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Corresponding Author:
d.strelnikova@fh-kaernten.at
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Utilizing Spatial Video to Analyse Roadside Advertisements in Villach, Austria

Dariia Strelnikova[1], Thomas Schneider[1] and Michael Leitner[1,2]

[1]Carinthia University of Applied Sciences (FH Kärnten), Austria
[2]Louisiana State University, USA

Abstract

Spatial video technology allows the acquisition of video data that includes information about the geographical location of each recorded frame. Such data are captured mostly for entertainment or as part of various sports activities. However, due to the potential of spatial video data to be used for location-based purposes, such as disaster and health management, spatial video technology has been receiving more attention from the scientific community. This paper discusses the capabilities of spatial video technology to serve as a data acquisition tool in an urban environment, using the example of roadside advertising analysis in the city of Villach, Austria. The study shows that the application of spatial video technology helps to reduce the data acquisition time and uncovers further advantages, but also some limitations of this method. The data acquired are used to reveal patterns of spatial distribution of roadside advertisements. These can be used to analyse the effects of advertising in the urban environment, such as distracting road users.

Keywords:

spatial video technology, roadside advertising, distractions in urban traffic

1 Introduction

Digitization Common methods of spatial data acquisition include conventional location-identification with the help of a tachymeter, remote sensing methods such as satellite and aerial imagery, laser scanning, determining positions by means of the Global Navigation Satellite System (GNSS), including Global Positioning System (GPS), and scanning or digitizing from analogue media. These data acquisition methods have a wide range of applications and can be used in combination with each other to provide a deeper understanding of the phenomenon under study. In certain situations, however, the use of these common methods is not optimal. For example, capturing data from vertical surfaces in an urban environment cannot be done effectively by means of satellites, because of the limitations of the aerial perspective. Aerial imagery acquired with the help of unmanned aerial vehicles (UAVs) can include the right perspective and offer relevant details, but the use of this method may be limited by local legislation: UAV flights in the urban environment may be prohibited or require an operational permit, as in France (Arrêté espace, 2015) or

Austria (LBTH 67, 2015). Conventional survey methods, e.g. a survey using an electronic tachymeter or a handheld GPS data collector, are applicable but time-consuming and therefore inefficient for large study areas. Furthermore, only selected contextual data are collected by these methods. Therefore, any further analysis of the data obtained in a conventional survey is limited by the initial choices of the researcher. If other attributes or contextual data are found to be relevant at later stages of the research, their acquisition requires an additional survey. Data acquisition methods free from such limitations are therefore needed, and a promising option is spatial video technology. Therefore, the first aim of this study is to assess the capabilities of this technology.

Even though raw spatial video data require processing before they can be entered into a geographic information system (GIS), the use of spatial video technology still reduces the time necessary for data acquisition in comparison to conventional survey methods, as will be discussed below in more detail. Spatial video technology has the advantage of capturing contextual data together with the data of interest and lends itself for use in the urban environment.

A typical example of an urban environment, the city of Villach, the seventh largest city in Austria, has a population of more than 60,000 people and an area of about 135 km2. It represents an important hub and a popular tourist destination for hundreds of thousands of tourists annually. The city has busy roads, and a large proportion of the roads' users are non-locals. Road safety plays an especially important role in this environment. There are many factors that can influence road safety, and this paper focuses on one of them, namely the distracting effect of roadside advertisements.

People's need to be mobile leads to increased time spent in traffic. Since navigating is a complex activity, road users tend to pay special attention to the stimuli in their environment, and this peculiarity of human attention is used by the advertising industry. In Austria, the location of roadside advertising signs requires a permit and is mostly limited to urban areas (StVO, 1960, §82–84). Regulations concerning the placement of advertising signs are supposed to ensure that there is a balance between business interests and traffic safety (Lachmayer, 2003). Nevertheless, roadside advertising is seen as one of the major causes of external distraction for drivers (Bendak & Al-Saleh, 2010), and for this reason the second aim of this study is to analyse the distribution patterns of roadside advertisements in Villach in terms of their potential to distract road users (e.g. cyclists, pedestrians and drivers).

