Unlocking the Power of Mobile Phone Application Data to Accelerate Transport Decarbonisation

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Abstract

Decarbonising transport is crucial in addressing climate change and achieving the Net Zero target. However, limitations arising from traditional data sources and methods obstruct the provision of individual travel information with comprehensive travel modes, high spatiotemporal granularity and updating frequency for achieving transport decarbonisation. Mobile phone application data, an essentially new form of data, can provide valuable travel information after effective mining and assist in progress monitoring, policy evaluation, and system optimisation in transport decarbonisation. This paper proposes a standardised methodology to unlock the power of mobile phone application data for supporting transport decarbonisation. Three typical cases are employed to demonstrate the capabilities of the generated individual multimodal dataset, including monitoring Londoners' 20-minute active travel target, transport GHGs emissions and their contributors, and evaluating small-scale transport interventions. The paper also discusses the limitations of mobile phone application data, such as issues surrounding data privacy and regulation.

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1 Introduction

Greenhouse Gases (GHGs) emissions, which contribute significantly to anthropogenic climate change, have emerged as a pressing global concern. The transport sector, a major source of GHG emissions, accounted for approximately 37% of worldwide CO_2 emissions from fuel combustion in 2021 [3]. Decarbonising transport is a multifaceted challenge involving the addressing of a variety of interrelated issues in policy, technology, and behavioural interventions. This includes encouraging model shifting, decreasing the high dependency on fossil fuels, expanding clean infrastructure investment, delivering transport interventions and regulations, and developing transport carbon credit trading market, etc [2]. In the meantime, numerous data-related challenges associated with these measures must also be resolved to support progress monitoring, intervention and policy evaluation, and the creation of effective policies and system optimisation for accelerating transport decarbonisation.

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To be more specific, the availability of high-quality, detailed spatiotemporal data on travel behaviour, GHG emissions, and energy consumption is often limited, which hampers the creation of targeted interventions and the evaluation of their effectiveness. Secondly, tracking active travel data, which involves irregular trips and informal infrastructure, is challenging. This difficulty complicates the evaluation of modal shifts towards sustainable mobility and the optimisation of transport policies and infrastructure. Thirdly, inconsistencies in data collection methodologies and reporting standards across different jurisdictions prevent effective comparisons and the aggregation of data for regional or global analyses. These inconsistencies also influence the creation of decarbonisation targets and the assessment of progress in transport decarbonisation. Fourthly, near real-time data is vital for the operation of a transport carbon credit trading market and for promptly responding to (un)planned transport disruptions. While efforts have been made to address these data challenges, existing limitations continue to hinder progress towards transport decarbonisation.

Mobile phone data, a new form of data, holds several unique advantages, including high spatiotemporal granularity, large-scale coverage, passive data collection, real-time information, and integration with other geospatial data. Coupled with advancements in geospatial analysis and artificial intelligence, it becomes feasible to infer more holistic travel mode and personal activities information. For instance, its fine spatiotemporal granularity can inform infrastructure planning, from the expansion of cycling and public transit networks to the deployment of electric vehicle charging stations. Additionally, this data can bolster emissions models, aiding targeted mitigation efforts and enhancing our understanding of the connection between transport and emissions [4]. While mobile phone data offers substantial potential, its full utilisation to accelerate transport decarbonisation remains a significant challenge. The intricacies of processing massive data, the lack of standardised methodologies, and privacy concerns are areas that require further exploration and research.

This paper mainly introduces how do we develop a standardised methodology for unlocking the power of mobile phone application data and applying it to support transport decarbonisation. In the next section, we will introduce the superior characteristics of mobile phone application data and the used dataset. The third section will introduce the proposed methodology for mining the mobile phone application dataset and its potential applications. The fourth section will demonstrate the applications in monitoring active travel, estimating transport GHGs emissions, and evaluating transport interventions. In the last section, we will draw conclusions and discuss the potential limitations of mobile phone dataset.

