Whitepaper

Traffic interpolation

Enhancing road insights with advanced machine learning

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ABOUT MACQ

"We help make the world a safer & healthier place."

At Macq, our purpose is to make the world a safer place for the estimated 7.8 billion people who call it home. We believe in the transformative power of innovative mobility solutions to connect and drive economic growth for this diverse global community.

As a leader in the industry, we are committed to promoting safety and security with over 1.3 billion vehicles on the road. We take our responsibility seriously and work to address the root causes of insecurity by implementing safety regulations and creating solutions that benefit everyone.

Our ambition is our driver: The global market of ANPR and AI based cameras for Smart Mobility purposes is still growing and we expect that within 4 years the market volume will at least double in size. Our ambition is to ensure our leading position in the ITS & Smart Mobility market and to become the most reliable and valued business partner, not only in Europe, but worldwide.

To achieve this, we will focus on both, establishing mutually rewarding international partnerships and building new compelling and outstanding solutions for our key customers. That's why research & development represents 30% of our sales revenue. Macq continually pushes its products & services into the realm of the unknown, the untried, or the highly desirable. Unique to Macq is that we consistently strive to provide the ITS & Smart Mobility market with cutting-edge products. Join us in our journey to revolutionize mobility and make it easier and healthier for everyone.

François Macq, CEO of Macq presents the company better than anyone:

"At Macq, we bring a 100-years expertise and knowledge in mobility to the table, honed by our understanding of the specific needs of each country.

Our history and understanding of the industry allow us to provide customized solutions that address the challenges of each market, resulting in a strong presence in multiple countries worldwide, especially in Europe where our headquarters are based, in Belgium. We are dedicated to constantly improving mobility through innovative solutions and pushing boundaries in the transportation industry. Our innovative spirit, combined with our extensive experience and strong partnerships, make us a leading and game-changing company in the field. As a Belgian family-run company, we have the advantage of in-house software and hardware development, enabling us to easily adapt to our customers' requirements. We focus on both, building outstanding solutions and establishing mutually beneficial partnerships.

Our goal is to continuously seek new and better ways to improve road safety and security, minimize disruption, and enhance quality of life, health, and environment. Our intelligent road solutions support policymakers in protecting citizens and promoting sustainable transportation options. With 100 years of experience, we understand the unique challenges of each market and provide customized solutions to meet the needs of our clients and partners."