2 Studies on Roadside Advertising Effects and Spatial Video Technology

Roadside Advertising

Participating in traffic is a complicated activity. The roles of different road users, such as cyclists, pedestrians and drivers, vary in complexity and in terms of the associated risks. Driving comprises several simultaneous tasks, such as navigating, changing lanes, interpreting traffic signs and maintaining an appropriate speed. It is therefore one of the most complicated and risky activities. For this reason, although roadside advertising has a certain impact on all road users, the majority of studies focus on its potential to distract drivers. Driving seems to be straightforward in a known environment, but it becomes challenging and requires full attention on unknown or poorly maintained roads or in streets with dense traffic. Processing information not related to driving itself decreases driving performance (Roberts et al., 2013; Young et al., 2009), and statistics show that 18.7% of road accidents are related to distraction (Hanowski et al., 2006).

The nature of advertising is to attract attention, thus distracting road users from their primary task. Bendak and Al-Saleh (2010) showed that the presence of roadside adverts increased the reckless crossing of dangerous intersections and drifting out of one's lane. In the same study, 22% of participants confirmed that they had been put in a dangerous situation at least once due to roadside adverts. Many studies have associated advertisements that are able to change their content with a higher level of distraction (Chattington et al., 2009; Domke et al., 2011; Roberts et al., 2013). Domke et al. (2011) proved that large billboards with light emitting diodes negatively influence drivers' vision, causing glare and making it difficult to notice traffic signs. Content intended to be memorized, e.g. phone numbers, were proven to cause greater distraction. Several studies revealed that advertisements along roads are associated with an increase in drivers' reaction times (Akagi et al., 1996; Clark & Davies, 2008; Edquist et al., 2011; Ewert, 2011). Crundall et al. (2006) discovered that drivers who are looking for potential hazards fix their eyes on street-level advertisements, probably as they unwillingly focus on the distracting content while looking for, e.g., pedestrians. Overall, roadside advertising has a lower potential to cause traffic accidents than mobile phone use or talking to passengers (Hanowski et al., 2006). The difference between these activities, however, is that paying attention to advertisements, especially illuminated or changing ones, is mostly unintentional and thus unavoidable.

In order to analyse possible effects of roadside advertising, detailed data on locations and characteristics of advertising signs are required. These data can be used to determine the proportion of advertising signs with the most distracting potential, or to analyse their spatial distribution. Comprehensive data on exact locations, media types and content of advertisements in the study area cannot be obtained from local authorities or advertising agencies. One of the reasons for this is that obtaining a permit or even informing local authorities about the placement of certain advert types is not necessary. Such cases include flags used as an advertising media, advertisements of local events placed on the buildings where they will take place, or posters located in shop windows facing the road (City of Villach, 2018). To capture detailed data necessary to analyse roadside adverts in the city of Villach, given the limitations of commonly used data acquisition methods described above, this study utilized spatial video technology.

Spatial video technology

Spatial video, also called georeferenced video (Kim, Kim, & Yu, 2012), is geographically referenced videographic data, a video stream in which each frame is associated with a location and an orientation. It can be recorded from a survey vehicle (car, bicycle, boat, etc.), in the direction of travel (Lewis et al., 2011). Usually, cameras used for recording spatial video material are mounted on a survey vehicle at such an angle as to allow the capture of surfaces perpendicular to the road surface; parallel surfaces can also be captured, e.g. underwater surveys from a boat (Jerosch et al., 2006).

Spatial video technology presents certain challenges. There are no standards concerning the spatial video format or quality, and no centralized archives for the storage of footage (Lewis et al., 2011). Although some work has been carried out to facilitate efficient spatial video searches (Kim et al., 2012; Lewis et al., 2011), there are no standards concerning spatial video indexing and search, and its potential for being reused is rarely addressed. These challenges, however, do not prevent the continuing growth of the number of spatial video applications, for both commercial and academic purposes.