2 Mobile phone application dataset

With the widespread adoption of smartphones and an increasing reliance on mobile networks, mobile phone data has become an abundant and valuable resource for researchers, businesses, and policymakers. Mobile phone data is derived from two sources, including cellular tower data and mobile phone application data. Cellular tower data is inferred from the connection of mobile devices to cell towers. Mobile phone application data is generated from built-in sensors and collected by popular public applications equipped with location-based services. In addition to the general characteristics, mobile phone application data has three advantages over cellular tower data, which enables a more detailed understanding of mobility patterns, travel modes, and location-based activities:

- Higher spatiotemporal granularity: mobile phone sensors (e.g., GPS) can provide more accurate location information compared to cellular network-based data, which relies on cell tower triangulation.

- Rich variety of sensors: mobile phone is equipped with numerous sensors, including accelerometers, gyroscopes, and magnetometers, which can provide additional context and information about individual activities, such as speed and heading.
- Higher sample rate: mobile phone application usually has higher collect data at specific time intervals or based on user-triggered events, allowing for the collection of high-frequency data.

In this study, we utilise a mobile phone application dataset from Location Science AI, which is collected and combined from more than 50 popular mobile phone applications. This dataset encompasses about 1 million+ unique devices in 2020 and 2021 in the UK. On average, we have about 80 data points per device per day, with the horizontal accuracy being approximately 21.7 meters. This effectively alleviates the potential sample bias in the mobile phone application data from a single source and increases the data sample per device. The obtained dataset, collected from the UK from January 2019 to the present (live feeding), provides a robust approach to investigating transport decarbonisation across multiple periods.

3 Methodology

This research presents a standardised methodology to harness the power of mobile phone application data for accelerating transport decarbonisation (**Figure 1**). The methodology comprises two main steps: (1) the provision of travel information. (2) the potential applications.

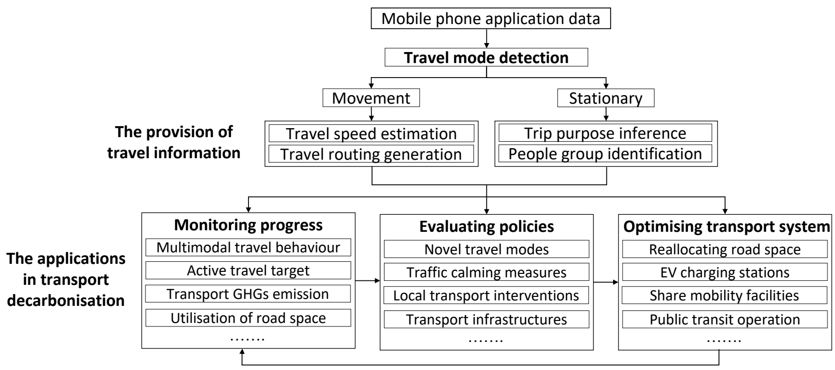

Figure 1 the methodology for unlocking the power of mobile phone application dataset.

Given the raw mobile phone application dataset does not offer any travel-related information, it is essential to adopt and improve novel algorithms to mine travel information from it. In this framework, travel mode detection plays a pivotal role in providing travel information. We improve the moving window SVM model and combine spatial analysis for accommodating the massive data volume of mobile phone application dataset [1, 5]. Seven typical travel modes are detected, including car, bus, train, tube, cycle, walk, and stationary. After classifying the raw dataset into movement and stationary groups, we first further deliver individual travel information (e.g., speed and routing), which can be further aggregated to street-level traffic flow or regional-level OD flow. Besides, trip purpose (e.g., working and shopping) and people groups (i.e., residents, people with trip attractions, pass-through people) can be identified based on machine learning and spatial analysis methods by combining other spatial datasets (e.g., land use and POIs).

With detailed and comprehensive travel and activity information, many specific challenges in progress monitoring, policy evaluation, and transport system optimisation can be addressed. Mobile phone application dataset and this standardised methodology become the linkages between these three key aspects, thereby accelerating the achievement of transport decarbonisation. It should be noted that this framework only presents a part of travel-related information extraction and its applications, which could be further expanded to other unexplored fields.