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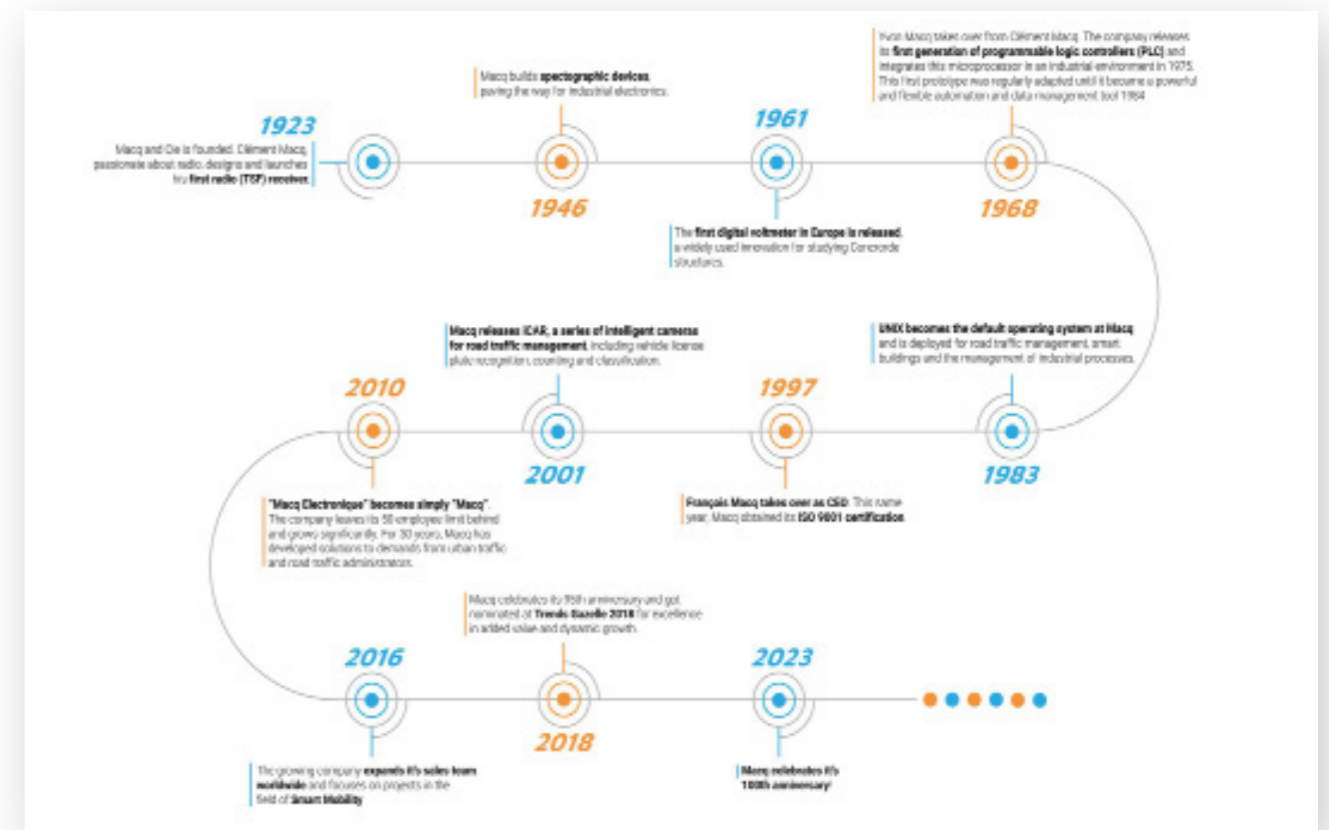
FIVE FOCUS AREAS, ENDLESS SOLUTIONS

If you are a city planner, road manager, in politics or law enforcement, Macq has the best cutting-edge solutions for you. Discover what we propose.

Smart Cities & Roads

Building Tomorrow's Mobility: Today's Solutions for Future Movement. Macq provides integral solutions for smart cities and road operators to address mobility challenges such as traffic congestion, road safety, and air pollution. Our comprehensive approach includes tools for both monitoring and managing mobility, empowering smarter, safer, smoother and sustainable environments.

Challenges you may have:

• Secure your restricted traffic zones
• Reduce pollution in your city
• Manage your car parks
• Understand your mobility ecosystem
• Increase the use of sustainable transport
• Improve your traffic flow & road safety

SCAN ME

Mobility Insights & Data

Gain Clarity, Drive Mobility Decisions: Traffic monitoring and analytics for Informed Action. Ensuring smart, safe, smooth and sustainable mobility demands continuous vigilance and data gathering. Macq provides smart sensors, traffic models and visualisation tools for real-time traffic monitoring and insightful analysis, facilitating informed decisions.

Challenges you may have:

• Measure the impact of your decisions
• Understand your mobility ecosystem
• Monitor the use of your car parks
• Improve your traffic flow & road safety

SCAN ME

Climate & Environment

Protecting Today, Preserving Tomorrow: Analyse & ban harmful emissions from your City. Improve air quality, combat climate change and protect your citizens' health by monitoring harmful emissions. Transform your city into a Low Emission Zone & encourage the modal shift to more sustainable modes of travel.

Challenges you may have:

• Reduce pollution with low emission zones
• Increase the use of sustainable transport
• Improve your traffic flow & road safety
• Understand your mobility ecosystem

SCAN ME

Safe Schools

Improve Traffic Safety around your schools and other Sensitive Areas. Macq's Safe Schools Solution (S³) offers a holistic end-to-end approach to enhance road safety around schools and other sensitive areas. S³ adresses speeding and parking violations, alerts drivers of crossing pedestrians, and controls entry to car-free zones, ensuring thorough safety measures.

