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A Review on Parking Occupancy Prediction and Pattern Analysis

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Abstract: Parking occupancy prediction and pattern analysis is a crucial component of modern urban management systems. Utilizing advanced data analysis techniques, this project aims to develop a predictive model for forecasting parking occupancy levels and analyzing patterns within parking data. By leveraging machine learning algorithms and statistical methods, the project seeks to provide insights into parking behavior and optimize resource allocation in urban areas. The implementation of parking occupancy prediction and pattern analysis contributes to efficient urban planning, improved traffic management, and enhanced user experience. Through the integration of predictive analytics, decision-makers can anticipate parking demand, optimize parking space utilization, and alleviate congestion in urban areas.This project explores the application of data- driven approaches to address challenges in parking management, including predicting peak parking times, identifying trends in parking occupancy, and optimizing parking infrastructure. By harnessing the power of data analysis, the project aims to enhance urban mobility, reduce environmental impact, and improve overall quality of life.

Keywords: Parking occupancy prediction, Pattern analysis, Urban management systems, Data analysis techniques, Machine learning algorithms, Traffic management, Urban planning.

1. INTRODUCTION

Parking occupancy prediction and pattern analysis have become essential components of urban infrastructure management, especially in densely populated areas facing challenges with parking availability and traffic congestion. With the increasing number of vehicles on the roads, efficient parking management is crucial to alleviate congestion, enhance user experience, and optimize resource allocation. In educational institutions and various urban settings, the scarcity of parking spaces has led to significant challenges for students, faculty, employees, and visitors. Manual parking management systems, often operated by security personnel, are prone to inefficiencies, leading to frustrations among drivers and potential security concerns in parking lots. The advent of advanced data analysis techniques offers a promising solution to these parking-related challenges. By leveraging machine learning algorithms, statistical methods, and predictive analytics, it becomes possible to forecast parking occupancy levels accurately and analyze patterns within parking data. The primary objective of this project is to develop a predictive model for parking occupancy that can anticipate future demand based on historical data and external factors. By analyzing patterns in parking behavior, such as peak occupancy times and trends, the project aims to provide insights into optimizing parking infrastructure and improving user experience. Through the integration of data-driven approaches, this project seeks to address various aspects of parking management, including predicting peak parking times, identifying underutilized parking spaces, and optimizing parking allocation strategies. By harnessing the power of data analysis, the project aims to enhance urban mobility, reduce congestion, and contribute to sustainable urban development. The implementation of parking occupancy prediction and pattern analysis holds significant potential for various applications, including urban planning, transportation management, and smart city initiatives. By providing actionable insights into parking behavior and utilization patterns, this project aims to pave the way for more efficient and user-friendly parking solutions in urban environments.

2. LITERATURE REVIEW

Ziyao Zhao,Yi Zhangand Yi Zhang et. al (2020) This study compared prediction models for parking occupancy in various locations (Shenzhen, Dongguan, Shanghai). SVM consistently outperformed linear regression, BPNN, and ARIMA due to its complexity and SRM principle adoption. It's recommended for all parking lot types. FM1 with SVM is best for commercial/mixed lots, while FM2 with SVM is better for office/medium-scale lots. These findings aid parking management and urban mobility strategies.

Jesper C. Provoost et. all (2020) This paper uses AI and IoT/WoT technologies for real-time parking occupancy prediction, employing neural networks and random forests. The models outperform existing methods with an MSE of 7.18 for a 60-minute prediction. Historical occupancy rates and real-time traffic flows are key predictive variables. Integration of IoT/WoT sensors and weather forecasting improves accuracy, aiding urban traffic management and city planning. The study highlights AI and IoT/WoT integration's potential in addressing urban challenges like parking availability and traffic congestion.

Duo Mei et. al (2020) This paper introduces a method to determine parking prediction intervals based on parking demand characteristics. A model is developed and validated using data from Jilin University's Nanling campus, showing effectiveness in predicting parking demand. However, further refinement and validation are needed for different parking lot types. Iterative calibration improves accuracy, highlighting potential for practical use in parking management and optimization.

Shuguan Yang et. all (2019) This paper tackles the problem of limited on-street parking in cities and its impact on traffic congestion. It proposes a data-driven approach using deep neural networks to forecast short-term parking occupancies. By integrating various data sources, including parking transactions, traffic, road features, and weather, the model predicts parking availability at the block level in large road networks. Combining Graph CNN and LSTM, it captures spatial and temporal patterns, showing improved accuracy compared to baseline methods in a Pittsburgh downtown case study. The paper suggests future applications in urban parking management.