Before spatial video technology was developed, researchers utilized analogue video for spatial analysis. In 1994, Taylor and Taylor videotaped 705 billboards on a 690-mile route through Michigan and compared content patterns for urban and rural areas. Further development of the tool's potential gave birth to the spatial video. Several studies (Curtis, Curtis et al., 2015; Curtis & Mills, 2012; Curtis, Mills, Kennedy et al., 2007; Curtis, Mills & Leitner, 2007; Lue et al., 2014; Paulikas et al., 2014) applied spatial video to the consequences of natural disasters. Burke et al. (2015) used spatial video from bicycles to collect data on second-hand smoke exposure on a college campus. Curtis, Blackburn et al. (2013) used spatial video for health-risk mapping, and Curtis, Blackburn et al. (2016) showed how spatial video technology can support field epidemiology. To date (March 2018), we have found neither any studies conducted with the help of spatial video technology in Austria, nor any exploiting spatial video technology specifically for roadside advertisement analysis.

3 Data Acquisition Approach and Analysis Methodology

Data Acquisition by Means of Spatial Video Technology

The utilization of spatial video for roadside-advertising data acquisition in an urban environment presents substantial advantages over other methods. It allows the time-efficient collection of comprehensive data with necessary attributes, reducing the time required for fieldwork, and creates an archive that can be used for further analysis, as well as for the retrieval of additional attributes or contextual data. Such video archives can also be used as historical documents. With some limitations, the footage can be used for other projects that have the same study area.

The quality and completeness of data captured with the help of spatial video depend on the route chosen. For the purposes of this study, the route comprised main and highly frequented roads in the city of Villach, the identification of which was based on local knowledge of the city structure. In order to compensate for obstacles that might conceal some of the advertising signs, such as large vehicles, to avoid poor visibility on wider roads and to capture two-sided advertising signs, the route included travelling each major road or street in both directions. OpenStreetMap served as the background information for the route planning. The survey was conducted during the daytime, on Sunday, 17 December 2017 from 10:00 am to 12:15 pm.

Spatial video recording was conducted with the use of three Contour cameras (http://contour.com/), two of which were attached to the side windows at the back of a car (Figure 1a, b), and one was mounted on the windshield (Figure 1c). Contour cameras are equipped with GPS sensors and produce video files in mp4 format with embedded GPS tracks. After turning on a Contour camera, it takes several minutes to establish a GPS connection. During this time the camera produces some GPS data that do not describe the survey route. Contour cameras automatically create a new video file every 40 minutes, with a size of about 4 GB at their highest resolution. For a longer survey, as in the case of this study, it is reasonable to have memory cards of at least 16 GB capacity and to keep cameras connected to a charger using the car's cigarette lighter (Figure 1d) for the duration of the survey.

Figure 1: Equipment used for spatial video acquisition

The study utilized the free software Contour Storyteller 3.6.2.1043 in order to extract GPS tracks in GPX format from the recorded video files. An open-source GIS QGIS 2.18 and ArcGIS 10.4 were used for further data processing, which included digitizing locations of advertising signs along the extracted GPS trajectories and supplying each of them with corresponding attributes. The Austrian Web Mapping Tile Service provided by basemap.at was used as a background for the digitalization of advertisements. Data transfer into GIS with 8 attributes for each advertising sign, including the GPS track conversion and the timestamp alignment (explained in Section 4 below), took 40 hours. The research team had no previous experience with the spatial video technology. Since the creation of the first 35% of points took as long as the other 65%, it is expected that data transfer time can be significantly reduced with experience.

Analysis Methodology

An important step in data acquisition is deciding which attributes are relevant to the study subject, and then developing classification criteria that guarantee the consistency of the classification. Since the main focus of this paper is the spatial video technology itself and its application to the investigation of the distracting effects of urban roadside advertising, we discuss further only those aspects of the collected data that are relevant to this focus.