Challenges you may have:

• Reduce speed violations near schools
• Enforce your kiss & rides
• Secure your restricted traffic zones
• Understand your mobility ecosystem

SCAN ME

Effective Police

Enhance your jurisdiction's Police efficiency, global security & reduce crime rates thanks to intelligent camera systems or tailor made solutions such as speed section control. The safety of drivers in the face of reprehensible faults requires authorities attention. With Macq surveillance technologies, your law enforcement forces can prevent and punish dangerous behaviours.

Challenges you may have:

• Improve people's safety, reduce speeding
• Secure your jurisdiction
• Manage vehicle access to certain areas
• Track & find wanted vehicles in real time
• Punctual control of vehicles
• Automatic inspection of trucks

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OUR PRODUCTS

QCAM3

QCAM3, our "Green one". The powerful & power efficient ANPR road camera to satisfy your basic traffic & mobility requirements. This device scan at up to 180 km/h on 2 lanes.

Integrating the latest cutting-edge technologies (deep learning-based algorithms), the QCAM3 ANPR camera delivers unprecedented number plate recognition capabilities. Additionally, its outstanding image resolution and a unique set of functionalities designated to provide further vehicle characterization makes this product the "best in class" within its category.

· **High Resolution**
5 MP, road monitoring up to 2 lanes, up to 180 km/h

· **Powerful Hardware**
Equipped with a motorized lens, Wi-Fi, 4G or 5G

· **Embedded AI**
Detection of all parameters, including Make & Model

· **High Quality & Flexibility**
Customization possible: in-house product development

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QCAM5

QCAM5, our "Flagship". AI based ANPR Camera for roads & highways. This device scan at up to 300 km/h on 4 lanes and is officially homologated for Speed Section Control.

Integrating the latest cutting-edge technologies (deep learning-based algorithms), the QCAM5 ANPR camera delivers unprecedented number plate recognition capabilities. QCAM5 can operate on 1 to 4 lanes and is able to differentiate all kind of vehicles (e.g. cars, trucks, busses, motorcycles, bicycles, trams, etc.), objects and persons. QCAM5 is today Macq most advanced device.

· **High Resolution**
12 MP, 35.7 FPS, up to 4 lanes, up to 300 km/h

· **Powerful Hardware**
Equipped with a motorized lens, Wi-Fi, 4G or 5G

· **Embedded AI**
Detection of all parameters, vehicles, persons & objects

· **High Quality & Flexibility**
Customization possible: in-house product development

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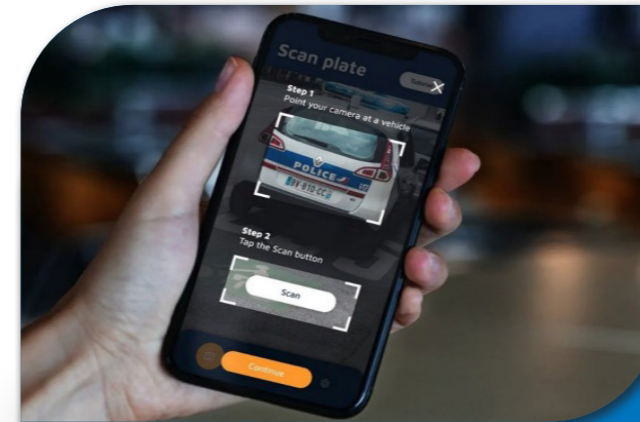
QCAM-App

QCAM-App for Android smartphones, destined for Police & parking managers. This application includes a real time plate reader integrated, working even offline. Your next-gen mobility management app.

This app is easy to use and helps the user to know in real-time the number plate, the country, the make, and model of the car, the color of the car (under certain acceptable lighting conditions).

Software upgrades are available once per year. The smartphone app connects with M³ (Macq Mobility Manager), cloud-based software platform providing data storage and real-time information.

It is not only possible just to take a photo of every single car you may encounter and read the number plate, but you can also analyze in real-time with the video mode.

Any blacklisted vehicle may be displayed in real-time, any vehicle that the user might want to blacklist shall be recorded in the cloud. This software package can be sold "as a service".

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Macq Mobility Manager

Secure your Smart City with our Macq Mobility Manager (M³), the Smart Mobility & Enforcement platform tailored to your needs. Dive into the world of Big Data, secure et protect your roads and city, reduce pollution, increase your Police efficiency... and so much more.

