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Intelligent Food Delivery Time Prediction

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ABSTRACT

This paper presents a machine learning approach to accurately predict food delivery times by analyzing factors such as the delivery person's age, ratings, vehicle type, and the distance between the restaurant and delivery location. Using a Long Short-Term Memory (LSTM) neural network trained on historical delivery data, the model captures complex relationships to improve prediction accuracy. The system is implemented as a Python Flask web application, allowing users to input delivery parameters and receive real-time predictions, while administrators can manage users and feedback securely. The proposed solution aims to enhance operational efficiency, optimize logistics, and improve customer satisfaction in the competitive online food delivery industry.

Keywords: Food delivery time prediction, LSTM, machine learning, delivery logistics, Flask, customer satisfaction.

I. INTRODUCTION

The online food delivery industry has experienced exponential growth over the past decade, fundamentally transforming the way consumers access meals. Driven by the proliferation of smartphones, widespread internet connectivity, and evolving consumer lifestyles, food delivery platforms such as Uber Eats, DoorDash, Zomato, and Swiggy have become integral to the modern food ecosystem. These platforms offer unparalleled convenience, allowing customers to order meals from a variety of restaurants and receive them at their doorstep with minimal effort. However, with this convenience comes the critical challenge of ensuring timely delivery, which directly impacts customer satisfaction, operational efficiency, and the overall success of food delivery services.

Timeliness in food delivery is a key determinant of customer experience. Delays or unpredictable delivery times can lead to customer dissatisfaction, negative reviews, and loss of business. Conversely, accurate delivery time predictions help manage customer expectations, reduce perceived waiting times, and improve trust in the service. From an operational perspective, precise delivery time estimates enable better route planning, resource allocation, and workforce management, which in turn reduce delivery costs and increase the number of orders fulfilled. Therefore, predicting food delivery times with high accuracy is a vital competitive advantage in the highly dynamic and competitive food delivery market.

Traditional methods of estimating delivery times often rely on simplistic heuristics such as fixed average times or distance- based calculations that fail to capture the complex, real-world factors influencing delivery duration. Variables such as the delivery person's experience and ratings, the type of vehicle used, traffic conditions, weather, and the distance between the restaurant and the delivery

location all interact in non-linear ways that challenge conventional prediction techniques. Consequently, there is a growing interest in leveraging advanced machine learning models that can learn from historical data and uncover hidden patterns to provide more reliable delivery time predictions.

This project focuses on developing a machine learning model based on Long Short-Term Memory (LSTM) neural networks to predict food delivery times. LSTM networks, a type of recurrent neural network (RNN), are particularly well-suited for time-series and sequential data due to their ability to capture long- term dependencies and complex temporal relationships. By training the LSTM model on a dataset containing key features such as the delivery person's age, ratings, vehicle type, and the distance to the delivery location, the model learns the intricate relationships between these variables and delivery time. This approach aims to improve prediction accuracy beyond traditional methods, thereby enhancing both customer satisfaction and operational efficiency.

To make the system accessible and practical, the predictive model is integrated into a Python-based web application developed using the Flask framework. The application provides a user-friendly interface where customers can input relevant parameters to receive estimated delivery times in real-time. Additionally, the system includes secure administrative functionalities, allowing admins to manage user accounts, monitor predicted delivery times, and collect user feedback for continuous improvement. This dual-user design ensures that both customers and service providers benefit from the predictive insights, fostering a more transparent and efficient delivery process.

The significance of this work lies in its potential to address key challenges faced by online food delivery businesses. By accurately predicting delivery times, the system helps manage customer expectations, reduce cancellations, and improve overall satisfaction. For delivery operations, it enables optimized route planning and better allocation of delivery personnel and vehicles, which can reduce fuel consumption and operational costs. Furthermore, the feedback mechanism incorporated in the application allows continuous refinement of the model, adapting to changing conditions and improving prediction robustness over time.

In summary, this project contributes to the growing body of research on applying machine learning to logistics and delivery services by demonstrating the effectiveness of LSTM networks in predicting food delivery times. The integration of this predictive model into a web-based platform highlights the practical applicability of the approach in real-world scenarios. As online food delivery continues to expand globally, such intelligent systems will play an increasingly important role in enhancing service quality, operational sustainability, and customer loyalty.

II.RELATED WORK

1. Forecasting Food Delivery Time: An Exploration of Predictive Models and Factors Impacting Delivery Time Estimation, Authors- Dr. Ayyappa Chakravar, Shaik Eesa Ruhulla Haq,Madapakula Venkata Anil, Bathula Venkata Vamsi, Gogireddy Venkata Reddy,

This project addresses the ongoing challenge of delayed deliveries in the online food delivery industry by developing advanced predictive models for more accurate delivery time estimation. By

analyzing factors such as geography, traffic, order complexity, and operational dynamics using historical data and analytical techniques, the study aims to improve forecasting, reduce delays, and enhance operational efficiency. The insights gained are expected to boost customer satisfaction, retention, and business growth in the competitive food delivery market.

