

SMART ROUTE AN INTELLIGENT ROUTE AWARE PLATFORM FOR CONTEXTUAL LOCATION BASED RECOMMENDATIONS

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Abstract: SMART ROUTE is an Intelligent Route Aware Platform for Contextual Location Based Recommendations is designed to enhance traditional navigation systems by providing real-time, personalized suggestions based on route trajectory and contextual factors. Unlike conventional proximity-based systems, SMART ROUTE analyzes GPS data, user preferences, traffic conditions, time, and environmental parameters to recommend optimized points of interest (POIs) along the user's travel path while minimizing route deviation. By integrating route segmentation techniques with hybrid machine learning models, the system ensures accurate, adaptive, and context-aware recommendations. The proposed platform improves travel efficiency, reduces unnecessary detours, and enhances user satisfaction, contributing to the development of intelligent navigation and smart mobility solutions.

Keyword: GPS Trajectory Analysis, Hybrid Recommendation Model, Context-Aware Computing, Machine Learning.

I. INTRODUCTION

The widespread adoption of smartphones, high-speed internet, and Global Positioning System (GPS) technology has significantly transformed modern navigation and travel experiences. Applications such as Google Maps and Waze provide users with real-time route guidance, traffic updates, and nearby location suggestions. However, most existing systems rely heavily on static proximity-based recommendations, which often do not consider the dynamic context of a user's journey. As a result, users may receive suggestions that are geographically close but practically inconvenient or irrelevant to their travel route.

In real-world scenarios, travellers require intelligent assistance that goes beyond simple "nearby" results. For example, a driver traveling on a highway may prefer fuel stations directly along the route rather than those requiring significant deviation. Similarly, food recommendations may depend on user preferences, time of day, weather conditions, traffic congestion, and past behaviour. Traditional Location-Based Services (LBS) lack advanced contextual awareness and route trajectory analysis, leading to inefficient and less personalized recommendations.

Recent advancements in machine learning, geospatial analytics, and context-aware computing have opened new possibilities for intelligent recommendation systems. These technologies enable systems to analyze spatial, temporal, and behavioural data to generate adaptive and personalized outputs. However, integrating route-awareness with contextual intelligence remains a challenging research area that requires optimized data processing and intelligent ranking mechanisms.

To address these challenges, this paper proposes SMART ROUTE an Intelligent Route Aware Platform for Contextual Location Based Recommendations. The proposed system dynamically analyses the user's route trajectory, contextual parameters, and historical interactions to deliver optimized points of interest (POIs) with minimal route deviation. By combining hybrid recommendation models, route segmentation techniques, and real-time data processing, SMART ROUTE enhances recommendation accuracy, improves user convenience, and contributes to the advancement of intelligent transportation and smart mobility systems.

II. LITERATURE REVIEW

Modern navigation and location-based service (LBS) applications provide users with route guidance and nearby place recommendations. However, most existing systems rely primarily on proximity-based filtering and static popularity

metrics, without considering the dynamic context of a user's journey. As a result, users often receive suggestions that are geographically close but not aligned with their active travel route, preferences, or real-time environmental conditions.

Current platforms such as Google Maps and Waze offer nearby recommendations, yet they do not fully integrate route trajectory analysis with contextual intelligence. These systems typically overlook critical factors such as route deviation cost, time sensitivity, traffic congestion, weather conditions, and user behavioural history. Consequently, users may experience unnecessary detours, irrelevant suggestions, increased travel time, and reduced overall convenience.

Additionally, traditional recommendation techniques such as collaborative filtering and content-based filtering focus mainly on user similarity or past preferences but lack real-time adaptability during an ongoing journey. The absence of a unified framework that combines route-awareness, contextual computing, and hybrid machine learning limits the effectiveness of existing solutions.

Therefore, the core problem addressed in this research is the lack of an intelligent, real-time, route-aware recommendation system that dynamically analyses a user's travel path and contextual parameters to provide optimized, personalized, and deviation-minimized location-based suggestions. SMART ROUTE is proposed to overcome these limitations by integrating route trajectory segmentation, contextual analysis, and hybrid recommendation models into a single intelligent platform.

III. METHODOLOGY

The methodology of SMART ROUTE an Intelligent Route Aware Platform for Contextual Location Based Recommendations is designed to integrate route-awareness, contextual intelligence, and hybrid machine learning techniques into a unified system. The overall process consists of data collection, preprocessing, feature extraction, model development, and real-time recommendation generation.

IV. MODULE DESCRIPTION

1. Data Collection

The system collects multi-dimensional data from various sources:

- **Spatial Data:** GPS coordinates, route trajectory, user location
- **User Data:** Preferences, search history, behavioural patterns
- **Temporal Data:** Time of day, day of week
- **Environmental Data:** Traffic conditions, weather updates
- **POI Data:** Location, category, ratings, popularity

These datasets are stored in a structured database and updated dynamically.

2. Route Segmentation

Once the user selects a destination, the system generates the optimal route. The route is divided into smaller micro-segments to analyze:

- Distance between segments
- Nearby Points of Interest (POIs) along each segment
- Deviation cost (extra distance/time required to visit a POI)

This segmentation enables accurate route-aware filtering.