Endless possibilities. All our Macq products, services and software are compatible in our M³ platform. All data retrieved via ANPR cameras or other equipment in the field help to provide all sorts of important information to be able to perform efficient traffic management in your jurisdiction, municipality or region.

· **Modular & Easy to Implement**
Tailored to your own needs, easy installation

· **Scalable, Reliable & Redundant**
Big Data, Cluster architecture, Data backup guaranteed

· **Open System & State-of-the-Art Technologies**
Integration of all third-party devices, databases & API

· **High access & Data Security**
Encryption, anonymisation & partitioning of Data

SCAN ME

TRAFFIC INTERPOLATION

The traffic interpolation model of Macq provides estimates of traffic counts and speeds, even at locations without measuring equipment.

Figure 1: The principle behind traffic interpolation. Estimates of traffic metrics are provided at different locations on the network (triangles) based on real-life measurements from sensors (circles) used during the training phase of the interpolation model.

DESCRIPTION

The traffic interpolation model developed by Macq is an advanced tool designed to provide precise estimates of traffic counts and speeds, which we refer to as traffic metrics, on various road segments. This model is particularly beneficial as it can generate these estimates even in areas where there is no direct measurement equipment installed. The Macq traffic interpolation system utilizes a state-of-the-art machine learning model, which integrates multiple data sources into a single, highly accurate stream of traffic information.

Macq's traffic interpolation model achieves its high level of accuracy by fusing data from various sources. These sources include but are not limited to, sensor data from installed traffic monitoring equipment, GPS data from vehicles, and historical traffic data. By combining these diverse data inputs, the Macq traffic interpolation model can create a holistic picture of traffic conditions. This fusion of data sources is a key aspect of the model's design, ensuring that it can provide reliable traffic metrics even in data-sparse regions.

Furthermore, the integration of multiple data sources not only enhances the accuracy of the traffic metrics but also improves the model's robustness. In cases where one data source may be compromised or unavailable, the model can still function effectively by relying on the remaining data inputs. This redundancy ensures that the traffic metrics provided

by the Macq model are consistently reliable, regardless of the availability of individual data sources.

The application of the Macq traffic interpolation model is broad and versatile. Traffic authorities can use it to monitor and manage road networks more effectively, identifying potential congestion points and optimizing traffic flow. Urban planners can leverage the model's insights to design better road systems and plan for future infrastructure needs.

In summary, the Macq traffic interpolation model is a cutting-edge solution that delivers precise traffic metrics across road segments, even in the absence of direct measurement equipment. By integrating multiple data sources through advanced machine learning techniques, it provides a comprehensive and reliable picture of traffic conditions. This model is an essential tool for anyone involved in traffic management, urban planning, or transportation logistics, offering a significant advantage in understanding and optimizing road traffic.

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WORKING PRINCIPLES

Every machine learning model is first trained on existing historical data. While the interpolation model is device agnostic it requires the following data to be trained:

Counts and speeds coming from the available equipment and sensors on the road network, such as inductive counting loops, traffic- and ANPR cameras.

This data constitutes the target on which our model is trained, hence it is important that

it is properly processed and cleaned before training.

Floating car data (FCD), more specifically, average speeds and partial counts. For example, with TomTom as FCD provider, the partial counts are called sampleSize (i.e. the amount of devices observed and used to create the traffic information from TomTom).

While the Macq interpolation model is robust to missing data, the quality and availability of the two aforementioned data sources

will determine the quality of the output of the model. Besides reference traffic metrics and FCD, the model can be fed other spatiotemporal and socio-economic features that are relevant to the road network under investigation.