2. Efficient Food Delivery Management: Predicting Delivery Times for Improved Customer Experience, Authors- Vasudha Kumar, Dr. Anwesha Mishra, This paper tackles the challenge of accurate food delivery time prediction by developing and comparing several machine learning models, including Linear Regression, Lasso, Decision Tree, XGBoost, and RandomForest. Through thorough data preprocessing, feature engineering, and exploratory data analysis, the study identifies key predictors and optimizes model performance using GridSearchCV. The results highlight the strengths of each approach and recommend the best-performing model for real-world implementation. The findings emphasize the importance of precise delivery time estimates in improving customer satisfaction and operational efficiency in the food delivery industry.

3. Food Delivery Time Prediction in Indian Cities Using Machine Learning Models,Authors-Ananya Garg, Mohmmad Ayaan, Swara Parekh, Vikranth Udandarao,

This research enhances food delivery time prediction by incorporating real- time contextual factors like traffic, weather, local events, and geospatial data, especially in Indian cities. By comparing multiple machine learning models, it finds LightGBM performs best with high accuracy (R^2 = 0.76, MSE = 20.59). The study offers practical insights for improving urban delivery logistics and shares its code for further research.

4. Food Delivery Time Prediction in Indian Cities Using Machine Learning Models, Authors-Authors:Ananya Garg, Mohmmad Ayaan, Swara Parekh, Vikranth Udandarao,

This research enhances food delivery time prediction in Indian cities by integrating real-time contextual factors such as traffic density, weather, local events, and geospatial data into machine learning models. By systematically comparing algorithms like Linear Regression, Decision Trees, Random Forest, XGBoost, and LightGBM on a comprehensive urban dataset, the study finds that LightGBM delivers the highest accuracy, achieving an R^2 of 0.76 and a Mean Squared Error of 20.59. These results highlight the importance of dynamic, context-aware features for improving operational efficiency and logistics strategies in complex urban environments, with methodology and code made publicly available for further research.

5. A Predictive Data Analytics Methodology for Online Food Delivery, Authors: Mariam

Al Akasheh, Nehal Eleyan, Gurdal Ertek, This study presents a systematic approach to analyzing and predicting key performance indicators (KPIs) in the online food delivery sector using various classification and regression algorithms. Results from the case study show that the Random Forest algorithm consistently outperforms others in predicting most KPIs. The proposed methodology is adaptable and can help uncover operational issues and their root causes in similar e-business contexts.

6. A Real-time Food Image Recognition System to Predict the Calories by Using Intelligent Deep

Learning Strategy, Authors: G. Ramkumar, Venkatramanan C. B., V. Manonmani, S. Palanivel, This paper proposes a deep learning- based approach to accurately estimate the calorie content of food items from user-captured images. Using a layer- based methodology, the system not only identifies food categories but also predicts their calorie values, enabling users to monitor daily caloric intake effectively. The model achieves a high accuracy of 98%, demonstrating its potential as a reliable tool for managing dietary choices and promoting healthier lifestyles.

III. METHODOLOGY

The methodology for predicting food delivery times using an LSTM neural network is structured in a series of systematic steps to ensure accuracy and practical applicability. The process begins with **data collection and preprocessing**, where relevant features such as the delivery person's age, ratings, vehicle type, and the distance between the restaurant and the delivery location are gathered and cleaned. This step may include handling missing values, normalizing numerical features, and encoding categorical variables to make the data suitable for machine learning algorithms

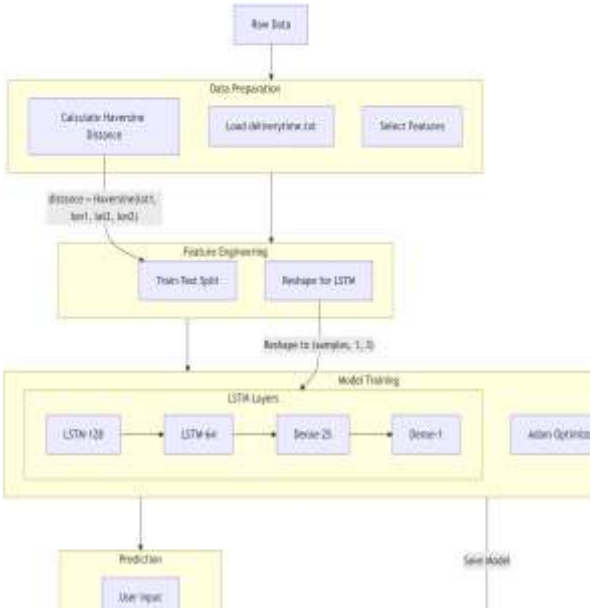


Fig1: Proposed Methodology

The methodology for the intelligent food delivery time prediction system is outlined as follows:

3.1 Data Collection:

The system initiates by gathering comprehensive delivery data from food delivery platforms and historical order records. Key features collected include the age and ratings of delivery personnel, vehicle type, and the distance between the restaurant and the delivery location. Additional contextual data such as order time, weather conditions, and traffic information may also be incorporated to enhance model accuracy. Data is collected continuously to ensure the prediction model remains relevant and reflective of real-world conditions.

