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Investigation of Non-Compliance at Pedestrian Crossings of Signalized Intersections Using Computer Vision Techniques

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Introduction

- Pedestrian non-compliance at signalized intersections is a major safety issue.
- Illegal crossings increase pedestrian-vehicle conflict risk.
- **Traditional studies rely on manual observations.**
- **Computer vision** allows automated trajectory extraction and behaviour analysis.
- Need to evaluate automated detection accuracy.

Research Aim

- Legal vs illegal crossings
- Signal phase detection
- Pedestrian behaviour analysis
- TTC estimation
- Manual vs automated comparison

The aim of this study is to analyse pedestrian behaviour at a signalized intersection using manual observations and automated computer vision methods, and compare the accuracy of automated detection.

Methodology

Study Site, Data Collection & Computer Vision Pipeline

- Signalized intersection at Omonia Square, Athens
- Video recordings collected
- Camera capturing pedestrians, vehicles and traffic signals
- Manual observations conducted from video
- Automated video processing using computer vision

- YOLOv8 → object detection
- ResNet-50 → object classification
- Homography transformation → real-world coordinates
- Hungarian algorithm → ID matching
- Kalman filter → trajectory smoothing
- TTC calculation

Results & Discussion

Results | Descriptive Statistics

- The descriptive statistics provide an overview of the interaction conditions at the signalized intersection.
- Pedestrian speeds varied depending on signal phase and crossing conditions.
- Vehicle speeds were generally lower near the crossing area due to signal control and pedestrian activity.
- **Illegal crossings were associated with shorter waiting times and higher pedestrian speeds**.
- This indicates that pedestrians tend to **accelerate during illegal crossings to minimize exposure time** on the roadway.
- The surrogate safety indicator TTC showed a wide range of values, indicating both safe and critical interactions.

Table 1: Descriptive statistics of main variables (speed, TTC)

Variables	Mean	Std	Min	25%	50%	75%	Max
MinTTC	inf	-	0.06	16.864	40.699	134.65	inf
Confidence_Pedestrian	0.694	0.198	0	0.614	0.741	0.828	0.956
Confidence_Vehicle	0.785	0.157	0	0.712	0.838	0.894	0.964
PedestrianSpeedMagnitude	1.428	1.924	0	0	0.839	1.855	9.999
VehicleSpeedMagnitude	8.314	6.638	0	3.825	7.221	10.973	39.960

Results | Detection Accuracy and Classification Performance

- Detection of illegal crossings is more difficult due to uncertainty in signal phase detection and transitional signal phases. Errors were mainly caused by:
  - **Signal occlusions by buses and trucks**
  - **Crossings during intergreen time**
  - **Partial pedestrian occlusion**
  - **Simultaneous crossings by multiple pedestrians**
- Most traffic light cycles achieved 50–80% accuracy, with peaks above 90%, but some dropped to very low values.
- Overall, **traffic light detection accuracy was 62.77%**.

