



**Corso di Laurea Magistrale in Informatica
Data Science & Machine Learning**

Implementazione di Modelli di Machine Learning in MLOps per la Pianificazione urbana delle Smart City: Un Caso di Studio su Breda e 's-Hertogenbosch, Paesi Bassi

**Prof. Fabio Palomba
Dott. Fabiano Pecorelli**

**Marco Costante
Mat.: 0522501330**

 m.costante1@studenti.unisa.it
 <https://github.com/comarco99>
 www.linkedin.com/in/marco-costante



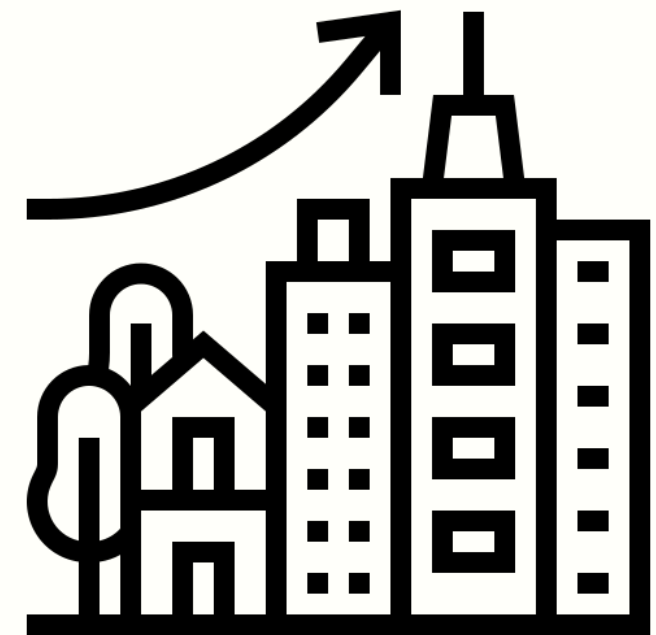


Il seguente lavoro di tesi è stato svolto durante un tirocinio presso la
Jheronimus Academy of Data Science



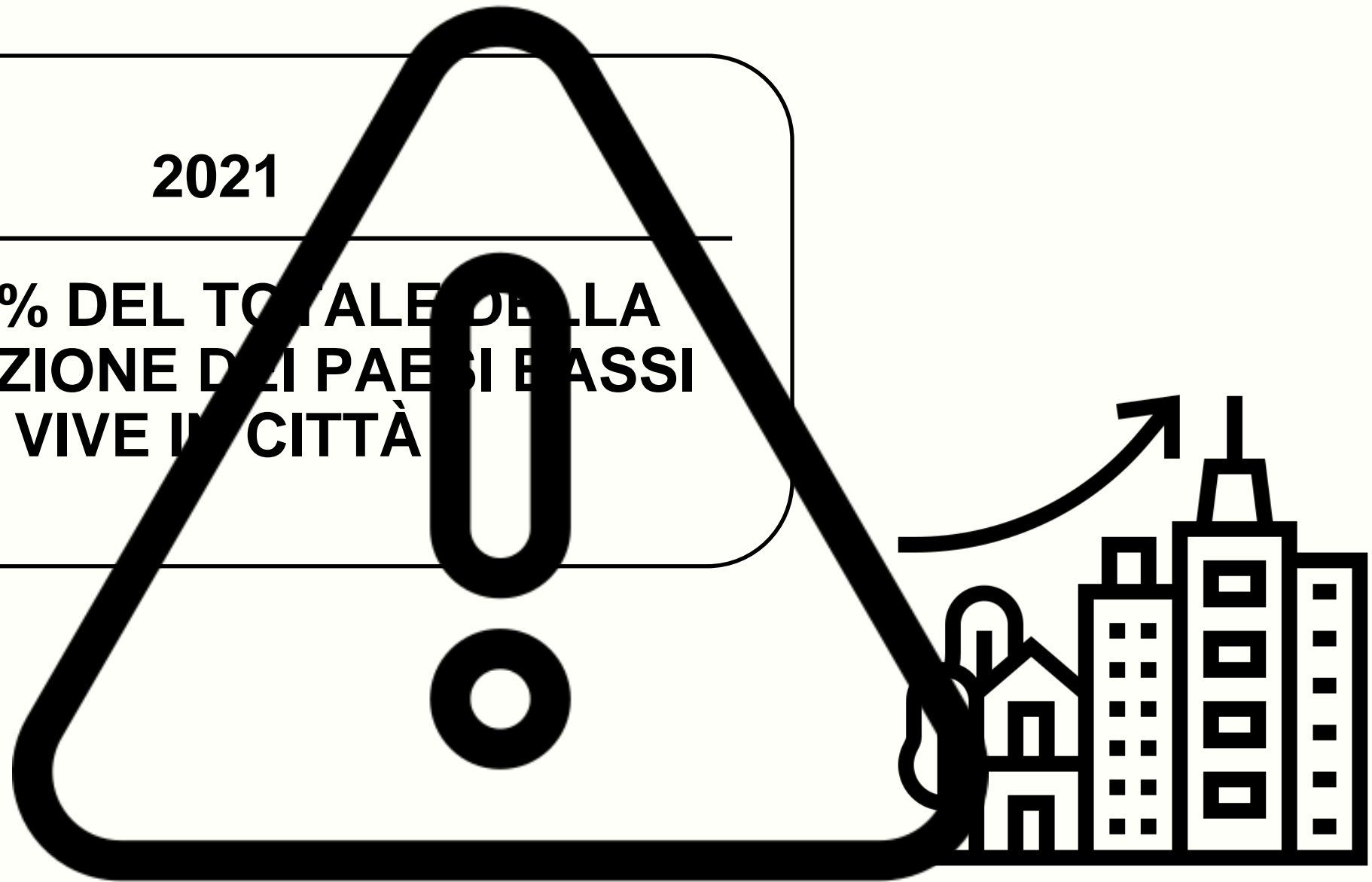
2021

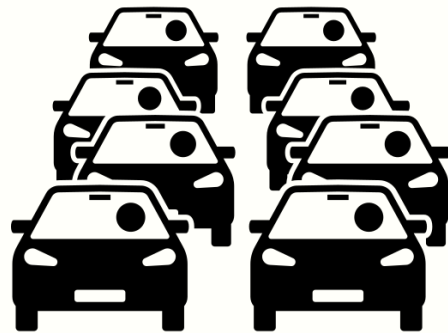
**IL 92.57% DEL TOTALE DELLA
POPOLAZIONE DEI PAESI BASSI
VIVE IN CITTÀ**



