AI-Enabled Video Analytics for Urban Mobility Digital Twins: A Microsimulation Study of the Via Caronda Corridor in Catania

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Abstract. Urban traffic cameras are increasingly available in metropolitan areas, yet their potential as operational data sources for simulation-based planning is still underexploited. This paper proposes an integrated framework that converts fixed-camera video streams into microsimulation-ready traffic inputs, combining AI-based vehicle detection, tracking, and movement counting with scenario-based traffic modelling. The proposed framework advances AI-driven urban analytics for transport planning by bridging urban video analytics and planning-oriented microsimulation. We move beyond approaches focused either on traffic detection alone or on simulation based on manual counts, linking data acquisition, model input generation and scenario-based decision support within a unified workflow. The work is framed within the broader UISH (Urban Intelligence Science Hub) perspective for the city of Catania, where existing municipal surveillance cameras are envisaged as part of a future pervasive and privacy-aware urban sensing infrastructure. The aim is to assess the technical feasibility of video-based traffic monitoring and demonstrate its operational value for urban planning by embedding AI-derived traffic observations into a microsimulation environment for ex-ante scenario evaluation.

The methodological workflow converts video observations into directional traffic flows. Then, data is used to feed and calibrate a microsimulation model for ex-ante scenario assessment. The approach is tested on a real-world case study in Catania (Italy), on Via Caronda corridor, considering the hypothesis of reopening a direct access to the ring road. Results demonstrate that the tested intervention, although envisioned to improve direct accessibility, produces a reduction in effective road capacity and a worsening in traffic performance during peak-hour conditions. We registered a decrease in levels of service and increases in average travel times along selected movements. Beyond the specific case study, the paper highlights the value of integrating urban video streams into simulation environments as a scalable solution for control rooms, traffic management in the view of mobility digital twins.

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1 Introduction

Urban mobility planning involves timely spatially detailed and operationally reliable traffic data to support evidence-based decisions. In modern cities, traffic conditions change rapid for recurrent congestion with local bottlenecks and infrastructure changes which create temporary disturbances. Traditional traffic surveys, even if still used, depend on manual counts or short observation campaigns on selected sections. These approaches are useful for calibration, but they are constrained by significant human-resource requirements, limited temporal coverage and a reduced ability to capture the full dynamics of complex intersections with multiple movement traffic patterns. Therefore, they give only a partial representation of the real traffic conditions, especially when planners need continuous observation for scenario assessment.

In this context, fixed urban cameras represent a promising yet underexploited source. Municipal traffic cameras can observe in continuous the critical nodes and give a fuller description of the traffic dynamics. Their value becomes greater if the video streams are combined with artificial intelligence (AI) for vehicle detection tracking and movement recognition. Through these techniques, the raw footage is transformed into structured traffic information: directional flows, turning movements trajectories and speed indicators. This makes the urban video streams relevant not only for traffic monitoring, but also for transport modelling and simulation-based planning.

In this regard, the developments in computer vision have expanded the video analytics for traffic observation. Research shows that AI-based detection can get reliable vehicle recognition in complex environments enabling more automated traffic data collection. The diffusion of digital platforms and the emergence of mobility digital twins are changing how we monitor transport systems. Cities want data pipelines connecting observation technologies traffic models and decision-support tools, but the operational use of fixed-camera streams for simulation planning remains less explored. Many studies focus on the technical performance of the detection pipeline: object recognition, accuracy, counting precision, tracking robustness. These aspects are very relevant, but they do not answer a key planning question: how to translate video-derived observations into model-ready traffic inputs for scenario assessment? And the microsimulation models used for evaluating road changes and traffic measures are still fed by manual counts or short surveys? This is a gap between AI-based traffic observation and simulation-based decision support. Bridging this gap is relevant for the urban mobility digital twins where data streams should not stay isolated monitoring outputs but should actively update and inform the simulation environments.

Starting from this, the paper proposes an integrated framework that transforms urban video streams from fixed municipal cameras into directional traffic inputs for microsimulation-based scenario analysis. The framework puts together AI-enabled video analytics with a transport simulation model to support urban planning decisions and the development of mobility digital twins. The idea is that urban cameras are not passive

observation devices but strategic parts of a decision-support architecture able to feed traffic control rooms calibration and policy evaluation.

This research also fits within a broader urban-intelligence perspective currently being developed for the city of Catania in the framework of the UISH (Urban Intelligence Science Hub) project. Within this ecosystem, mobility monitoring is conceived as part of a wider Digital-Twin-oriented architecture in which heterogeneous sensing layers, shared data infrastructures, and future decision-support functionalities are expected to interact continuously. In this perspective, the use of fixed urban surveillance cameras already installed across the city represents a particularly promising opportunity for the progressive development of pervasive, privacy-aware traffic observation pipelines capable of feeding both localized simulation models and future city-scale mobility analytics.