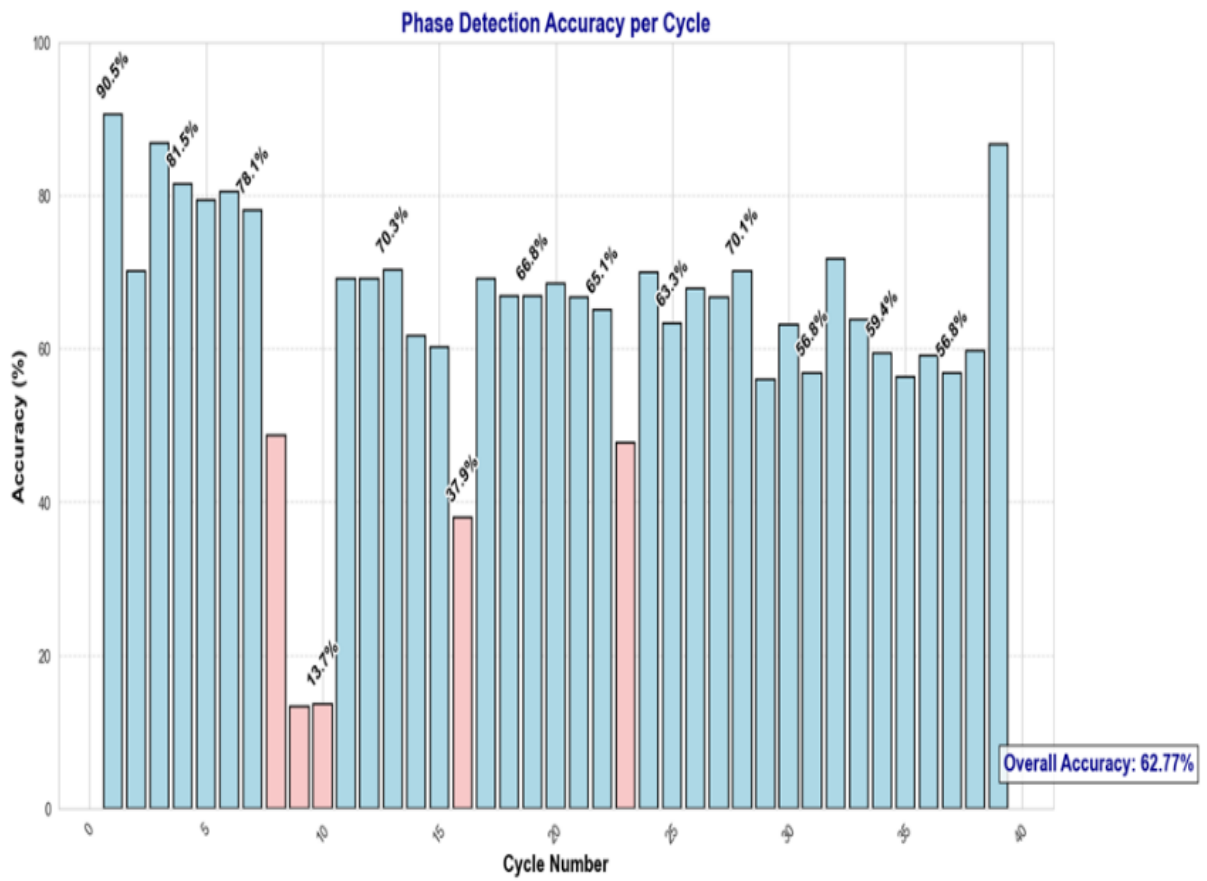

Fig. 1: Algorithm's Detection Accuracy per Cycle

Results | TTC & PET Results

- The automated system achieved 47.54% accuracy in illegal crossing detection compared to manual observations.
- The overall detection accuracy was 64.60%, higher than illegal crossing detection

(a) *(b)*

Fig2. *Algorithm´s Missclassified Cases: Obstacle (a) Crossing on a green signal s̓econds before it turns red (b)*

- Misclassifications were mainly caused by:
  - **Signal occlusion by large vehicles**
  - **Crossings that started on green and ended during red phase**
  - **Around 18% missing values were observed in the MinTTC dataset due to incomplete pedestrian–vehicle interaction pairs.**
- These results indicate that algorithm performance is limited under occlusions and complex traffic signal conditions.

Discussion

- Non-compliant pedestrians cross when the vehicle gap is sufficient.
- Illegal crossings are intentional decisions.
- Illegal pedestrians walk faster.
- They try to reduce exposure time on the road.
- Behaviour depends on traffic conditions and waiting time .
- Computer vision can analyse pedestrian behaviour.
- Accuracy affected by signal occlusions.
- Illegal crossing detection more difficult than legal crossing detection.
- TTC useful for interaction severity analysis.
- Manual observations still important for validation.

Policy Implications, Limitations and Future Research

Policy Implications

- Proactive safety assessment using video analysis
- Identification of high-risk locations
- Signal timing optimization
- Infrastructure improvements
- Automated monitoring systems

Limitations

- Single study location
- Limited dataset size
- Signal occlusions affecting detection accuracy
- Traffic light detection based on color recognition
- Missing values in interaction dataset
- Manual observations may include subjectivity

Future Research

- Improve signal detection accuracy.
- Analyse more intersections.
- Combine video and telematics data.
- Study driver behaviour.
- Develop predictive safety models

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