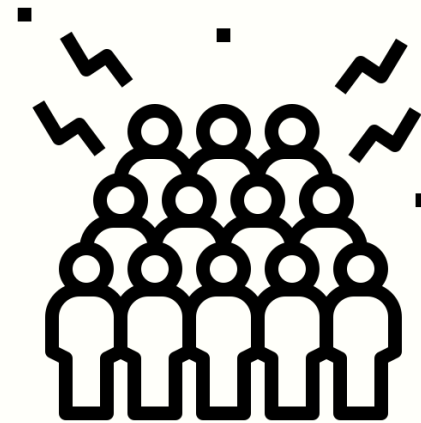
2021

**IL 92.57% DEL TOTALE DELLA
POPOLAZIONE DEI PAESI BASSI
VIVE IN CITTÀ**





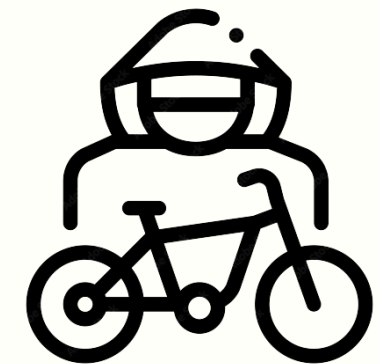
**CONGESTIONE
DEL TRAFFICO**



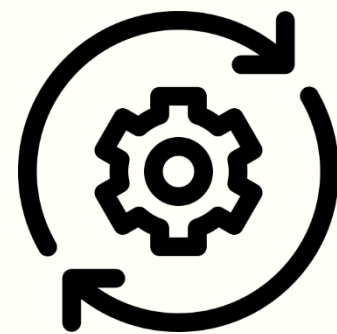
**STRADE
AFFOLLATE**



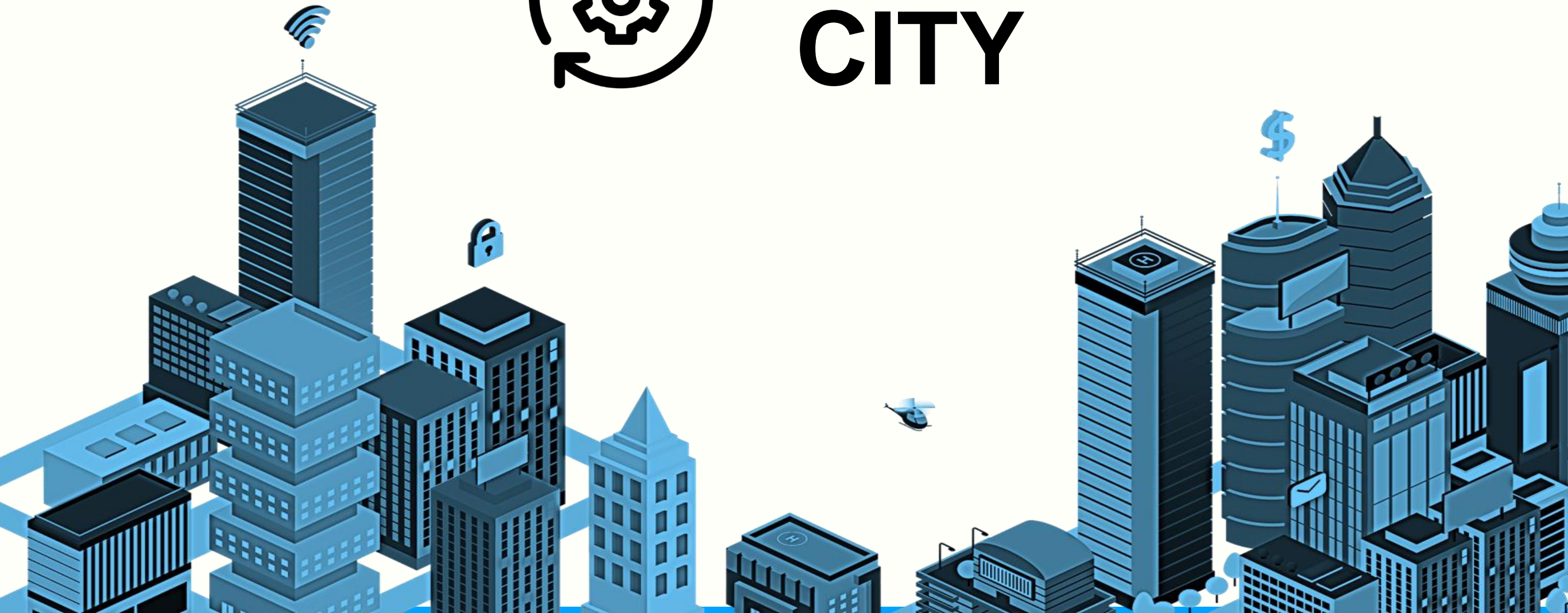
BORSEGGI

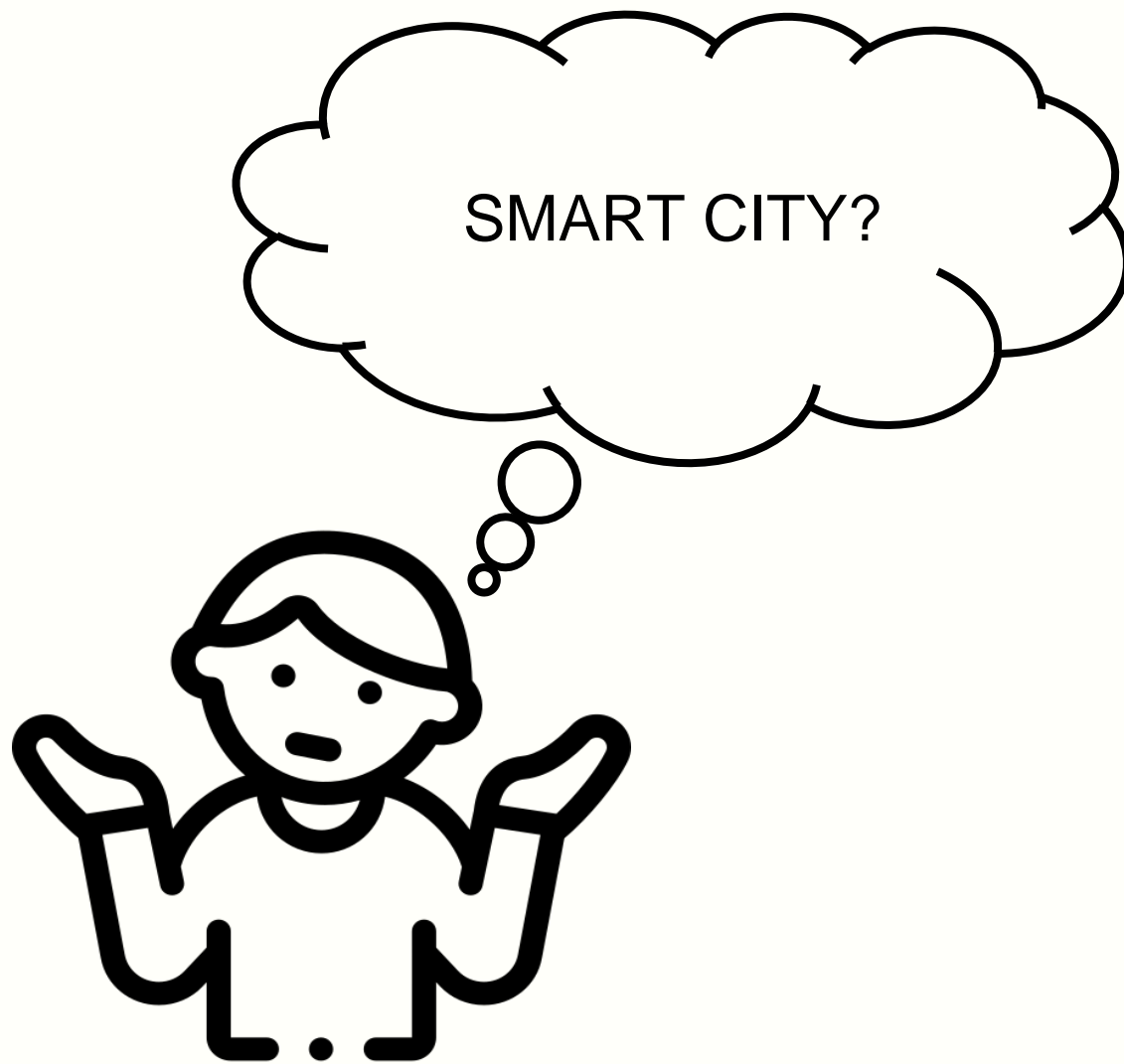


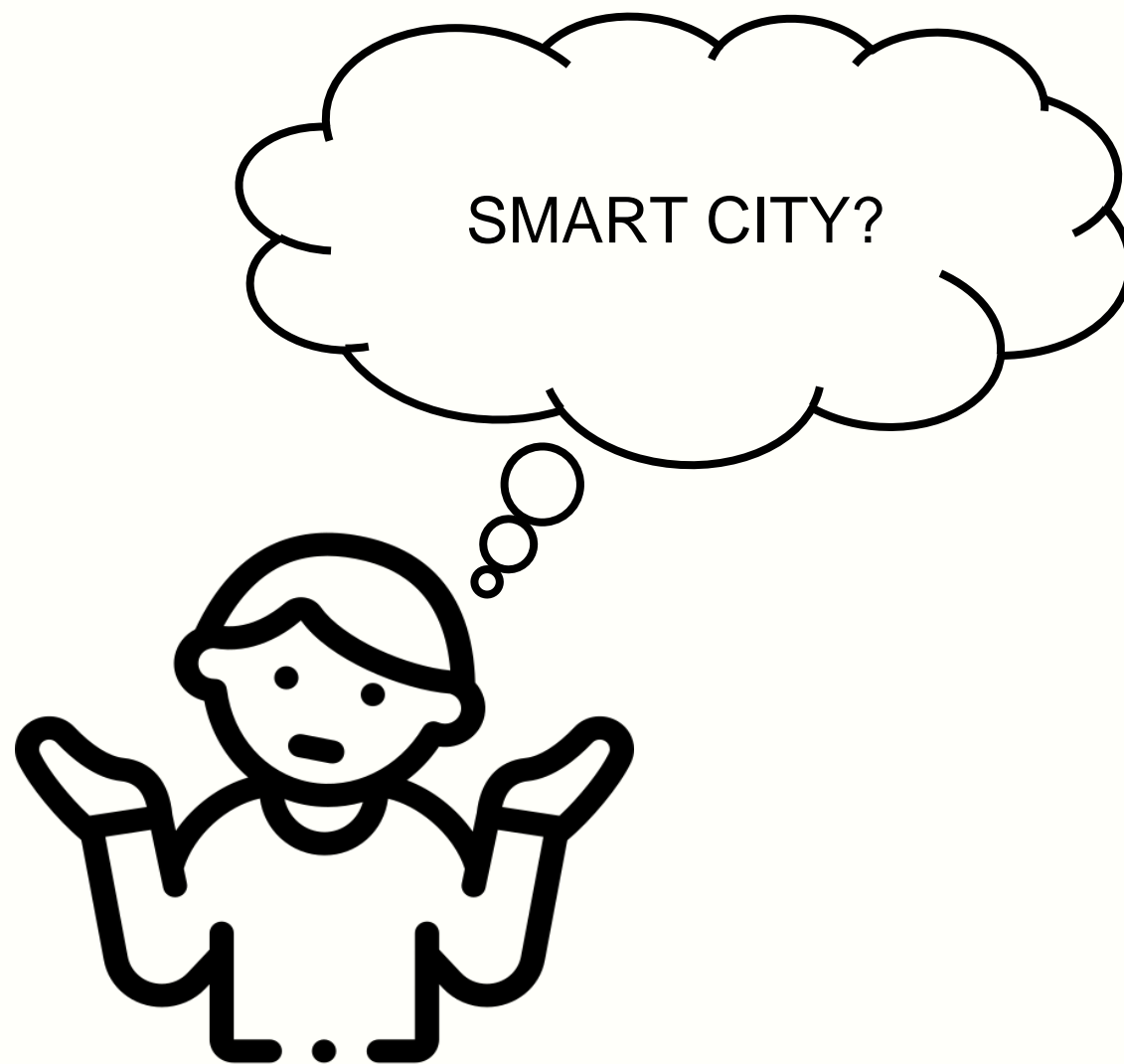
FURTI DI BICI



SMART CITY





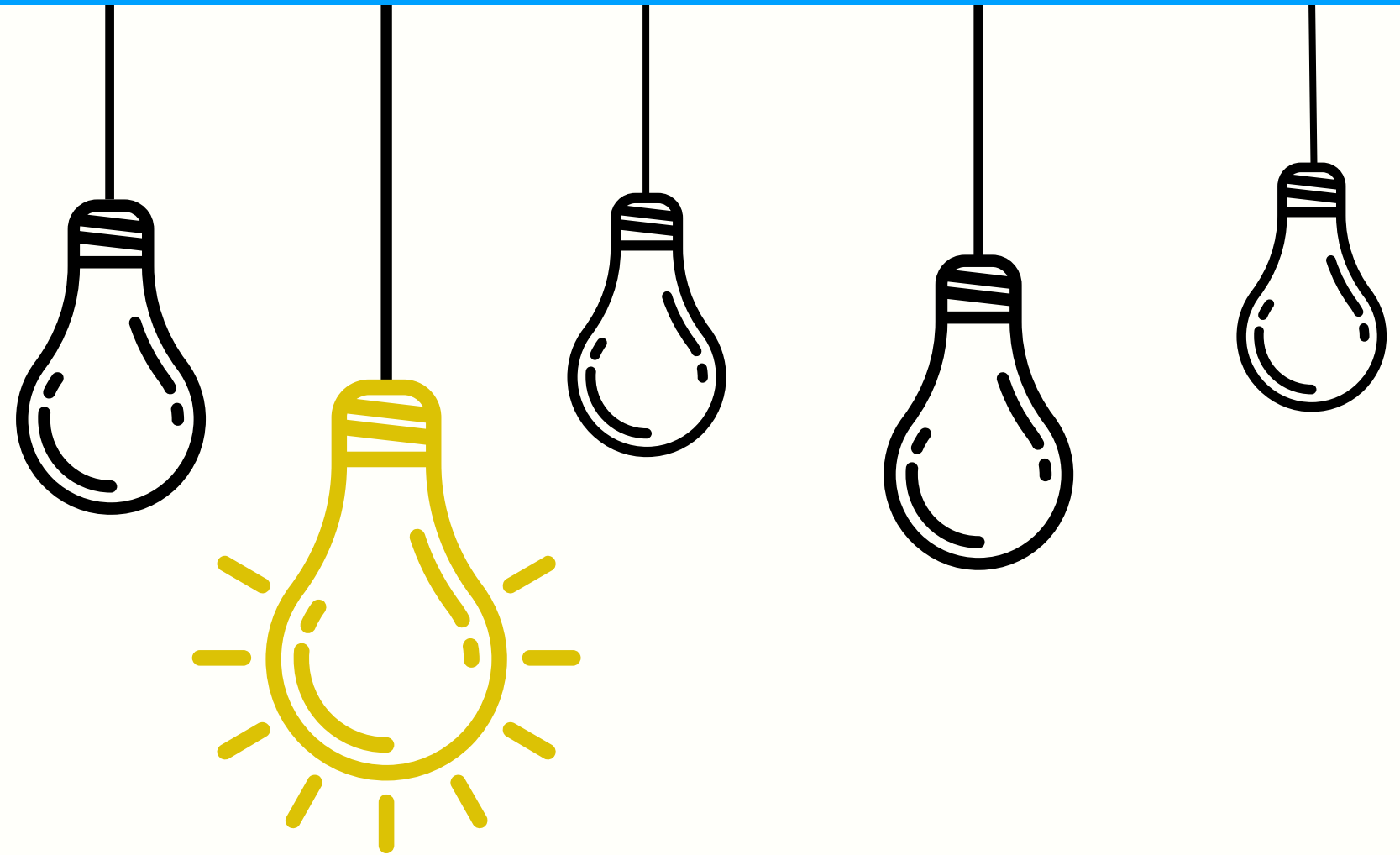


Una visione di sviluppo urbano
che integra in modo sicuro
l'ICT e l'IoT al fine di gestire
gli asset di una città



CYBER-PHYSICAL-SYSTEMS





SMART CITY MONITOR





ANALISI DEL TRAFFICO

ANALISI DELLE FOLLE

MOTION TRACKING

STUDIO DI PERCORSI

LIMITAZIONI

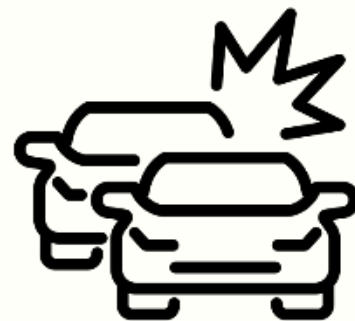
Dominio ristretto



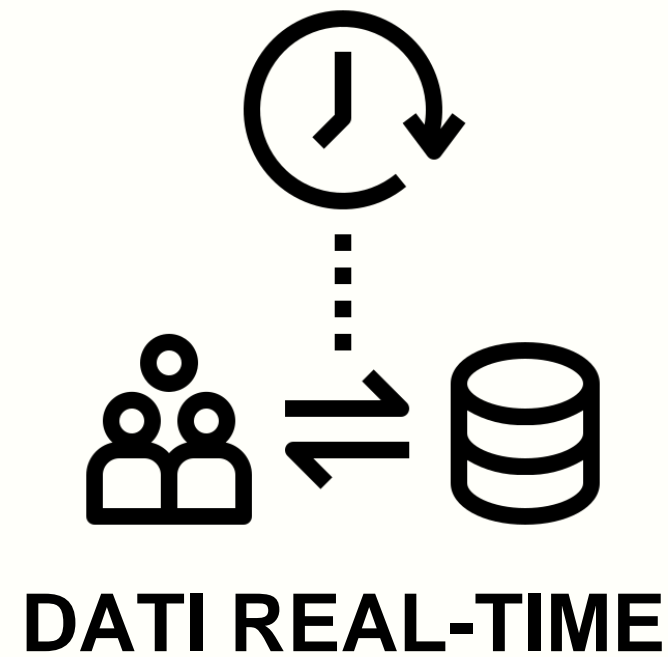
CATEGORIE
PROTETTE

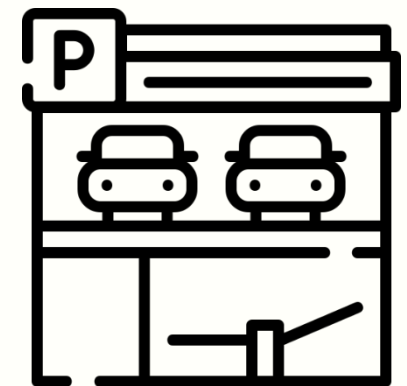
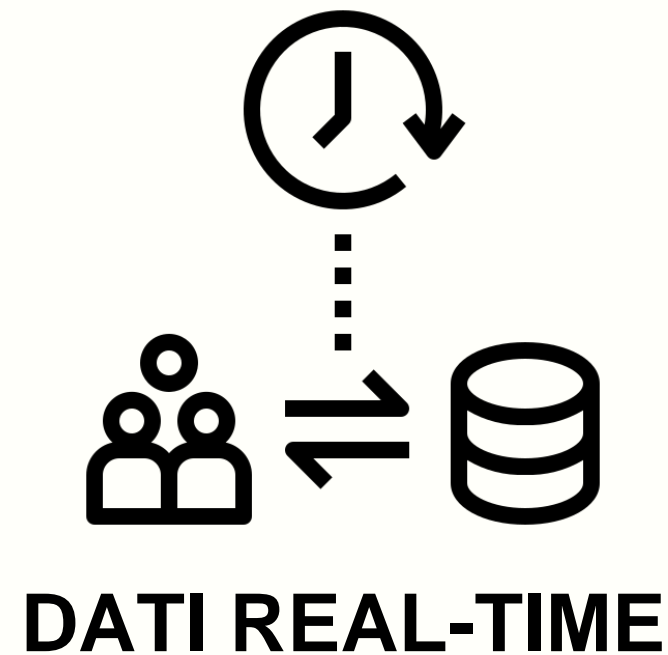


AMBIENTI CHIUSI



INCIDENTI





Research Question 1

Quali sono le features più adatte a descrivere un problema di predizione di serie temporale in un'ottica di smart city?

