TRA

TRANSPORT RESEARCH ARENA BUDAPEST

18-21/05/26

Video-Based Analysis of Pedestrian Behaviour and Pedestrian–Vehicle Interactions in Urban Environments

Elena Theodoraki, with Stella Roussou, Apostolos Ziakopoulos, Paraskevi Koliou, Katerina Folla and George Yannis

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Introduction

- Pedestrian safety is a **major issue** in urban areas.
- Many crashes occur in dense city centres.
- **Illegal crossings and risky behaviour** increase conflict risk.
- It is important to study **pedestrian-vehicle interactions** using proactive safety indicators.
- Traditional crash data are limited.

Research Objective

- Illegal crossings occur frequently in urban areas
- Pedestrians often cross to save time
- Waiting time is a major factor
- Risk perception influences decisions
- Driver yielding behaviour also important
- Touristic areas present additional challenges

The aim of this study is to analyse pedestrian behaviour and pedestrian-vehicle interactions using video-based trajectory data and surrogate safety measures such as TTC and PET.

Methodology

Methodology overview | Video Analysis Process & Surrogate Safety Measures

- Video recordings collected
- Object detection and tracking algorithm
- Calculation of TTC and PET
- Statistical analysis of interactions

•Object detection (YOLOv8)

•Tracking and ID assignment

•Homography transformation

•Trajectory extraction

•Interaction detection

•Time to Collision (TTC)

•Post Encroachment Time (PET)

•Used to measure conflict severity

•Low TTC → high risk

•Low PET → high risk

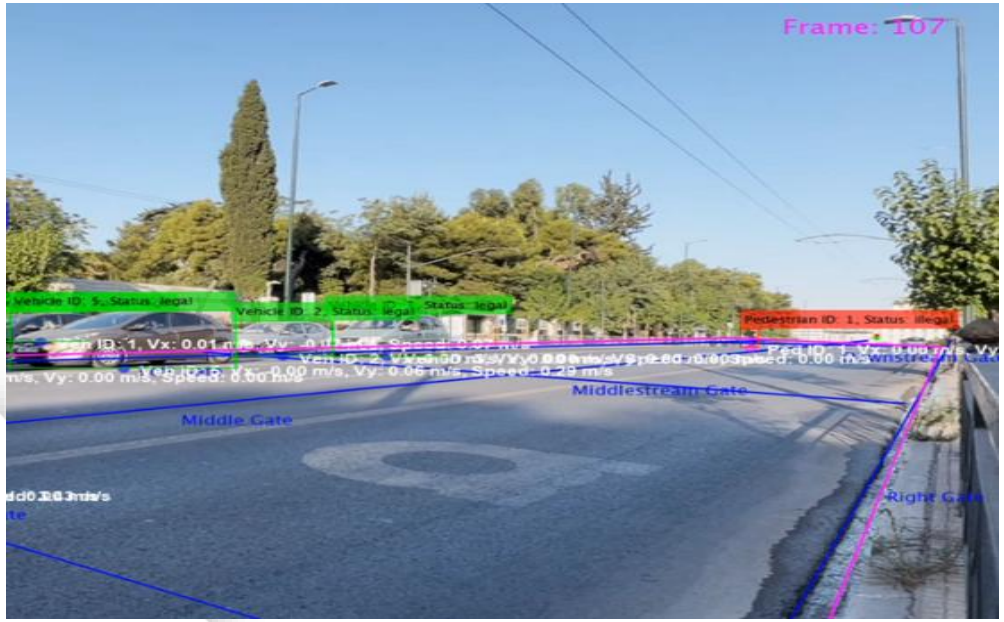
•Used instead of crash data

Results & Discussion

Results | Athens TTC & PET Results

Athens exhibits consistently short safety margins (n=22 events).

- The **minimum PET** has a median of 0.89 s (IQR 0.21-1.20), with **50.0% of events < 1.0 s** and 37.5% < 0.5 s.
- These shares indicate that at least half of illegal crossings reached sub-second separations at the conflict point, and **over one-third entered the very-high-risk PET** (< 0.5 s).
- For minimum TTC, the median is 5.24 s (IQR 4.36-13.24), with 25.0% < 3.0 s and 50.0% < 5.0 s.



(a) Algorithmic Output at Vas. Amalias Av., Athens

Metric	n (events)	Median(s)	IQR(s)
MinPET	22	0.89	0.21-1.20
minTTC	22	5.24	4.36-13.24

Threshold	Count	% of events
PET < 0.5 s	8/22	36.4%
PET < 1.0 s	11/22	50.0%
TTC < 3.0 s	6/22	27.3%
TTC < 5.0 s	11/22	50.0%