The interpolation model is flexible, meaning it can be used to provide traffic metrics for various vehicle classes for different time intervals, as long as the source data contains the information.
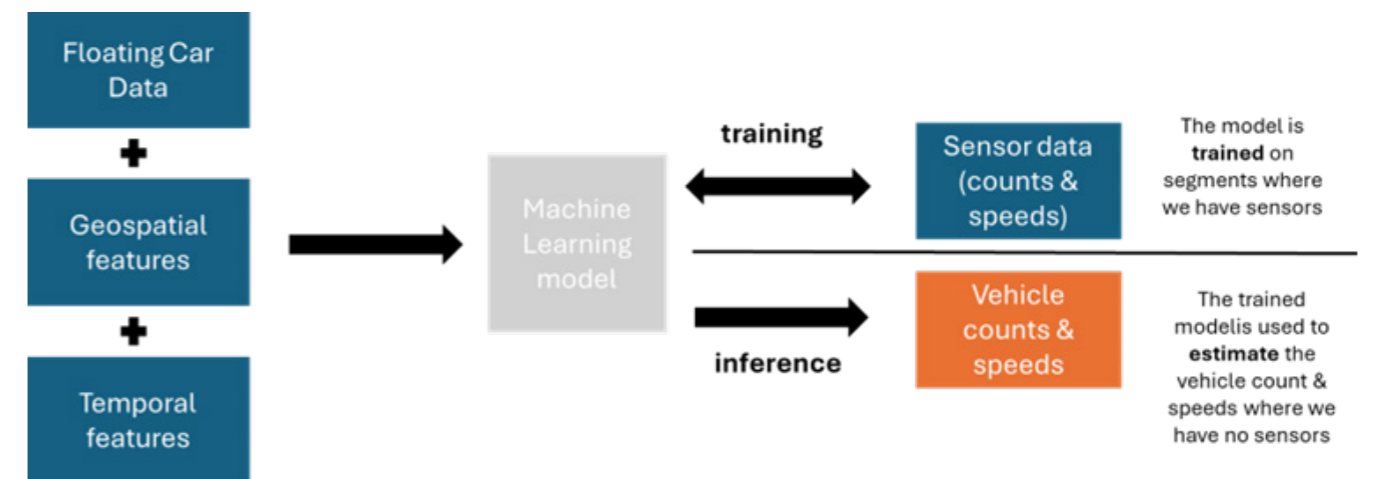

Figure 2: schematic of the working principle of the Macq interpolation model

ADDED VALUE OF OUR SOLUTION COMPARED TO FLOATING CAR DATA

The strength of our traffic interpolation model lies in its capacity to "compensate" for the weaknesses inherent in Floating Car Data (FCD). While FCD provides valuable insights into speeds and levels of service across an entire road network, it has significant limitations that our model addresses comprehensively.

First, FCD only represents a portion of the actual traffic. Since it relies on data collected from equipment equipped with the relevant technology, it is inherently incapable of providing an accurate representation of total vehicle volumes. This limitation means that FCD alone cannot offer a complete picture of traffic conditions, often leading to gaps in data and potential inaccuracies in traffic analysis.

Furthermore, FCD is generally agnostic to the types of vehicles on the road. While some data providers might offer limited categorization, the majority of FCD does not differentiate between vehicle classes such as cars, trucks, buses, or motorcycles. This lack of granularity can be a significant drawback for applications requiring detailed traffic composition, such as infrastructure planning, congestion management, and environmental impact assessments.

Our Macq traffic interpolation model effectively bridges these gaps by combining the precision of direct traffic measurements with the extensive coverage offered by FCD. By integrating data from various sources, including inductive counting loops, traffic cameras, and ANPR cameras, our model ensures that traffic counts and speeds are accurately captured and processed. This data forms the target on which our model is trained, allowing it to deliver precise traffic metrics across different vehicle classes.

Additionally, the interpolation model leverages Floating Car Data (FCD) to enhance its geographical reach. This fusion of data sources means that even in areas lacking direct measurement equipment, our model can provide reliable traffic estimates. The model's robustness to missing data ensures that it remains effective even when certain data inputs are unavailable, maintaining the accuracy and reliability of its outputs.

Another significant added value of our solution is its adaptability to various spatiotemporal and socio-economic features relevant to the road network under investigation. By considering these additional factors, the Macq interpolation model can account for variations in traffic patterns due to socio-economic activities, seasonal changes, and other temporal dynamics, thereby offering a more comprehensive and

thereby offering a more comprehensive and nuanced understanding of traffic conditions.

