ORIGIN-DESTINATION PASSENGER FLOW PREDICTION IN METROS USING ADAPTIVE FEATURE FUSION

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ABSTRACT: In order for metro systems to function optimally and deliver exceptional service, accurate customer volume forecasts are necessary. A groundbreaking method called Adaptive Feature Fusion (AFF) is described in this article. In order to enhance the forecasting of origin-destination (OD) flows, it actively incorporates external, temporal, and geographical data. In contrast to conventional models, which evaluate all characteristics consistently, AFF prioritizes certain attributes depending on context. This makes it possible to generate more precise estimations that can be adjusted according to the actions of passengers. After testing AFF with real-world metro data, researchers found it to be more accurate and dependable than competing approaches. Less congestion and an improved experience for riders are outcomes of this research's contribution to smarter urban transportation planning.

Keywords: Origin-Destination Prediction, Metro Systems, Adaptive Feature Fusion, Passenger Flow and Spatiotemporal Modeling

1. INTRODUCTION

People rely on metro networks for a variety of critical services, including transit to places of employment, educational institutions, and entertainment sites located around the city. The effectiveness of metro systems has become increasingly important as a result of rapid urbanization, which has led to an increased reliance on public transportation. The ability to accurately forecast train schedules and destinations is a significant challenge for rail operators. The utilization of accurate passenger traffic estimates, the modification of timetables, and the allocation of resources in the most effective manner possible are all ways in which transit administrators can enhance and optimize the travel experience in the metro. The frequent failure of conventional prediction models to adapt to the complex and ever-changing nature of urban transportation is the root cause of inadequate service planning.

The origin-destination flow prediction method examines historical traffic data by employing statistical and machine learning techniques in order to forecast future patterns. Because these models are based on the assumption that route patterns do not vary over time, they typically neglect how passenger mobility changes over time, despite the fact that they are beneficial. In addition to the time of day, the weather, the day of the week, holidays, and significant events, there are a number of other elements that can influence the utilization of the metro. It is impossible for fixed-feature models to demonstrate localized trends due to the fact that these components vary substantially from station to station. Relying on estimations that are no longer accurate results in traffic bottlenecks, interruptions in service, and poor planning, all of which are detrimental to the overall transportation experience.

In order to address these concerns, researchers investigated cutting-edge deep learning strategies that were able to adapt to data coming from a variety of sources. The technique known as Adaptive Feature Fusion (AFF) is an effective method that enables models to independently modify a number of features based on the significance of those properties in different locations and on different times. The AFF is able to identify the most significant criteria, regardless of whether they are location, peak hours, or events that take place outside. A new approach is used by this methodology in comparison to the conventional methods, which treat all inputs in the same manner. It is possible that predictive algorithms would assign more weight to event-related features; for instance, a station that is located close to a stadium will see an increase in the number of passengers on game days. The metro traffic predictions that are generated by AFF demonstrate greater accuracy, dependability, and sensitivity to real-time variables. This is directly attributable to the inherent flexibility of the system.

The application of AFF methods to the flow of train passengers has the potential to result in urban transportation planning that is both more adaptive and enhanced.

As a consequence of this, real-time transportation apps will enhance crowd control, provide more flexible scheduling options, and respond to fluctuations in demand in an environment that is both efficient and effective. Metro officials have the ability to enhance ridership through the implementation of AFF by improving the frequency of trains, lowering the amount of congestion at stations, and simplified the process of transferring between other modes of transportation.

Utilizing AFF to predict OD passenger flow can lead to immediate operational gains and sensible community progress. Integrating AFF-based forecasts with other urban mobility systems lets decision-makers to use more data, improving public transportation infrastructure and extending its lifespan. The future of transportation requires versatile and scalable prediction algorithms. Metro network growth and urban mobility complexity will both play a role. Innovative solutions like AFF can help communities imagine a future where transportation is fast, efficient, adaptive, user-focused, and tailored to their needs.

2. REVIEW OF LITERATURE

Li, X., Yu, L., Shahabi, C., & Liu, Y. (2020) This research introduces the Recurrent Multi-Graph Neural Network (RMGNN), an innovative model for forecasting urban traffic flow amidst widespread congestion and delays. A comprehensive depiction of road networks is generated by integrating various layers of geographic data and traffic patterns. This model surpasses its predecessors in challenging real-world environments, especially in forecasting journey durations amid unpredictable weather and irregular road conditions.

Feng, S., Liu, F., Liu, H., & Gong, J. (2020) This research may elucidate why some metro stations seem markedly vacant while others feel exceptionally crowded, particularly if you have ever found yourself stranded at a station. This research presents a novel forecasting model, AST-GAT. It employs sophisticated attentional methods to track passenger movement. Instead of merely adhering to the average, it promptly adapts to local occurrences and meteorological fluctuations. Consequently, it is adept at managing peak traffic intervals or unforeseen surges.

