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Naturalistic Aerial Approaches for Monitoring Powered Two Wheelers

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Summary

During the latest years, Powered Two Wheelers (PTW) have become a complete game-changer in everyday commuting, since their distinctive characteristics from the rest of the traffic make them an attractive means of transport. However, PTW related studies are mostly safety oriented probably due to the lack of naturalistic driving data. Although there have been studies that extract PTW trajectories from video recordings, limitations such as the arterial monitoring extent, and conspicuity issues, can affect the quality of results and research opportunities. In this paper, the above-mentioned limitations are reviewed and novel data collection capabilities and directions are identified using Unmanned Aerial Systems (UAS). The advantages of UAS monitoring traffic streams from above as an "eye-in-the-sky" solution, covering large areas in short time intervals and discreetly recording drivers' behavior can play an important role when it comes to creating naturalistic datasets. The discussion concludes by underlining that, if technical, privacy and legal issues that have emerged from their early use are to be tackled, UAS can be transformed into an integral part of the Intelligent Transportation System (ITS) infrastructure.

Background

Over the past few years, many Europeans have turned to Powered Two Wheelers (PTW) as their choice for everyday commuting (ACEM, 2017). Although PTW related studies are mostly safety oriented, understanding the way PTW move in traffic is one of the hot topics in Transportation Engineering as a basic step for traffic optimization, improving traffic conditions and tackling safety issues (Barmpounakis, Vlahogianni, & Golias, 2016a). To this end, a problem researchers face is the lack of detailed naturalistic PTW driving data, in relation to both the kinematic characteristics and the positioning on the road which differentiates in a number of ways from the rest of the traffic. In this paper, we review the limitations of using one fixed camera. Moreover, we discuss the use of novel approaches for PTW related data collection based on Unmanned Aerial Systems (UAS) via traffic monitoring case studies.

Method – Identifying Limitations to PTW tracking in Urban Environment

In previous PTW oriented studies several limitations have been identified when it comes to recording naturalistic trajectory data. The most important of them when modelling PTW overtaking probability is the fact that by using only one fixed camera, it is not possible to monitor PTW movements for an extended arterial section (Barmpounakis, Vlahogianni, & Golias, 2016b). This significantly restricts the number and complexity of phenomena that may be monitored and recorded. For example, as identified in (Katachanaki, Barmpounakis, Vlahogianni, & Golias, 2015) the limitations in the recorded section lead to a limited number of cases

concerning heavy vehicles and/or passengers on the PTW, which affect manoeuvrability. Although these factors were found influential, they were not found statistically significant mainly due to restricted availability of cases to be studied.

Moreover, the viewing angle of the camera may lead to many "hidden points" (Lee, 2007; Lee, Polak, & Bell, 2009; Nguyen & Hanaoka, 2013). Although the camcorder can be set as high as possible to reduce such issues, when there is a heavy vehicle on the road or when distances are too short many difficulties emerge. Therefore, in order not to create a database with important errors some overtaking attempts were chosen not to be included in the database.

Finally, an important issue concerning the study of such phenomena related to the behavioural aspects of driving. Specifically, when having a limited section to monitor, the "memory of each driver" and the effect of previous actions taken by the driver, the PTW interaction with the rest of the traffic and its effect to driving risk and comfort cannot be studied. For example, in a game theoretic approach of PTW overtaking phenomena it was seen that it is not possible to examine whether a risky overtake conducted by a PTW driver, will affect his next decisions or not (Barmpounakis, Vlahogianni, & Golias, 2017a).

Objective - Overcoming limitations with Unmanned Aerial Vehicle

The above limitations relate either to the length of the arterial recorded, or to the height of the camera. In order to overcome the restrictions mentioned above, research has underlined the use of Unmanned Aerial Systems (UAS) for recording video footage from a high point (Kanistras, Martins, Rutherford, & Valavanis, 2014). An UAS, commonly known also as a "drone", is an aircraft without a human pilot on-board, but it is controlled from an operator on the ground. UAS offer many advantages both for professional and researching purposes. Although Manned Aerial Vehicles (MAV) have been used to collect traffic data or report traffic conditions for police reports, the UAS appear to be a more appropriate solution for a number of reasons including cost, risking human lives and proximity to the place of interest.

Results

The most important advantage of UAS against MAV and other recording methods is that they can collect video recordings from an extended arterial section discreetly, without affecting drivers' behaviour due to their small size and their being in higher altitudes, out of drivers' sight. Another crucial advantage of using drones to monitor drivers' behaviour is that due to the almost vertical viewing angle, no hidden points appear that allow better accuracy in estimating short distances between vehicles and better vehicle identification since their boundaries are clearly visible. In addition, latest advances in their materials and mechanical parts allow them to cover a large area in short times with an extreme low cost. Moreover, by using UAS, researchers do not have to limit areas of studies only where higher points are available (like pedestrian bridges, buildings etc.) but can fly almost anywhere as long as no obstacles for the safe flight of the UAV are present. Finally, their small size offers the possibility of recording videos from places that were inaccessible before, while the capability of hovering that some UAS offer can provide increased capabilities to the researchers. Benefits of UAVs are further analysed in (Barmpounakis, Vlahogianni, & Golias, 2017b). With the latest advances in the UAV industry and hardware improvements, the detailed microscopic kinematic characteristics of PTW in relation to the rest of traffic can be

measured and/or calculated in more detail. These data are critical to the modelling under mixed traffic conditions.

