Challenges to implementing cyclist counting systems on rural roads

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1 INTRODUCTION

In Spain, the presence of sport and recreational cyclists on rural roads has increased notably in recent years. In fact, the number of federation licences reached 75,638 cyclists and 3,634 cycling clubs in 2020 [1]. As the number of cyclists on these roads has increased, so has the number of accidents. Despite regulations, information campaigns and measures taken by the Spanish Directorate-General for Traffic in recent years, the number of crashes involving cyclists in rural environments remains plateaued at near 50 cyclist fatalities per year [2].

Most Spanish rural roads do not have specific infrastructure for cyclists – e.g. cycle lanes. Then, cyclists and drivers share the road and interact; being the overtaking manoeuvre one of the most dangerous interactions. These interactions imply risk of rear-end and side-on collisions with cyclists and head-on collisions with oncoming vehicles during the overtaking manoeuvre. Since traffic crashes and risk exposure are highly correlated, every interaction between cyclists and/or with motorised vehicles increases the likelihood of a traffic crash. Consequently, to properly assess road safety on rural roads, an adequate estimation of cycle volume is needed.

On the other hand, cyclists may ride in groups in different configurations (in-line or two-abreast), which can also affect the traffic operation by creating queues and increasing the delay time of motorised vehicles [3]. Therefore, determining the volume of cyclists on a rural road segment is a necessary challenge in order to integrate them into safety and traffic operation analyses.

Cycle volume is of great interest for many applications. In fact, knowing the spatial and temporal distribution of cycle volume across a road network can help engineers to plan and manage these roads, improving road safety and traffic operation.

Furthermore, knowing cycle volume can also help motorised drivers. Warning drivers about the presence of cyclists before reaching them improves road safety, as drivers can adapt their behaviour to interact with cyclists more safely. One tool to inform drivers of the presence of cyclists in this environment is the use of vertical signs. These systems have evolved in recent years, from simple static signs (informing of the possible presence of cyclists), to the implementation of active and intelligent signs. Active or dynamic signs alert drivers about the presence of cyclists in real time, raising their level of attention. This is extremely important, since driver inattention or speeding was present in half of crashes involving cyclists on Spanish rural roads.

There are many technologies for cyclist detection. Most of them have been used in urban areas, where cyclists have specific facilities. However, rural roads present particularities due to the type of infrastructure, users, and how they interact. For this reason, the main objective of this study is to analyse what challenges existing counting systems must overcome in order to be effective on rural environment. The analysis will consider the particular characteristics of the phenomenon to be detected, both the characteristics of the cyclists themselves and of the road.

2 METHODOLOGY

The methodology to be followed is shown in Figure 1. As a preliminary step to the characterization of the counting systems, it will be necessary to analyse the phenomenon.

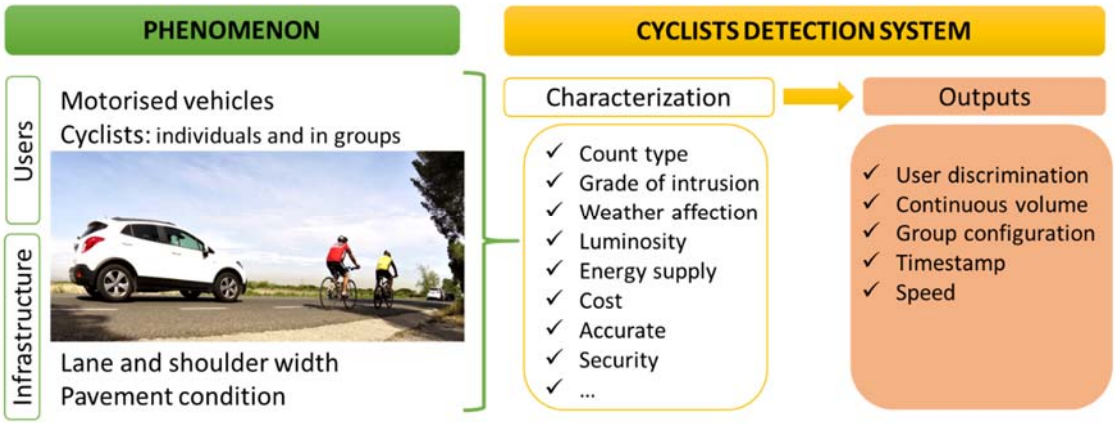

Figure 1: Workflow.