In summary, the Macq traffic interpolation model not only addresses the inherent limitations of FCD but also enhances its utility by providing accurate, detailed, and reliable traffic metrics. This hybrid approach ensures that our solution delivers unparalleled insights into traffic conditions, supporting more informed decision-making for traffic management, urban planning, and infrastructure development.

VERSIONS

The Macq interpolation model can be deployed in two distinct versions, depending on your actual needs or focus area.

1. Historic traffic metric interpolation:

This offline variant is the de-facto version of our model, used to obtain traffic data for the entire road network with limited resources.

Applications include shadow tolling, long-term traffic analytics, roadwork planning and strategic support for the evaluation of a mobility policy and the measures taken within it.

This model maximizes the use of all data sources and provides the most accurate estimation we can currently offer.

2. Real-time traffic metric interpolation:

The Real-time variant is often used for traffic monitoring.

This model can directly capture the trends occurring in traffic in your area.

The accuracy and availability of the results are often limited by the availability of the source data used during the estimation of the traffic metrics.

ROAD TRAFFIC FORECASTING

Macq's road traffic forecasting model helps you to obtain varied and comprehensive mobility data, but above all: accurate traffic predictions.

Forecast traffic
& flux efficiently
by using our
next generation
solutions

DESCRIPTION

The traffic forecasting model developed by Macq offers advanced and precise predictions for various time horizons, ranging from as short as 15 minutes to as long as 2 hours. These predictions encompass crucial traffic metrics, including traffic counts and speeds, for specific road segments. One of the most notable aspects that sets our model apart from traditional forecasting systems is its remarkable ability to provide accurate forecasts even for road segments that are not equipped with any measuring sensors. This unique capability allows it to act as a "predictive interpolation" model, filling in gaps where data is not directly available.

Our model represents a cutting-edge advancement in the field of traffic forecasting, leveraging state-of-the-art machine learning techniques. It integrates and synthesizes diverse data sources, transforming them into a cohesive and comprehensive source of traffic information. By doing so, the Macq traffic forecasting model not only improves the accuracy of predictions but also enhances the scope and reliability of traffic management systems.

Furthermore, the model's sophisticated algorithms and data fusion capabilities allow it to adapt to various traffic conditions and scenarios, providing robust performance across different environments. Whether it's urban areas with complex traffic patterns or rural roads with sparse data, the Macq model

ensures consistent and reliable forecasts.

In addition to its predictive prowess, the model is designed with scalability and flexibility in mind. It can be seamlessly integrated into existing traffic management infrastructures, offering a valuable tool for city planners, transportation authorities, and traffic engineers. The insights generated by the Macq traffic forecasting model enable proactive traffic management strategies, helping to alleviate congestion, optimize traffic flow, and improve overall road safety.

In essence, the Macq traffic forecasting model stands at the forefront of traffic prediction technology, offering unparalleled accuracy and versatility. Its ability to provide meaningful forecasts even in the absence of direct sensor data marks a significant leap forward, underscoring its role as an indispensable asset in the realm of intelligent transportation systems.

WORKING PRINCIPLES

Every machine learning model is first trained on existing historical data. While the forecasting model is device agnostic, it requires the following data to be trained:

• Historical counts and average speeds coming from roadside equipment and sensors on the road network, such as inductive counting loops, traffic- and ANPR cameras. This data constitutes the target on which our model is trained, hence it is important that it is properly processed and cleaned before training.

• Floating car data (FCD), more specifically, average speeds and partial counts. For example, with TomTom as FCD provider, the partial counts are called sampleSize (i.e. the amount of devices observed and used to create the traffic information from TomTom). The wide geographical coverage of FCD, i.e. its availability on all segments of a road network, is essential for the proper functioning of our interpolation model.

While the Macq forecasting model can handle missing data, the quality and availability of the two aforementioned data sources will determine the quality of the output of the model at inference time. Since a forecasting model must operate in (semi) real time, the availability of the different data sources is crucial for a proper

forecast. The working principle of our model, together with the different associated processing phases, is included in **Figure 1**.

Besides reference traffic metrics and FCD, the model can be fed other spatiotemporal and socio-economic features that are relevant to the road network under investigation.