The approach is tested on a real case study in Catania (Italy), i.e. the Via Caronda corridor and considering the idea of reopening a direct access to the ring road. This case is important because it is a critical node where an intervention that looks good for direct accessibility can create broader effects on the network operations. Microsimulation helps to see these effects before doing the work and video-derived traffic flows show how AI-based observation can make more realistic simulation inputs.

The contribution is double. First, it shows that traffic information elaborated from fixed-camera video streams can be structured as input for microsimulation models linking computer-vision with transport planning. Second it demonstrates how this integration can help ex-ante assessment of local road changes and provide evidence on impacts of alternative scenarios. Our framework bridges the two aspects in a planning view, unlike studies that consider only at video traffic detection or only at microsimulation with manual counts. Beyond this, the paper also contributes on AI-supported urban analytics. It highlights the role that video data continuously available can make more robust the analytical capabilities of public administrations, especially if integrated with simulation tools and digital twin logics. This is relevant for cities that want to improve responsiveness of mobility management, make better infrastructure choices and move toward data-driven governance. Therefore, our research framework highlight that the value of AI in planning is to turn observed traffic phenomena into knowledge for scenario design.

The remainder of the paper is organized as follows. Section 2 presents the state of art; Sect. 3 proposed methodological framework, from video acquisition and processing to microsimulation input generation. Sect. 4 introduces the study area and describes the analyzed traffic scenario. Section 5 discusses the results of the simulation-based assessment, comparing the current road configuration with the tested intervention hypothesis. Finally, Sect. 6 summarizes the main findings, outlines the planning implications, and discusses future developments toward a more comprehensive AI-supported mobility digital twin.

2 Related Work

The literature for this study can be positioned considering three components: AI-based video traffic monitoring, use of observed traffic data for transport simulation, and mobility digital twins for planning. To review these domains together is essential, because the

contribution here is not only video analytics and not only microsimulation and the real point is the methodological bridge between them.

2.1 Video-Based Traffic Monitoring and AI

Video-based traffic monitoring has gained increasing attention as advances in computer vision and deep learning have enabled more reliable extraction of traffic information from image streams. Recent review papers have highlighted the growing role of camera-based systems, fixed and aerial, in traffic surveillance, vehicle counting, trajectory reconstruction, and congestion analysis [1, 2]. The transition from manual interpretation to automated AI-enabled pipelines has improved a lot the scalability of traffic monitoring, especially in complex urban environments where many movements happen at the same time.

A substantial part of recent literature has focused on vehicle detection and tracking from video using deep-learning architectures. For example, [3] investigated road traffic monitoring from UAV images with deep learning networks, while [4] proposed a deep-learning-based image segmentation approach for traffic analysis from UAV streaming [5]. showed that UAV videos can extract key traffic parameters validated against on-board vehicle data, and [6] demonstrated the potential of drone-based large-scale traffic observation through the pNEUMA experiment. Altogether these studies confirm that AI-based video processing can support not only vehicle detection and counting, but also richer outputs like trajectories, lane usage, and movement patterns. Despite these advancements the major focus of literature is still mainly technical. Most contributions assess the accuracy of detection models, the robustness of tracking procedures, or the quality of traffic parameter extraction under specific imaging conditions. At the same time, less attention has been given to the transformation of video-derived observations into structured inputs for transport models and scenario-based planning. This issue is relevant when considering fixed municipal cameras, that are increasingly available in urban areas and may act as continuing sensing infrastructures for mobility management. In this respect, the challenge is not only to detect vehicles accurately, but also to organize video-derived information into traffic variables, such as directional flows and turning movements, suitable for simulation and decision support.

Beyond technical performance, the use of urban video streams raises also broader issues related to privacy, transparency, data governance, and responsible use. To employ fixed cameras as long-term traffic sensing devices, the design of the analytical pipeline should consider data minimization, operational explainability and aggregation procedures to support planning without unnecessary exposure of private information. These aspects are not in the core of transport engineering studies, but they are increasingly important in AI-enabled urban planning applications.

2.2 Video-Derived Data for Transport Simulation

Transport simulation has traditionally relied on observed traffic data for model calibration, demand estimation and validation. Relevant studies on traffic counts and O-D matrix estimation showed that observed flows are essential for updating travel demand representations and improving the predictive quality of transport models [7–9]. In this regard,

measured counts are not simple descriptive data, but core elements for reconstructing the interaction between transport demand and network supply.

