Repurposing existing traffic data sources for COVID-19 crisis management

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Abstract—**Mobility behavior was impacted severely by the COVID-19 health crisis. To understand the changing situation, crisis managers need access to credible and timely data. In this paper, we look at the potential of traffic management data for crisis management. We list the different categories and types of traffic data sources and provide an overview of how policymakers, research institutions and private companies can repurpose their data to monitor the effect of the crisis and the accompanying lockdown measures on mobility behavior. Finally, we illustrate this through two use cases in the Belgian city of Ghent, and conclude that existing information from connected infrastructure in smart cities can be quickly repurposed with minimal effort.**

I. Introduction

The COVID-19 health crisis disrupted the mobility behavior in several ways. During the lockdown measures, people were working from home, students were participating in electronic classes, and across the world recreational activities were limited.

These profound changes in mobility behavior have started intense discussions on how governments can manage the situation and what they could do to nudge the transportation industry towards a more sustainable future after the crisis is finished [1–4].

Policymakers need access to credible data to support their decisions. However, in the case of a crisis, such as a global pandemic, this information is not always easily and readily accessible to them. Because the acute nature of the crisis, timely data access is of the utmost importance, and therefore there is usually not enough time to wait for the purchase, establishment and collection of novel data sources.

Thus, a more suitable option is to look for data that a city or region is already collecting as part of its existing endeavors. Typically, the required infrastructure to collect that data is already present, and there are existing processes for the management, visualization and analysis of the resulting information. Smart cities that adhere to technical standards [5] can rapidly adapt their data streams. Furthermore, existing data sources have the advantage that historical data are available, which enables policymakers and crisis managers to compare the current situation to a baseline.

In this paper, we look specifically at the potential of data that is gathered for traffic management and the potential to repurpose it towards crisis management.

II. Traffic management data sources

Depending on the size of a city, it may have access to a larger or smaller selection of traffic management data sources to support decision making. These traffic management centers (TMC), along with some other departments in various city administration departments, have access to a wealth of data sources on human mobility, logistics, and the environment. In this section, we review four emerging categories of mobility data sources used in TMC [6]. We then offer examples of how these data sources provide insight into the effects of widespread crises.

A. Connected travelers

Over the past couple of years, information gathered from connected travelers through smartphones and GNSS (Global

This work was supported by the TMaaS project, realized in collaboration with the city of Ghent. The project partners are Ghent University, Waylay, Be-Mobile, TomTom, De Staatse Ruiter, the European Passengers Federation and Mintlab (KU Leuven), TMaaS is co-financed by the European Regional and Development Fund through the Urban Innovative Actions Initiative, www.uia-initiative.eu

978-1-7281-8294-0/20/$31.00 ©2020 IEEE

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Navigation Satellite System) trackers has become increasingly important for commercial purposes, research, and policy making. Aggregated mobility tracking data is an excellent source of information on people's transportation habits, and origin-destination (OD) information on trips for each transport mode [7, 8]. These aggregated traffic flows are invaluable to examine the impact of crisis-specific policies on population mobility patterns. Several commercial entities active in this domain have already published resources on how their data sets could be used to assess the impact of crises - such as the ongoing pandemic - on urban mobility.

Facebook has previously used precise location information gathered from their social media apps to generate detailed disaster maps that offer insights into large-scale population movement (i.e., ongoing evacuations), power availability, and cellular network coverage [9].

Mobile phone network operators, such as Deutsche Telecom in Germany [10], along with O2 and British Telecom in the United Kingdom, have also offered support in combating the crisis by creating movement maps from call detail records (CDR).

Pepe *et al.* have studied the impact of restriction measures on the populace through the analysis of a large-scale data set of geolocated smartphone users [11]. Using a smartphone app, they collected data from 167.000 users in Italy starting on February 22 of 2020. From this information, the researchers derived several indicators showing the effectiveness of the intervention policies. For example, they show the relative difference of incoming traffic to each of the Italian provinces and a reduction of spatial range for individual mobility patterns.