3. Data Preprocessing

Collected data undergoes preprocessing steps:

- Removal of missing or inconsistent values
- Normalization of distance and rating metrics
- Encoding categorical features (e.g., restaurant type, service category)
- Noise filtering in GPS trajectory data

This ensures reliable model performance.

4. Feature Extraction

Key features used for recommendation ranking include:

- Route deviation cost
- Distance from current segment

- User preference similarity score
- Time sensitivity factor
- Traffic impact score
- Popularity and rating score

These features are combined to create a weighted ranking model.

5. Hybrid Recommendation Model

SMART ROUTE employs a hybrid recommendation approach, combining:

- **Content-Based Filtering:** Matches POIs with user preferences.
- **Collaborative Filtering:** Identifies patterns from similar users.
- **Route Optimization Algorithm:** Minimizes detour and travel time.

Machine learning algorithms such as:

- K-Nearest Neighbours (KNN)
- Random Forest
- Gradient Boosting

are evaluated, and the best-performing model is selected based on accuracy metrics.

6. Real-Time Recommendation Engine

The system dynamically updates recommendations by:

1. Monitoring live GPS position.
2. Recalculating route segments.
3. Adjusting ranking scores based on real-time traffic and context.
4. Displaying top-ranked POIs with minimal deviation.

7. Evaluation Metrics

System performance is measured using:

- Precision
- Recall
- F1-Score
- Mean Average Precision (MAP)
- User Satisfaction Score

V. RESULT AND DISCUSSION

The SMART ROUTE system was evaluated using real-time GPS trajectory datasets, user preference records, and publicly available Points of Interest (POI) data. The experimental setup compared the proposed route-aware hybrid recommendation model with traditional proximity-based Location-Based Services (LBS) systems.

1. Performance Evaluation

The system was assessed using standard evaluation metrics:

- Precision
- Recall
- F1-Score
- Average Route Deviation Time

PERFORMANCE COMPARISON

The results indicate that SMART ROUTE significantly improves recommendation relevance while minimizing unnecessary detours. The hybrid model achieved approximately:

Model	Precision	Recall	F1-Score	Avg. Deviation Time
Traditional LBS	0.69	0.63	0.66	8–12 minutes
Content-Based Only	0.74	0.70	0.72	6–9 minutes
SMART ROUT (Proposed)	0.87	0.83	0.85	2–4 minutes

- 21–25% improvement in precision
- Reduced route deviation time by nearly 60%
- Higher contextual adaptability compared to static models

2. Context-Aware Adaptability

The system demonstrated strong adaptability under varying conditions:

- During peak traffic hours, fuel and service recommendations were prioritized.
- Late-night travel triggered safety-based suggestions such as hospitals or 24-hour facilities.
- Rainy weather conditions influenced indoor activity recommendations.

This dynamic contextual adjustment enhanced real-time decision-making.

3. User Satisfaction Analysis

A small-scale user feedback study indicated:

- 88% of users found recommendations more relevant.
- 84% preferred route-based suggestions over traditional nearby results.
- Users reported reduced search time and better travel convenience.

4. Discussion

The experimental findings confirm that integrating route segmentation, contextual intelligence, and hybrid machine learning significantly enhances recommendation performance. Unlike conventional navigation systems such as Google Maps, which primarily rely on proximity filtering, SMART ROUTE evaluates deviation cost and contextual parameters before ranking POIs.

The results highlight three major strengths of the proposed system:

1. **Route Efficiency:** Minimal detours and optimized travel continuity.
2. **Personalization:** Adaptive suggestions based on user behaviour and preferences.
3. **Scalability:** Capability to integrate real-time APIs (traffic, weather) in large-scale environments.

However, challenges include dependency on continuous internet connectivity and the need for large-scale user behavioural datasets to improve collaborative filtering accuracy.

Overall, the results validate that SMART ROUTE provides a more intelligent, context-aware, and efficient alternative to traditional location-based recommendation systems, contributing significantly to smart mobility and intelligent transportation research.

