A Comparative Field Study: Commercial Versus Low-cost Camera-based Automated Passenger Counting systems

 **Pronello** Cristina and **Garzon Ruiz** Ximena R. 

Interuniversity Department of Regional and Urban Studies and Planning at Politecnico di Torino

cristina.pronello@polito.it; ximena.garzon@polito.it

Context

- Transport companies seek to **increase efficiency** by using automatic passenger count (APC) systems to estimate vehicle occupancy, boarding and alighting
- Commercial APC **optical-based solutions** claimed to have an accuracy and precision between 98% and 99%
- Commercial APC systems represent a **high cost** for the transport companies

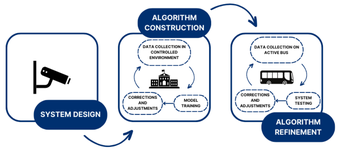
GOAL

Evaluate the accuracy of a commercial APC system

- Under real operational conditions
- Compare it with a low-cost APC system developed by the authors

Methods

Design of the low-cost system



RaspberryPi 3 Model B + Pi camera + external battery. Controlled environment test to simulate real in-field conditions and to test different object detection algorithms. During algorithm refinement, 5000 videoclips of operational data were collected to re-train and test the algorithm

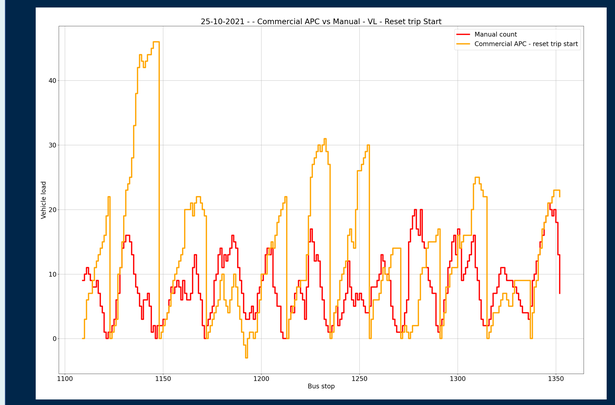
EXPERIMENTAL SET-UP
6 days of manual count and video-data collection.
Turin, Italy

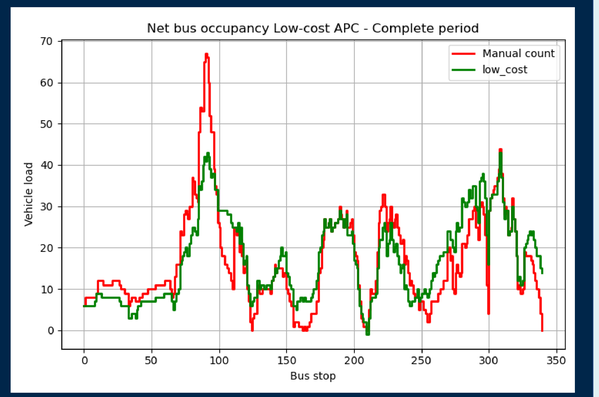
Manual count collection
20 days of data (7am-4pm)
Asti, Italy

DATA PROCESSING
Calculate the vehicle load by resetting it at start of each day or at the beginning of each journey.

DATA ANALYSIS AND VALIDATION
Symmetric Mean Absolute Percentage Error (SMAPE) is used.

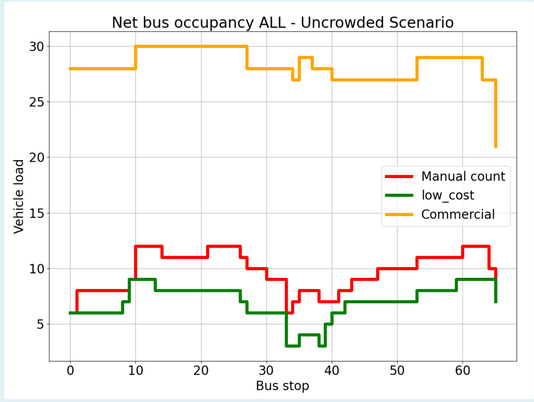
Current APC systems may not work as well in real life, and low-cost systems might be just as accurate or even better than the commercial ones

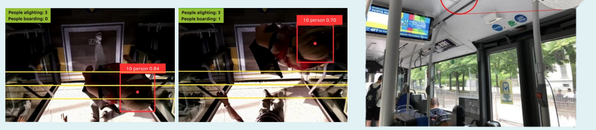




APC system	Boarding	Alighting	Vehicle Occupancy
Low-cost APC system			
Overall accuracy in 6-day period	72.27%	74.59%	81.59%
Uncrowded line	**83.53%**	**94.87%**	**82.46%**
Crowded line	65.83%	66.68%	80.38%
Commercial APC system			
Overall accuracy Asti's 20-day period	53.17%	55.29%	57.74%
Uncrowded line	77.69%	83.33%	50.94%
Crowded line	-	-	-

Results





Object detection algorithm: YOLOv5m, Tracking and counting algorithm: DeepSORT

The **highest overall accuracy** of the **Commercial APC** system was achieved for 25 October 2021, with a vehicle occupancy accuracy of **60.40%**; on that day, the accuracies for boarding and alighting were, respectively, 56.25% and 54.67%.

The **percentage accuracy** of the commercial system was between **50% to 60%** considering **individual journeys**

For **Asti** the **highest accuracy** came from restarting the vehicle load on each **journey**; while for **Turin** it came from restarting the once starting the service **day**.

Politecnico di Torino · UNIVERSITÀ DI TORINO

Dipartimento Interateneo di Scienze, Progetto e Politiche del Territorio