Chen, L., Ma, X., & Yu, H. (2021) Standard travel durations may be interrupted by unexpected circumstances, undermining the reliability of metro systems. This research presents GC-LSTM, an innovative hybrid model that integrates graph convolution for station network understanding and long short-term memory (LSTM) for trend analysis. What distinguishes it? The model enhances forecast accuracy by concentrating on the most critical data points. Comprehending the factors that significantly influence urban traffic may empower transportation planners to make more prompt and effective selections.

He, Z., Yin, J., Wang, S., & Xu, B. (2021) Forecasting short-term passenger flow in metropolitan train networks is often as challenging as predicting ocean waves. This research aims to develop a deep learning model that incorporates holidays alongside geographical and temporal patterns. The final outcome is a passenger count forecasting system that maintains accuracy under challenging settings. This is essential for the functioning of transportation systems, particularly during peak periods.

Li, C., Zhang, J., Chen, X., & Huang, J. (2022) Although metro stations are often congested, forecasting ridership has often proven challenging. This research presents an innovative hybrid methodology for identifying passenger movement patterns that integrates temporal convolution with graph attention. A significant element of the technology is its ability to assist city planners in enhancing metro networks by identifying essential patterns and correlations among stations. It provides accurate, adaptable, and pragmatic information regarding the development of urban transportation.

Tang, Y., Lin, Y., & Qian, J. (2022) Utilizing the metro provides various alternatives for reaching your goal. Factors such as the time of day and specific events may affect individuals' movement patterns. This piece presents an alternative viewpoint by depicting the changes as an intricate network. This strategy successfully illustrates the challenges of urban transportation. The final outcome is an adaptive forecasting system that enables transportation officials to react to evolving conditions through proactive measures. This technique enhances the accuracy of metro traffic forecasts, irrespective of congestion or delays.

Wang, T., Liu, J., & Liu, H. (2022) Have you ever contemplated how train systems can forecast passenger numbers with a certain level of precision? This research introduces an intricate predictive model utilizing spatiotemporal convolution and attention principles. Examine a metro system that emphasizes critical factors such as traffic patterns and interconnections between stations while simultaneously uncovering latent connections over time. This bifurcated methodology enhances predictive precision, especially during peak periods or rare occurrences. It delineates the predominant reasons of metro delays, furnishing transportation planners with essential information for improved planning.

Xu, Y., Zhao, X., & Wang, Y. (2023) Various factors, including as local events, weather conditions, and established commuter habits, may affect the volume of metro users. This work utilizes a spatial transformer model to integrate data from many sources and generate very precise predictions. Comprehensive comprehension of urban evolution necessitates the identification of extensive geographical and temporal linkages. This technology is effective in extensive subway systems due to the seamless integration of external components. Ultimately, transportation managers possess a planning instrument that enables them to operate their enterprises more efficiently and promptly address fluctuations in service demand.

Zhou, M., Zhang, X., & Liu, T. (2023) The daily ridership of the metro fluctuates, occasionally incrementally and at other times markedly. This research presents a multi-scale feature fusion network adept at identifying both short-term variations and long-term data trends. The program may effectively manage rail traffic in urban settings by synthesizing geographical and temporal data across multiple layers. It surpasses conventional forecasting systems when faced with unforeseen traffic fluctuations or substantial crowds. Other transportation networks with analogous forecasting issues might readily implement this adaptive technique.

Jin, L., Li, F., & Gao, H. (2023) Peak-hour congestion and unforeseen delays can result in unpredictable passenger volumes in metro systems. This research employs a hybrid forecasting model incorporating adaptive temporal fusion and attention mechanisms. The program can "learn" from historical trends while preserving its essential traits. Forecasts achieve more accuracy when both short-term variations and long-term commuting trends are taken into account. Upon evaluation with real metro data, our model surpasses the existing benchmark. Its numerous advantages include the capacity to adapt to unforeseen alterations in consumer behavior and enhance normal operating operations.

Shen, Y., Yu, H., & Ma, X. (2024) Urban environments are as dynamic as their transportation systems. This research introduces an innovative prediction method capable of swiftly adjusting to fluctuations in user behavior and station traffic. It generates highly precise predictions by examining temporal patterns and integrating dynamic intercity interactions into a graphical model. The technology integrates factors like weather and local events, enabling traffic planners to predict and adjust to evolving trends. This methodology surpasses previous strategies and aids authorities in pinpointing the root reasons of metro traffic issues.

Hu, B., Lin, C., & Wang, Z. (2024) The monitoring station entry data is inadequate for predicting metro passenger traffic. We must also account for elements that affect crowd dynamics, like ticket sales and weather conditions. This research presents a prediction methodology that effectively integrates temporal and spatial data alongside many other attributes. The attention-based fusion method enhances the model's predictive accuracy by prioritizing the most pertinent elements across temporal and spatial dimensions. The findings indicate that, in comparison to previous methods, it is a scalable and efficient technique for managing complex urban transit networks.