At the operational level, microsimulation models are widely used to assess traffic performance under alternative management or infrastructure scenarios, but their validity is strongly influenced by proper calibration and validation. Comparative studies on car-following behaviour and simulation calibration have long emphasized the need to align model outputs with observed traffic conditions before using simulations for decisions [10, 11]. More recent works confirm that simulation-based assessment remains highly dependent on the quality, spatial coverage, and representativeness of the empirical traffic inputs used to feed the model.

Within digital-twin-oriented applications the integration of observed data into simulation models has become even more important [12]. presented a case study within Digital Twin Munich where loop-detector data were used for calibrating a microscopic traffic simulation [13, 14]. proposed an integrated approach for O-D matrix calibration using empirical traffic counts and a macro-simulation framework, highlighting how heterogeneous traffic data can be progressively embedded into simulation environments supporting a Digital Twin of Mobility. These studies demonstrate that transport simulation is moving away from isolated modelling exercises toward more data-connected architectures.

But a specific gap remains for video-derived data. While transport simulation routinely uses manual counts, loop detectors, radar sensors, or aggregated survey data, the direct operational use of traffic variables extracted from urban video streams is still limited. There is a lack of studies that address explicitly how AI-processed video data can be transformed into movement-based demand inputs for microsimulation. This gap is relevant for urban nodes where directional flows, route choices and localized conflicts must be represented with high spatial detail. The present work addresses this issue by using video-derived turning movements as model inputs for scenario-based microsimulation.

2.3 Mobility Digital Twins for Urban Planning

The concept of digital twin has progressively appeared in transport and planning literature, as a framework for integrating data, models and decision support. A recurrent distinction is pointed out between conventional models and digital twins: both aim to represent a physical system, but digital twins are expected to maintain a closer and more dynamic connection with the real-world through continuous and recurrent data updates [15]. In urban studies digital twins have been described as key components of smart-city strategies, able to support what-if analyses, performance monitoring and multiple scenario planning [16].

In the field of mobility, digital twins have been framed as virtual environments where transport infrastructures, demand patterns, traffic conditions and operational services can be jointly represented and evaluated [17]. provided one of the most systematic conceptualizations of the mobility digital twin, defining its architecture, case-study logic and future research directions. And other contributions have stressed the role of real-time or near-real-time data integration for enabling predictive analysis and simulation-based management. For example, [18] discussed the synergy between traffic data streams

and simulation for virtualizing motorway dynamics, while [19] addressed the empirical challenge of building and validating a large-scale traffic digital twin for Barcelona.

A further line of research concerns the urban-planning use of digital twins as decision-support environments and not only visualization platforms [20]. emphasized the importance of mobility and transport data for city digital twin modelling and exploitation, and [21] discussed the design of smart-city digital twins with 3D representation and what-if analysis capabilities. In this same perspective recent applications have shown how simulation-centred digital twins can support evaluation of urban interventions [22]. proposed a digital twin simulation framework for assessing street experiments in Acireale, while [23] highlighted the importance of integrating real-time communication, heterogeneous data, and transport models within the SAMOTHRACE smart mobility framework.

The literature suggests that mobility digital twins are evolving toward increasingly integrated ecosystems, where sensing technologies, transport models, and decision-support tools interact in a continuous loop. But one of the main unresolved issues is the transformation of heterogeneous observational data into model-ready information. In practice this means that the effectiveness of a mobility digital twin depends not only on the simulation engine itself, but also on the quality of the pipeline linking field data acquisition, traffic variable extraction, demand reconstruction, and scenario evaluation. In this context fixed urban cameras represent a potentially valuable but still under-used source of information. The present study contributes to this research direction by proposing a framework in which video-derived traffic flows are directly used to support microsimulation-based planning, so reinforcing the operational link between urban sensing and mobility digital twins.

3 Methodological Framework

The proposed methodology is structured as a multi-step framework aimed at linking urban video analytics with traffic microsimulation for planning-oriented applications. Figure 1 summarizes the proposed methodological framework, which consists of three main phases: (i) video acquisition from fixed traffic cameras and AI-based extraction of traffic information, (ii) transformation of the extracted observations into simulation input data and (iii) microsimulation-based scenario assessment. Following this research approach, the raw video streams are progressively converted into operational knowledge that can support the evaluation of traffic management and infrastructure modifications.

The rationale behind this framework is that the urban traffic cameras are treated as part of the existing sensing infrastructure of the city, thus providing a continuous and spatially detailed source of traffic observations. Their value for planning lies in the possibility of converting image-based observations into model-ready traffic variables. And in this respect the methodology is designed to bridge the gap between AI-based traffic monitoring and simulation-based decision support, within a perspective that is coherent with the progressive development of a Mobility Digital Twin.

