Visualization of Overlapping Origin Destination Links of the Munich MVG Rad Bicycle Sharing System

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Summary

This paper deals with an approach to visualize origin destination data by counting the number of overlapping buffers created around the origin destination links. This procedure is applied to data from the MVG Rad bike sharing system in Munich, Germany. The results highlight the most strongly frequented bike sharing journeys, as well as the most attractive origins and destinations within the area of observation.

KEYWORDS: origin destination links, OD pairs, spatial analysis, geospatial visualization

1. Introduction

Due to the rise of GPS capable devices such as smartphones, large amounts of data on mobility and other movements can be collected. Therefore, finding simple and convenient procedures to visualize these origin destination data sets has become increasingly important.

One possibility to visualize origin destination (OD) data relies for instance on kernel density estimations. Krisp and Peters (2011) perform a directed kernel density estimation with movement data vectors of airplanes in Germany. An advantage of that strategy is that the dynamic behavior of the examined data points is recognized, yielding result closer to reality. Changes in density appear as ripples or wave-like effects (Krisp and Peters 2011). Guo and Zhu (2014) also adopt kernel density estimations with the aim of smoothing origin-destination flows. Furthermore, an attempt to bundle the edges of origin-destination flow data with the aid of clustering algorithms was presented by Graser et al. (2019).

For this paper, the GIS software ArcGIS by Esri was applied to the freely available data set of the MVG Rad bike sharing system in Munich, Germany. This public bike sharing system consists of bike stations not only in the city of Munich, but also in the suburbs of the district of Munich. Additionally, an area of free return is located inside of the inner city. This sets the MVG Rad apart from many other bike sharing systems in the world, which seldom combine both aspects (Mátrai and Tóth 2016).

2. Methodology

The purpose of the following procedure is to visualize a selection of origin-destination pairs in hotspot areas, i.e. areas with a high density of incident points. It is assumed that origin and destination points of a given data set, in this case the Munich MVG Rad bike sharing data, have already been implemented in a GIS software.

To analyze origin-destination pairs, for every origin point the respective destination point must be found. This leads to a significantly high runtime complexity and therefore necessitates a preselection

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of the used data points. A useful approach consists of examining only a small area and all journeys originating from it or ending there. With the ArcGIS Pro feature “Select by Location”, origin or destination point data sets can be intersected with a self-drawn or previously created polygon feature class, so that the selection only contains points inside the desired area.

To begin finding the most important routes to an area of interest, all origin or destination points within a given polygon around this area can be utilized. For suburban hotspots, selecting the corresponding destination or origin points in a relevant radius from the center of the hotspot, for example ten kilometers, is useful to limit the possible routes to those with a high probability. In downtown areas, the total number of data points might also need to be reduced to accelerate run times. This can be achieved with the help of the ArcGIS Pro feature “Select by Attributes”.

A direct approach to interconnect origin-destination pairs in ArcGIS Pro is provided by the instrument “Generate Origin-Destination Links”. A pair of point layers, one for the origin features and one for the destinations are needed as input parameters, and one output feature class is created. It is also necessary to specify an origin and destination group field by using a corresponding primary key, for example the row number. Otherwise, ArcGIS would try to connect every point from one layer with each point from the other. As the origin points are being connected to the destination points in a 1:1 relation, it is very important to select the “Row” field both as Origin and as Destination Group Field. That way, the corresponding pairs are matched.

A large set of origin-destination pairs is difficult for users to assess. Therefore, creating buffers around them and counting the number of overlaps is a very useful approach to aid with this task. There are several different tools in ArcGIS Pro for creating buffers. The distance of the buffer can either be specified in a linear unit or taken from a field of the input feature. The user may also select the geodetic method for generating buffers instead of the planar method. The geodetic method has the advantage that the shape of the buffers is conserved.