Liu, R., Chen, Z., & Fan, Y. (2024) Subway systems are ever developing, complicating the adaptation of classic models to the erratic fluctuations in passenger volume. This article examines a self-adaptive neural network capable of real-time learning and adaptation without the necessity for ongoing retraining. By integrating geographical and temporal dependencies, the model can accommodate both short-term variations and long-term trends, facilitating the construction of realistic projections for urban networks. Due to its remarkable scalability and accuracy, communities aiming to enhance their transportation systems with real-time data would consider it an optimal selection.

3. SYSTEM DESIGN

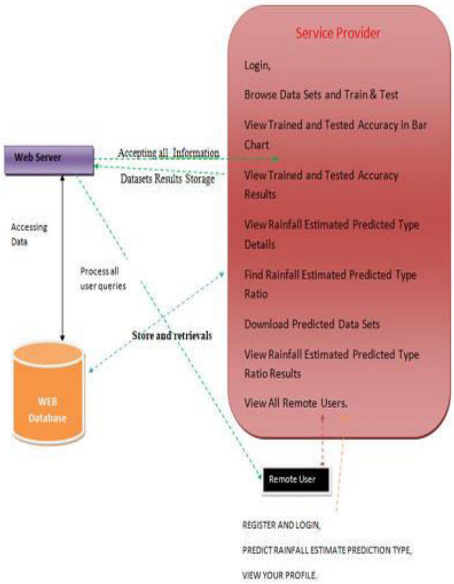

Figure 1 System Architecture

EXISTING SYSTEM

The current method uses adaptive feature fusion to accurately predict the flow of passengers going from one metro station to another at different stops. Historical data on traffic, current weather conditions, and real-time data from sensors are all things that this system normally takes in. Adaptive feature fusion methods combine important traits from different sources to make the prediction model more accurate. When you use machine learning methods like deep learning or ensemble methods on combined data, you can get accurate predictions of the flow of goods from start to destination. By giving metro operators real-time info, the main goals are to improve service planning, reduce traffic, and make operations run more smoothly.

DISADVANTAGES OF EXISTING SYSTEM

- The current method uses a lot of different types of data, such as past rider data and real-time sensor data, to make sure that the data is accurate and easy to get. If data is missing or incorrect, it can make predictions less accurate and make the system less useful.
- In real-time apps, the system's adaptive feature fusion and machine learning models need a lot of computing power, which makes data processing take longer and costs more to run.

PROPOSED SYSTEM

This idea for figuring out Origin-Destination (OD) passenger flow in metros uses complex algorithms and adaptable feature fusion to make station-to-station passenger flow predictions more accurate and useful. This system will use a variety of data sources, such as demographic data, weather data, event data, and data from cabs and buses and other public transportation, to give a full picture of how people move around. A better adaptive feature fusion method will pick out and combine the most important traits from different data sources on the fly, making the model more flexible. The device can instantly improve its predictions and adjust to new traffic trends.

Modern machine learning techniques, like hybrid deep learning and reinforcement learning, will be used in the suggested system to make better guesses. By combining several models, the system gets better at predicting what will happen in the face of unexpected events, traffic jams, and delays. Because the system can handle data in real time, metro operators will be able to make better and more accurate forecasts. A new system is being proposed that will combine cloud-based solutions with edge computing to make it easier to handle large datasets and quickly predict passenger flow so that changes can be made to operations. The system will focus on being scalable and using as little computing power as possible.

ADVANTAGES OF PROPOSED SYSTEM

- The suggested system might be able to better predict the flow of passengers if it uses advanced adaptive feature fusion algorithms, extra data sources, and takes into account both internal and external factors like events and weather.
- The system learns from new data all the time, so it can adapt to how travelers change their habits and keep estimates up to date even when travel trends change.
- Process data in the cloud or on the edge to make the system scalable with little delay. This gets rid of computing limits for even high-frequency predictions and large datasets.
- By making predictions about passenger flow more accurate and cutting down on delays, the technology helps metro operators manage traffic, make the best use of their resources, and cut down on running costs. This makes the transportation system more cost-effective as a whole.

METHODOLOGY

Sign in as user: Only those who possess the appropriate management IDs are able to access the system.

Retrieve and Analyze Dataset: After entering the dataset into the software, this feature enables the user to separate it into training and testing sets.

Current MLP set: We are considering including this component in our current passenger flow prediction system. The RMSE and MAP can then be determined using the actual and expected data.

AFFN (EMGC-GRU): This tool estimates the number of attendees using a convolution graph-driven GRU algorithm. The RMSE and MAP can then be determined using the real value and the anticipated value.