Attributes of advertising signs related to their distraction potential included their size and the ability to change content. The size categorization relied on the length of the longer side of the advertisement. Possible values were 1 (up to 1 m), 2 (up to 2 m), and 3 (up to 3 m).

The density of advertising was analysed by means of kernel density estimation (KDE) in ArcGIS, using the normal (Gaussian) function and a search radius of 150 m. KDE calculates density values for each cell of the overlaid surface by means of various kernel functions (normal, quartic, uniform, etc.) as absolute values or probabilities (Longley et al., 2011). Two sets of weights were applied to the dataset for the KDE calculation. Since larger advertisements have more potential to attract road users' attention than smaller signs, we utilized the size attribute of the advertisement as a weight, in order to account for both the location and the space that the advertisement occupies. Another set of weights was based on the ability of advertising signs to change content: digital screens that are bright and can display dynamic video content received a weight of 3, signs that rotated mechanically at regular intervals got a weight of 2, and all other signs were weighted with 1. Results of the application of both sets of weights and the differences between the resulting advertising density maps are discussed in the following section.

4 Survey Results and Discussion

A drive of 2+ hours on the main and most popular roads in Villach, Austria, over a distance of more than 71 km, yielded 2,070 individual roadside advertisement points (Figure 2). We found that the use of spatial video technology speeded up the data collection process significantly. For example, if the coordinates of each advertising sign had to be manually captured with the help of a mobile GPS device, it would not be reasonable to use a car to travel around the city due to the frequent need to stop and park, which is problematic in city traffic. Cycling between the locations of advertisements increases travel time threefold; travelling on foot takes even longer. It is also important to note that conducting a survey by bicycle or on foot strongly depends on suitable weather. Utilizing spatial video technology from a car, however, is possible in most weather conditions, since rain or snow, if not too heavy, do not substantially impair the video quality.