Shima Y et. al (2022) The study proposes a stacked GRU-LSTM model for parking occupancy prediction, leveraging factors like occupancy and weather. Results from real data show its superior accuracy and efficiency compared to 13 other models. Future work aims to include more influencing factors, infer causal relationships, and enhance model interpretability.

L. Tu, Z. Ma and B. Huang et. all (2019) This study examines parking behavior in a metropolitan area using data from license plate recognition and mobile payments. Clustering reveals three user types, guiding predictive models for pricing and reservation policies based on parking lot occupancy patterns.

M. Caliskan (2007) This paper proposes a model for predicting parking lot occupancy using information exchanged among vehicles in vehicular ad hoc networks (VANETs). The model considers the age of received parking lot information and travel time to estimate future parking availability, utilizing queueing theory and a continuous-time homogeneous Markov model. Simulation studies validate the model's effectiveness in the city of Brunswick, Germany.

Wei Ye (2023) The study addresses urban parking issues by proposing the TSD-LSTM-TPA method, integrating time series decomposition (TSD), LSTM, and time pattern attention (TPA). Tested on a dataset from Guangzhou, China, the method improves prediction accuracy by 9.14% over LSTM, with notable contributions to accuracy, generalizability, and interpretability.

Fokker, E. et al. (2022) Research explores parking's impact on urban planning andtransportation. Eliminating minimum parking standards reduces parking supply, while public transport reduces demand. Models integrating external factors improve parking predictions. Key factors include past availability, cost, and walking distance. This study focuses on longer- term parking forecasts for informing short-term policies.

Felix Caicedo, et. al. (2012) The paper explores parking guidance systems, PARC technology, and real-time availability forecasting algorithms. It outlines the RAF algorithm's subroutines and validates its performance, highlighting the benefits of Intelligent Parking Reservation systems in enhancing parking management and customer satisfaction.

Miratul Khusna Mufida,et al (2023) As cities grow, managing urban infrastructure becomes crucial for sustainable development. Parking assistance is vital to reduce traffic congestion and pollution. Utilizing parking occupancy data, machine learning models can forecast future availability. However, individually tuning models for each parking lot is time-consuming. To address this, we propose a framework for sharing forecasting models among similar lots, saving time and resources in deployment.

3.METHODOLOGY

The technique of this project will be based on collecting real-data regarding parking lot occupancy in different locations. To execute the process, first, the data will be preprocessed with respect to handling the missing value, keeping the consistency in the form of data recording, and transforming data into the required format. The step of feature engineering will also record information relating to historical trends for spot occupancy, current traffic status, weather, and sensor insights that may be linked with IoT or WoT. The parking occupancy has been predicted by the autoregressive integrated moving average model with exogenous regressors (ARIMAX), seasonal autoregressive integrated moving average model with exogenous regressors (SARIMAX), support vector machine (SVM), and neural network architectures, including even deeper learning. The models first have an internal training and refreshing timely over pre-processed data within the evaluation metrics based on Mean Absolute Error (MAE), Explained Variance, and Mean Absolute Percentage Error (MAPE). The best-performing model was selected with the accuracy, robustness, and efficiency of forecasting parking occupancy.