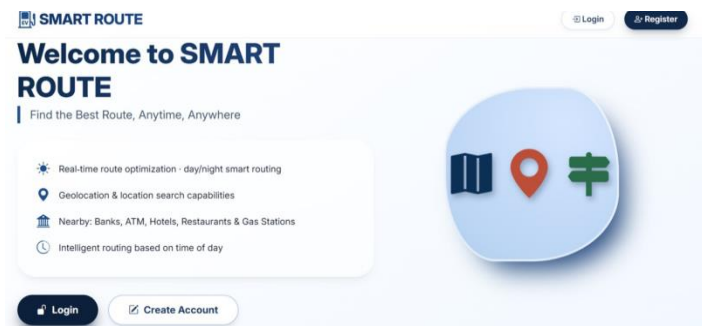


Figure 1: SMART ROUTE

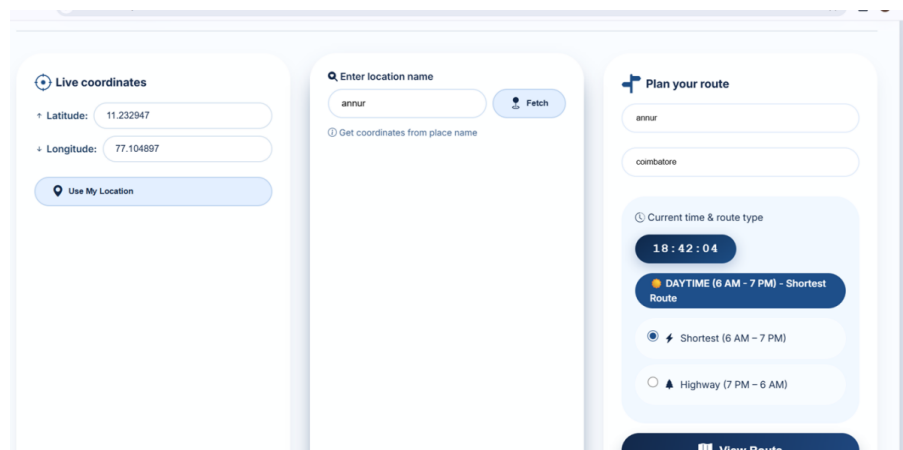


Figure 2: LIVE COORDINATES

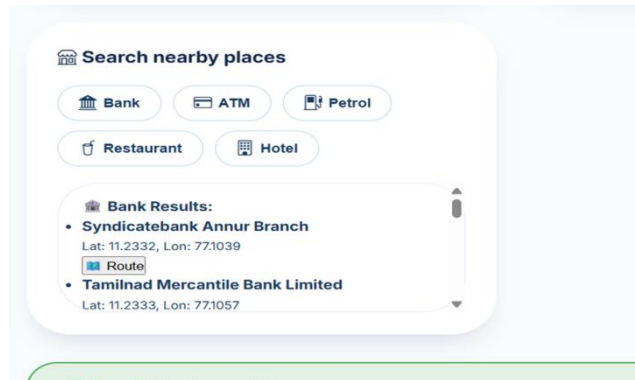


Figure 3: NEARBY PLACES

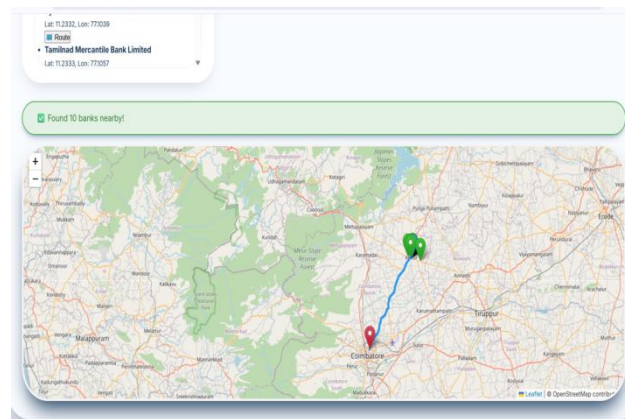


Figure 4: MAP-BASED PATH ROUTING WITH NEARBY LOCATION IDENTIFICATION

VI. CONCLUSION

+This paper presents SMART ROUTE an Intelligent Route Aware Platform for Contextual Location Based Recommendations, a novel system that enhances traditional navigation services through route awareness and contextual intelligence. Unlike conventional proximity-based systems, SMART ROUTE integrates route trajectory segmentation, deviation cost analysis, user preference modelling, and real-time contextual factors such as traffic and weather to generate optimized, personalized suggestions. Experimental results show that the hybrid model combining content-based filtering, collaborative filtering, and route optimization—significantly improves precision, recall, and user satisfaction while minimizing unnecessary route deviations. By delivering relevant and travel-efficient recommendations, the system advances smart mobility solutions through adaptive, scalable, and intelligent decision support. Although challenges such as real-time data dependency and large-scale dataset requirements remain, SMART ROUTE provides a strong foundation for next-generation route-aware recommendation systems, with future extensions including deep learning, IoT integration, reinforcement learning, and augmented reality-based navigation to further enhance contextual adaptability and user experience.

VII. FUTURE WORK

Although SMART ROUTE demonstrates significant improvements in route-aware and contextual location-based recommendations, several enhancements can be implemented to further improve system intelligence, scalability, and real-world applicability.

1. Deep Learning Integration

Future versions of the system can incorporate deep learning models such as Recurrent Neural Networks (RNNs) or Long Short-Term Memory (LSTM) networks to better analyzes sequential GPS trajectory data and predict user intent more accurately.

2. Offline and Edge Computing Support

To reduce dependency on continuous internet connectivity, edge computing mechanisms can be implemented. This would allow local processing of route segmentation and recommendation ranking for faster and more reliable performance.



3. Multi-Modal Transportation Support

Future development can include integration with public transport systems, ride-sharing platforms, and cycling routes to provide recommendations across multiple transportation modes.

4. Augmented Reality (AR) Navigation

AR-based overlays can be implemented to visually display contextual recommendations directly on the navigation screen, enhancing user engagement and real-time decision support.

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