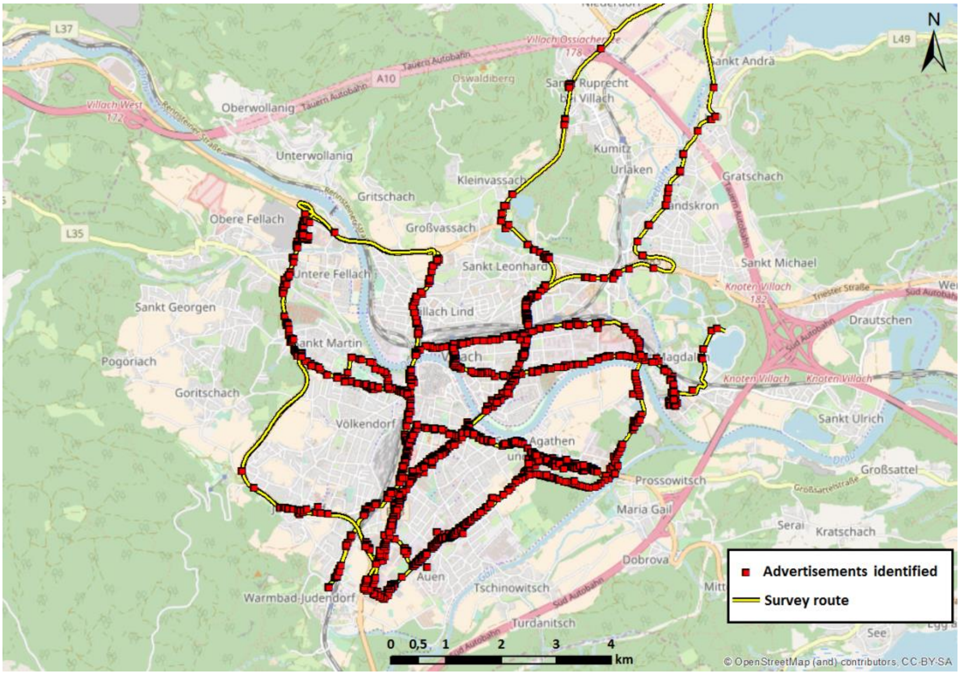


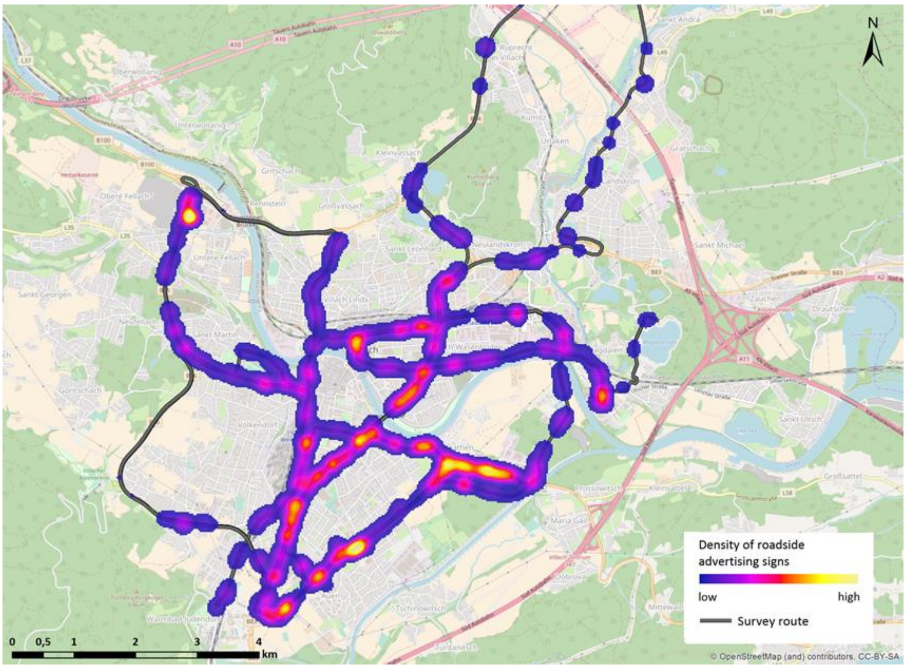
Figure 2: Survey route and locations of roadside advertising signs in Villach, Austria

One of the limitations of spatial video technology discovered in this study is associated with the simultaneous use of several spatial video cameras. Even if several cameras are turned on simultaneously, they do not become connected to the GPS at the same moment. As a result, timestamps corresponding to the same geographical point vary slightly from camera to camera. The Align GPS Data functionality of the Contour Storyteller software used to derive GPS trajectories from the video files only partially solves this problem, because in a longer survey each of the newly created video files would start from a different location.

