Economic and Social Research Council

Data Analytics & Society

How Reliably Can Vivacity Cameras Count People?

Inter-Rater Reliability Between The Vivacity Countline And Speed Data Counts

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1. INTRODUCTION

Vivacity Labs – a tech company – specialises in building real-time object detection systems, essentially cameras with integrated video analytics systems to automatically count and measure the travel speed of road users such as pedestrians and cyclists. Two types of data are produced: countline and individual speed data (see Methods). The countline data contains aggregated counts of road users in specific time blocks such as 5-minutes, whereas the speed data contains the exact time at which a road user is detected by the camera and the average travel speed with which the road user crosses the camera's field of view.

The speed data can be aggregated in specific time blocks to obtain the aggregated counts of different road users. In addition, the average travel speed can also provide an estimate of the physical activity level of an individual road user. Therefore, the speed data is more valuable than the countline data. However, Vivacity has stated that the speed data may contain multiple entries of the same object (Figure 1) and that counts should be taken from the validated countline data. Therefore, establishing the speed data counts as reliable compared to the countline data counts is necessary.

This project investigates the inter-rater reliability (IRR) between the two Vivacity count sources for specific time blocks: 5-minute (n=74592), 15-minute (n=24864), 30-minute (n=12432), 1-hour (n=6216) and 1-day (n=259). This work - part of my internship - was done in collaboration with my supervisors and project partners: Manchester Urban Observatory and Buro Happold. The data is from the Levenshulme Active Neighbourhood Project being monitored by Vivacity cameras. Results from one (Road A) of the two Levenshulme roads (Roads A & B) analysed during the internship are presented here. The analysis was based on about 8.5 months of data.

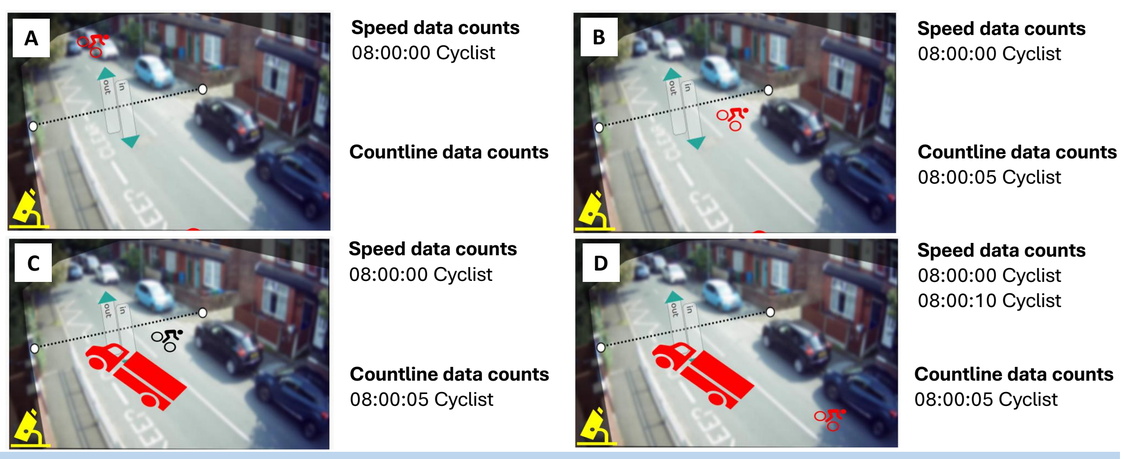


Figure 1: The Difference in the Data Generation Process Between the Vivacity Countline and Speed Data Illustrated Using a Cyclist

2. METHODS

A | Countline Data Structure

Day	Time	Direction	Pedestrian Counts	Cyclist Counts
12/07/2021	8:00:00	In		
12/07/2021	8:00:00	Out		
12/07/2021	8:05:00	In		
12/07/2021	8:05:00	Out		
…	…	…	…	…

B | Individual-Speed Data Structure

Day	Time	Class ID (0 – Pedestrian, 1- Cyclist)	Speed (m/s)
12/07/2021	8:00:00	0	
12/07/2021	8:00:00	1	
12/07/2021	8:02:00	0	
12/07/2021	8:30:00	0	
…	…	…	…