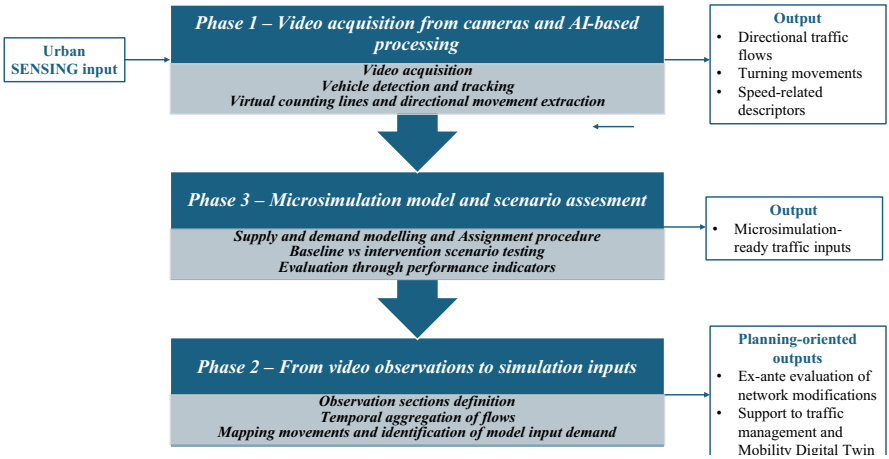

Fig. 1. Workflow of the proposed methodological framework

3.1 Video Acquisition from Fixed Cameras and Processing Pipeline

The first phase concerns the acquisition and processing of video streams collected from fixed urban cameras. Different from temporary survey devices, these cameras are considered like already available elements of the urban monitoring infrastructure, potentially suitable for recurrent or continuous observation of critical road nodes. In the specific case of Catania, this perspective is consistent with the broader UISH framework, within which existing municipal video-surveillance infrastructures are envisaged as part of a distributed observational backbone for future Digital Twin applications. The present case study should therefore be interpreted not only as a stand-alone local test, but also as a proof-of-concept for the progressive integration of AI-based video detection into a wider city-scale monitoring ecosystem. This makes them particularly relevant for applications in urban traffic management, control-room support, and simulation-based planning.

To extract traffic information from the recorded footage the methodology relies on an AI-based processing pipeline including vehicle detection, tracking, and movement counting. In line with recent video analytics approaches each frame is processed to identify vehicles and associate them across consecutive frames, so reconstructing their trajectories within the observation area. This step is essential to move beyond frame-by-frame counting and to interpret vehicle movements as continuous trajectories across the monitored junction or corridor. After reconstructing the vehicle trajectories, virtual counting lines and movement-specific zones are defined inside the video scene. These virtual elements act as digital observation sections and allow the system to detect crossing events and directional transitions. In this way, each tracked vehicle can be assigned to a specific movement pattern according to the sequence of lines or zones crossed during its path. This approach makes it possible to estimate turning flows, directional distributions, and, more generally, the traffic patterns at the observed node. The use of virtual counting sections is particularly advantageous in complex urban intersections, where multiple simultaneous manoeuvres must be observed without interfering with traffic operations. Compared with conventional manual counts, this solution enables a

more systematic reconstruction of vehicle movements and reduces the dependence on human presence on-site. In addition, when image resolution, perspective conditions, and geometric calibration are sufficiently robust, the same pipeline may also provide complementary descriptors like approximate speed-related information, lane usage and potentially non-compliant manoeuvres.

In our framework however the core output of the video processing phase is represented by directional movement flows, which constitute the most reliable and directly usable information for the simulation stage.

3.2 From Video Observations to Simulation Inputs

The second phase consists in converting video-derived observations into traffic inputs suitable for microsimulation. This step represents the methodological core contribution of our framework, because it transforms image-based information into planning-oriented variables for model calibration and scenario assessment. To this end, the monitored area is first schematized into observation sections corresponding to main entries, exits, and internal movement paths of the study network. Then, the directional traffic information extracted from the video is organized according to these sections and aggregated over selected time intervals. Temporal aggregation is necessary to convert individual vehicle trajectories into stable traffic flow variables that can be assigned within the simulation model. Moreover, the selection of the aggregation interval depends on objectives of the analysis and variability of traffic conditions, but it should remain consistent with the temporal resolution adopted in the simulation. After aggregation observed movements are translated into traffic demand inputs by associating each directional flow with the corresponding turning movement or travel path in the network model. In practice, the set of video-derived movements is used to reconstruct the local demand structure at the analyzed junction or corridor, ensuring coherence between empirical observation and simulated traffic patterns. This is especially relevant in urban contexts with multiple route alternatives, restricted manoeuvres, and localized congestion, where simple link counts may not reproduce actual operational conditions.