Similarly, Google and Apple have used their connected traveler information to provide anonymized and aggregated insights that can help policymakers tailor their decisions based on the feedback provided by these sources [12, 13]. Their results show that the motorized traffic intensity in numerous large and medium-sized cities in Europe has decreased significantly during the lockdown.

Be-Mobile, together with the Flemish news agency VRT NWS and the Flemish Traffic Control Centre, used connected traveler information to estimate the impact of the COVID-19 lockdown measures on motorized traffic on the Flemish highways [14]. They compared the number of observed traffic jams and the number of vehicles on March 9 (the baseline), 16 (first measures), and 23 (lockdown active). While car traffic decreased by almost 60 percent, they also reported that the number of trucks grew slightly. The authors repeated this effort on May 18, while the quarantine measures were systematically reduced, and found that activity levels were gradually climbing again to the pre-crisis baseline [15].

B. Connected vehicles

Connected vehicle technology enables cars, buses, trucks and other infrastructure to sense their environment and communicate with each other. Data from connected vehicles can be useful in aggregated form. A large fraction of commercial cars and car-sharing companies have built-in location and activity trackers for fleet management. This data is useful to monitor real-time link speeds and to analyze changes in traffic intensity in certain areas during a crisis.

TomTom, a Dutch location technology company, has analyzed traffic patterns gathered by their in-vehicle GNSS navigation aids to track the effect of lockdowns around the globe [16].

C. Connected infrastructure

ITS infrastructure has been the primary source of information for TMC for over 35 years now. Sensors, such as vehicle detection and counting systems and closed-circuit television (CCTV) cameras, enable the traffic managers to monitor the real-time traffic situation efficiently. With the advent of the Internet of Things (IoT), these sensors have started to deliver increasingly real-time, large-scale data sets. A vast selection of technologies for automated vehicle counting exists, such as typical inductive loop sensors, magnetic detectors, microwave radar or infrared sensors, or even cameras that use advanced machine learning techniques for vehicle detection.

Much of this data is complementary to other data from connected travelers or connected vehicles. Because of the price of installing the sensors, the cost of connected infrastructure is high compared to data from connected travelers or connected vehicles. However, it has the advantage of delivering highly accurate ground truth information on vehicle speeds and traffic intensity, which can be used to calibrate the aggregated results from other types of TMC data sources.

Data from WiFi and Bluetooth scanners, which have been used previously for long-term monitoring of visitors to shops and touristic hot spots [17, 18], can also be repurposed to monitor real-time business in shopping districts. Automated systems can use this information to send alerts to city officials, so that they can temporarily restrict access to certain areas to avoid overcrowding.

D. Transactional data

Transactional data describes certain events that happened at specific timestamps. In the mobility domain, ticketing system data is considered to be transactional data.

Time-series information from ticketing machines in public parking garages and on-street parking zones can be a new source of information in crisis management. Unlike data from static vehicle counters, which merely convey information on traffic intensity, parking garage and on-street parking occupancy data can also inform crisis managers about trip destinations and trip purposes. The ticketing machines and parking garages typically have geographical coordinates attached to them, and we can use these as a proxy for the actual destination of a car trip within the city.

The increasing popularity of shared cars, bicycles, and steps in European urban areas provides an additional opportunity for monitoring changes in mobility behavior in case of crises. These vehicles typically accommodate some form of real-time location tracker. These location trackers, along with information on ticketing and reservations, is typically only used

Category	Data source	Availability
Connected traveler	Mobility tracking smartphone app	
	Mobility tracking private companies	✓
	CDR tracking	
	Social media	✓
Connected vehicle	Floating car data - flows	✓
	Floating car data - speeds	✓
	Floating car data - fleets	
Connected infrastructure	Vehicle detection systems - counts	✓
	Vehicle detection systems - flows	✓
	Bike counts	✓
	Pedestrian counts	✓
	Environmental sensors	✓
	V2I/I2V systems	
Transactional data	Off-street parking	✓
	On-street parking	✓
	Tolling data	
	Public transport ticketing	
	Shared vehicle ticketing	
	Shared bicycle ticketing	✓

TABLE I: Availability of operational traffic management data sources in Ghent, Belgium