In areas with high spatial density, the number of OD links should be reduced to accelerate the following procedures. Different buffer sizes are to be tested, as a larger buffer size leads to more overlaps with other buffers. For all calculations, planar buffers suffice due to the relatively small lengths of the OD links.

“Count Overlapping Features” displays the number of overlaps in graduated colors. Defining a minimum number of overlaps is essential to eliminate all origin-destination links that are seldomly frequented. Finally, the overlapping buffer features are counted. Different values for minimal overlap counts are applied to a preselected portion of the buffer layer.

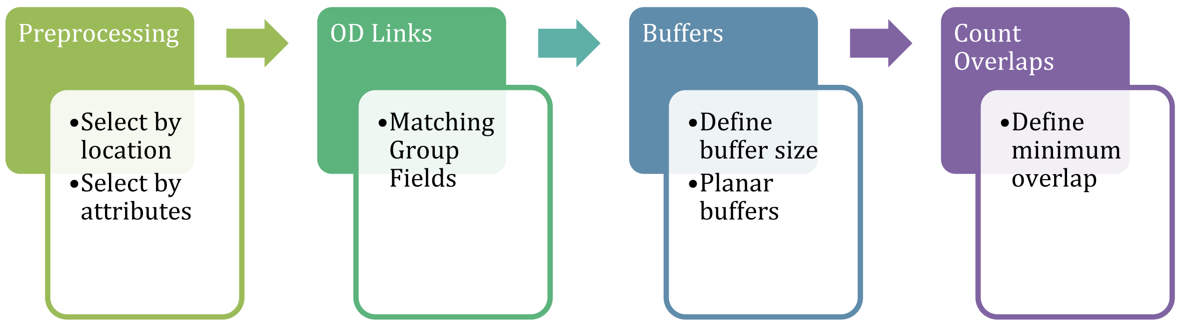

Figure 1 Outline of proposed approach to detect highly frequented origin-destination pairs

3. Results

The displayed map views use the WGS 1984 UTM Zone 32N as coordinate system.

For journeys to the inner-city hotspot at the Technical University of Munich TUM (Arcisstraße 21, 80333 Munich, Germany), data from 2016 is selected. All origin-destination links from within the operating area of the MVG Rad towards the TUM main campus were calculated (**Figure 2**). Subsequently, only every 40th origin-destination link is chosen to be buffered and utilized to count overlaps to accelerate runtimes.