The forecasting model is flexible, meaning it can be used to provide traffic metrics for various vehicle classes for different time intervals, as long as the source data contains the information.
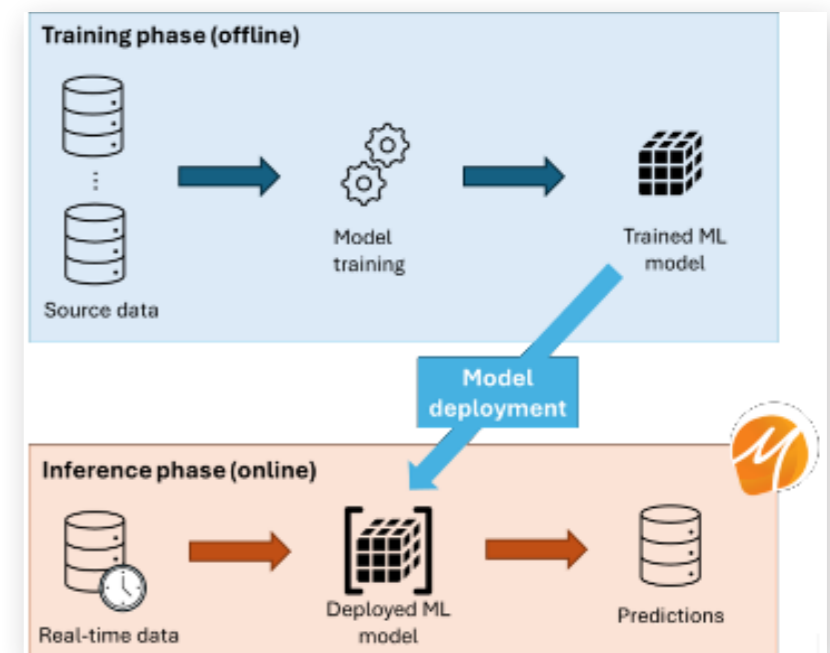

Figure 1

ADDED VALUE OF OUR SOLUTION

Unlike traditional forecasting models, our model fulfills two essential functions:

(1) accurate prediction of traffic metrics on equipment at different forecasting horizons,

(2) precise prediction on road segments that are not equipped with roadside sensors.

This dual capability offers a significant advantage in terms of flexibility and coverage, allowing for comprehensive traffic management across both well-monitored and less-equipped areas

The Macq forecasting model harnesses the power of state-of-the-art machine learning techniques, ensuring that traffic predictions are both reliable and timely.

By integrating data from multiple sources, such as fixed traffic sensors and floating car data (FCD), our model transcends the limitations of conventional systems that rely solely on sensor data.

This fusion of diverse data sources enables the Macq model to generate highly accurate traffic metrics for various vehicle classes across an extensive road network.

One of the key benefits of our model is its ability to provide valuable insights into traffic conditions on road segments lacking direct measurement infrastructure.

This predictive interpolation capability means that traffic authorities and planners can receive real-time forecasts for virtually any part of the road network, enhancing their ability to manage and respond to traffic conditions dynamically.

Moreover, the accuracy of our model's predictions is reinforced by its capacity to learn from historical traffic patterns and real-time data inputs.

This continuous learning process ensures that the model adapts to changing traffic behaviors and evolving road conditions, maintaining high levels of precision over time.

The added value of the Macq traffic forecasting model also extends to its user-centric design. Traffic managers can easily integrate our model into existing traffic management systems, leveraging its forecasts to optimize traffic flow, reduce congestion, and improve overall road safety.

Additionally, the model's ability to differentiate between vehicle classes allows for targeted interventions, such as prioritizing emergency vehicles or managing heavy truck traffic during peak hours.

In summary, the Macq traffic forecasting model stands out for its innovative approach to traffic prediction, combining the accuracy of traditional measurement-based forecasts with the extensive reach of predictive interpolation.

By offering precise, actionable insights across the entire road network, our model empowers traffic authorities to make informed decisions, enhance operational efficiency, and ultimately create a safer, more efficient transportation environment.

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LET'S GET IN TOUCH!

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