Figure 1 – Recording limited length using one fixed VS recording using a UAS over an extended area

Discussion/ Impact

With the latest advances in the UAV industry for military, civil, commercial and both the technological and research interest around them, novel directions for data collection in Traffic Engineering emerge. Although attempts to collect traffic information from UAS-based images have been made in the past, the use of drones in traffic studies is still in an early stage. While most studies focus on macroscopic traffic parameters and/or on reducing errors in microscopic parameters, not much research has been made concerning PTW, in order to reduce error since their movements and size are different than other vehicles and therefore more complex phenomena can occur while extracting traffic data from UAV video footage. The latter is of crucial importance concerning PTW oriented studies, not only for traffic improvements and optimization as reported earlier, but for safety reasons too, as PTW drivers are one of the most vulnerable road users (Theofilatos & Yannis, 2015, 2016). Therefore, while the potential of UAS has been identified, researchers should focus on dealing with technical (real-time data acquisition, flight time, etc.) and legal (privacy, entering restricted areas etc.) issues that have emerged from their early use. As a result, in the years to follow, dealing with such issues while identifying ways and solutions to fully integrate UAS into the ITS infrastructure should be the concentration of researchers and industry to fully make the most of their capabilities.

References

ACEM. (2017). European registrations of motorcyles and mopeds up by 9.1% compared to 2015. Retrieved February 21, 2017, from http://www.acem.eu/item/449-european-registrations-of-motorcyles-and-mopeds-up-by-9-1-compared-to-2015

Barmpounakis, E. N., Vlahogianni, E. I., & Golias, J. C. (2016a). Intelligent Transportation Systems and Powered Two Wheelers Traffic. *IEEE Transactions on Intelligent Transportation Systems*, *17*(4), 908–916. http://doi.org/10.1109/TITS.2015.2497406

Barmpounakis, E. N., Vlahogianni, E. I., & Golias, J. C. (2016b). Vision based multivariate statistical modeling for Powered Two-Wheelers Maneuverability during Overtaking in Urban Arterials. *Transportation Letters: The International Journal of Transportation Research*, *8*(3), 167–176.

Barmpounakis, E. N., Vlahogianni, E. I., & Golias, J. C. (2017a). Modeling Cooperation and Powered-Two Wheelers Short-term Strategic Decisions during Overtaking in Urban Arterials. *International Journal of Transportation Science and Technology*, *In Press*.

Barmpounakis, E. N., Vlahogianni, E. I., & Golias, J. C. (2017b). Unmanned Aerial Systems for Transportation Engineering: Current practice and future challenges. *International Journal of Transportation Science and Technology*, (February), 1–12. http://doi.org/10.1016/j.ijtst.2017.02.001

Kanistras, K., Martins, G., Rutherford, M. J., & Valavanis, K. P. (2014). Survey of Unmanned Aerial Vehicles (UAVs) for Traffic Monitoring. In *Handbook of Unmanned Aerial Vehicles* (pp. 2643–2666). Springer. http://doi.org/10.1109/ICUAS.2013.6564694

Katachanaki, P., Barmpounakis, E. N., Vlahogianni, E. I., & Golias, J. C. (2015). Multivariate Statistical Methods for explaining Powered Two Wheelers' Traffic in Urban Arterials. In *7th International Congress on Transport Research - ICTR*.

Lee, T.-C. (2007). An agent-based model to simulate motorcycle behaviour in mixed traffic flow, (October), 1–227. Retrieved from http://ethos.bl.uk/OrderDetails.do?uin=uk.bl.ethos.486415

Lee, T.-C., Polak, J. W., & Bell, M. G. H. (2009). New Approach to Modeling Mixed Traffic Containing Motorcycles in Urban Areas. *Transportation Research Record: Journal of the Transportation Research Board*, *2140*, 195–205. http://doi.org/10.3141/2140-22

Nguyen, L. X., & Hanaoka, S. (2013). Safety spaces for overtaking movements in motorcycle traffic flow. *Proceedings of the Eastern Asia Society for Transportation Studies*, *9*(2008), 2–12. Retrieved from http://easts.info/on-line/proceedings/vol9/PDF/P357.pdf

Theofilatos, A., & Yannis, G. (2015). A review of powered-two-wheeler behaviour and safety. *International Journal of Injury Control and Safety Promotion*, *22*(4), 284–307. http://doi.org/10.1080/17457300.2014.908224

Theofilatos, A., & Yannis, G. (2016). Investigation of powered 2-wheeler accident involvement in urban arterials by considering real-time traffic and weather data. *Traffic Injury Prevention*, *0*(0), 1–6. http://doi.org/10.1080/15389588.2016.1198871