4 Applications

In this study, we choose London as the study area and demonstrate three applications of transport decarbonisation based on mobile phone application data, specifically: active travel target achievement, transport GHGs emissions estimation, and transport intervention evaluation.

4.1 Monitoring the progress of active travel target

According to the Mayor of London's Transport Strategy, all Londoners should engage in at least 20 minutes of active travel by 2041. This means that local residents should be able to access essential services, amenities, and recreational opportunities within a 20-minute walk or cycle from their homes. This approach encourages people to use active and sustainable modes of transport, instead of relying on private cars. Consequently, it's important to monitor progress towards these targets to better direct sustainable mobility infrastructure development and related intervention formulation. However, continuous monitoring of active travel, including cycling and walking, is challenging with traditional statistics and surveys. Mobile phone application data could easily monitor local residents' active travel and assess the target achievement, making it simpler to optimise infrastructure investment and transport interventions. **Figure 2** presents the achievement of 20-minute active travel target at Middle Super Output Area (MSOA) level in London. Most MSOAs have not fully achieved the target, and MSOAs located in inner London have better progress in target achievement.

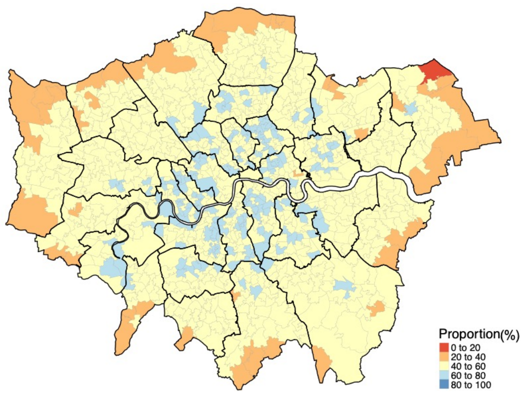

Figure 2 the achievement of 20-minute active travel targets in London.

4.2 Estimating transport GHGs emissions

Estimating transport GHG emissions is a critical task for understanding the environmental impact of transport systems and for developing effective decarbonisation strategies. However, due to the complex nature of transport systems, the variability in vehicle technologies,

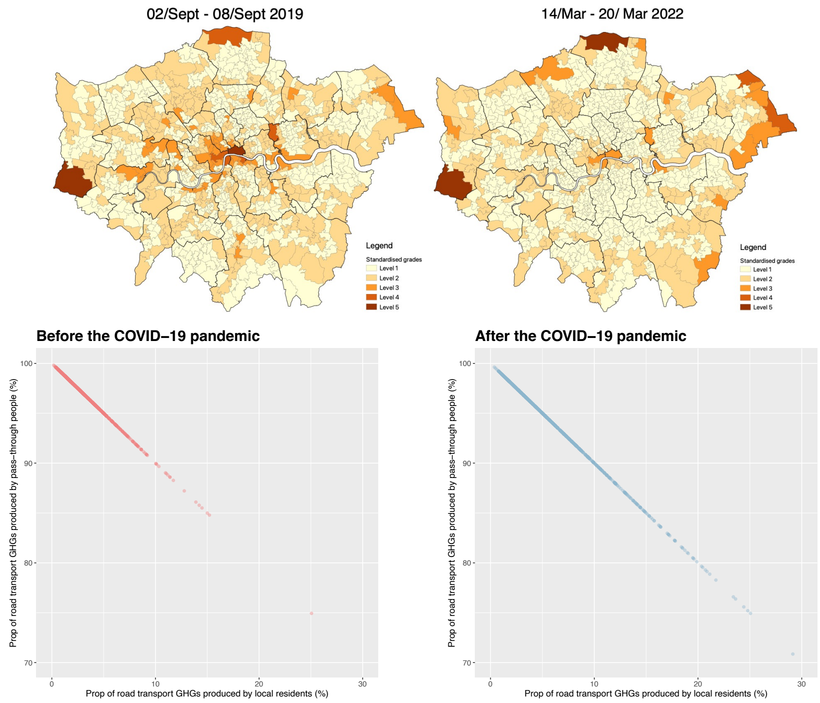

Figure 3 The spatial distribution and contribution of transport GHGs emissions.