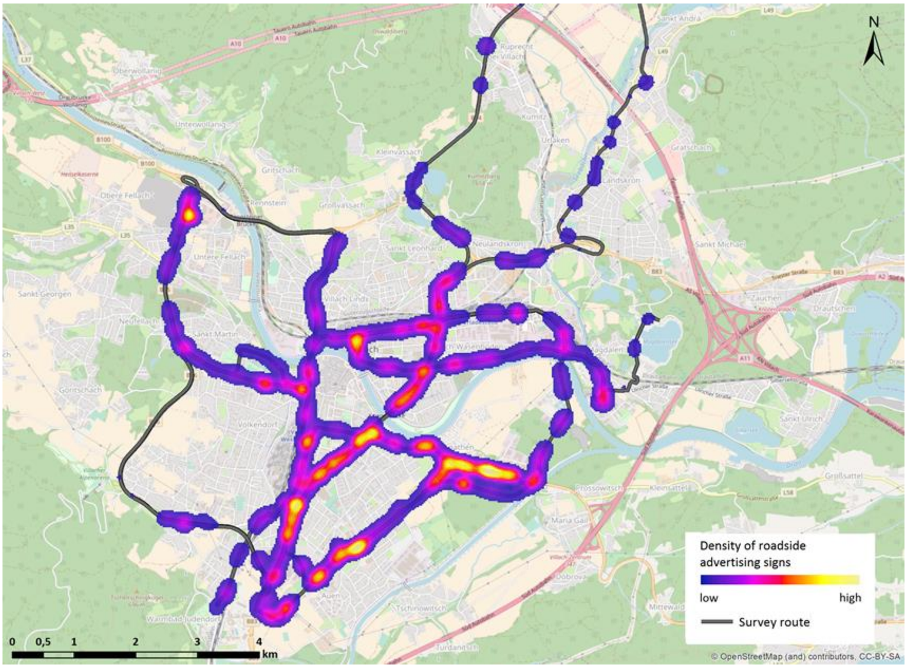
The main advantages of spatial video technology are associated with the speed of data acquisition and its cost. Professional handheld data collectors (such as those manufactured by Trimble, Spectra, Leica, etc.), allow fast acquisition of GPS data. The high speed of data collection by means of these devices is achieved because the acquisition of coordinates is done simultaneously with the input of attributes. Furthermore, these devices allow the automatic copying of previous attribute values for new coordinates. However, capturing attributes using spatial video equipment requires less time than the input of attributes using a handheld device, since it is more convenient to work with a full-sized keyboard. Another important difference between these two technologies is the price. The cost of the full set of spatial video equipment used in this study (3 Contour cameras, 3 charging kits and 3 memory cards) was just a little over 1,000 US$, whereas a single professional handheld GPS data collector usually exceeds 3,000 US$. Nevertheless, spatial video technology is not optimal in cases when the acquisition of very precise locational data is needed; it can, however, provide faster data acquisition in unfavourable weather conditions.

Spatial video technology implies the possibility of further automation, not least thanks to recent significant developments in artificial intelligence technology. LIDAR and GPS/GNSS technologies typically used in autonomous vehicles can be utilized to identify the exact location of target objects located along the travel route. In the acquisition of roadside advertising data, artificial intelligence technologies associated with text- and image-recognition can be applied to the identification of the advertising media and the content advertised. In this respect, automatic recognition of the roadside advertising signs may present less of a challenge than, for example, recognizing the damage associated with a natural disaster, because advertisements generally target drivers and are meant to be easily recognized and comprehended by them. This suggests that at least for some target objects, such as roadside advertisements, the laborious manual spatial video data processing (i.e., the digitizing of features and attribute input in a GIS from the video content) may have the potential to be further simplified and accelerated.

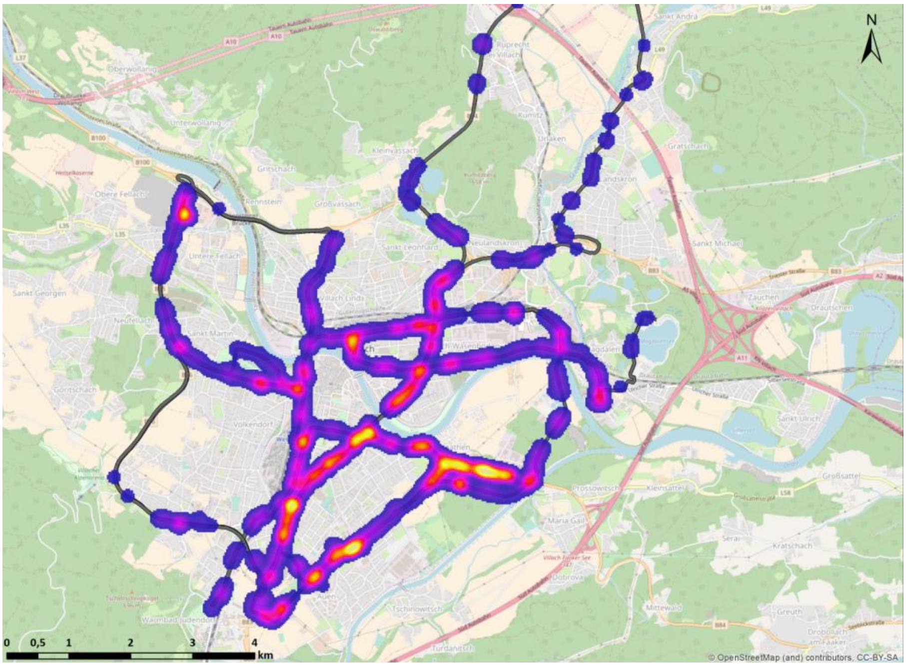
We used the roadside advertising data acquired in this study to analyse the distribution patterns of the advertising signs in the city of Villach. The results of KDE utilizing the size attribute of advertising signs are given in Figure 3a. The results of KDE based on the ability of advertising signs to change content are presented in Figure 3b. The unweighted KDE results are given in Figure 3c.