Step 1: Create People class (Pedestrians + Cyclists) & aggregate the counts in specific time blocks (5-minute, 15-minute, 30-minute, 1-hour, 1-day)

C | Aggregated Countline Data Counts

Day	Time	People Counts	Pedestrian Counts	Cyclist Counts
12/07/2021	8:00:00			
12/07/2021	8:05:00			
…	…	…	…	…

D | Aggregated Speed Data Counts

Day	Time	People Counts	Pedestrian Counts	Cyclist Counts
12/07/2021	8:00:00			
12/07/2021	8:05:00			
…	…	…	…	…

Step 2: Merge C and D to Visualise and Calculate the Inter-Rater Reliability (IRR) using both consistency (ICC-C) and agreement (ICC-A) forms of Intraclass Correlation Coefficient (ICC) and Krippendorff's Alpha (KA) (agreement). Although consistency was calculated, the agreement between the counts is more important. 0.8 is generally taken as an acceptable level and is chosen as the cut-off threshold for an acceptable/good agreement.

ICC-C: Two-way mixed effects, consistency, single rater (ICC (3,1)).
ICC-A: Two-way mixed effects, absolute agreement, single rater (ICC (A,1)).

3. RESULTS

Table 1: Counts of Different Classes (Road Users)

Object Class	Road A (counts)		
	Countline Data (A)	Speed Data (B)	Difference (A-B)
People	313290	165039	148251
Pedestrian	274556	133749	140807
Cyclist	38734	31290	7444

Table 1 shows that countline data contains more counts for all classes. The difference in pedestrian counts is much larger than that of cyclist counts. People count is heavily influenced by pedestrians as there are more Pedestrians than cyclists.