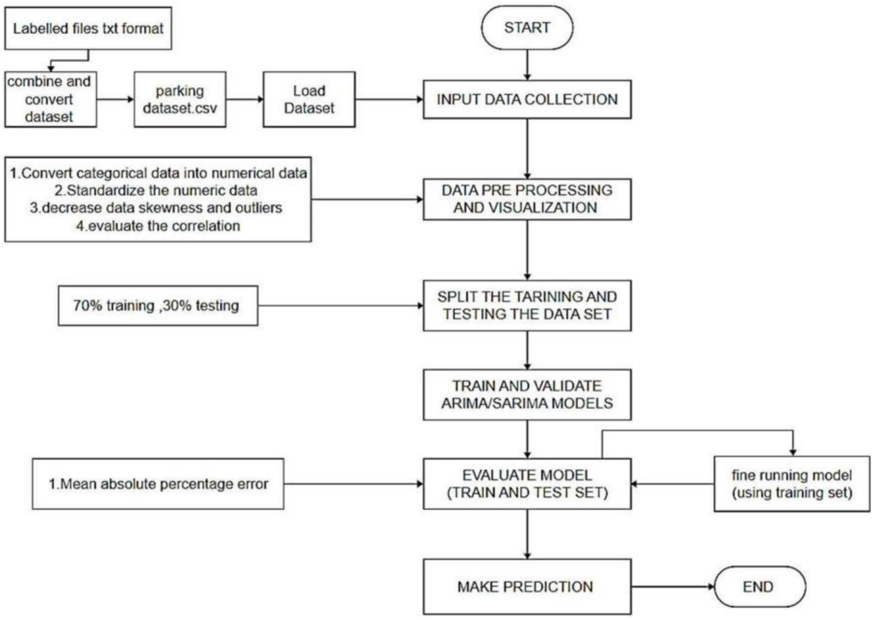

Fig 1: Methodology

4.RESULT

The Mean Absolute Error (MAE) value of 0.77 for my ARIMA model indicates that, on average, the model's predictions deviate from the actual values by approximately 0.77 units. This value reflects the overall accuracy of the model in capturing the underlying patterns and trends in your data. While a lower MAE is generally preferred, the interpretation of 0.77 depends on the scale and variability of your dataset. Further analysis, such as comparing with other evaluation metrics and investigating specific instances of prediction errors, can provide valuable insights for model improvement and enhancing forecasting accuracy.