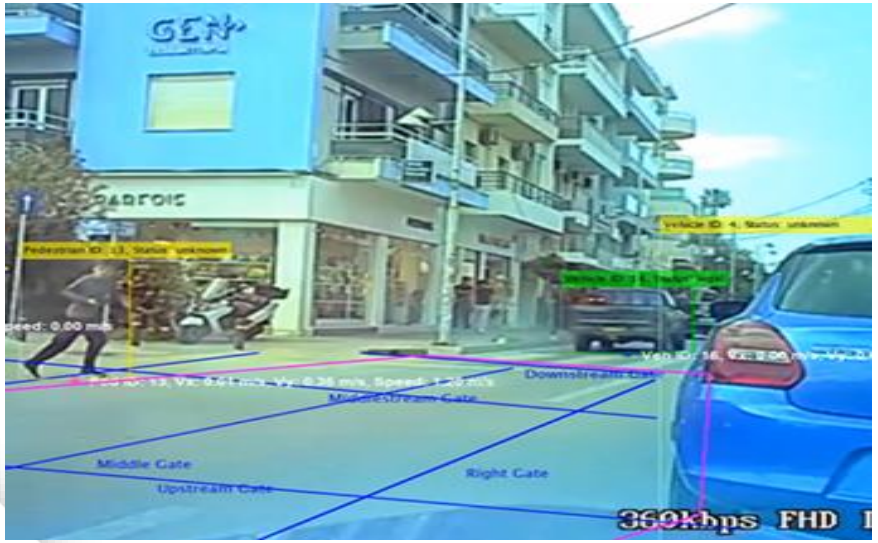
Table 1.

Event-level for Athens and Threshold shares for Athens

Results | Rethymno TTC & PET Results

Rethymno presents **larger safety margins** overall (n=18).

- The minimum PET median is 5.65s (IQR 0.86-7.91), with 28.6%< 1.0s and 0%< 0.5s (Table 2).
- The minimum TTC median is 19.48s (IQR 13.21-48.13), and no events fall below 3.0s or 5.0s.
- Thus, while **some events** approach sub-second PET, **very-high-risk PET** (< 0.5s) is absent, and TTC never enters the < 5s at the critical instant, which is consistent with a **less acute interaction profile than Athens**.



(b) Kountouriotou street, Rethymno

Metric	n (events)	Median(s)	IQR(s)
MinPET	18	5.65	0.81-7.91
minTTC	18	19.48	13.21-48.13
Threshold		Count	% of events
PET < 0.5 s		0/18	0.0%
PET < 1.0 s		5/18	27.8%
TTC < 3.0 s		0/18	0.0%
TTC < 5.0 s		0/18	0.0%

Table 2. *Event-level & Threshold shares for Rethymno*

Results | TTC & PET Results

- Distributional tests show **significantly lower minimum TTC in Athens**.
- The min TTC has a Mann-Whitney p = 0.043, while the minimum PET, based on the Mann-Whitney analysis, has a p = 0.093, demonstrating a **strong trend**.
- **Athens shows far higher shares under TTC** < 5s (50.0% vs 0.0%, p<0.001) and TTC < 3s (27.3% vs 0.0%, p=0.016).
- For PET, the very-high-risk band <0.5s is much more common in Athens (36.4% vs 0.0%, p=0.004), while **PET < 1.0s remains higher in Athens** but not statistically significant at α=0.05 (50.0% vs 27.8%, p=0.154).

Table 3. *Distributions based the Mann–Whitney U and Threshold contrasts (two-proportion tests)*

Metric	Athens median (IQR)	Rethymno median (IQR)	p-value
min PET (s)	0.89 (0.21–1.20)	5.65 (0.86–7.91)	0.093
min TTC (s)	5.24 (4.36–13.24)	19.48 (13.21–48.13)	0.043
Threshold	Athens	Rethymno	p-value
PET < 0.5 s	8/22 (36.4%)	0/18 (0.0%)	0.004
PET < 1.0 s	11/22 (50.0%)	5/18 (27.8%)	0.154
TTC < 3.0 s	6/22 (27.3%)	0/18 (0.0%)	0.016
TTC < 5.0 s	11/22 (50.0%)	0/18 (0.0%)	<0.001

Collectively, distributions and thresholds converge on the same result that illegal-crossing interactions in Athens are more acute and time-critical.

Discussion

- Most interactions **occurred under relatively safe conditions**, but critical conflicts exist.
- **Low TTC and PET** indicate potentially critical pedestrian-vehicle **conflicts.**
- **Illegal crossings increase conflict risk.**
- **Waiting time** influences pedestrian behaviour.
- **Driver yielding behaviour** affects safety.
- **Touristic areas show different behaviour.**
- TTC and PET are useful surrogate safety indicators
- Video-based analysis allows proactive safety assessment.

Policy Implications and Future Research

Strategic Policy Recommendations

- **Video analysis** is becoming useful for safety assessment.
- TTC and PET are effective indicators.
- Illegal crossings linked with higher risk.
- **Behaviour influenced by waiting time and environment**.
- Infrastructure and policy measures are needed.
- **Surrogate safety metrics** are useful for proactive safety analysis.

Limitations and Future Research Directions

- More locations to be explored are needed.
- A larger amount of data is also very crucial to expand the analyses.
- Combining video data and telematics data could give more information regarding the pedestrian safety.
- Studying driver behaviour is another factor that should be explored and combined with the pedestrian data.
- Combining simulation models to enhance the results.

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