Group anomaly detection for optimizing urban planning of rental bike services

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Abstract

In major cities, bike-sharing programs provide a convenient and eco-friendly transportation mode. However, managing and maintaining a large fleet of rental bikes can be logistically challenging and costly. This study analyzes rental bike rides in Munich over the past five years (2019–2023) from the Münchner Verkehrsgesellschaft (MVG) bike-sharing service to optimize the spatial arrangement of rental bike stations and free return regions through urban planning initiatives. We solve urban planning tasks through the point process model of extreme value theory, a group anomaly detection technique. To identify potential free return regions in non-free return areas, a group anomaly detection task is built based on bike ride end locations. All bike rides ending in a specific bike station region in a non-free return area form a group, where the expected distance from the end location to the nearest station should be close to zero. In this setting, anomalous groups might indicate potential free return regions for urban planning. Furthermore, another group anomaly detection task is aimed at optimizing the distribution of bike stations. In this case, a group refers to all bike rides starting from the same bike station and ending in non-free return areas. Anomalous groups provide valuable insights for improving the distribution of station locations, ensuring better accessibility and convenience for users.

Keywords: Group anomaly detection, Extreme value theory, Smart cities, Transportation network optimization

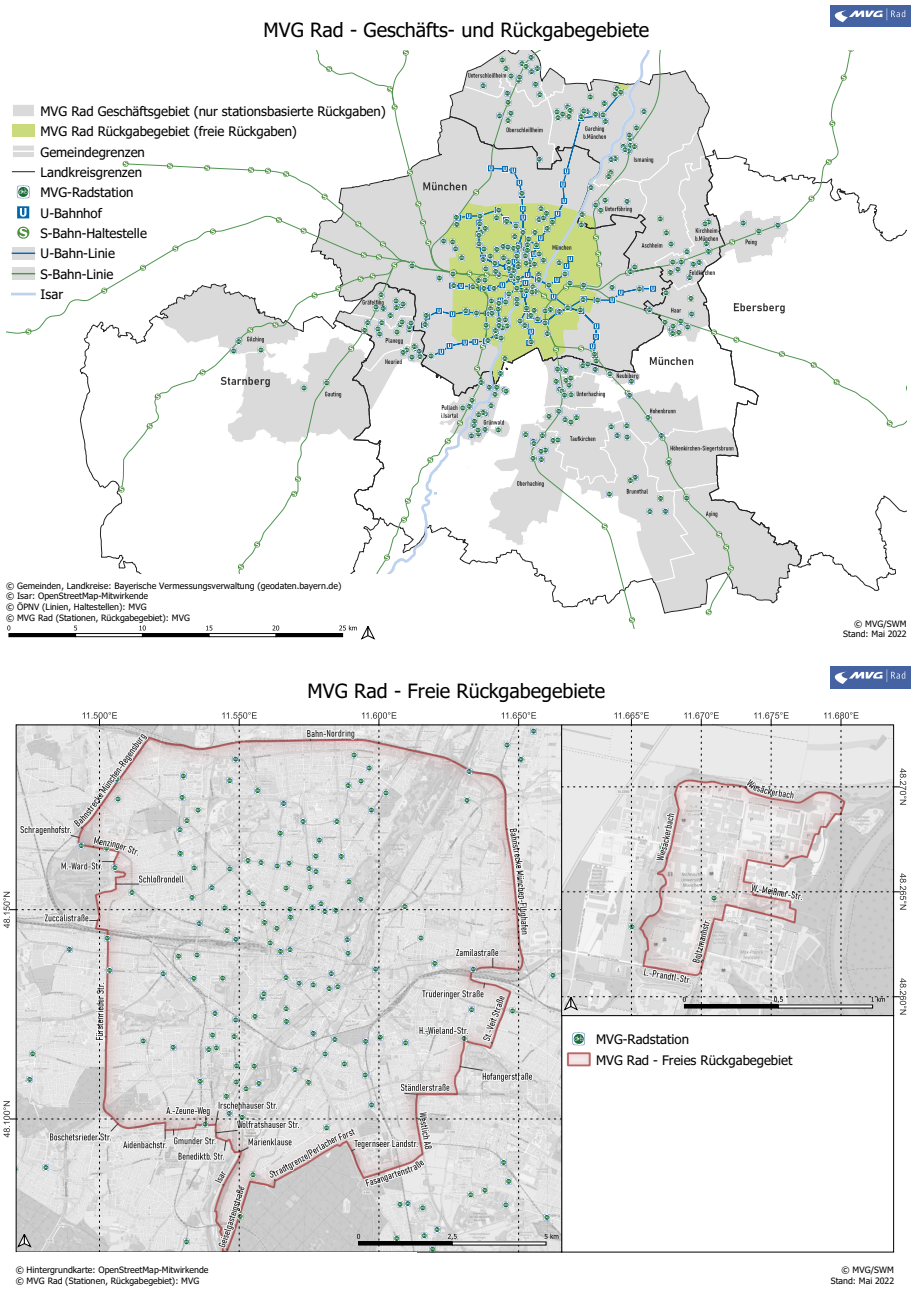

Figure 1: The map of rental bike free return regions in the area of Munich