Characterization of the phenomenon: In Spain, motor vehicles and cyclists can share rural roads. Spanish Regulations allow cyclist groups to ride in line, and if there is enough sight distance, they can ride at maximum two-abreast. Cyclists must ride along the shoulder or, if not possible due to its width or maintenance level, along the right side of the lane. The overtaking manoeuvre is also regulated, requiring a minimum lateral distance of 1.5 m. To facilitate traffic operation, overtaking bicycles even with a solid line is allowed [4].

Cyclists detection system: It is necessary to characterize the detection and counting technologies to identify the specific constraints that limit their use in relation to the analysed phenomenon. The main limitations are related to the way in which they count (continuous or discontinuous): the degree of intrusion on the infrastructure (taking into account the speed reached by motorized vehicles on rural roads); the environmental impact, ensuring a detection resistant to weather and not affected by luminosity. In addition, in an interurban environment, a counting system must be sufficiently autonomous and not require continuous maintenance. The risk of vandalism must also be taken into account. Taking into account the particularities of each counting system analysed as well as their combination, the most interesting technology will be the one that can provide the results shown in the Figure 1. These variables are of great interest for the efficient and secure management of the infrastructure.

3 RESULTS

A total of 29 scientific articles and more than 16 websites related to detection and counting systems applied to transport have been reviewed. From the analysed data, Table 1 has been composed, showing the main analysed technologies for detecting and counting cyclists on two-lane rural roads considering their main advantages and limitations (to be implemented in these environments).

Some of these technologies have already been used to detect road users on urban environment (cyclists and/or pedestrians), such as 2D LiDAR or magnetic loops, with good results. However, it is necessary to validate them for accurate estimation of cycle volume on rural roads, especially regarding when cyclists ride in groups.

The detection and counting system has to discriminate cyclists from other road users. This will be achieved by incorporating an algorithm that allows this discrimination to be made by processing the information captured by the sensors. A potential tool for discrimination is the Artificial Intelligence through machine learning techniques; which allows the system to feed back the input data, recognise a cyclist and count him/her.

Table 1: Detection and counting technologies analysed with their main advantages and limitations.

Technology	Advantages		Limitations	
RFID devices	Economic Individual information	Permanent counting Groups of cyclists	Low penetration rate	
Pneumatic tubes	Economic	Easy installation	Temporal counting Intrusive	Uncomfortable and unsafe
Piezometric sensors	Permanent counting	Not affected by weather	Intrusive Non-covered areas	Groups of cyclists occlusion
Magnetic loops	Permanent counting	Not affected by weather	Intrusive Non-covered areas	Specific for carbon fibre
RADAR sensors	Permanent counting Not affected by weather	Non-intrusive Speed registration	High cost	Groups of cyclists occlusion
Thermic sensors	Permanent counting Low luminosity	Non-intrusive	Extreme weather	Complex Hardware
LiDAR scanners	Permanent counting Low luminosity	Non-intrusive Speed registration	High cost	Complex Hardware
Visible HD cameras	Non-intrusive	Image support Speed registration	High cost Privacity	Needs luminosity Complex Hardware

4 CONCLUSIONS

Due to the continuous increase in the number of sport cyclists on two-lane rural roads, combined with the stagnation of crashes involving cyclists and the affection on traffic operation, it is necessary to analyse and implement new measures to improve safety and traffic operation on these roads. Knowing the volume of cyclists on these roads allows a more realistic and efficient planning of countermeasures.

The first step in designing and implementing a real-time detection and counting system for cyclists on roads is a review of existing technologies for detecting and counting cyclists. These counting systems also provide information on the temporal distribution of the volume of cyclists on a road. Detection and counting systems have to overcome the specific limitations related to the environment and the characteristics of the road users. A counting system must to be continuous, and must discriminate cyclists from the rest of road users. Another requirement is to detect all cyclists when riding in a group.

Several detection and counting systems have been analysed, listing their advantages and disadvantages for use in the detection of cyclists on rural roads. The use Artificial Intelligence algorithms improves the discrimination of cyclists in these conditions. The possibility of combining different of the mentioned systems and tools has also been considered, giving rise to a complex system. From this review, the best systems are selected and taken to phase two, where they will be field-tested for validation.

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