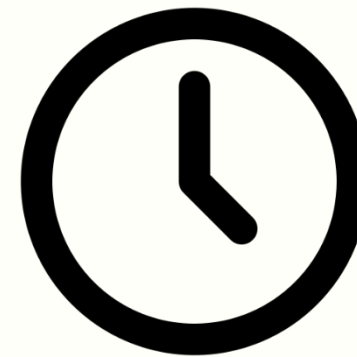




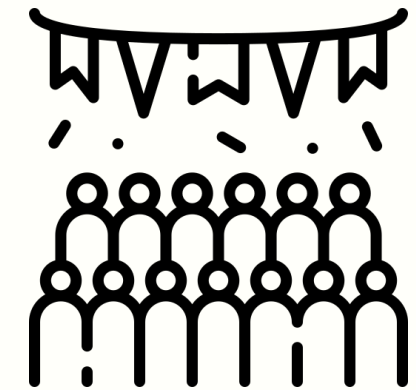
**FESTE
NAZIONALI**



**DATI
METEO**

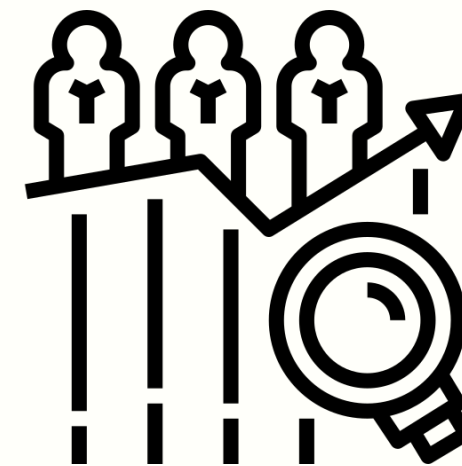
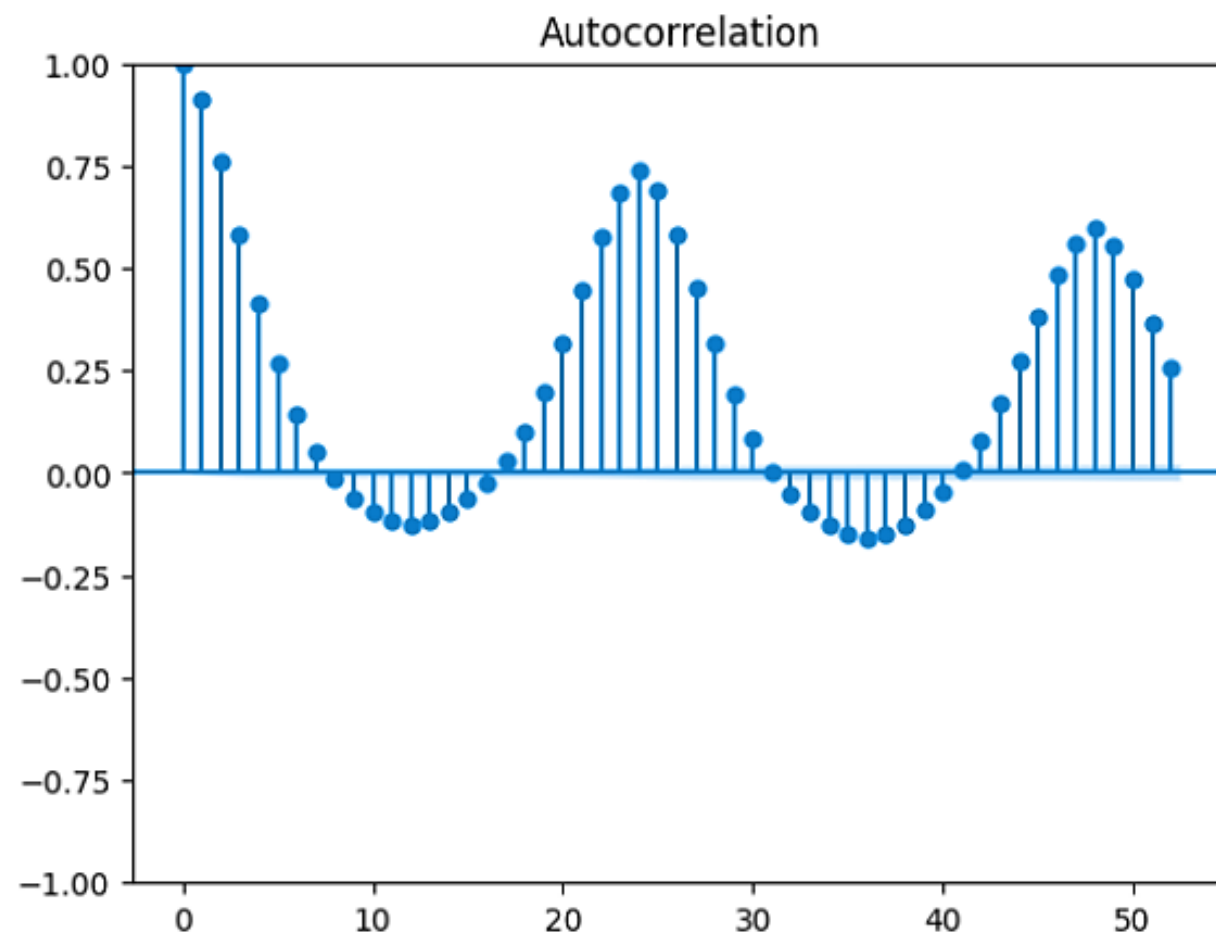


**DATA
ORARIO**



**EVENTI
PUBBLICI**

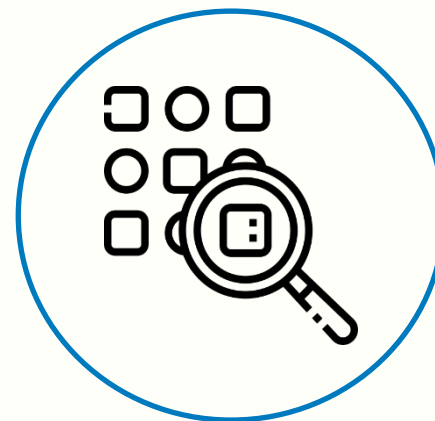
STAGIONALITÀ

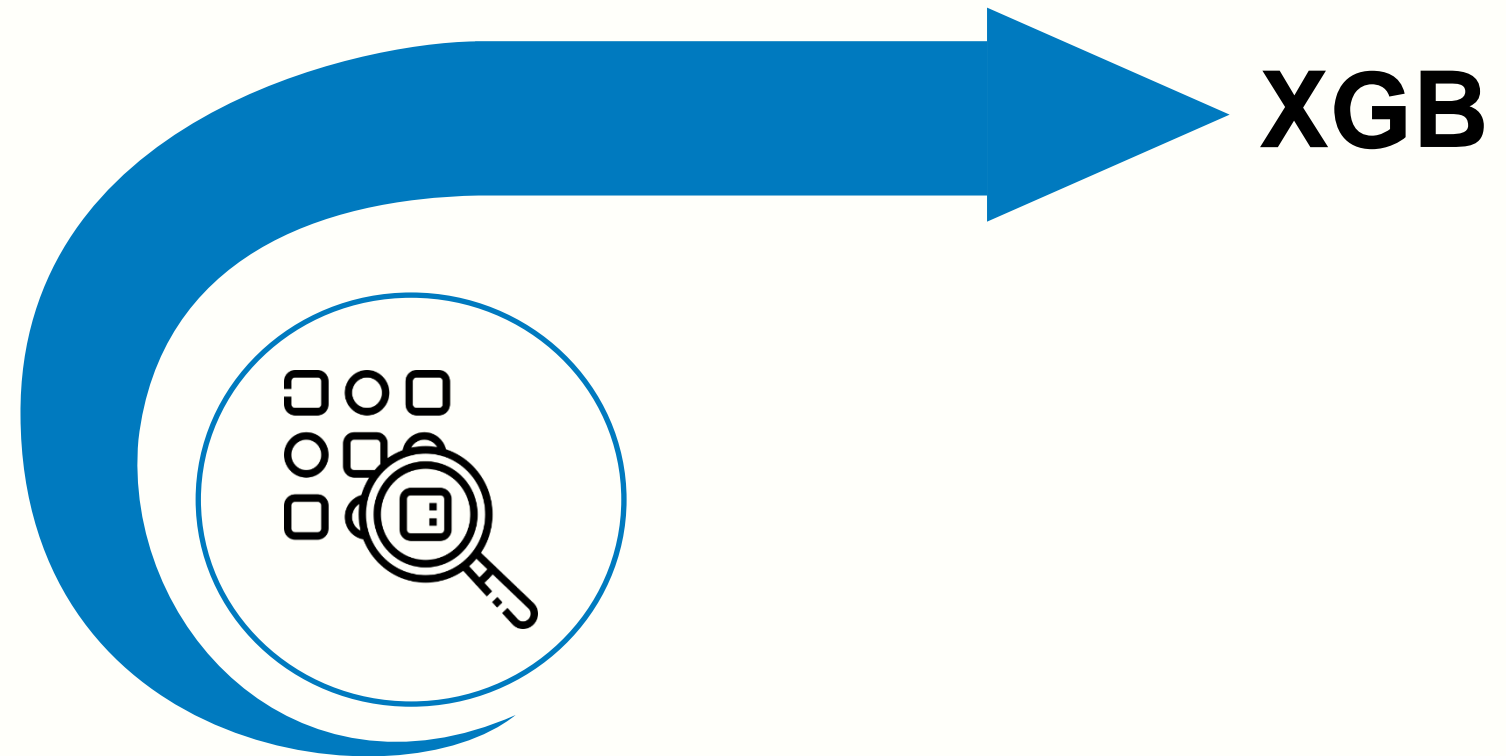


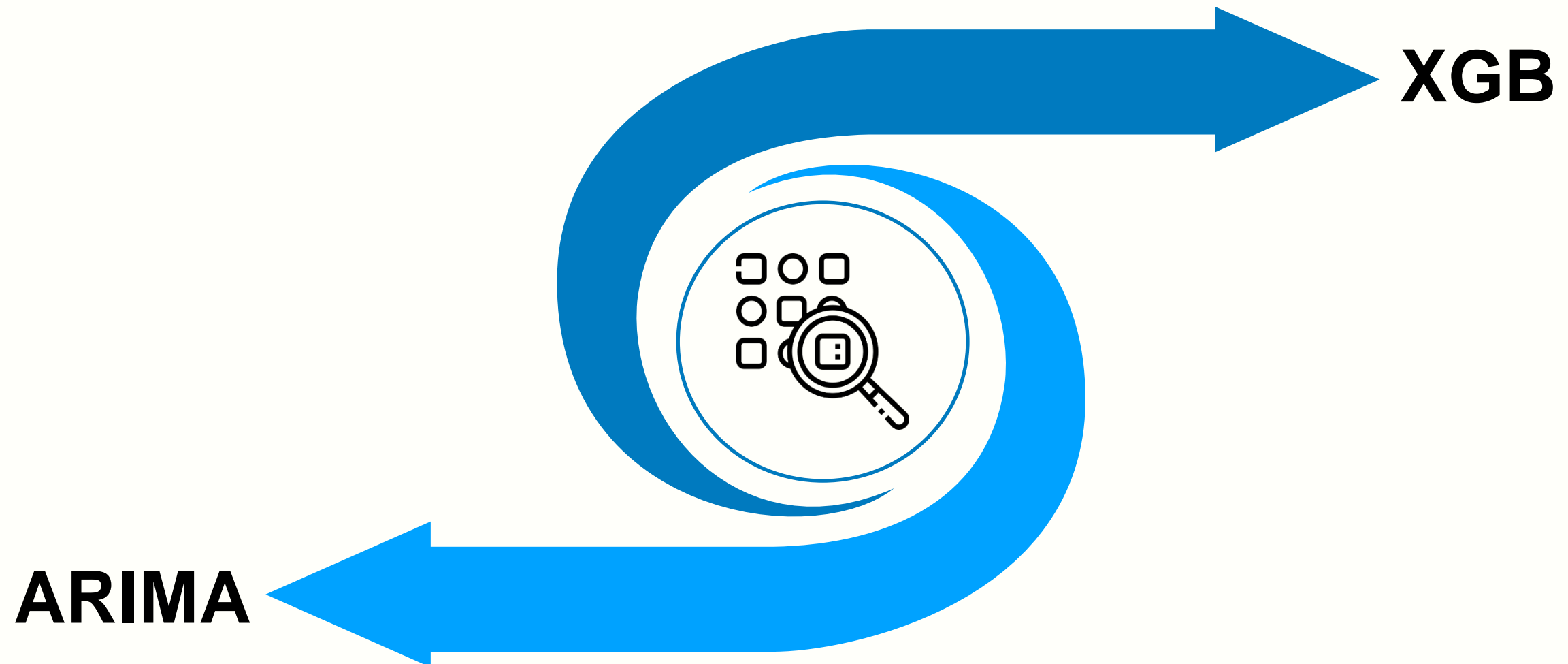
Research Question 2

Quali sono le strategie e i modelli di Machine Learning più adatti per gestire e modellare un problema di smart city forecasting?