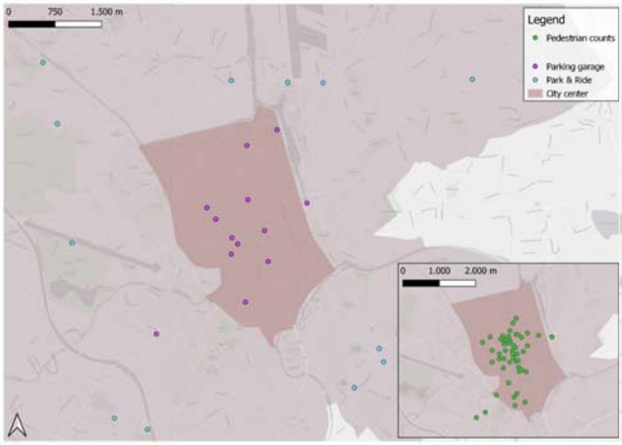

Fig. 1: Location of the parking garages, park & ride facilities and pedestrian counters

by the sharing companies for billing and fleet management. However, crisis managers can quickly repurpose it towards monitoring mobility, as the start and end locations, along with vehicle reservation times, can be used to build time-dependent origin-destination matrices for each of these transport modes. These matrices offer insight into when and where people are traveling.

III. Applications in Ghent

The Belgian city of Ghent, a medium-sized city with roughly 260.000 inhabitants, is one of the pilots for the Traffic Management as a Service (TMaaS) platform. This project started in 2018 and provides a new generation of interactive traffic management dashboards for traffic operators and for citizens [19]. It leverages existing open spatial data along with data feeds from commercial parties to provide an affordable solution for small- and medium sized cities that are interested in professional mobility management. 20 different data sources were incorporated for Ghent, including traffic incidents reported by Waze users, the real-time location of shuttle buses, and live availability of bicycle and car parking facilities.

While these data sets, summarized in Table I, were initially only gathered for traffic management purposes, the COVID-19 health crisis provided an opportunity to see how the city of Ghent can repurpose the data sources for more effective crisis management. This section offers two use cases illustrating the potential of traffic management data for crisis management.

A. Off-street parking

Ghent has fifteen public car parking garages and park & ride facilities that offer real-time occupancy data. Some of these parking facilities are owned by the city, while others are managed by commercial parties, who share their data with the traffic management center. Figure 1 shows that the paid parking garages are located in the city center, while the free park & rides are located primarily on the outskirts of the city.

Figure 2 shows the evolution of the average daily occupancy of a selection of these parking facilities from February 08 until June 18. The first measures taken by the Belgian federal government became active on March 10. These mild measures had a minor effect on the parking occupancy. When the schools closed on March 14, this also reduced the average occupancy. However, when the next wave of measures ordered everyone to stay home and only to make essential displacements, the occupancy rates of several facilities drop significantly. The city center parking garages, such as Sint-Pietersplein and Reep, were affected the most, as shops and workplaces were closed, and there was therefore little incentive to visit the city center. Others, such as parking Tolhuis, were barely affected by the lockdown measures or showed a more gradual decline.

B. Pedestrian counters

Since 2016, Ghent owns fifty pedestrian counters located in various places in and close to the city center (see Figure 1). The information gathered from these sensors was originally used to evaluate the effect of changes to the car circulation plan on the number of visitors to shops and restaurants in the car-free city center, but can also be used in crisis situations for crowd management.

The effect of the lockdown measures is clearly visible in Figure 3. The total number of counted visitors drops rapidly to roughly twenty-five thousand per day once the schools were closed and only essential displacements were allowed. The visitor numbers increase gradually as the re-opening phases progress, but as of June 18 the counts are still significantly lower than the pre-crisis baseline.

