parking area (grey) vs. FSR (orange). Darker areas indicate overlaps.

3.3 Commute patterns & jobs' quality

An origin-destination dataset allowed us to map over 18M daily commutes, enabling the extraction of information about flows and urban character, but also about the quality of employment (age and salary bands). We mapped predominantly residential vs. predominantly commercial areas, and the different jobs' qualities. These could inform the first guidelines to prioritize development.

3.4 Neighbourhood Character

To explore the differences between neighbourhoods, we profiled the neighbourhoods of the LA Metropolitan area against a range of metrics key to understanding the redevelopment needs in each.

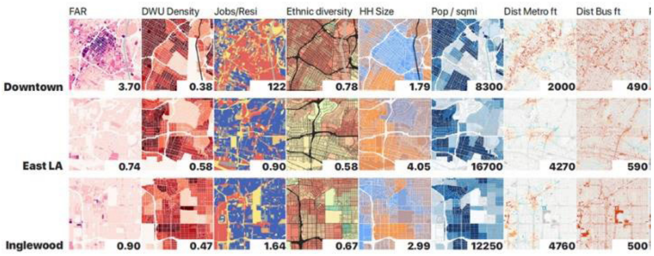


Fig 5. Mapping of multiple metrics per neighborhood: Floor Area Ratio, Dwelling Unit Density, Ratio of Residents to Jobs / Workers, Ethnic diversity, Household (HH) Size, Population per square mile, Distance to Metro stop Distance to Bus stop and Parking area

4. RESULTS & DISCUSSION

One of the main aims of this exercise was to show redevelopment potential of each lot assuming sensitive local development density -resulting from our first analyses. In order to extract some first high level numbers, we started by developing a model which analysed the nearby density of each parking lot (within a 200m radius), and simulated developing each lot up to that density. If 100% of the parking lots in LA county were developed to a density matching their immediate surroundings, over a million new homes could be created, housing over 3 million more people. On a second stage, this model was further refined to incorporate other morphological metrics and socioeconomical indicators, in an effort to prioritize areas where redevelopment could be more beneficial for the residents and the city, and to add a level of sensitivity towards the different groups represented in each neighbourhood.

4.1 Prioritizing development

In order to obtain a reasonable way to prioritize this repurposing, we generated several sub-models that we later combined. One was given the task of categorizing lots that complied with certain socioeconomic and built environment variables (for instance, areas with low residential provision, young workers with long commuting times, close to strategic centres, etc.), another one analysed provision of green areas per neighbourhood.

4.2 Green space provision

The large majority of neighbourhoods have more surface-level parking than green-space. According to the Trust for Public Land, only 55% of Los Angeles residents have walkable access to a park (within half a mile), making Los Angeles' green space much less accessible than some other large cities (such as New York (97%), Philadelphia (93%) and Chicago (92%)). Repurposing some parking as green space could be one way to improve access.

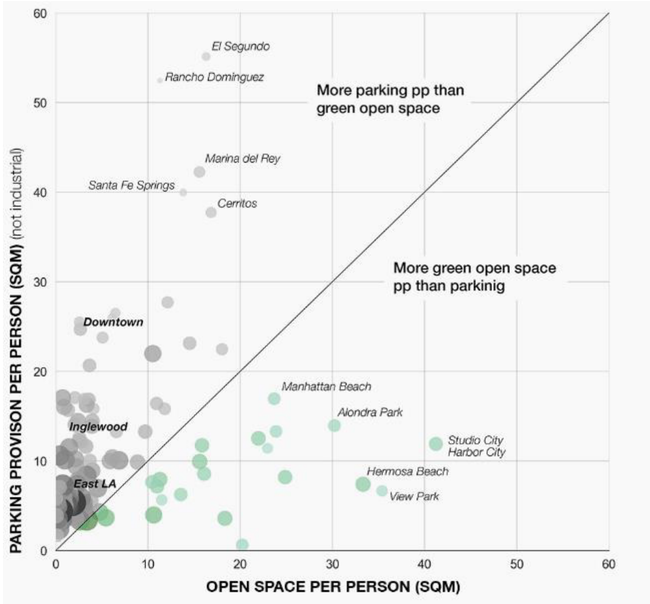


Fig 4. Green-space provision vs parking provision per person for neighbourhoods within the metropolitan area of LA.