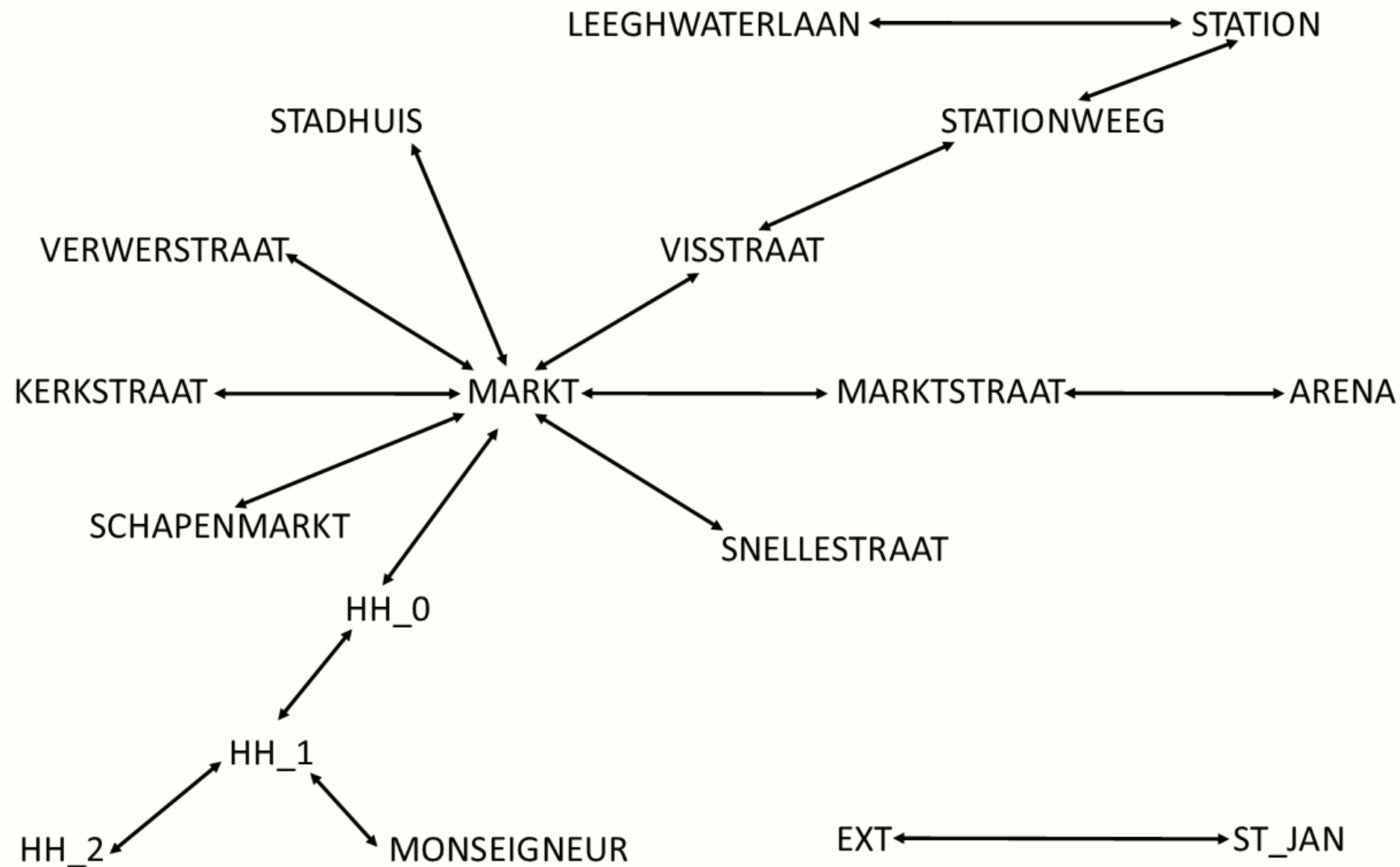
TRAFFICO PEDONALE DEN BOSCH



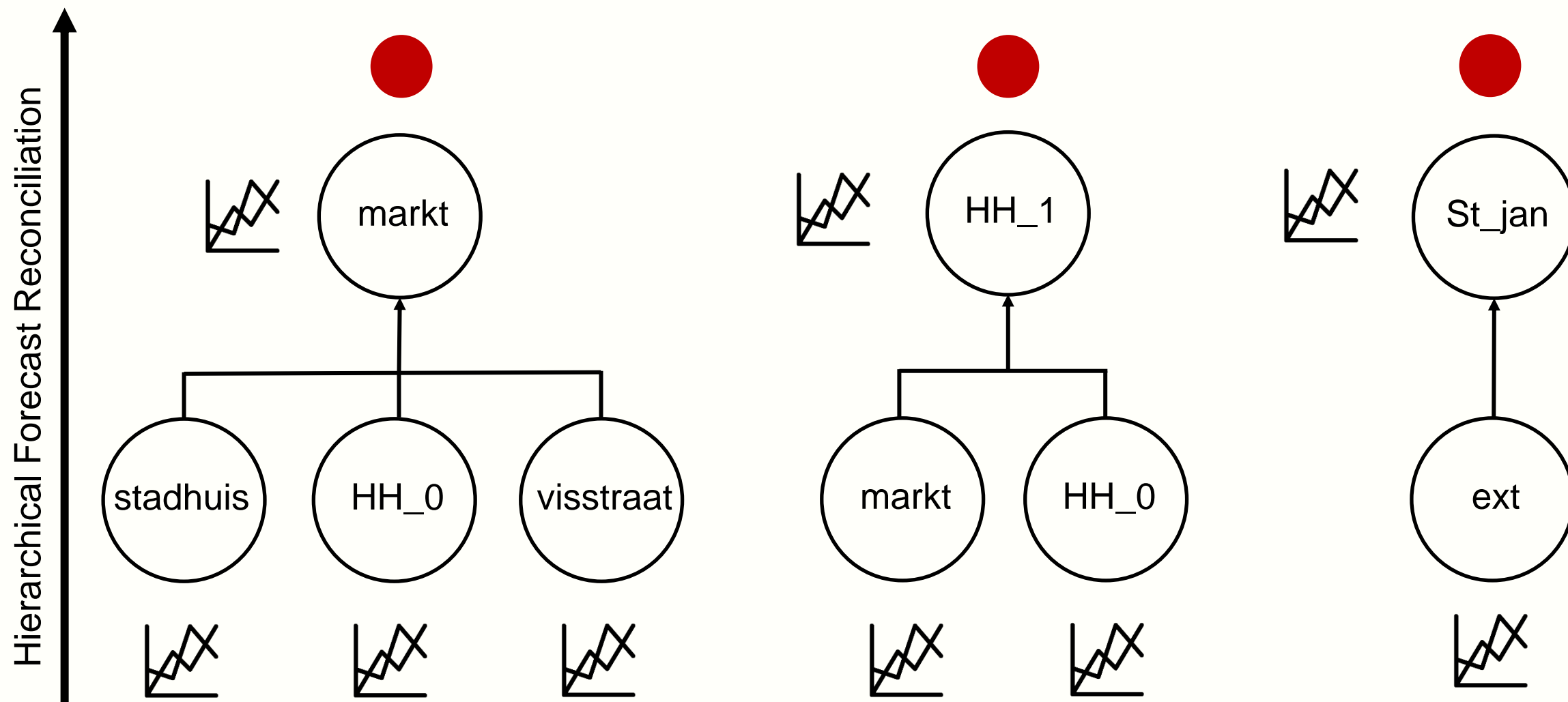
TRAFFICO PEDONALE DEN BOSCH



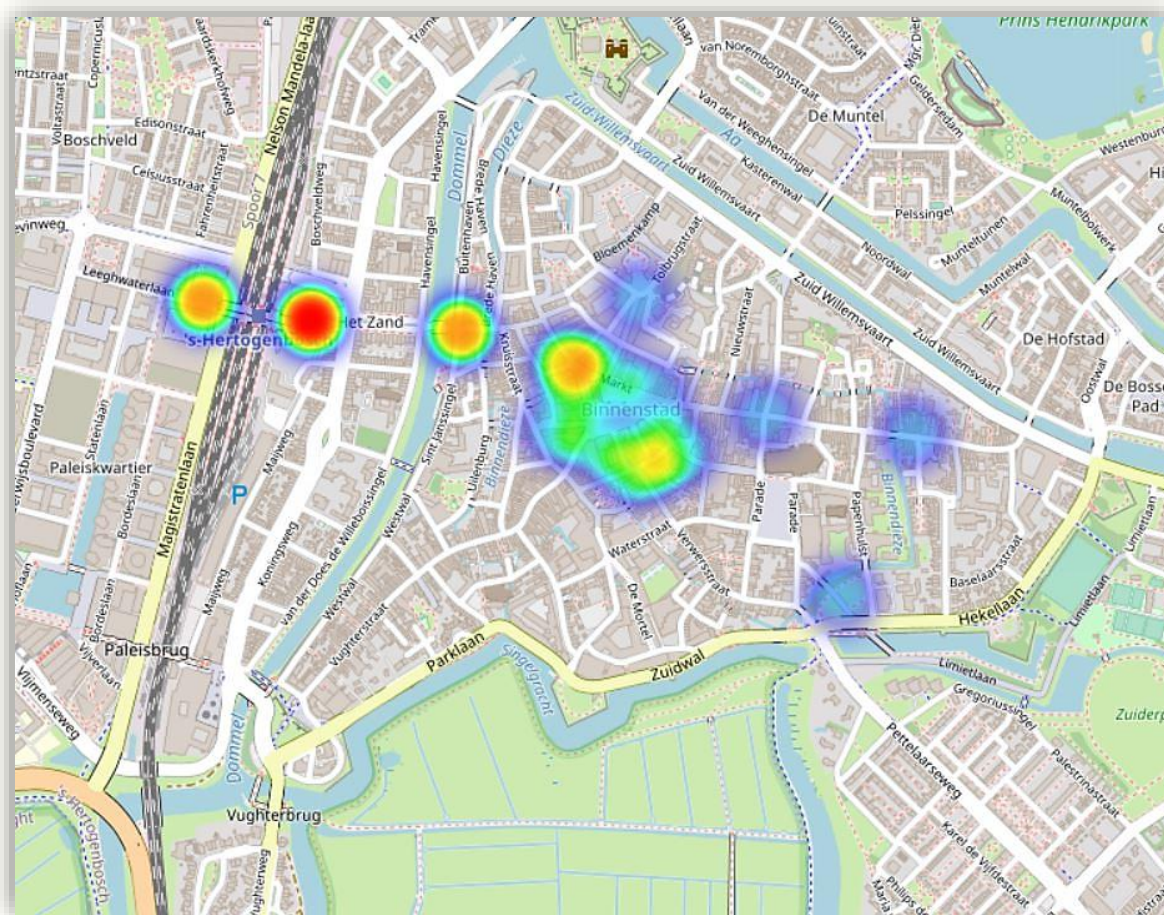
LE CONNESSIONI
STRADALI FORMANO
UNA GERARCHIA



SERIE TEMPORALI GERARCHICHE



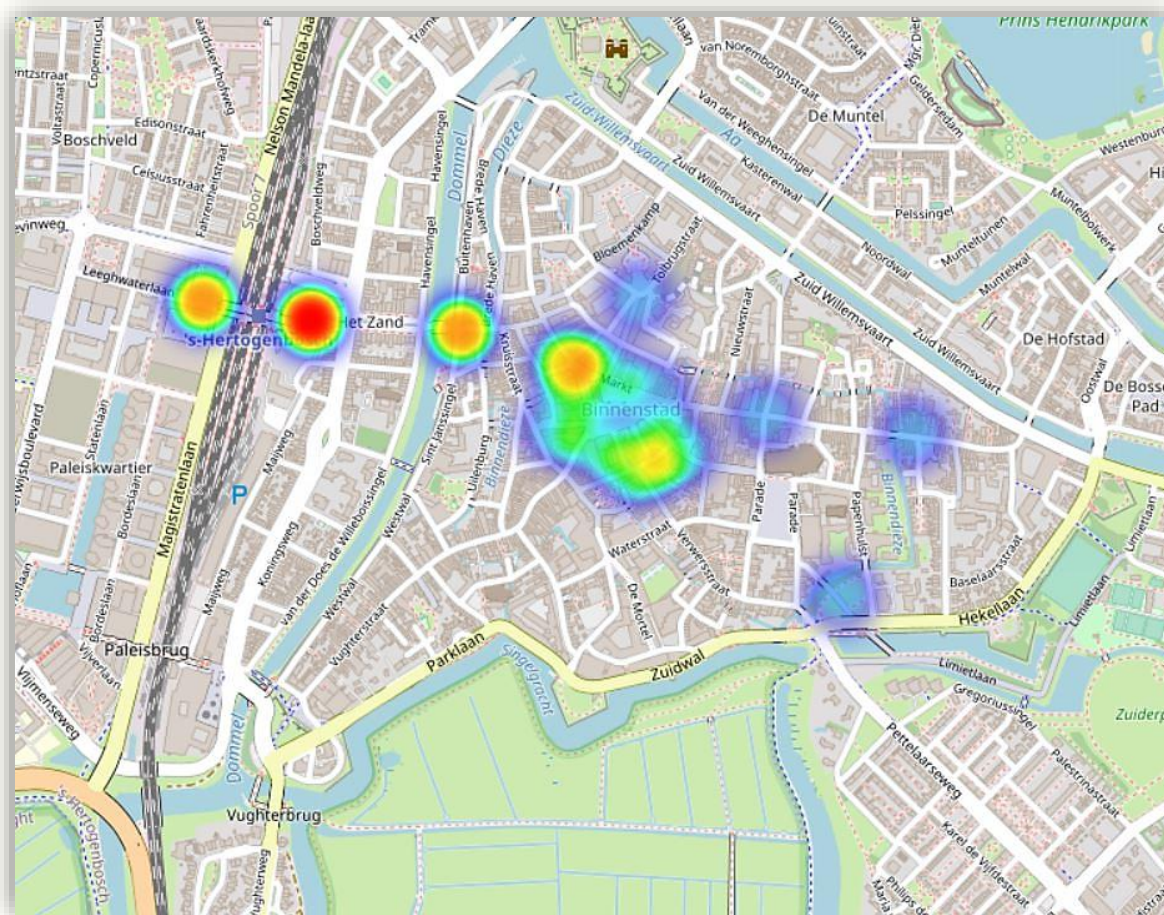
PREDIZIONE TRAFFICO PEDONALE DEN BOSCH



ERRORE QUADRATICO MEDIO

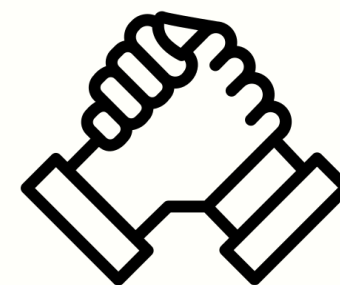
NODO	XGB	ARIMA
Station	454,91	812,44
Stationweeg	419,13	459,80
St_Jan	20,30	40,17

PREDIZIONE TRAFFICO PEDONALE DEN BOSCH



ERRORE QUADRATICO MEDIO

NODO	XGB	ARIMA
Station	454,91	812,44
Stationweeg	419,13	459,80
St_Jan	20,30	40,17