IV. Conclusion

To support swift and flexible decision making in times of crises, policymakers need access to credible data to support their choices. Existing traffic management data sources can provide such curated information, as these have been calibrated

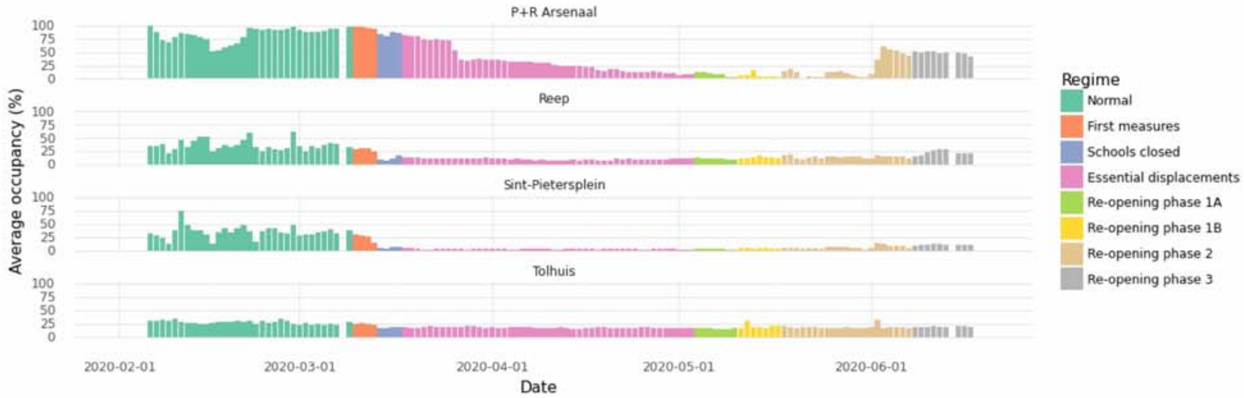

Fig. 2: Evolution of the average daily occupation of a selection of parking garages and park & ride facilities

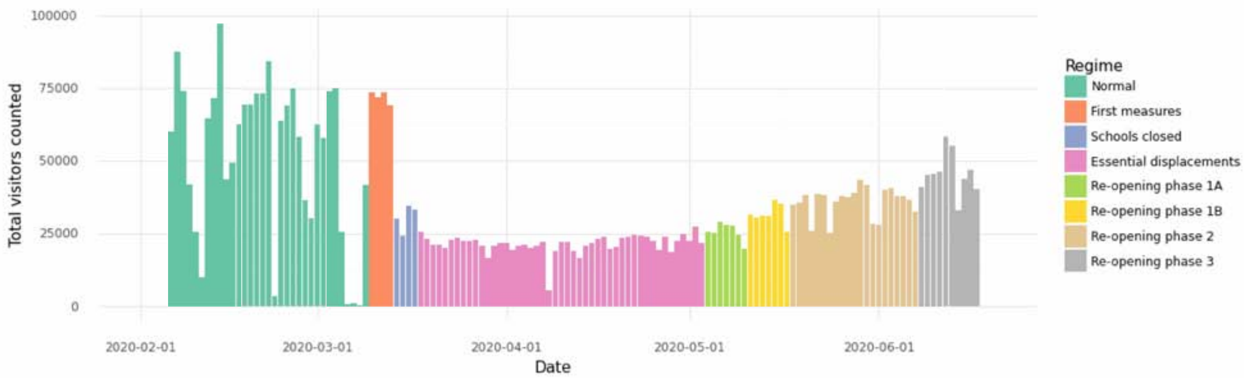

Fig. 3: Evolution of the total amount of pedestrians counted during the COVID-19 crisis

in the context of traffic monitoring and can therefore provide reliable data. The existing expertise in mobility management can then be used to assess the impact of public policy on the citizens' mobility behavior during such crises. Additionally, city officials can partner with private mobility technology providers to gain insight in their connected mobility data.

The two examples, based on data sources available in Ghent, show that existing information from connected infrastructure can be quickly repurposed with minimal effort. Both sources show that the COVID-19 lockdown had a severe impact on urban mobility. The data from parking garage ticketing can be used as a proxy for trip destination analysis, while pedestrian counters are useful for realtime crowd control and long term hotspot analysis.

In future research, we will perform a thorough investigation of the spatial and social context of the parking garages and pedestrian counting points, to provide further insights on how this data can be used for crisis management.

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