Compared with conventional manual counting campaigns the proposed approach offers two main advantages. First, it allows simultaneous observation of several movements within the same observed scene, improving completeness of the traffic dataset. Second, it provides a more scalable procedure for updating simulation inputs over time, enabling repeated calibrations or scenario checks as new video observations become available. Additionally, if speed estimates are sufficiently reliable, they may be used as complementary calibration information; however, in the present framework flow and movement data remain the primary simulation inputs, as they are the most robust outputs of the video-processing pipeline.

3.3 Microsimulation Model and Performance Indicators

The third phase is about the implementation of the microsimulation model and the definition of performance indicators used for scenario assessment. The model reproduces the geometric and operational characteristics of the analyzed road network, including lane configuration, turning connectors, permitted manoeuvres, priority rules, and conflict

areas at junctions. This represents the supply side of the system, and it is essential for capturing the local operating conditions, in order to shape traffic behaviour.

On the demand side the traffic flows derived from video observations are assigned to the corresponding paths and directional movements identified within the network. In this way the simulation environment reproduces the interaction between the reconstructed transport supply and the empirically observed demand pattern. Traffic dynamics are simulated through a car-following and lane-changing logic capable of representing local propagation of queues, the interaction among competing flows, and the resulting variation in operational performance under different configurations.

Once the base model is implemented alternative scenarios can be tested by modifying the network configuration or the movement structure associated with the analyzed intervention. This enables ex-ante evaluation of road-network changes before physical implementation, supporting planning decisions with a risk-free virtual environment. And in this logic microsimulation does not serve only as a descriptive tool, but as an operational support for understanding if a proposed intervention improves or worsens the functioning of the system.

The scenario analysis focuses on three main Key Performance Indicators (KPIs): Level of Service (LOS), travel time, and queue length. LOS is used to express the overall quality of traffic operations at nodes or along selected movements, synthesizing the operational conditions experienced by users. Travel time is adopted as a direct indicator of accessibility and network efficiency, since it captures the temporal cost associated with crossing the study area under each tested configuration. Finally, queue length is used to identify localized criticalities and spillback effects, especially in congested approaches or sections affected by bottleneck formation. All these indicators give a coherent basis for comparing the current state with the tested intervention scenario and for reading the potential impact of the proposed modification at both node and corridor level.

Therefore, our methodological framework combines urban video analytics and microsimulation within a unified planning-oriented workflow. Its added value lies in the possibility of transforming continuously available urban sensing data into simulation inputs that support scenario analysis, traffic management, and the progressive implementation of AI-enabled mobility digital twins.

4 Case Study

The proposed framework is applied to a real-case study located in the urban road network of Catania (Italy), a metropolitan city in eastern Sicily characterized by high motorization levels and recurrent congestion at major access corridors. In the last years the vehicular traffic in Catania has increased a lot and the city is now among those with the highest motorization rate in Europe. This fact makes the local traffic conditions particularly critical and the need for efficient planning tools even more urgent. Within this context the analyzed study area concerns the intersection between Via Caronda and Viale Odorico da Pordenone, positioned immediately downstream of the Tondo Gioeni node, which represents one of the most strategic connections to the inner ring-road system of the city (Fig. 2). This zone has been object of a deep rethinking of the road layout. In fact, the road configuration changed passing from an intersection with staggered levels to an at-grade

roundabout. But this roundabout presents unusual aspects because it has a geometric layout that does not reflect the classic and functional canons of a roundabout, due to some space limits which constrains the structural reconfiguration of the intersection. As already observed in other traffic studies developed for Catania, critical urban nodes in this area are strongly influenced by concentrated commuting flows and by the limited flexibility of the surrounding network under peak-hour conditions. The selected case study is particularly relevant because it concerns a critical access point to the ring road where local geometric constraints, route restrictions and heavy directional flows interact within a relatively compact urban space. the operational relevance of the site derives not only from its role as a traffic distribution toward different city sectors, but also from the fact that even localized modifications at this node may produce broader effects on nearby approaches and on the performance of the surrounding road system. For this reason, the area provides a suitable test bed for assessing how video-derived traffic information can support simulation-based evaluation of alternative traffic configurations.