Errore medio
70 PEDONI

DISPONIBILITÀ PARCHEGGI DEN BOSCH

Errore Quadratico Medio
1558

Errore Assoluto Medio
929

DISPONIBILITÀ PARCHEGGI DEN BOSCH

Errore Quadratico Medio
1558

Errore Assoluto Medio
929

DISPONIBILITÀ PARCHEGGI BREDA

Errore Quadratico Medio
1199

Errore Assoluto Medio
773

DISPONIBILITÀ PARCHEGGI DEN BOSCH

Errore Quadratico Medio
1558

Errore Assoluto Medio
929

DISPONIBILITÀ PARCHEGGI BREDA

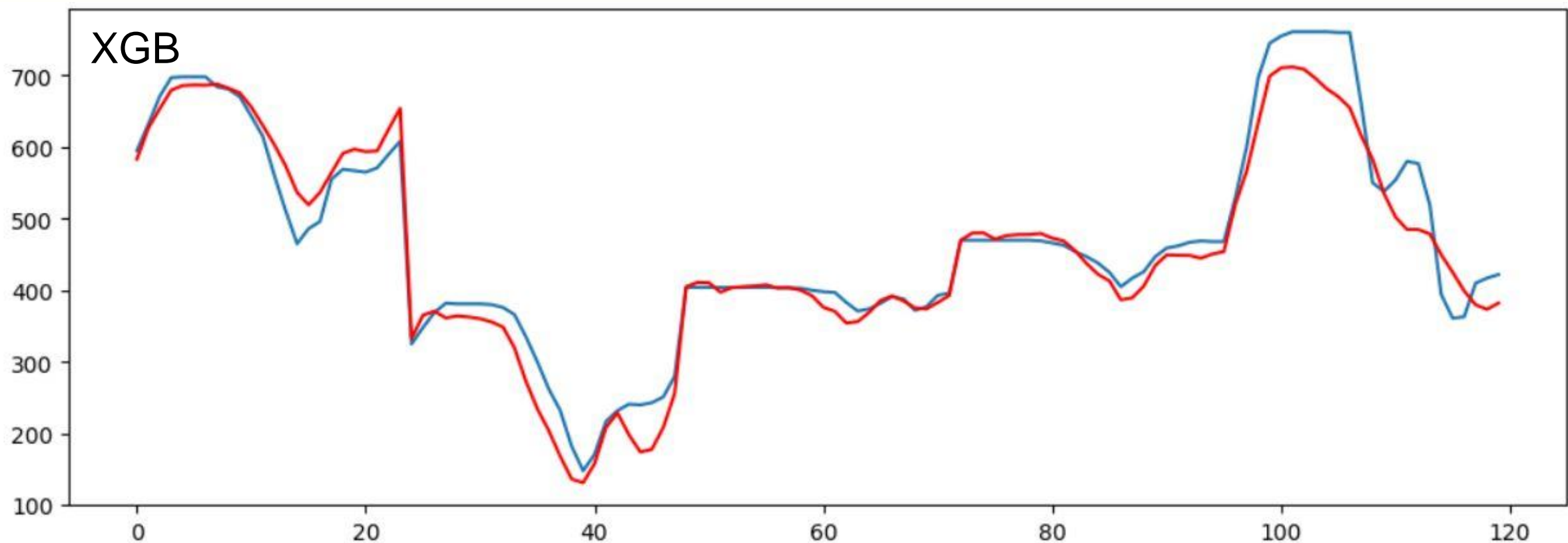
Errore Quadratico Medio
1199

Errore Assoluto Medio
773

I parcheggi possono avere capienze che superano i 10 000 posti auto

PREDIZIONE DISPONIBILITÀ BIKE PARKING BREDA

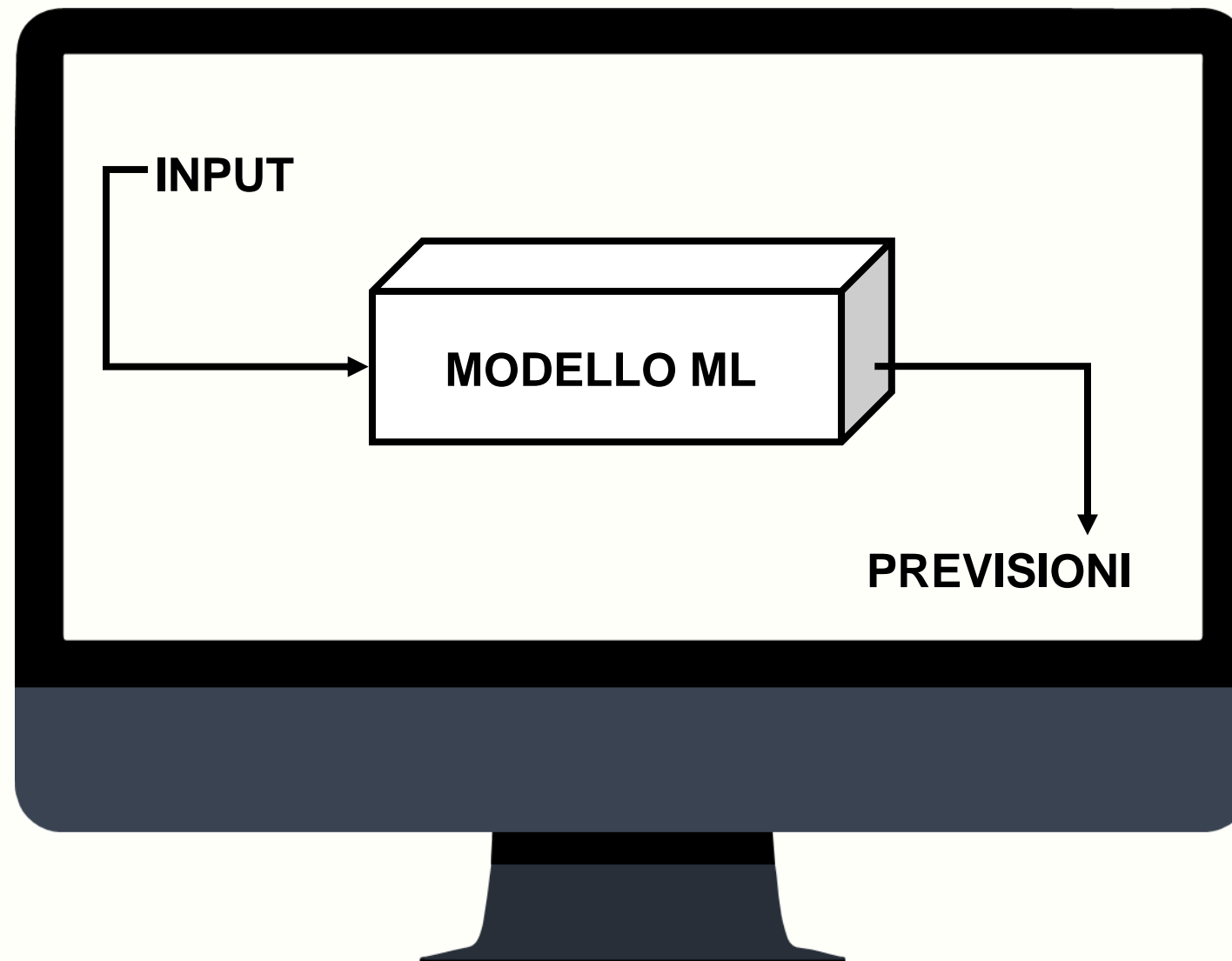
Errore medio 39 unità

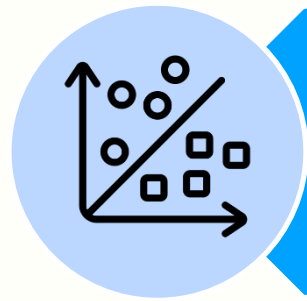




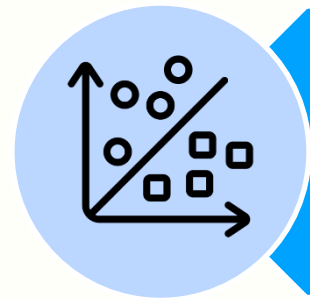
MLOps

WEB DASHBOARD

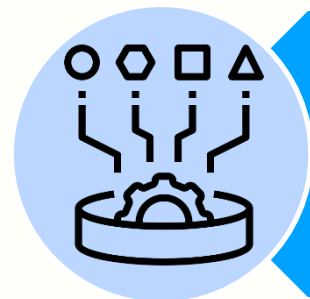




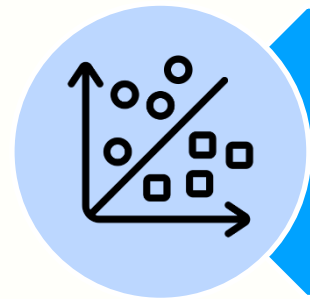
SVILUPPO DI MODELLI PER MONITORAGGIO E PIANIFICAZIONE URBANA



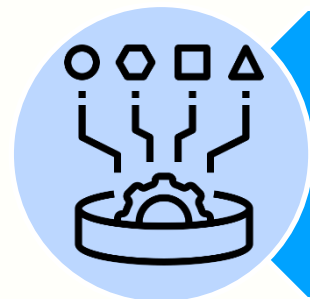
**SVILUPPO DI MODELLI PER MONITORAGGIO
E PIANIFICAZIONE URBANA**



**COMBINARE VARIABILI TEMPORALI ED
ESOGENE MIGLIORA LE PERFORMANCE**



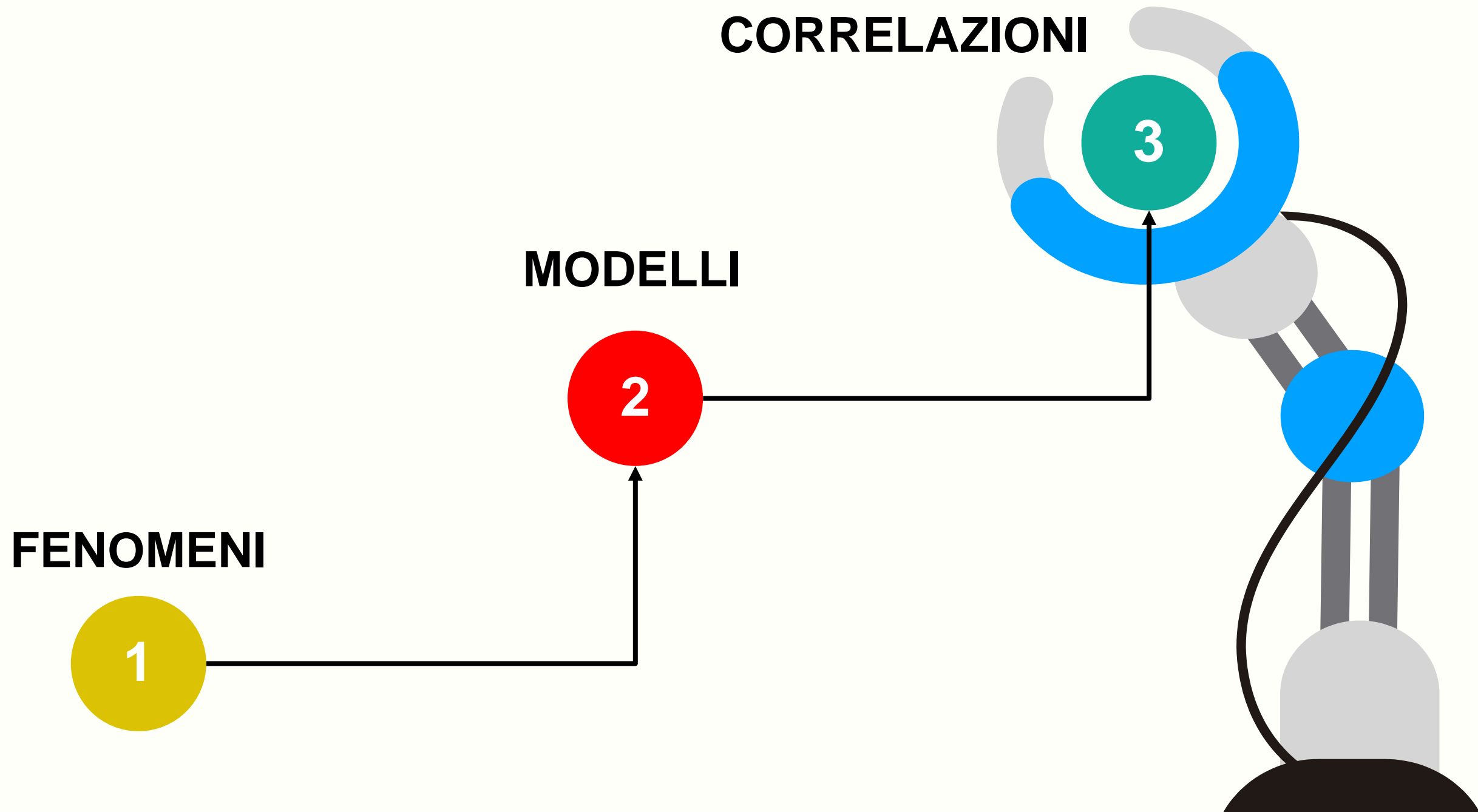
**SVILUPPO DI MODELLI PER MONITORAGGIO
E PIANIFICAZIONE URBANA**



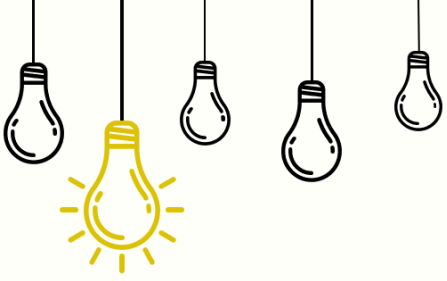
**COMBINARE VARIABILI TEMPORALI ED
ESOGENE MIGLIORA LE PERFORMANCE**



**MODELLI STATISTICI E DI ENSAMBLE
OFFRONO PERFORMANCE
GENERALMENTE ACCURATE**



INTRODUZIONE JADS seso



SMART CITY MONITOR

m.costante1@studenti.unisa.it
<https://github.com/comarco99>
www.linkedin.com/in/marco-costante

Data Science per Smart City
 Marco Costante
 Università degli Studi di Salerno

STATO DELL'ARTE JADS seso

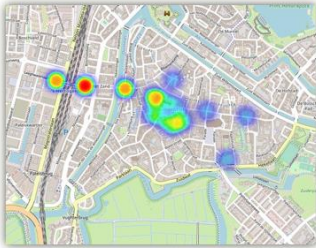


m.costante1@studenti.unisa.it
<https://github.com/comarco99>
www.linkedin.com/in/marco-costante


Data Science per Smart City
 Marco Costante
 Università degli Studi di Salerno

RISULTATI JADS seso

PREDIZIONE TRAFFICO PEDONALE DEN BOSCH



ERRORE QUADRATICO MEDIO		
NODO	XGB	ARIMA
Station	454,91	812,44
Stationweeg	419,13	459,80
St_Jan	20,30	40,17

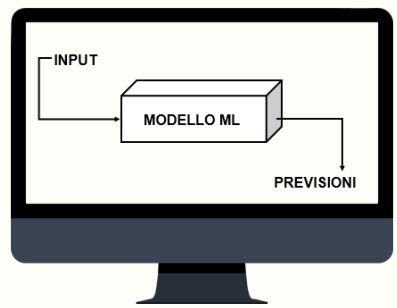
 Errore medio 70 PEDONI

m.costante1@studenti.unisa.it
<https://github.com/comarco99>
www.linkedin.com/in/marco-costante