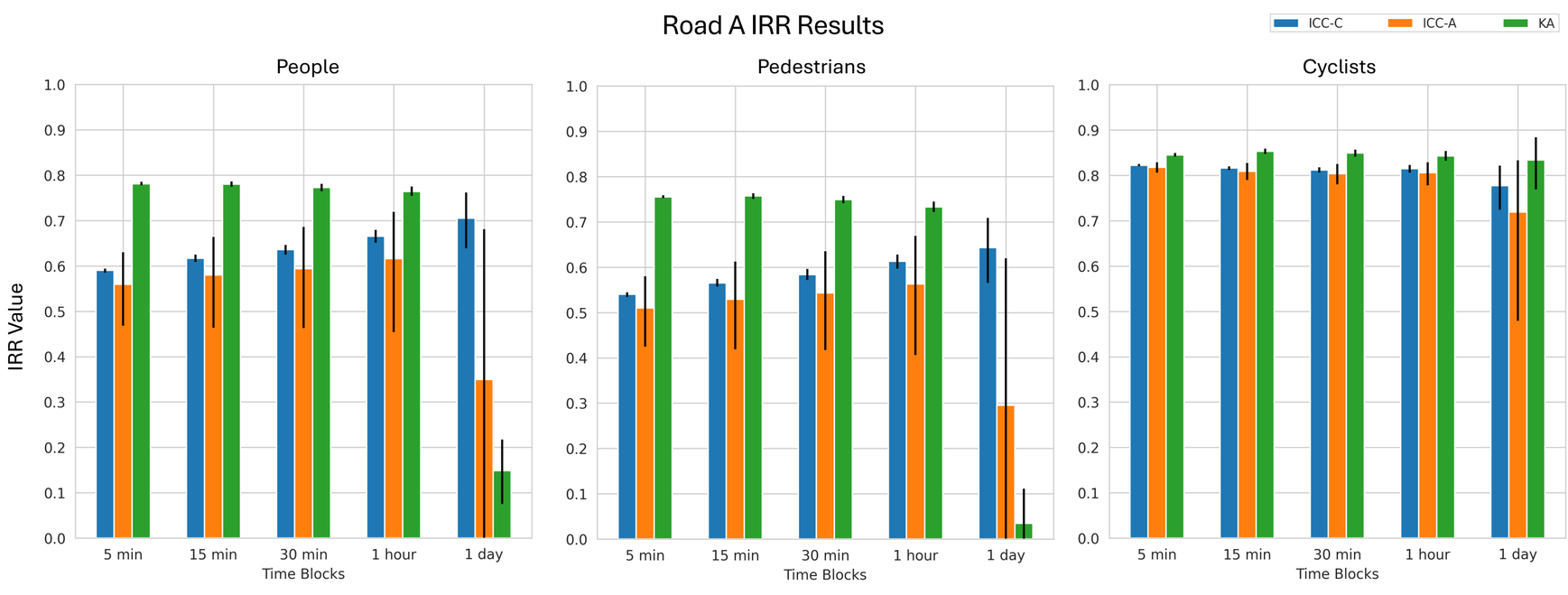


Figure 2: IRR Estimates with 95% CI

Figure 2 shows that based on the acceptable IRR value of 0.8, pedestrian (and people) counts show neither acceptable agreement nor consistency for any time block. In contrast, cyclist counts show both acceptable agreement and consistency for all time blocks except for 1-day time blocks where the lower limits of the 95% CI of both ICC and KA estimates are below 0.8; the 95% CI of ICC-A and KA of cyclist counts range from 0.479 – 0.833 and 0.769 – 0.884, respectively. However, the probability of failing to achieve a KA of 0.8 here is only 12.8%.

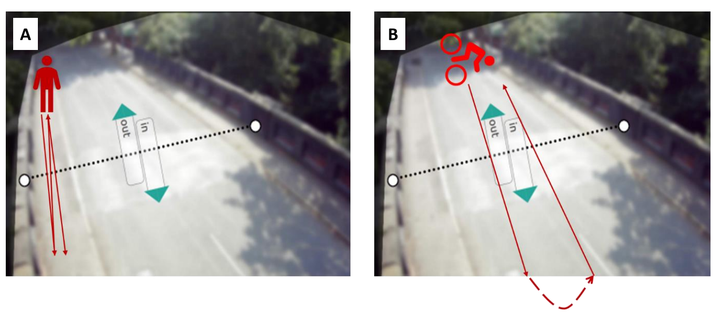
4. DISCUSSION

ICC is a parametric test that performs best when the data has a normal distribution which our data does not have. Therefore, ICC may not be a valid test here. KA, however, is a non-parametric test. Therefore, conclusions will be based on KA.

The results indicate that pedestrian counts did not achieve the minimum agreement of 0.8. On the other hand, cyclist counts show good agreement.

The results were surprising because we expected more counts in the speed data than the countline data. Vivacity was asked whether an object would be counted twice in the countline data if, after crossing the virtual countline, it decides to turn back and cross the countline again while remaining within the camera's view for the entire duration.

The answer was that it would be counted again but in the opposite direction, partly explaining the results. Perhaps most pedestrians cross the countline multiple times while remaining within the view of the camera while the cyclists pass through the camera's field of view (even if they return, maybe they do it outside the camera's view) (Figure 3).



A: Pedestrians may be crossing the virtual countline multiple times without going out of the camera's view. **B:** Cyclists maybe are crossing the countline and going out of view of the camera. Even if they return, maybe they do it outside the view of the camera.

Figure 3: An Explanation for the IRR Results

However, this does not explain instances where the countline count is 0, but the speed data count is >0 and vice versa (Figure 4).

5. CONCLUSION AND RECOMMENDATIONS

Only cyclist counts show good agreement between the Vivacity countline and speed data for all time blocks. The results need to be discussed with Vivacity, especially when one dataset shows 0 counts and the other more than 0.

Both counts also need to be compared against manual counts to reach definitive conclusions.

Further analysis should also be done based on day and night, as light levels may affect the Vivacity cameras' performance.

Figure 4: Scatter Plots and the Univariate Distributions of the Counts from the Vivacity Countline and Speed Data (Only 5-Minute Time Block is Shown)

Scan the QR code to see the visualisations for the other time blocks of Road A, and Road B, for which similar results were obtained.

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