Fig. 2. Study area - Via Caronda

4.1 Current Road Configuration

In the state of affairs in Fig. 3 the direct access from Via Caronda to Viale Odorico da Pordenone is closed. This point is an entry to the Catania ring road, a main urban orbital that connects different parts of the city. The present condition is the baseline scenario against which the intervention hypothesis is tested. From an operational point of view the existing configuration does not let vehicles coming from Via Caronda to merge directly into the ring-road system at this location. And so, the users must take alternative longer routes to get to where they need to go, with more travel time and more kilometres. This constraint is a reason why the reopening of this access has been considered as a possible intervention. But we must remember that the node already works under tight geometric

conditions. Therefore, any change in access regulation must be looked at not just for the direct accessibility gain for that specific movement, but also for the wider effect on road capacity and how the whole junction performs.

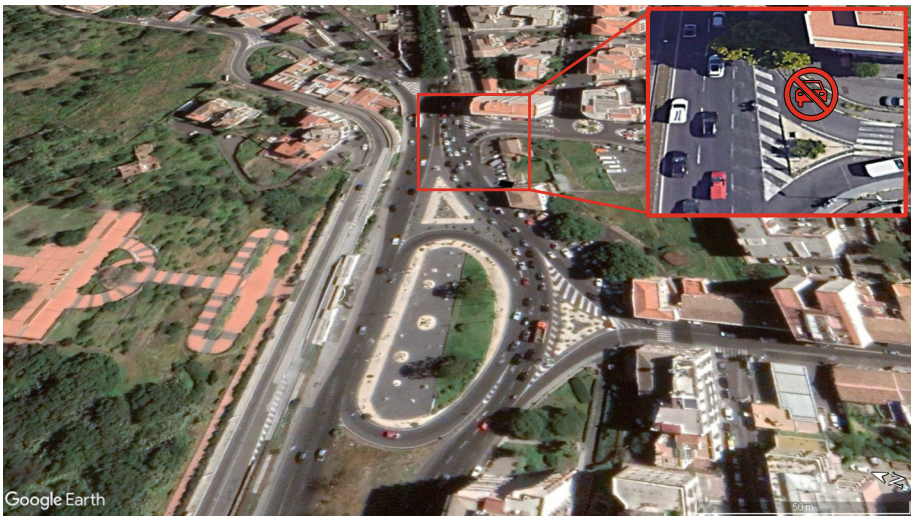

Fig. 3 Current state of via Caronda.

4.2 Tested Intervention Scenario

The analyzed scenario focuses on the hypothesis of reopening the direct access from Via Caronda to the ring road through Viale Odorico da Pordenone. Remember this is the point where traffic from Via Caronda tries to enter the main orbital of Catania. According to the examined design configuration this intervention would need a new channelizing island and would also suppress the third lane that now exists in the study section. Thus, the opening of this access changes the effective capacity of the approach. The current three-lane setup becomes a two-lane configuration in the direction of Ognina. This is central for the scenario assessment. Because it means that a possible gain in direct access for one movement comes together with a reduction of capacity for the main traffic stream. To put the new scenario inside the microsimulation model, the flow of the movement called manoeuvre g in the technical scheme was taken and redistributed as a new entering flow to the ring road. And this additional flow was split fifty-fifty between the two main directions: Ognina and Misterbianco. The demand from Via Caronda was assigned 50/50 to the two alternative paths.

The scenario was therefore designed to compare two conditions: the current state of affairs with the closed access from Via Caronda and three lanes available on the main approach, and the project hypothesis with the reopened access plus the geometric changes needed to make it happen. The comparison lets us see if the better directness for vehicles from Via Caronda is enough to pay for the loss of roadway capacity on the corridor. In

this sense the case study is good for simulation-based ex-ante evaluation. Because the expected effects are not obvious in one direction. They depend on the balance between the better accessibility and the worse traffic performance.

5 Results

5.1 Video-to-Flow Extraction Results

The first outcome of the framework concerns the extraction of traffic movements from the urban video streams and their transformation into directional flow inputs for the microsimulation model. The AI-based processing pipeline has analyzed the recorded video and has given in output the vehicle movements inside the monitored scene. The trajectories were reconstructed and each vehicle was associated to a specific directional path using virtual counting sections. In this way the raw video footage has been converted into structured traffic data usable for the planning analysis. The extracted information was organized according to the main movements of the study node and its connected approaches, ad shown in Fig. 4; and the resulting dataset was used to represent the directional structure of the traffic demand at the intersection system of Via Caronda, Tondo Gioeni, and Viale Odorico da Pordenone.



Fig. 4 Reconstruction of flow distribution

The flows were aggregated over the analysis period and put as input for the baseline microsimulation model, giving the empirical basis for the demand pattern of the scenario. The present work does not aim at a full technical validation of the video-processing chain; what we demonstrate here is the operational usefulness of video-derived traffic observations for generating simulation inputs. The case study shows that urban video can extract movement-based traffic data in complex nodes where many manoeuvres

happen at the same time in a limited space. This is important when the objective is not just monitoring the traffic but feeding a simulation environment with movement-specific demand information. The extracted flows are therefore the link between the observation part and the modelling part of the framework.