Data Science per Smart City
 Marco Costante
 Università degli Studi di Salerno

IMPLEMENTAZIONE JADS seso

WEB DASHBOARD



m.costante1@studenti.unisa.it
<https://github.com/comarco99>
www.linkedin.com/in/marco-costante

Data Science per Smart City
 Marco Costante
 Università degli Studi di Salerno

Implementazione di Modelli di Machine Learning in MLOps per la Pianificazione urbana delle Smart City: Un Caso di Studio su Breda e 's-Hertogenbosch, Paesi Bassi


GRAZIE PER L'ATTENZIONE



Questa tesi ha contribuito a piantare un albero in Kenya

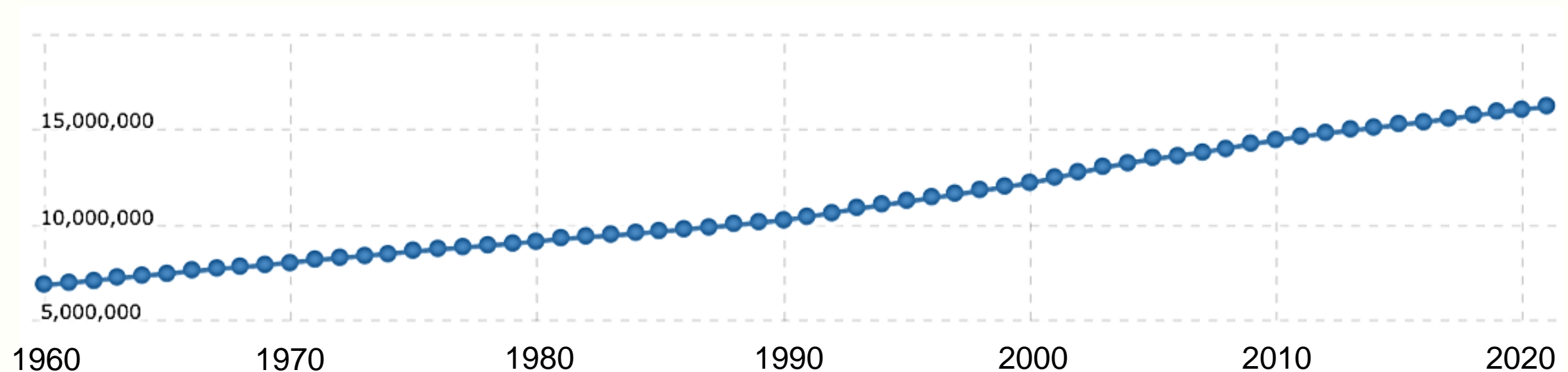


Marco Costante

m.costante1@studenti.unisa.it 
<https://github.com/comarco99> 
 @marco-costante 

SLIDE DI BACKUP

TASSO DI URBANIZZAZIONE DEI PAESI BASSI





DOVE SIAMO?



INTRODUZIONE



~ 17 milioni di abitanti

~ 23 milioni di biciclette

~ 1,3 bici per ogni cittadino

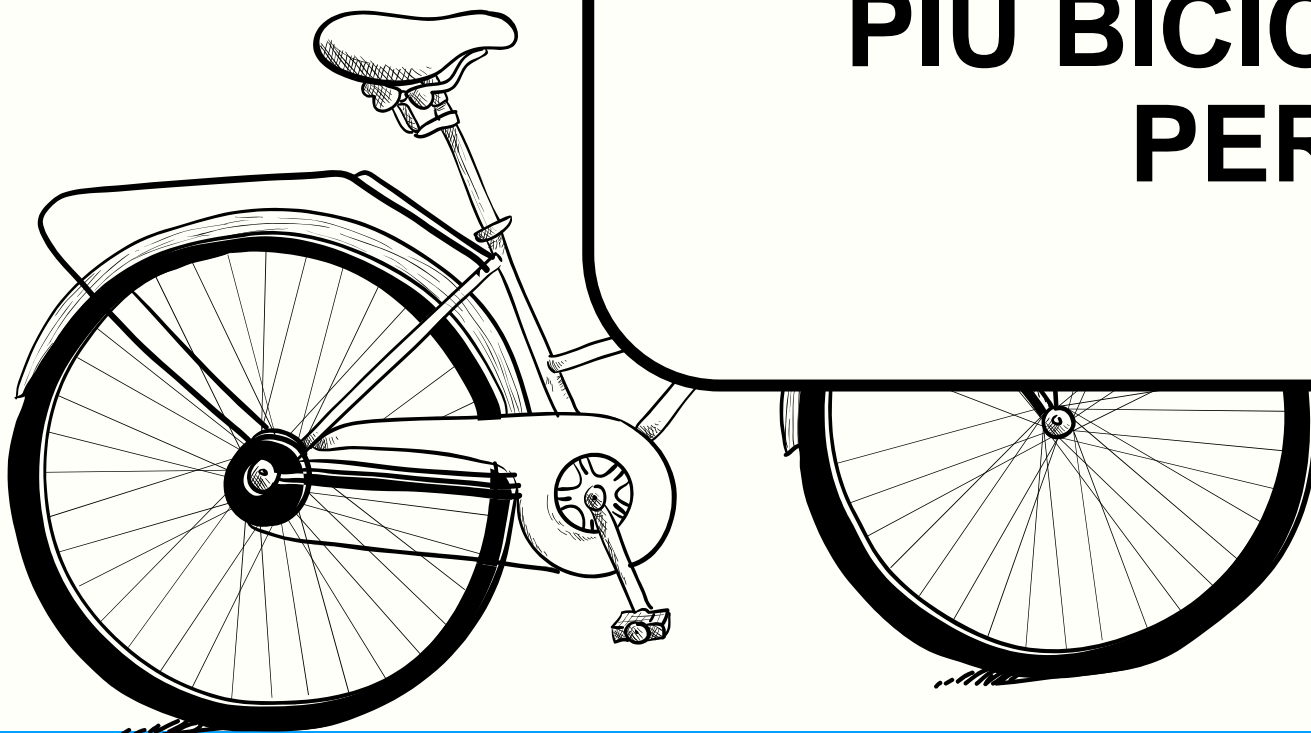


~ 17 milioni di abitanti

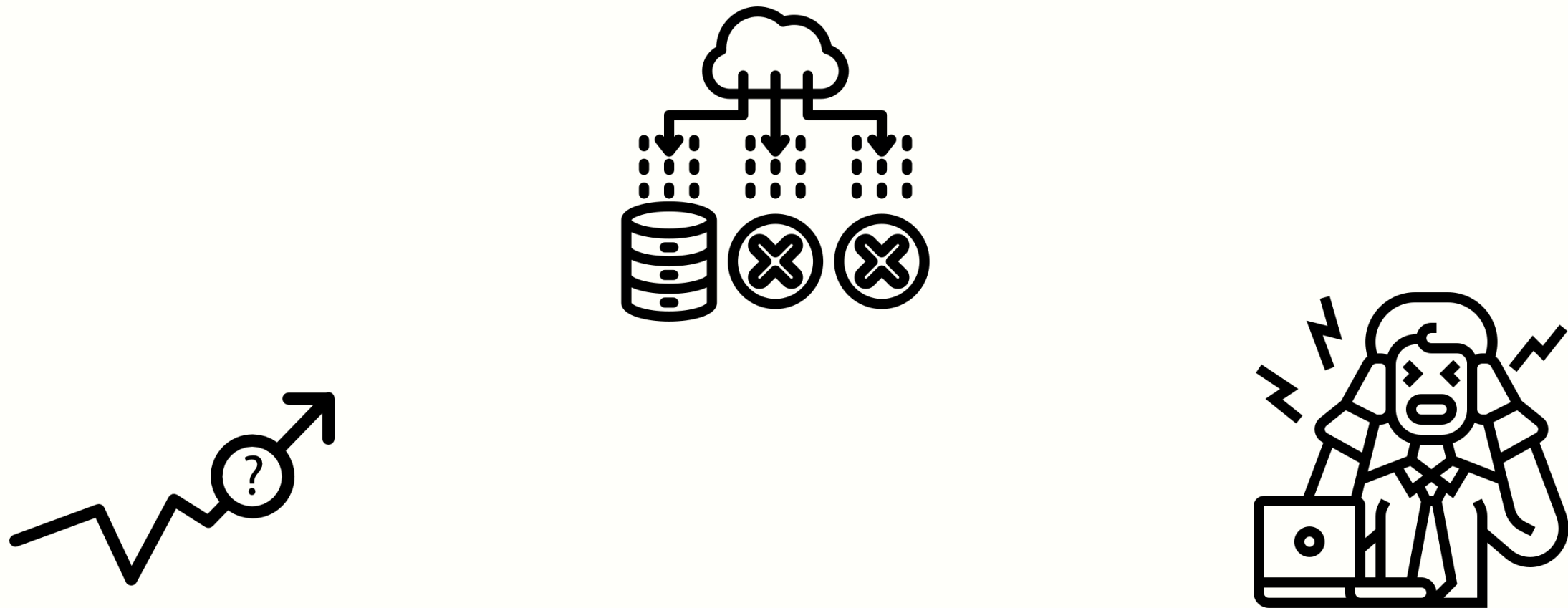
**NEI PAESI BASSI CI SONO
PIÙ BICICLETTE CHE
PERSONE**

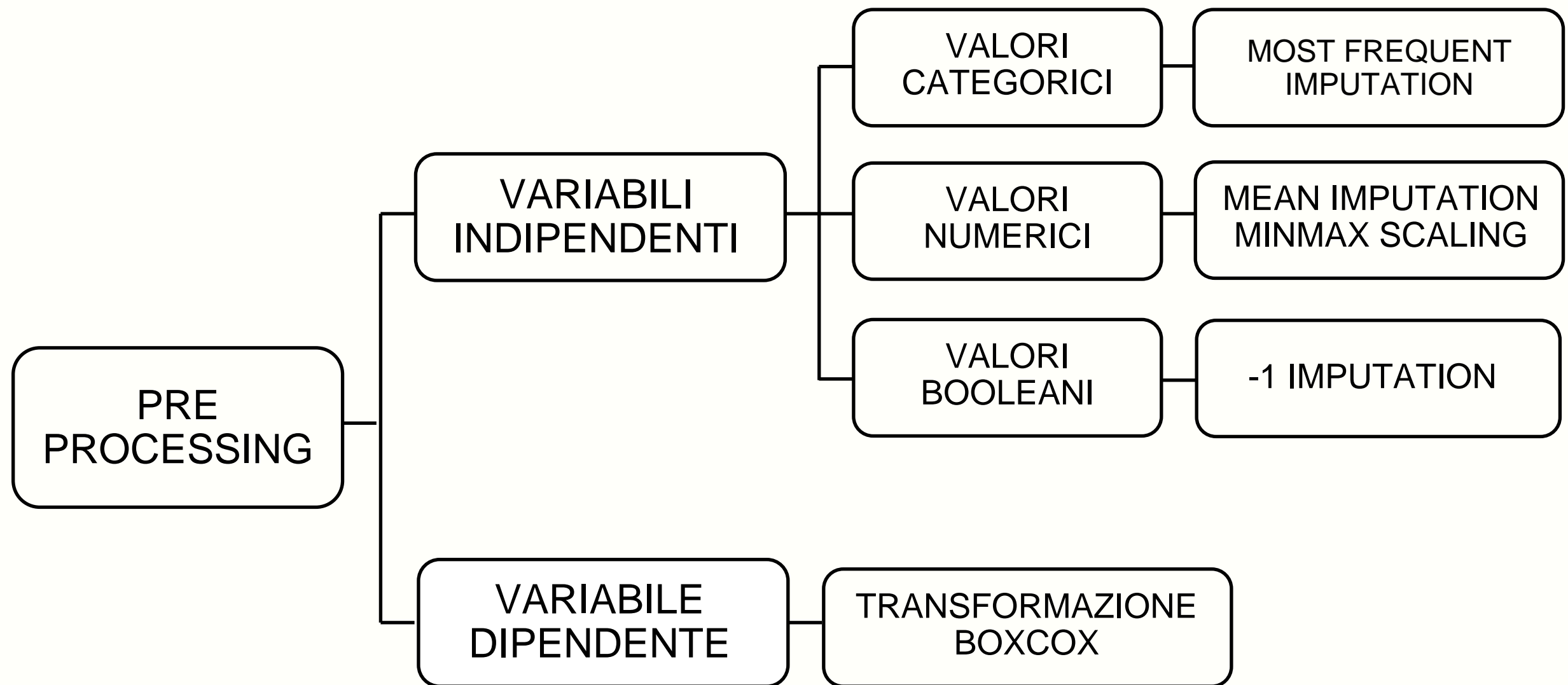
Biciclette

cittadino



GESTIRE DATI REAL-TIME COMPORTA DEI PROBLEMI



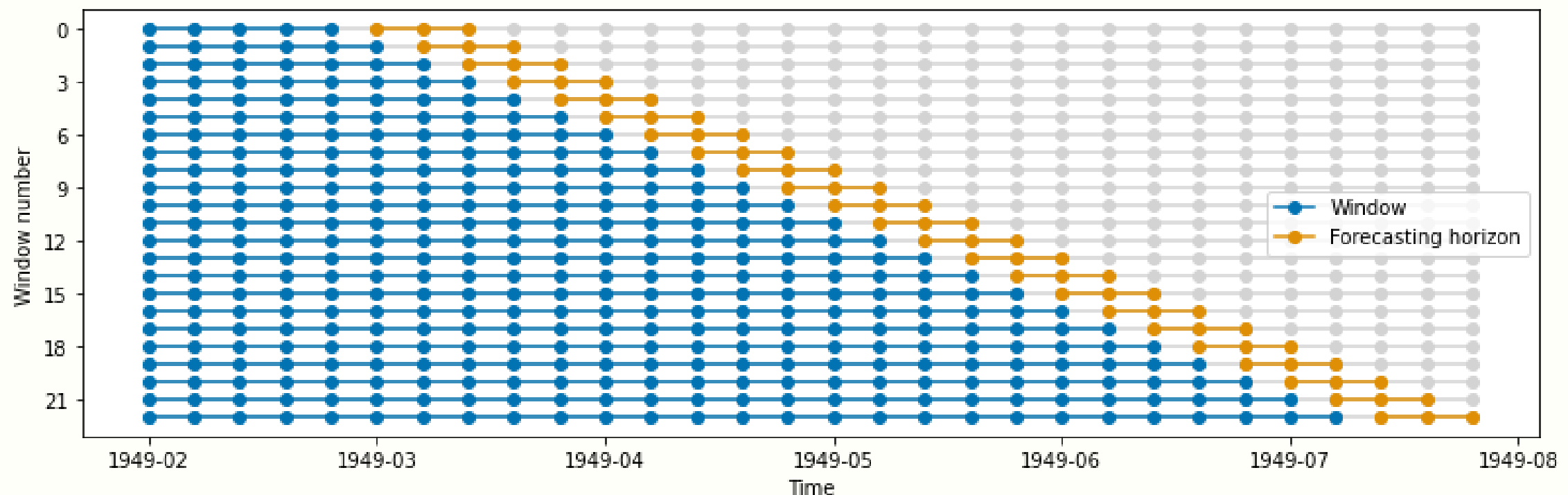


EXTREME GRADIENT BOOSTING



EXTREME GRADIENT BOOSTING

GRID SEARCH CROSS-VALIDATION EXPANDING WINDOW SPLITTER



AUTOREGRESSIVE INTEGRATED MOVING AVERAGE



AUTOCORRELAZIONE PARZIALE

correlazione tra una serie e i suoi ritardi,
eliminati gli effetti di quelli intermedi.