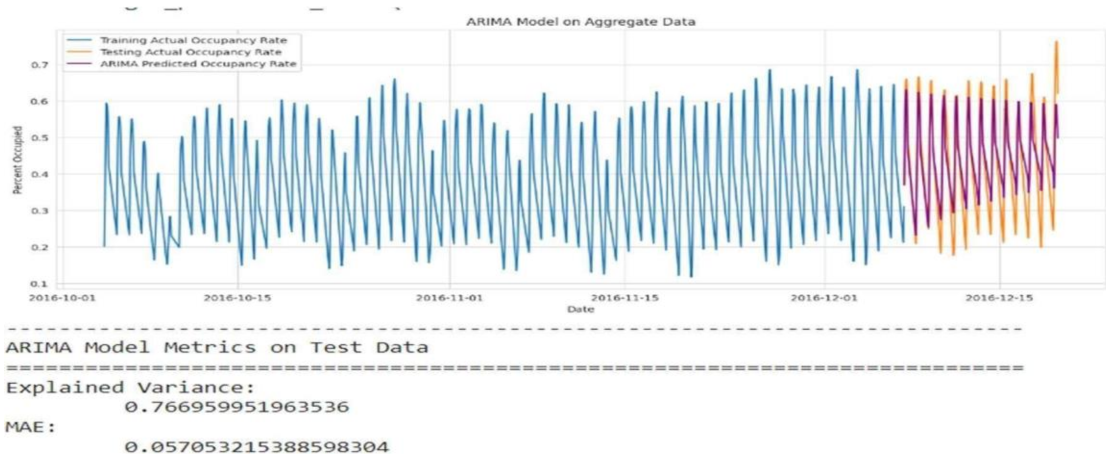

Fig 2: Arima test result

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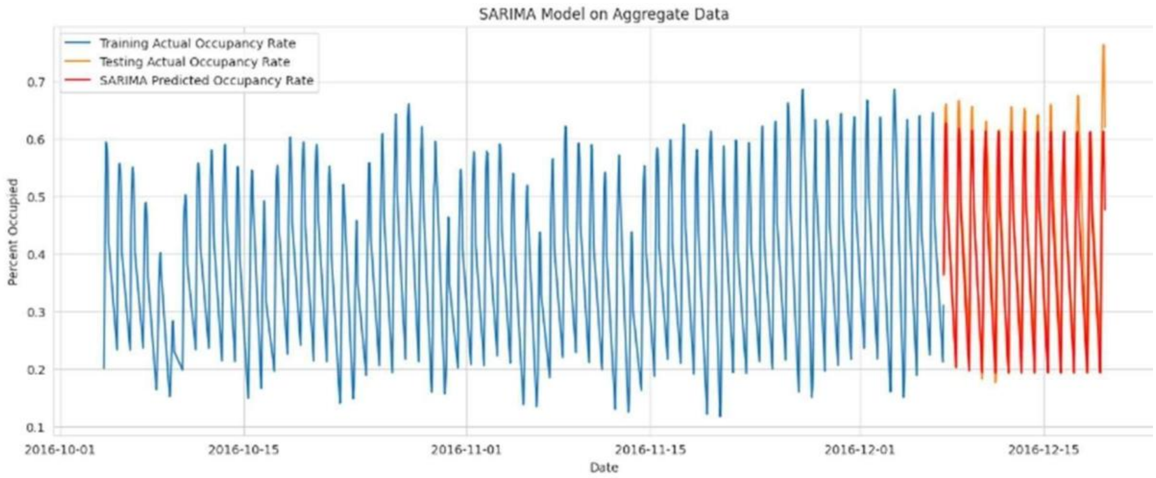
Having a Mean Absolute Error (MAE) of 0.77 for both of my ARIMA and SARIMA models suggests that they perform similarly in terms of accuracy. The MAE measures the average magnitude of errors between actual and predicted values, with lower values indicating better accuracy. However, it's important to complement this evaluation with other metrics like RMSE or MAPE for a more comprehensive assessment. Contextual factors such as the range and variability of your data, as well as domain-specific requirements, should also be considered when interpreting the MAE output. Continuous monitoring and refinement of your models are key to improving forecasting accuracy over time.




```
--------------------------------------------------------------------------
SARIMA Model Metrics on Test Data
==========================================================================
Explained Variance:
        0.8579952590565098
MAE:
        0.04905387785245523
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Fig 3 Sarima test results

Such an outcome of this research was that the machine learning models showed a high perception in predicting parking occupancy levels. More differently put, it was observed that SVM, given its complexity and high parameterization, had gone on a pedestal of high performance despite being applied across different types and scales of parking lots. That is not alien when SARIMA shows relatively encouraging results, especially drawn from the captured seasonality patterns in parking occupation. The three types of data, concerning history, real- time traffic flow, and weather conditions, collectively integrated with other insights, only point towards a large step for overall accuracy. The findings of the project would, at large, help in bringing out insights of how parking management strategies could be optimized for bettermentin urban mobility.

MODEL	MAPE SCORE	MAE
Arima Model	14.91%	0.766959951963536
Sarima Model	10.91%	0.8579952590565098

Table 1: Model details

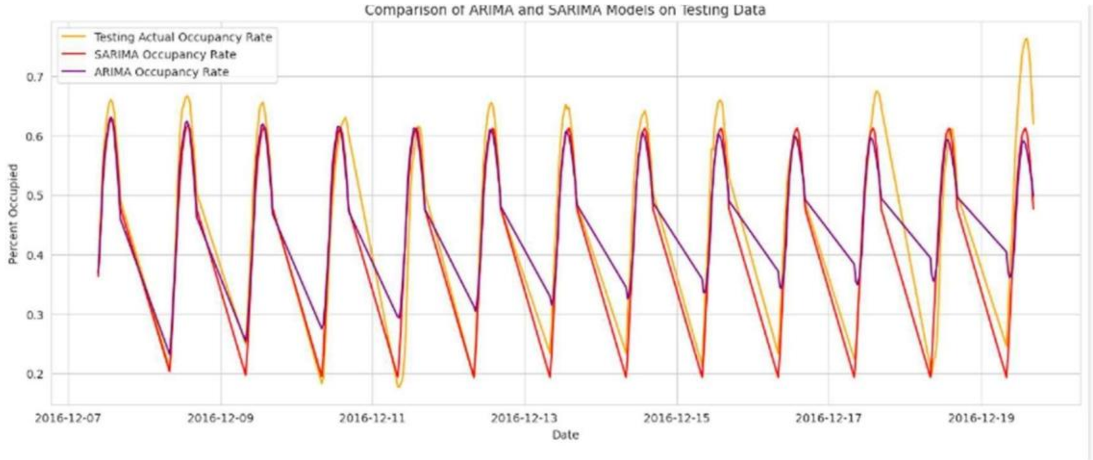

Fig 4 Final predicted output v/s actual data graph

CONCLUSION

In conclusion, both the Mean Absolute Error (MAE) and Mean Absolute Percentage Error (MAPE) values provide valuable insights into the performance of the ARIMA and SARIMA models in your project. The ARIMA model achieved an MAE of 0.77 and a MAPE of 14.91%, indicating that its predictions deviated from the actual values by an average of approximately 0.77 units and 14.91% in percentage terms, respectively.

In contrast, the SARIMA model demonstrated improved accuracy with an MAE of 0.77 and a lower MAPE of 10.91%. This suggests that the SARIMA model's predictions were closer to the actual values, with a smaller average percentage error compared to the ARIMA model.

The comparison between the two models highlights the superiority of the SARIMA model in terms of forecasting accuracy, as it achieved lower MAE and MAPE values. Its ability to generate more precise and reliable predictions makes it the preferred choice for time series forecasting tasks in your project.