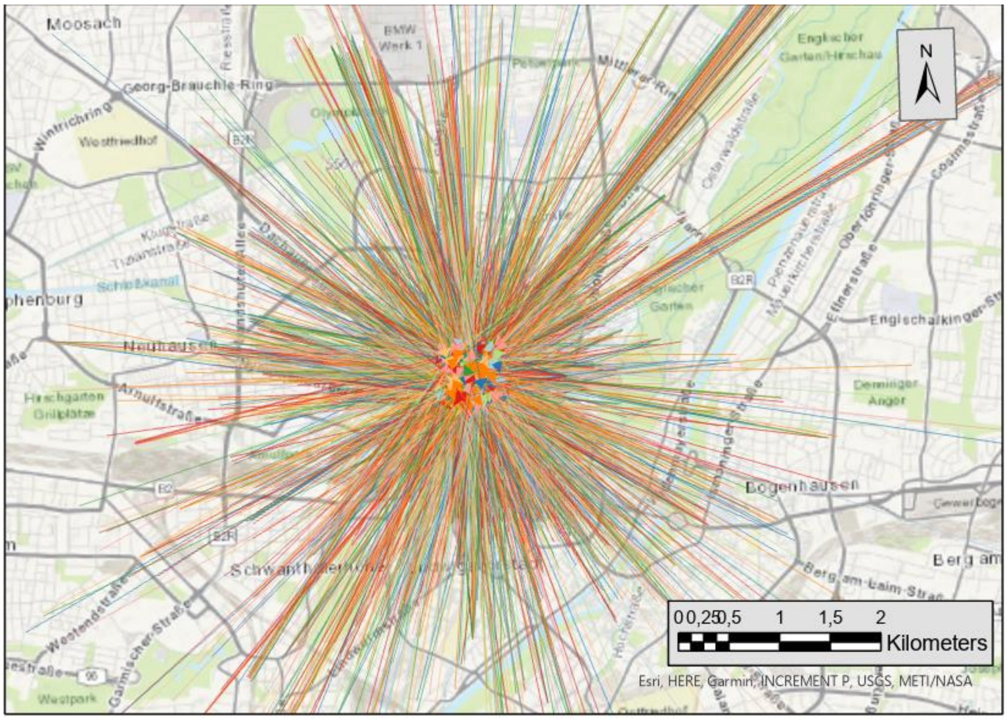

Figure 2 All origin-destination links toward TUM main campus in 2016

For the origin-destination links towards the main campus of the TUM, buffers with a width of 50 m are created. Afterwards, the overlapping features are counted with a minimum overlap count of ten, see **Figure 3**. There are two bike stations of the MVG Rad at the TUM, but the one in Theresienstraße 90 is the most popular return destination at this campus by far. The journey from the LMU main campus (red oval) to TUM appears to be the most strongly used connection. The public transport station Universität at LMU (University of Munich) is directly connected to another TUM campus at Garching Forschungszentrum via the subway U6. Therefore, the combination of MVG Rad and subway provides a fast and convenient way to travel from one TUM campus to another.

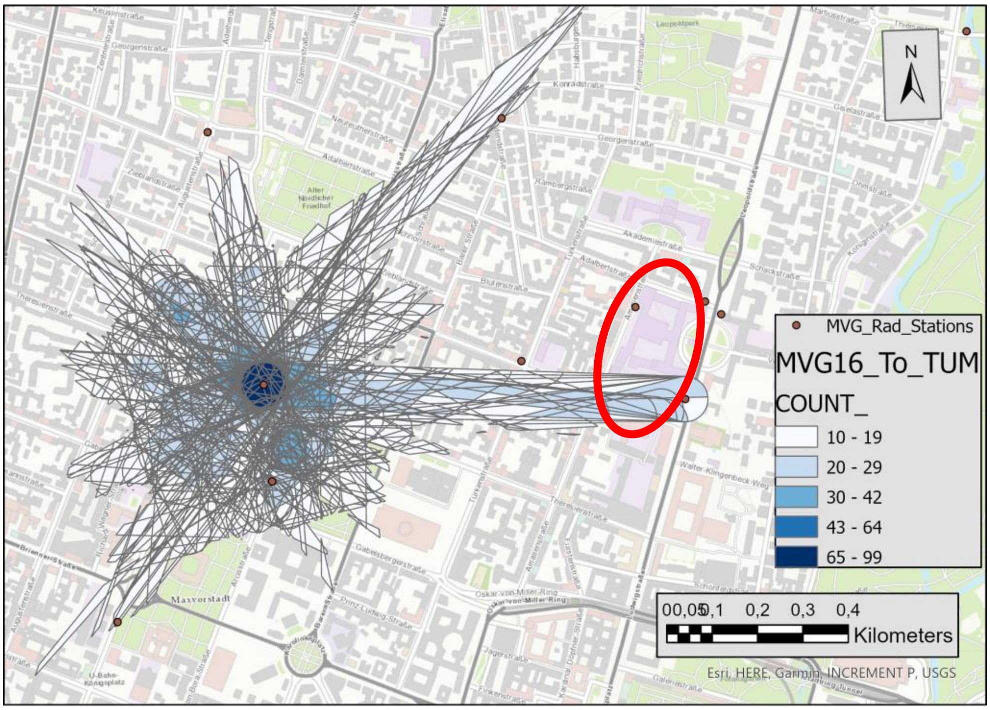

Figure 3 Overlaps of every 40th trip to TUM, 50 m buffer

Outside the return area, the town Unterhaching is examined, as it contains several hotspot clusters and is not too close to the city. To produce origin-destination links towards Unterhaching, origin points within a radius of ten kilometers around the municipality were taken into consideration. The amount of OD links is afterwards reduced by a factor of eight.