5.2 Scenario Assesment

To evaluate the intervention, we first reproduced in the microsimulation model the current state, that is the baseline condition with the access from Via Caronda closed and the three-lane configuration on the main approach. After that we implemented the project hypothesis, which consists in the reopening of the access together with the geometric modifications already described. The objective of the simulation was to put in light the sustainability of the intervention to quantify their impacts on worsening the traffic conditions. This is because it was already reasonable that opening a new entry point on a congested ring road could create additional traffic-related issues. The question to support planning decision are related to how much does the Level of Service decrease and how much the queues length increase.

All the evaluations presented in this paper refer to the peak hour condition. The simulation results give clear evidence. The reopening does not bring any overall improvement. On the contrary, the network performance gets significantly worse. The reduction from three lanes to two on the main approach creates a bottleneck that was not there before. The Level of Service distribution over the whole study area is reported in Fig. 5, where the comparison between the current state and the opening hypothesis is shown.



Fig. 5 Level of Service distribution over the whole study area

A detailed view of the Via Caronda intersection is provided in Fig. 6. From the LOS maps it is evident that several movements that in the current state have an acceptable or moderate Level of Service (LOS C or D) pass directly to LOS F in the opening scenario.

This is the case for the movements from Tondo Gioeni toward Ognina, from Tondo Gioeni toward Via Caronda, and from Viale Andrea Doria toward Ognina. And the same happens for the return movement from Viale Andrea Doria, which goes from LOS D to

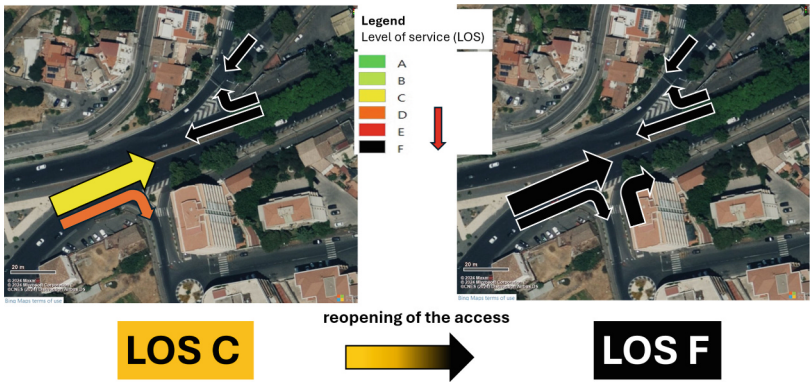

Fig. 6. A detailed view of the Via Caronda intersection

LOS F. The worsening is not only a matter of LOS classification. It has concrete effects on travel times and on the surrounding intersections. The travel time values for the two main directions are synthesized in Table 1.

Table 1. The travel time values

Direction	Current state: Via Caronda closed	Opening scenario
Ognina	1 min	3 min (+2 min)
Misterbianco	3 min	6 min (+3 min)

In the current state, during the peak hour, the average travel time for vehicles going toward Ognina is about 1 min. In the opening scenario this time becomes 3 min, with an increase of 2 min. For the direction toward Misterbianco the average travel time passes from 3 min in the current state to 6 min in the project hypothesis, with an increase of 3 min. So, the crossing times of the study area become practically the double. Moreover, the saturation created by the bottleneck does not remain confined to the Via Caronda node. The queue propagates and saturates also the following intersection along the ring road, creating a cascade effect that was not present in the baseline. The negative effects are not limited only to the peak hour. Even in off-peak conditions some movements show a degradation of service. The movement toward Via Caronda passes from LOS B to LOS C. The movements from Viale Andrea Doria toward Ognina and the return direction pass from LOS A to LOS C. This means that the intervention reduces the operational margin of the node even when the demand is not at its maximum. In conclusion, the scenario assessment demonstrates that the proposed reopening is not sustainable from an operational point of view. The local advantage of a more direct access for the vehicles coming from Via Caronda is largely compensated by the capacity loss on the ring road. The LOS drops from C or D to F on critical movements, the travel times double (from 1 to 3 min toward Ognina, from 3 to 6 min toward Misterbianco), and the congestion

propagates to the next intersection. The simulation has therefore quantified the trade-off and has given to the planning evaluation clear evidence: the intervention, even if it appears attractive for a specific user group, would produce systemic disbenefits that make it not recommendable.