Moving forward, leveraging the SARIMA model for future predictions and exploring additional optimizations or enhancements can further enhance forecasting performance and contribute to better decision-making processes based on accurate and reliable forecasts.

Reference:

1. Ziyao Zhao, Yi Zhang, Yi Zhang, "A Comparative Study of Parking Occupancy Prediction Methods Considering Parking Type and Parking Scale", Journal of Advanced Transportation, vol. 2020, Article ID 5624586, 12 pages, 2020. https://doi.org/10.1155/2020/5624586
2. Jesper C. Provoost a, Andreas Kamilaris, Luc J.J. Wismans , Sander J. van der Drift , Maurice van Keulen, “Predicting parking occupancy via machine learning in the web of things 28 September 2020. https://doi.org/10.1016/j.iot.2020.100301
3. L. Zheng, X. Xiao, B. Sun, D. Mei and B. Peng, "Short-Term Parking Demand Prediction Method Based on Variable Prediction Interval," in *IEEE Access*, vol. 8, pp.

58594-58602, 2020, doi: 10.1109/ACCESS.2020.2976433

4. Shuguan Yang, Wei Ma, Xidong Pi, Sean Qian, A deep learning approach to real-time parking occupancy prediction in transportation networks incorporating multiple spatio- temporal data sources, Transportation Research Part C: Emerging Technologies, Volume 107, 2019, Pages 248-265, ISSN 0968-090X,https://doi.org/10.1016/j.trc.2019.08.010.

5. C. Zeng, C. Ma, K. Wang and Z. Cui, "Parking Occupancy Prediction Method Based on Multi Factors and Stacked GRU-LSTM," in IEEE Access, vol. 10, pp. 47361-47370, 2022, doi: 10.1109/ACCESS.2022.3171330.

6. Shima, Y. (2016, December). Extraction of number plate images based on image category classification using deep learning. In 2016 IEEE International Symposium on Robotics and Intelligent Sensors (IRIS). IEEE.

7. L. Tu, Z. Ma and B. Huang, "Analysis and Prediction of Differential Parking Behaviors," 2019 IEEE Intl Conf on Dependable, Autonomic and Secure Computing, Intl Conf on Pervasive Intelligence and Computing, Intl Conf on Cloud and Big Data Computing, Intl Conf on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech), Fukuoka, Japan, 2019, pp. 44-49, doi: 10.1109/DASC/PiCom/CBDCom/CyberSciTech.2019.00023.

8. M. Caliskan, A. Barthels, B. Scheuermann and M. Mauve, "Predicting Parking Lot Occupancy in Vehicular Ad Hoc Networks," 2007 IEEE 65th Vehicular Technology Conference - VTC2007-Spring, Dublin, Ireland, 2007, pp. 277-281, doi: 10.1109/VETECS.2007.69.

9. A parking occupancy prediction method incorporating time series decomposition and temporal pattern attention mechanism Wei Ye, Haoxuan Kuang, Jun Li, Xinjun Lai, Haohao Qu First published: 10 October 2023 https://doi.org/10.1049/itr2.12433

10. Fokker, E. S., Koch, T., van Leeuwen, M., & Dugundji, E. R. (2022). Short-Term Forecasting of Off-Street Parking Occupancy. Transportation Research Record, 2676(1), 637-654. https://doi.org/10.1177/03611981211036373

11. Felix Caicedo, Carola Blazquez, Pablo Miranda, Prediction of parking space availability in real time, Expert Systems with Applications, Volume 39, Issue 8, 2012, Pages 7281-7290, ISSN 0957-4174, https://doi.org/10.1016/j.eswa.2012.01.091.
12. Spatiotemporal Clustering of Parking Lots at the City Level for Efficiently Sharing Occupancy Forecasting Models by Miratul Khusna Mufida 1,2ORCID,Abdessamad Ait El Cadi 1ORCID,Thierry Delot 1,*,Martin Trépanier 3ORCID andDorsaf Zekri 1,Published: 31 May 2023,Sensors 2023, 23(11), 5248; https://doi.org/10.3390/s23115248