and user behaviours, estimating transport GHG emissions can be challenging. With the provided travel information, transport GHGs emissions can be further estimated by using distance-based estimation methods. Besides, the allocation of transport GHGs emissions could be further conducted based on travel modes and people groups derived from the mobile phone application dataset. **Figure 3** illustrates the transport GHGs emissions at MSOA level, as well as the shares of contributors (i.e., residents versus pass-through people) in London, both before and after the COVID-19 pandemic. The transport GHGs emission in inner London is no longer significantly higher than those in the outer, and the proportion of local transport GHG emissions produced by residents is higher than pre-pandemic. These changes may be attributed to shifts in travel behaviour and lifestyle, such as the increased prevalence of remote work. The findings will aid in formulating decarbonisation policies and foster the development of carbon credit trading markets.

4.3 Evaluating transport interventions

Transport interventions are crucial in promoting transport decarbonisation and steering towards more sustainability. They aim to reduce GHG emissions by endorsing low-carbon transportation modes, improving energy efficiency, and encouraging behavioural change. Key interventions include enhancing public transportation, supporting active travel modes, incentivising electric vehicle adoption, and implementing policies such as congestion pricing and low-emission zones. After the outbreak of the COVID-19 pandemic, London rapidly introduced Low Traffic Neighbourhood Scheme (LTN) across many boroughs, with the goal of encouraging active travel, preventing traffic through traffic, and keeping social distances. Given the scheme's small scale (approximately 1 km^2) and uncertain implementation period, traditional datasets struggle to capture its impacts. Fortunately, the high spatiotemporal granularity of mobile phone application dataset enables us to unpack LTNs' impacts. **Figure 4** illustrates the re-routing of individual driving routes after introducing St Peter LTNs in London. According to the travel information delivered from mobile phone data, it is easy to track the redistribution of multimodal traffic flow and road space usage. This is a powerful approach for authorities to evaluate transport interventions and identify potential side-effects.

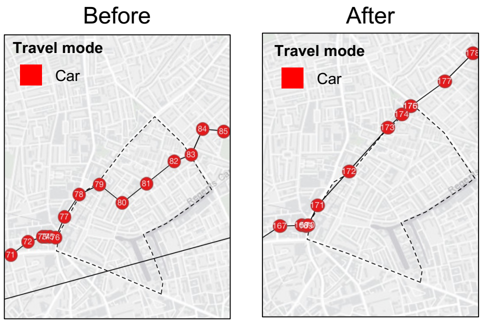

Figure 4 the re-routing of an individual driving route.

5 Conclusions

This study demonstrates how to unlock the power of mobile phone application data to accelerate transport decarbonisation and its potential applications. We reviewed the data challenges in transport decarbonisation and proposed a methodology to overcome them. We present three applications demonstrating how mobile phone application data can facilitate progress monitoring, transport GHGs emissions estimation, and policy and intervention evaluation. While mobile phone application data holds significant potential to support transport decarbonisation, two key limitations must be addressed in the future.

Firstly, while mobile phone application data offers valuable insights, it also contains sensitive information about individuals' movements and behaviours. It's crucial to strike a balance between utilising the potential of this data and ensuring privacy.

Secondly, data protection regulations, like the General Data Protection Regulation (GDPR) in the European Union, have been proposed or implemented worldwide to address growing data privacy concerns. These regulations dictate strict compliance regarding data collection, storage, and processing, which in turn pose new challenges to data availability and application. To mitigate these challenges, advanced data processing and management strategies, such as federated learning, should be developed or applied.

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