AUTOCORRELAZIONE

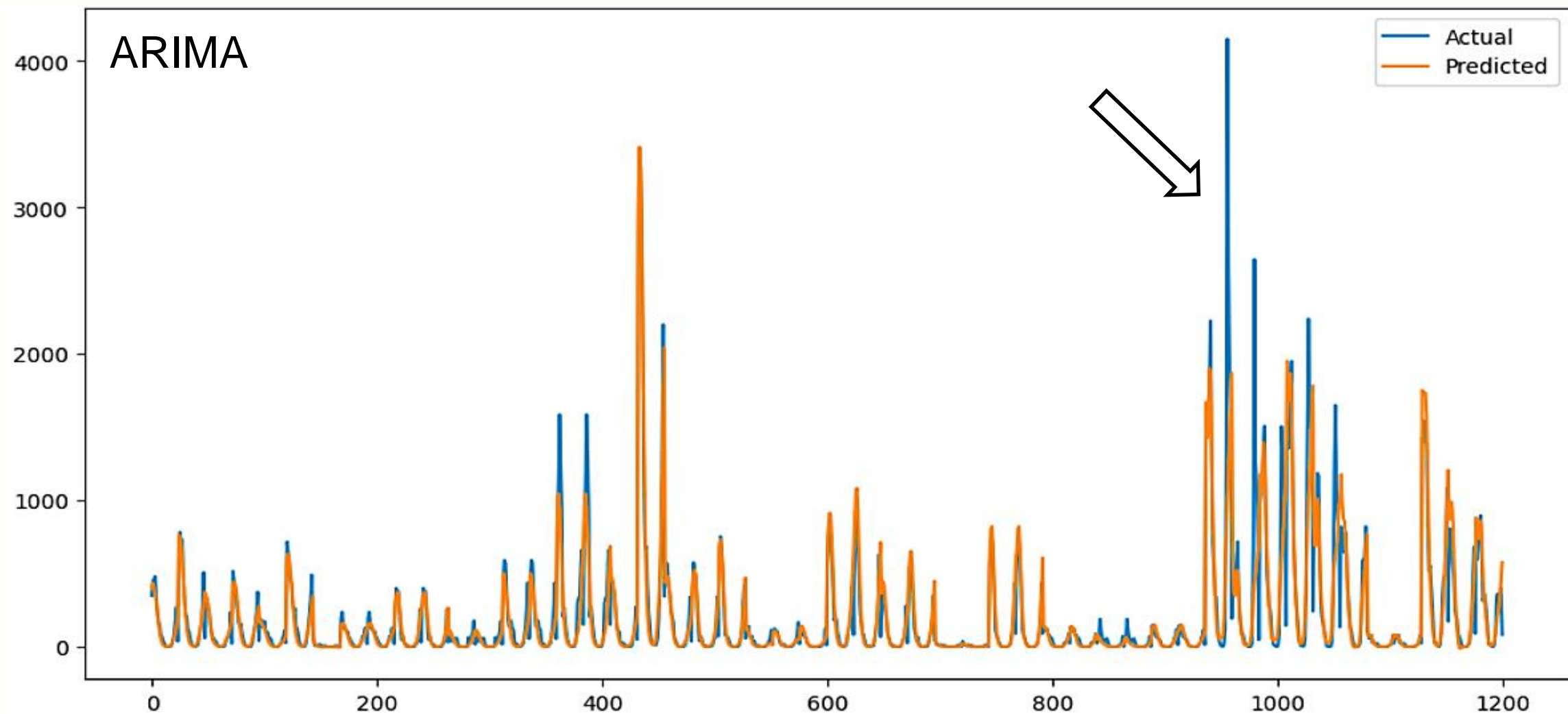
Correlazione della serie
con i suoi valori passati



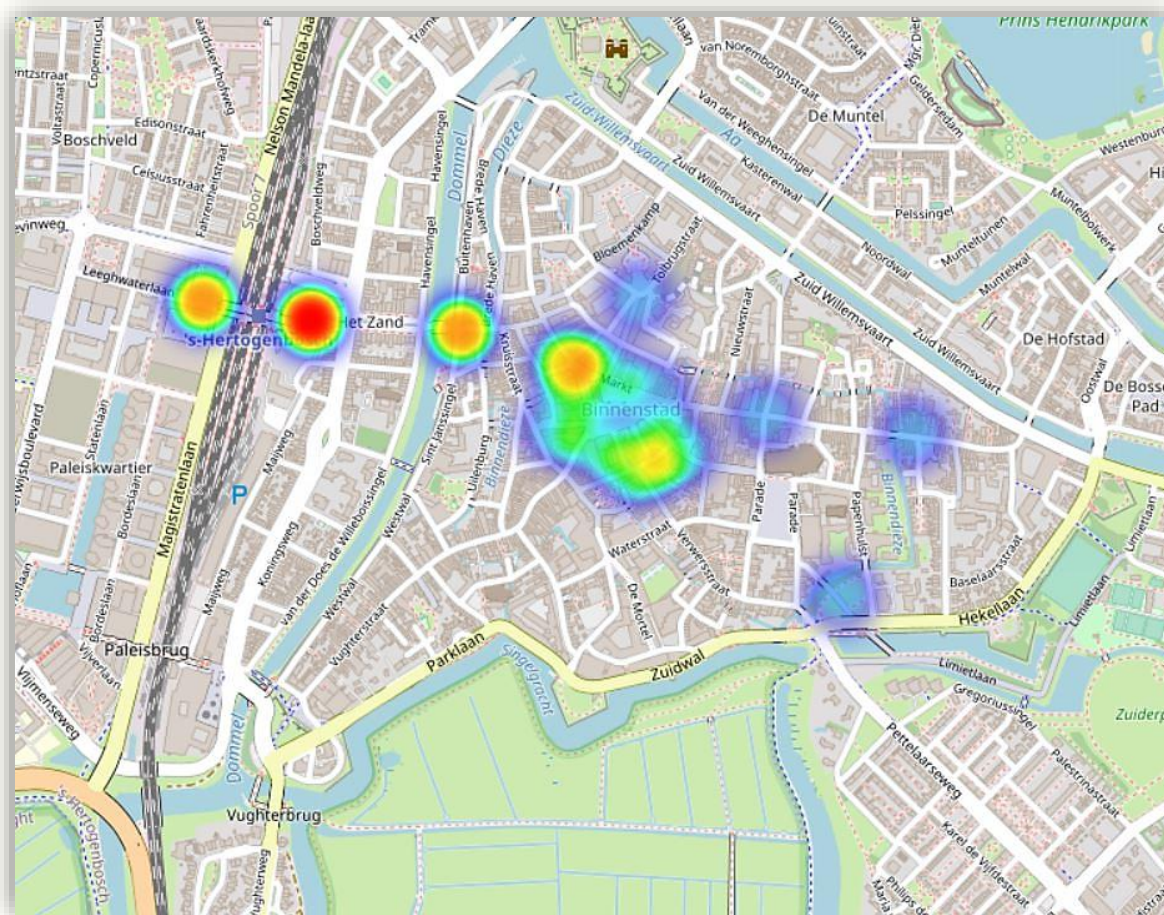
STAZIONARIETÀ

Media, varianza e auto-
correlazione costanti

PREDIZIONE TRAFFICO PEDONALE DEN BOSCH



PREDIZIONE TRAFFICO PEDONALE DEN BOSCH



ERRORE QUADRATICO MEDIO

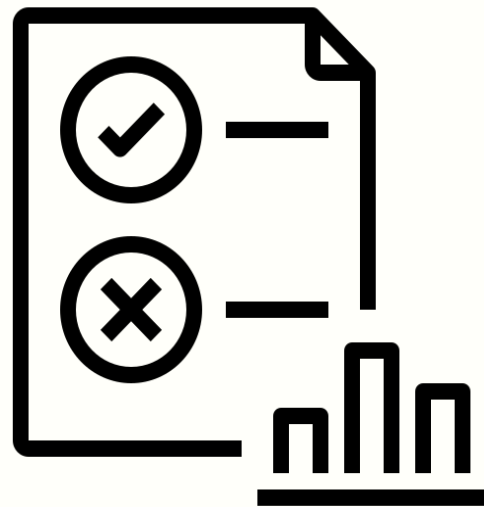
NODO	XGB	ARIMA
Station	454,91	812,44
Stationweeg	419,13	459,80
St_Jan	20,30	40,17

MODELLO

RMSE GENERALE

XGB	252,81
ARIMA	199,14

ARIMA VS XGB

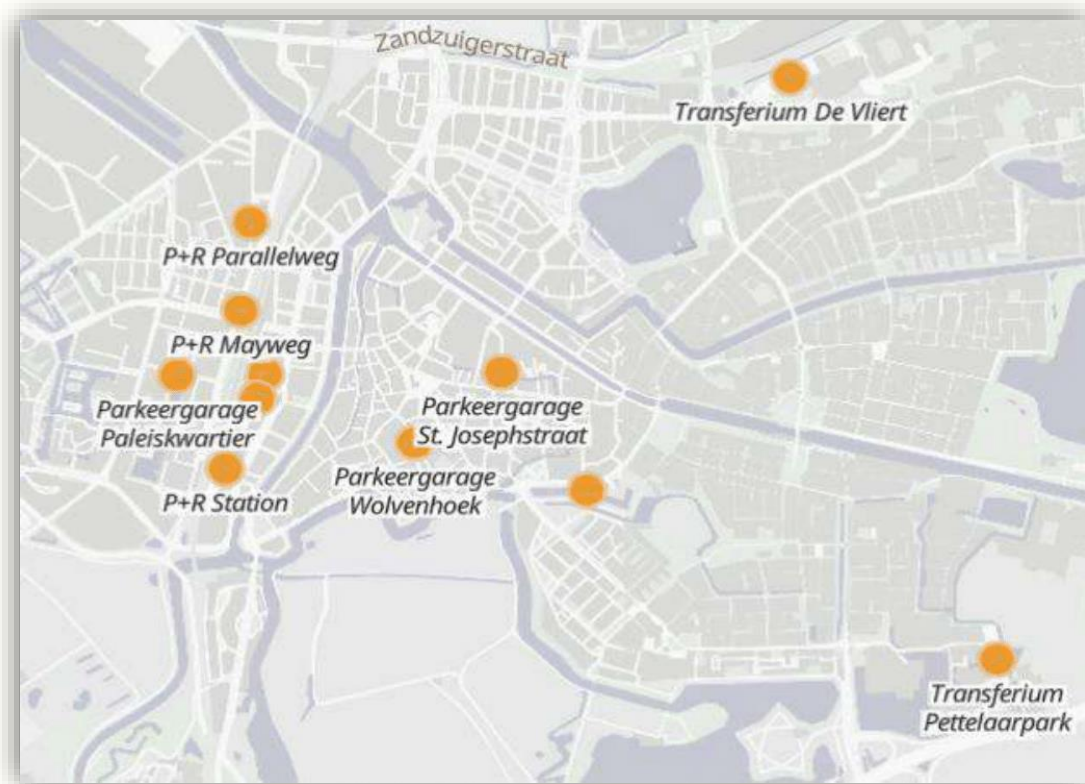


TEST DI WILCOXON

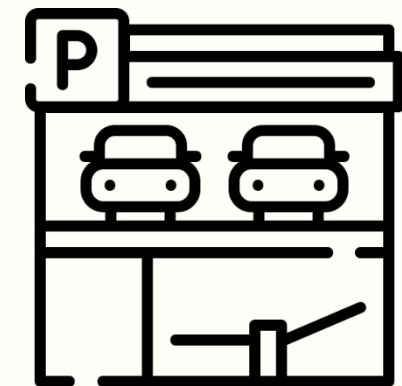
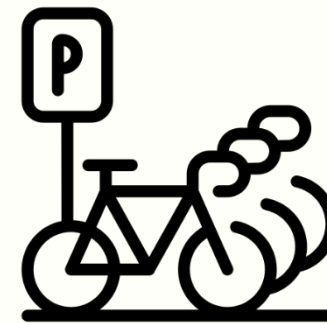
ARIMA VINCE!