In the map view in **Figure 4**, 50 m buffers are also used, and a minimum overlap count of five. The two S-Bahn (commuter rail) stops at Fasanenpark and Unterhaching (black circles) are popular destinations, but not the only ones. The most strongly frequented route (red oval) connects the northern S-Bahn stop Fasanenpark with the sports park Unterhaching, an important destination for leisure activities.

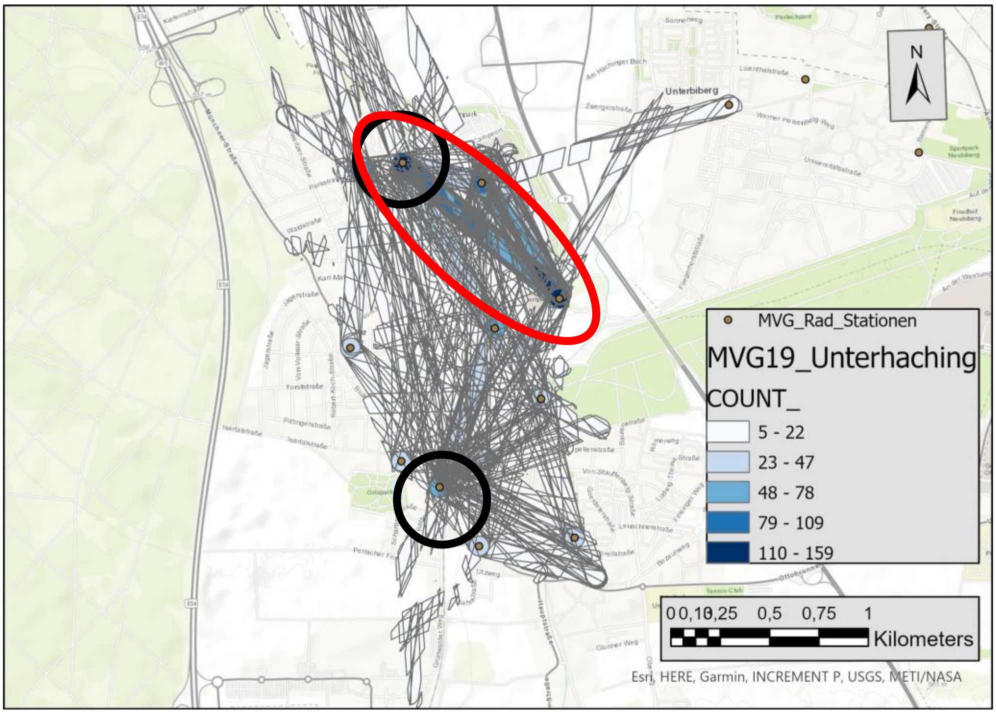

Figure 4 Overlaps of every 8th trip to Unterhaching, 50 m buffer

4. Discussion

The results of this simple visualization technique may become useful to identify highly frequented areas and trajectories. A larger number of intersecting gray lines signifies that the general bike sharing usage in this area is high, whereas darker tones of blue indicate the most popular journeys and origins or destinations.

With bicycle sharing data, this can show up weaknesses of alternative transportation systems, in case of downtown areas especially that of public transportation. However, this cannot be applied to every origin-destination relation, since the user group of bike sharing systems is not necessarily representative of the general population (Fishman et al. 2015). Furthermore, the bicycle infrastructure and other parameters influencing the use of bike sharing should be taken into account as well.

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Biographies

Magnus Doberenz is a student of B.Sc. Environmental Engineering at the Technical University of Munich (TUM). Afterwards, he plans to take part in the master's program M. Sc. Transportation Systems at TUM.

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