3.2 Data Preprocessing:

Raw data is subjected to a thorough preprocessing phase to improve data quality and consistency. This involves cleaning the data by removing duplicates, correcting anomalies, and handling missing or incomplete entries. Numerical features are normalized, and categorical variables such as vehicle type are encoded for machine learning compatibility. The data is then structured into feature vectors, and

timestamps are synchronized to ensure temporal consistency across all records.

3.3 Feature Engineering and Selection:

Relevant features are selected and engineered to maximize the predictive power of the model. This step includes calculating the exact distance using geolocation data, transforming ratings into usable scales, and categorizing vehicle types. Correlation analysis and feature importance techniques are applied to identify the most influential variables affecting delivery time.

3.4 Model Development and Training:

A Long Short-Term Memory (LSTM) neural network is designed and configured to model the sequential and temporal dependencies inherent in delivery operations. The dataset is split into training and testing subsets. The LSTM model is trained on the training data, learning to map input features to actual delivery times. Hyperparameters such as the number of layers, neurons, and learning rate are tuned to optimize model performance.

3.5 Model Evaluation:

The trained model is evaluated using the testing dataset. Performance metrics such as Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE) are computed to assess prediction accuracy. Cross-validation and error analysis are conducted to ensure model robustness and to identify potential areas for improvement.

3.6 Web Application Integration:

The validated LSTM model is integrated into a user-friendly Python Flask web application. The application provides distinct interfaces for users and administrators. Users can register, log in, and input delivery parameters (age, ratings, distance, vehicle type) to receive real-time delivery time predictions. The admin module allows administrators to manage user accounts, view prediction statistics, and access user feedback.

3.7 Visualization and Reporting:

Predicted delivery times and related analytics are visualized through intuitive dashboards. Users receive clear, actionable feedback on expected delivery durations, while administrators can monitor system usage and prediction trends through summary tables and graphical reports.

3.8 System Testing and Feedback:

The entire system undergoes rigorous integration and user acceptance testing to ensure reliability, security, and usability. Real-world scenarios are simulated to validate prediction accuracy and system performance. Feedback from both users and administrators is systematically collected and analyzed to drive iterative improvements and ensure the system meets stakeholder needs.

TECHNOLOGIES USED

4.1 Python

Python serves as the foundational programming language for the Social Media Analytics system. Renowned for its simplicity, versatility, and extensive library ecosystem, Python enables rapid development and integration of complex data processing, analytics, and visualization workflows. Its compatibility with a wide range of APIs and data science libraries makes it an ideal choice for extracting, analyzing, and presenting social media data in a scalable and maintainable manner.

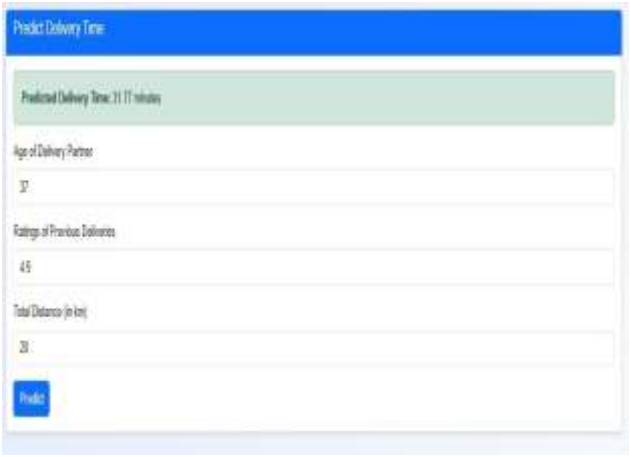
4.2 Pandas

Pandas is a powerful open-source data analysis and manipulation library for Python, extensively used in the system to handle structured data. With its intuitive DataFrame structure, Pandas simplifies data cleaning, transformation, aggregation, and analysis. It is particularly effective for managing large datasets extracted from social media platforms, allowing for efficient filtering, normalization, and computation of key metrics required for actionable insights.

4.3 Sklearn

Scikit-learn, commonly imported as sklearn, is a widely used open-source machine learning library for Python that provides a comprehensive suite of tools for data analysis and modeling[468]. It supports a broad range of machine learning algorithms for tasks such as classification, regression, clustering, dimensionality reduction, and model selection. Scikit-learn is designed to work seamlessly with other scientific Python libraries like NumPy, SciPy, pandas, and matplotlib, making it easy to integrate into data science workflows

IV. RESULT



Delivery time prediction page.

V. CONCLUSION

In this work, an intelligent food delivery time prediction system was developed using machine learning techniques, specifically leveraging a Long Short-Term Memory (LSTM) neural network to model the complex relationships among delivery person characteristics, vehicle type, and delivery distance. The proposed methodology demonstrated how accurate delivery time predictions can significantly enhance customer satisfaction, optimize operational logistics, and provide a competitive edge for online food delivery businesses. Integration of the model into a user-friendly Flask web application further enabled real-time predictions and efficient system management for both users and administrators. Overall, the system offers a robust, scalable solution that addresses key industry challenges, paving the way for smarter, data-driven decision-making in the rapidly evolving food delivery sector.

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