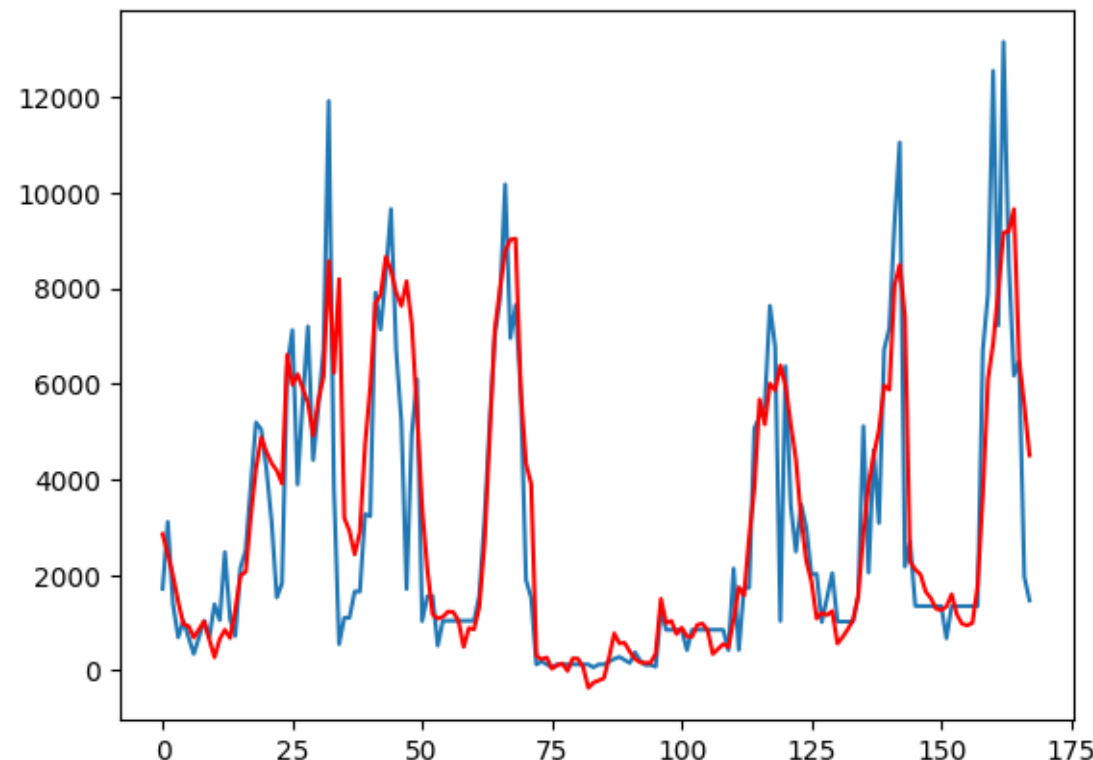
PARCHEGGI DEN BOSCH



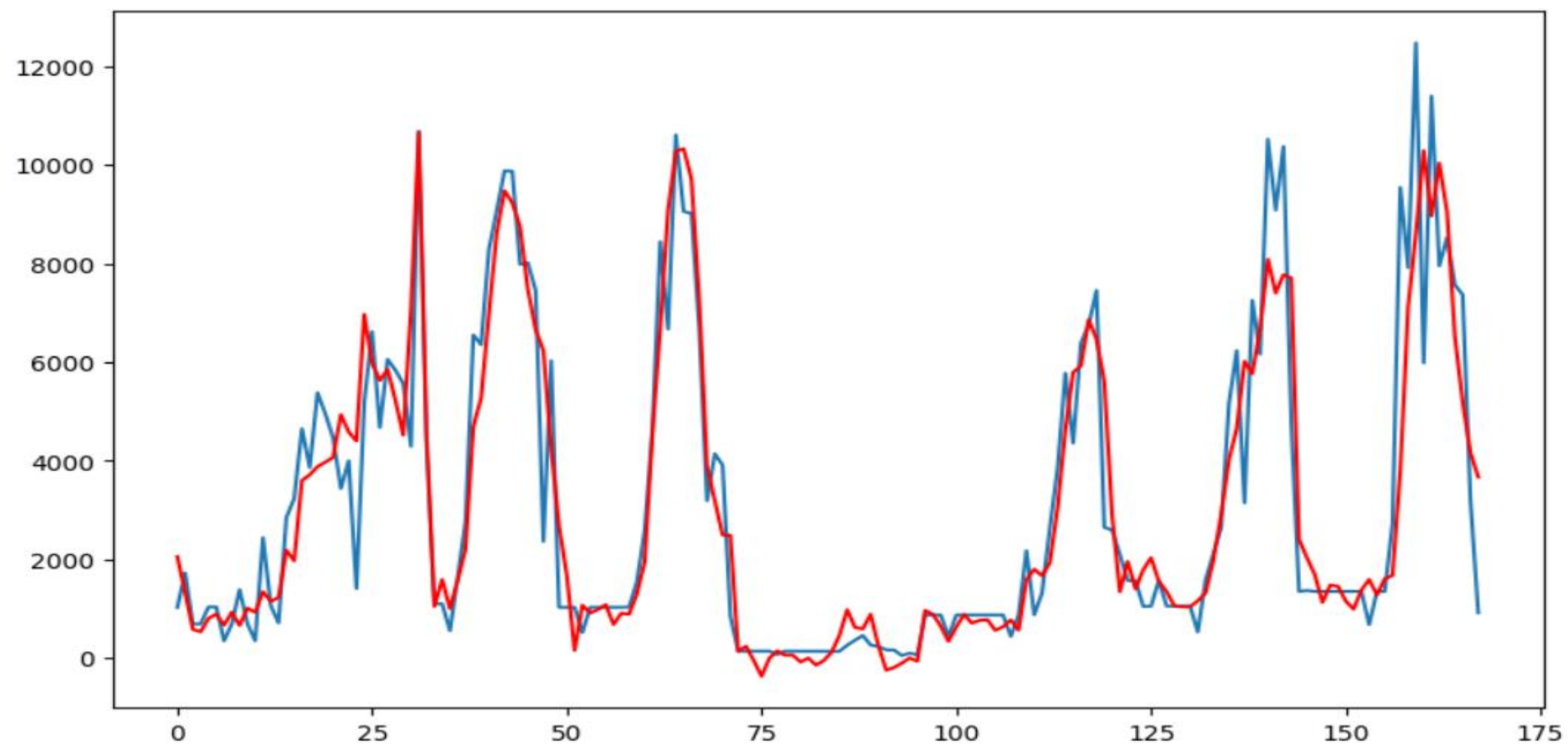
PARCHEGGI AUTO/BICI BREDA



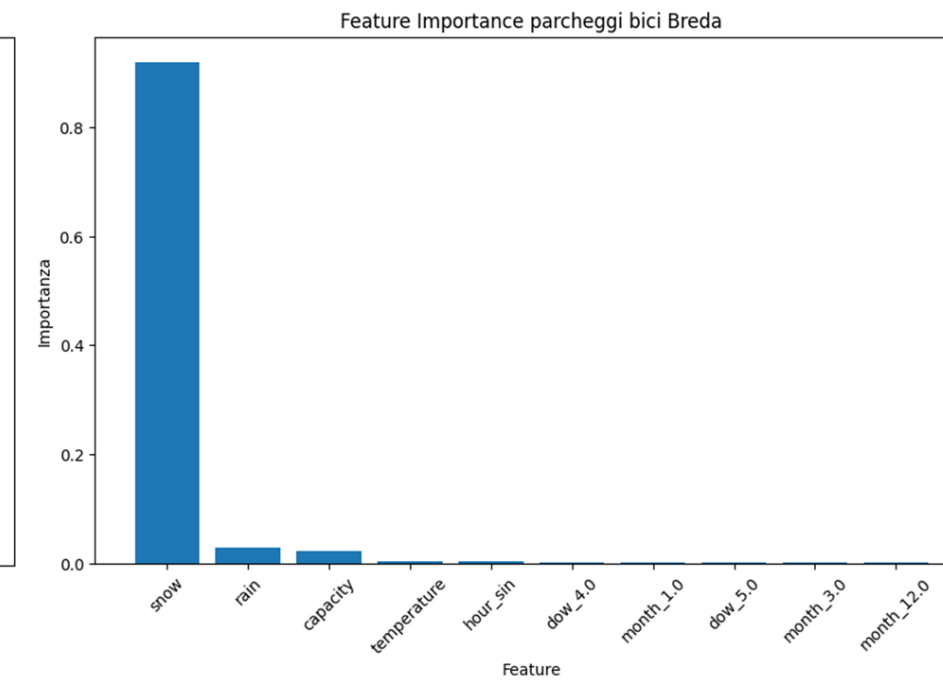
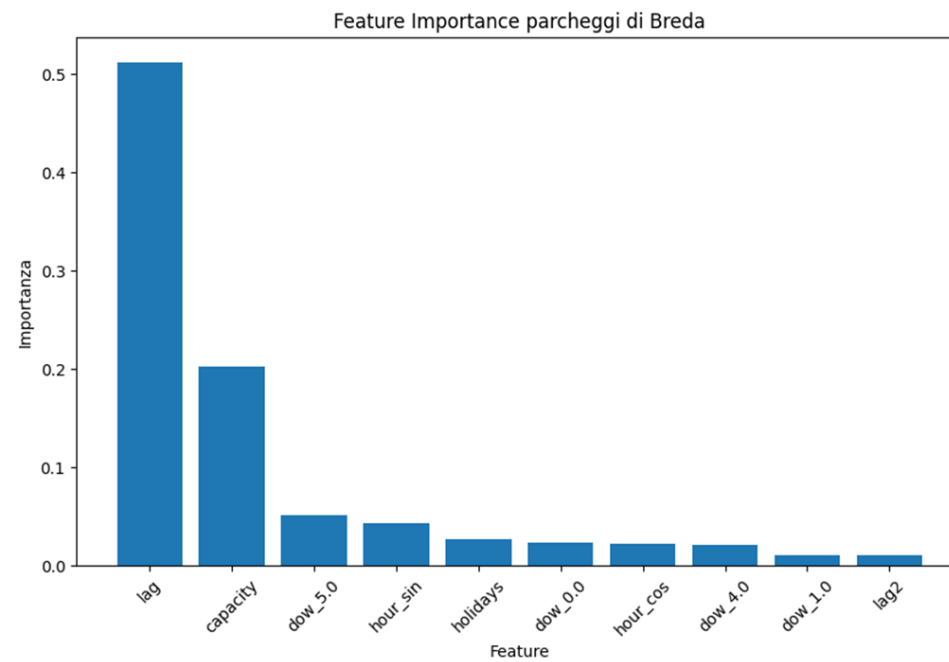
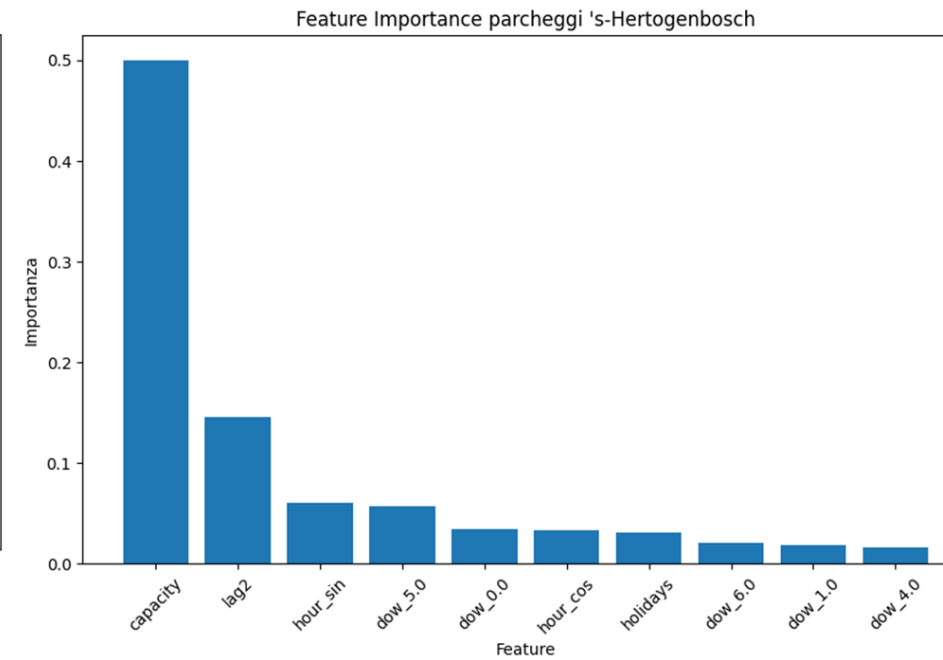
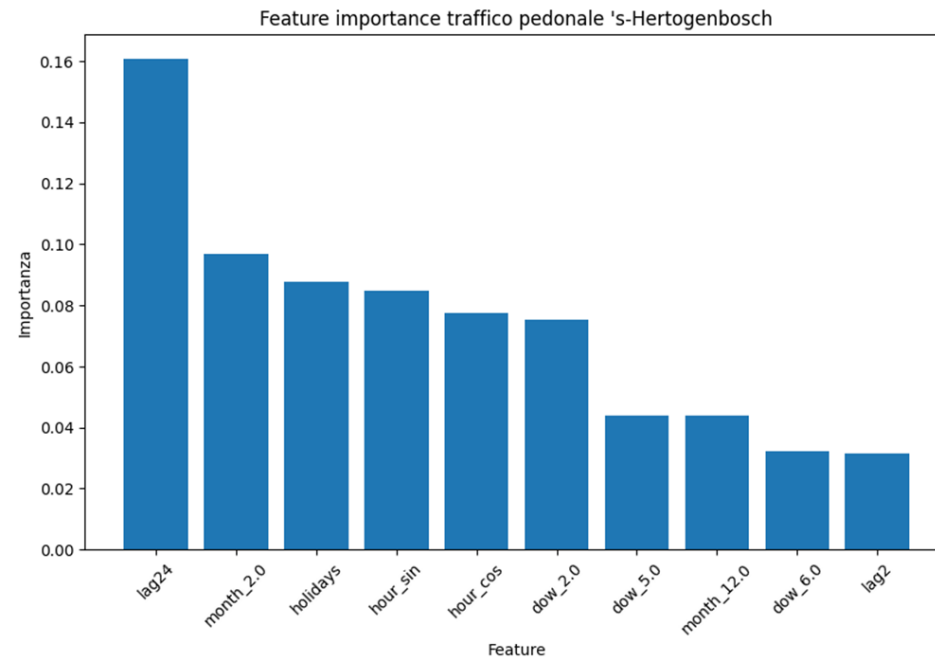
PREDIZIONE DISPONIBILITÀ PARCHEGGI DEN BOSCH



PREDIZIONE DISPONIBILITÀ PARCHEGGI BREDA



RISULTATI



mlflow™