5.3 Discussion

From a planning perspective the case study puts in evidence the importance of combining AI-supported traffic observation with simulation before doing modifications to critical urban nodes. The proposed framework consents to pass from raw traffic videos to planning-grade evidence. This allows public authorities to evaluate if an intervention that seems beneficial at a first look can instead create systemic disbenefits. In this sense the urban video analytics is an enabling layer for decision support and for digital twin applications in mobility planning.

A further aspect is about replicability. The workflow proposed in this paper could not be limited to the specific case of Via Caronda, but it can be extended to other urban intersections and corridors where fixed cameras are already present and where the local administration needs to assess the effects of access changes or lane reallocation. The main strength of the approach stays in the integration between sensing and modelling. Once the vehicle movements are extracted and organized into directional flows, the same logic works for different nodes and different scenarios. This supports recurring assessments over time, enriching the empirical basis of the simulation models. This replicability is especially relevant in the case of Catania, where the broader UISH framework already envisages the integration of existing municipal surveillance cameras into a Digital-Twin-oriented urban intelligence ecosystem. In this sense, the Via Caronda application can be read as an initial demonstrator of how AI-based video detection may evolve from a single case-study implementation into a more pervasive city-wide observation layer, capable of supporting traffic monitoring, simulation updating, and future decision-support services.

At the same time some limitations must be acknowledged. First the quality of the extracted traffic information depends on the visibility conditions of the monitored scene: camera angle, occlusions, lighting, image resolution. These factors can reduce the reliability of movement recognition, especially in congested conditions. Second the flow extraction is relatively robust but getting additional indicators like vehicle speeds needs more stringent geometric calibration and so must be treated with caution. And third the transferability of the framework depends on where fixed cameras are positioned and on the compatibility between what the camera sees and the movement structure that the simulation model needs to represent.

Finally, the use of urban video streams for planning requires attention to privacy and responsible use of data. In this framework the objective is not the identification of single road users. It is the extraction of aggregated traffic variables for model input and scenario assessment. The operational value of the approach is exactly this: converting video streams into anonymized movement-based traffic information. Information that can support simulation, control rooms, and future mobility digital twin implementations. And all this without relying on unnecessary data at personal level. The results of the scenario assessment are synthesized in Fig. 4, which shows the Level of Service distribution across the entire study area for both the current state and the opening hypothesis,

with a detailed focus on the Via Caronda intersection. The quantitative effects on travel times are reported in Table 1, where the doubling of the crossing times for the two main directions is clearly visible.

6 Conclusions

This paper presented an integrated framework for transforming urban video streams into microsimulation input data to support AI-enabled mobility planning. The framework combines vehicle detection, tracking, and directional movement extraction with a scenario-based microsimulation model. In this way it bridges the gap between traffic observation and transport simulation. The methodological contribution is the definition of an operational workflow that converts fixed-camera video data into movement-based traffic inputs. Inputs that are suitable for planning-oriented scenario assessment. The study gives a contribution to the research field at the intersection of urban video analytics, transport modelling, and mobility digital twins.

From the application side the case study on Via Caronda in Catania demonstrated that video-derived traffic flows can effectively support the ex-ante assessment of road-network modifications. The simulation put in light that the reopening of the direct access to the ring road, even if it gives a more direct route for a specific movement, reduces the effective capacity of the corridor due to the suppression of the third lane. The LOS on critical movements drops from C or D to F. The travel times double: from 1 to 3 min toward Ognina, from 3 to 6 min toward Misterbianco. And the queue propagates to the next intersection creating a cascade effect. These findings confirm the usefulness of the proposed framework for testing interventions before the implementation. And they help to identify systemic disbenefits that are not visible with a purely local or intuitive evaluation. The framework shows also the potential of fixed urban cameras as strategic data sources for traffic control rooms and simulation-supported planning. Their value is not only in the continuous observation. It is in the possibility to transform video streams into structured traffic knowledge that can update models, test scenarios, and support decisions inside complex urban systems. This is particularly relevant for cities that already have camera-based infrastructures and want to make stronger their analytical capabilities with AI-enabled tools.

Future research will specifically address the scaling-up of the proposed framework within the UISH ecosystem for the city of Catania. In this perspective, the processing of video streams from the broader network of municipal surveillance cameras already installed across the city may enable the creation of a pervasive observational layer capable of supporting more continuous traffic-flow reconstruction, broader simulation coverage, and progressively updated Digital Twin functionalities. Further developments will also investigate the integration of additional indicators, such as speed estimation and speed profiles, whenever geometric calibration and video quality allow robust extraction, as well as more continuous and quasi-real-time data feeds for recurrent model updates. The aim is to support recurrent model updates and a more dynamic interaction between monitoring systems and simulation. In this perspective the proposed framework is a first step toward a more comprehensive and operational AI-supported mobility digital twin for urban planning and traffic management.

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