4.3 Yields

We also developed an economical model that would allow us to understand the potential for redevelopment in each neighbourhood and the surface and financial yields derived from it in relation to its current status. A custom visualization was design to visually identify potential candidates, enabling a comparison in both relative and absolute values:

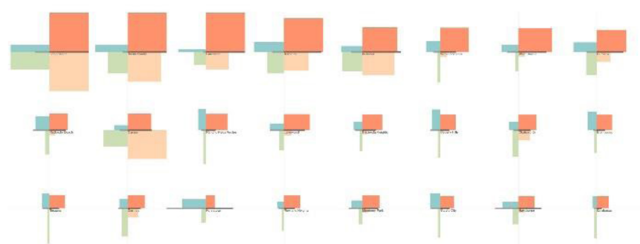


Fig 6. Custom visualization of surface and economical yields per neighborhood

4.4 Proof of concept

These models were used to select four neighbourhoods with diverse social, spatial and economic characters. Within each neighbourhood a prototypical site was chosen as a reference for which these metrics provided the socio-spatial benchmarks. For each of these four sites typology studies by the Woods Bagot design teams were presented as part of MoreLA.

These were also used in a second stage: a community consultation piece that would allow us to gather opinions of LA residents about how they would deal with this repurposing in each one of these selected neighbourhoods.

5. COMMUNITY CONSULTATION

To gauge public opinions on the balance of priorities and redevelopment level for these four neighbourhoods SUPERSPACE developed an interactive survey that allows the user to explore the untapped potential of LA's parking lots, and to voice their opinion on how the balance they would like to see as LA develops in this hypothetical scenario where all the parking lots are open to investigation. The survey allows the participant to choose one of four selected neighbourhoods and, using sliders, create a scenario of their like, balancing these questions:

- What percentage of parking lots should be developed?
- What percentage should be given to green space?
- What percentage higher than the local density should each lot be developed to?

A dashboard on the right side allows for quick exploration of the yields that the selected levels would have in terms of number of people that could be housed, number of dwellings, amount of new green spaces, and reduction in parking surface. The results can then be submitted for further analysis.

This survey was available to interact with at LACoMotion 2018, and is also online at more-la.superspace.agency.

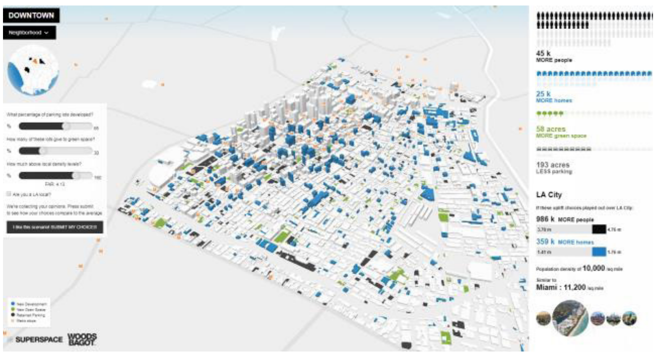


Fig 7. Online Survey interactive dashboard

5. REFERENCES

1. LEHD Origin-Destination Employment Statistics (LODES) https://lehd.ces.census.gov/data/#lodes

2. www.realtor.com/news/trends/the-metros-with-the-best-and-most-miserable-commutes/ via www.nytimes.com/2018/02/22/realestate/commuting-best-worst-cities.html

3. Parking Lot Boundaries 2014, Los Angeles County GIS Data Portal

4. 'The High Cost of Free Parking', Donald Shoup, 2011

5. www.latimes.com/projects/la-pol-ca-housing-supply/

6. 2017 City Park Facts, Trust for Public Land, accessed December 2018

7. Neighbourhood boundaries were taken from the LA Times boundary definitions. Data from the US census 2010, the American Community Survey 2011-2016 and the LA County data portal

8. Interactive survey application built with Mapbox