a. Weighted KDE utilizing the size of advertising signs



b. Weighted KDE utilizing the ability of advertising signs to change their content



c. Unweighted KDE

Figure 3: Kernel density estimation of roadside advertisements in Villach, Austria

The KDE analysis reveals that both sets of weights yield similar results. The results of the unweighted KDE and the weighted KDE that differentiates advertisements according to their ability to change content are almost identical due to a low proportion of changeable advertising signs. Major intersections and bends in Villach are often associated with the highest advertising density. This is an alarming discovery, as such locations of roadside adverts have been shown to present a higher safety risk for drivers (Bendak & Al-Saleh, 2010; Ewert, 2011; Roberts et al., 2013). In Villach, places with high advertising density are often associated with a high number of advertising flags. Analysis of the advertising media types shows that 14.2% of all adverts were vertical flags located on or near business sites. This high proportion can be explained by the fact that advertising on flags requires neither a permit from local authorities nor for the authorities to be notified. Because most of the time advertising flags are in motion, they may be more distracting than stationary advertising signs. On the other hand, the content of advertising flags is rarely intended to be memorized, and they have simpler graphics than posters and are not illuminated, all of which together may decrease their level of distraction for road users. It is worth noting that we did not find any studies discussing the extent of distraction posed by advertising flags. However, our research shows that this topic requires further analysis. Concerning advertising signs with the ability to change content and which have been proven to be of great distraction to drivers, their proportion in Villach is very low, namely less than 2%.

5 Conclusions and Future Work

In this study, we used spatial video technology for data acquisition in an urban environment. We collected data on more than 2,000 advertising signs and analysed their spatial distribution. Analysis results revealed that the highest advertising density in the study area is associated with bends and intersections, and that a large proportion of advertising signs contributing to the high density of advertisements in these locations are advertising flags. The proportion of signs with changing content, which have the highest potential to distract drivers, constituted less than 2%. The next possible step in this analysis, which was not feasible in this study because of its small scale and lack of relevant data, is a comparison of the advert distribution pattern with statistics for traffic accidents in the city of Villach. Such a comparison could reveal whether the distribution of advertising signs correlates with the location of traffic accidents.

The spatial video technology utilized for data acquisition in this study proved to have significant advantages, such as applicability in the urban environment, reduced data-collection time, the possibility of collecting data in unfavourable weather conditions, and the low cost of the equipment. Minor disadvantages were associated with the simultaneous use of several spatial video cameras, notably the lack of concurrent timestamps for GPS points captured by different cameras that did not start recording at exactly the same time. This, however, did not lead to any significant increase in data processing time.

Spatial video technology for data acquisition in the urban environment, and for roadside-advertising data collection in particular, has potential in further research. An important aspect in this respect is the facilitation of data transfer from a video into a GIS. Modern artificial intelligence technologies can facilitate the simplification of spatial video data processing. With respect to the analysis of roadside advertising, spatial video technology can be utilized in combination with tracking the movement of a driver's eyes. Such new research directions may help to reveal to what extent particular advertising signs distract the driver – for example, how much distraction is caused by advertising flags that are large in size, prone to motion and often located in groups, for which placement is less regulated than for billboards and posters. Another aspect that could be analysed with the help of spatial video technology is the advertised content, in order to better understand the role of advertising in contemporary society.

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