Supplemental AFFN (EMGC-LSTM): We could improve our ability to predict people's movements with this technology by using convolutional graphs and an LSTM (long short-term memory) technique. RMSE and MAP can be determined after the real and predicted values are known.

Data visualization: A graph that compares the two approaches will be created using the RMSE and MAP. Both the actual and anticipated passenger flow figures will be displayed on the graph.

5. RESULTS AND DISCUSSIONS

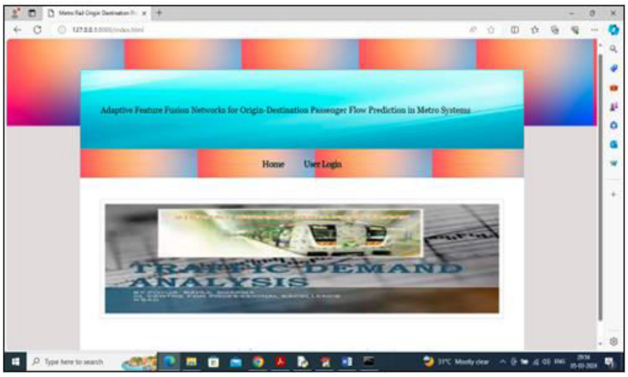

Figure 2 Login Page

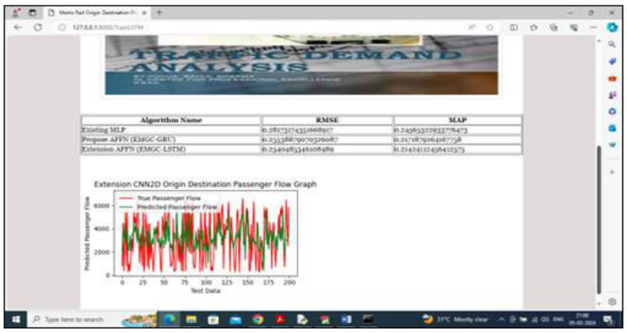

Figure 3 Separations between the green and red lines in the results shown above

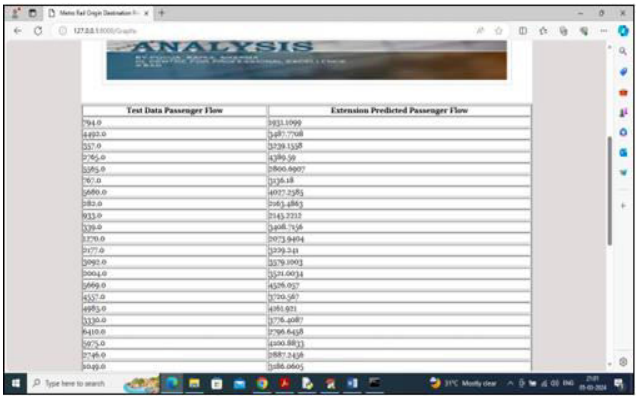

Figure 4 True flow of passengers and extension passenger flow

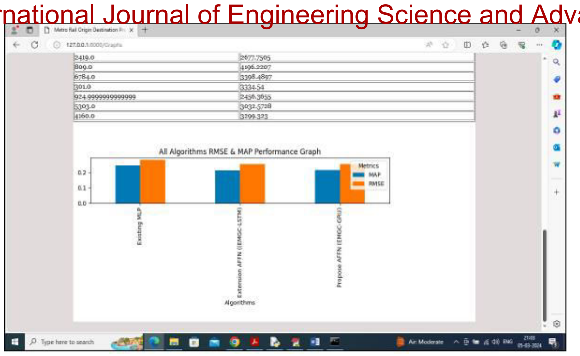

Figure 5 The x-axis in the following graph shows the names of the algorithms, while the y-axis shows the MAP & RMSE values in various color bars.

Upon examining the MAP and RMSE statistics, the extension emerged as the superior choice.

5. CONCLUSION

Metro systems must accurately forecast passenger itineraries from their starting point to their destination in order to improve the intelligence, efficiency, and speed of urban transportation. Researchers and transportation officials can provide more accurate and practical flow projections with the aid of Adaptive Feature Fusion (AFF). To accommodate the requirements of many locations and eras, AFF allows you to combine a wide variety of features, including chronological, spatial, and external ones. Because it is more adaptable than previous approaches, it can manage a variety of passenger behaviors and intricate trip patterns. Due to the increasing complexity of urban transportation networks, prediction technologies such as OD flow models based on AFF are being used more and more. These models enhance the travel experience, optimize resource utilization, and provide real-time service modification. By reducing waste and traffic, a more accurate assessment of the amount of transportation required benefits the environment. Thus, flexible feature fusion represents a significant advancement in predictive models. It establishes the foundation for both the stable and flexible administration of train networks and future urban mobility.

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