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SmartFlood Mumbai: AI Risk Mapping using Bayesian Network

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Project Guide
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Sustainable Development Goals (SDG) mapped

- **SDG 11: Sustainable Cities and Communities**

The system makes Mumbai more resilient by providing real-time flood predictions, safe navigation routes, and early warnings to protect urban communities and infrastructure from flood disasters.

Outline

- SDG Mapped
- Introduction
- Literature Survey of the existing systems
- Limitations of the existing systems
- Problem statement
- System Design
- Technologies and methodologies
- Implementation
- Conclusion
- References

Introduction

- **SmartFlood Mumbai: AI Risk Mapping** is a real-time system that predicts flooding in different areas of Mumbai using machine learning and live data. It helps citizens, emergency teams, and city planners by giving accurate flood risk updates and suggesting safe routes during heavy rains and extreme weather.

Motivation:

- Mumbai faces severe flooding challenges during monsoon seasons, with the 2005 and 2017 floods causing significant loss of life and property. Citizens lack access to real-time, localized flood predictions that could help them make informed decisions out travel, evacuation, and safety measures.
- Current weather systems provide city-wide alerts but fail to deliver ward-specific, actionable intelligence that accounts for local drainage capacity, elevation, and historical flood patterns.

Objectives

- To predict ward-level flood risk using the Random Forest classifier based on real-time rainfall.
- To group wards into flood-prone zones using KMeans clustering on rainfall patterns.
- To estimate flood probability under uncertainty using a Bayesian Network that links rainfall and historical flood data.
- To suggest safe travel routes during floods using the A* (A-star) search algorithm, avoiding high-risk areas.
- To provide ward-wise flood risk visualization on interactive maps with color codes, trend charts, and dashboards.

Literature Survey of the existing system

Sr. No.	Title	Author(s)	Year	Methodology	Drawbacks
1.	[1] Analysis of Mumbai floods in recent years	Tripathy S S., Chaudhuri S., Murtugudde R., Mhatre V. Parmar D., Pinto M., Zope P.E., Dixit V., Karmakar S., Ghosh S.	2024	Combined analysis of Mumbai flood events using traditional rainfall data, crowdsourced data, and parametric correction methods.	Additive and multiplicative corrections in parametric methods were ineffective, especially during heavy rainfall conditions.
2.	[2] Flood hazard analysis in Mumbai using geospatial and multi-criteria decision-making techniques	Yash P., Solanki, Vijendra K., Kul Vaibhav S., Arpan D., Deepak, T.	2024	Integrated GIS with Analytic Hierarchy Process (AHP); used land use, rainfall, elevation, drainage density, NDVI, distance from rivers and roads for spatial flood risk mapping.	Standard limitations in AHP and GIS-based methods; challenges in generalizing for dynamic urban contexts.
3.	[3] Social, economic and environmental assessment of urban sub-catchment flood risks: Mumbai City	Pathak S., Liu M., Jato-Espino D., Zevenbergen C.	2020	Multi-criteria approach combining social, economic, environmental data to evaluate flood vulnerability at sub-catchment level	Complex data integration; potential data quality variability

Literature Survey of the existing system

Sr. No.	Title	Author(s)	Year	Methodology	Drawbacks
4.	[4] Analysis of urban flood vulnerability at the sub-city scale: empirical evidence from Mumbai, India	Prajapat P., Joshi M., Yadav S., Parmar H., Ahmed S., et al.	2025	Multi-criteria flood risk assessment based on exposures, sensitivities, and adaptive capacities at the sub-city scale	Coarse urban land-use data poses limits; sub-city scale contextual issues
5.	[5] Flood risk assessment for Indian sub-continental river basins	Ali H., Modi P., Mishra V., et al.	2024	Hydrological and hydrodynamic modeling (HO8 + CaMa-Flood), considering dams, reservoirs, hazard, exposure, vulnerability	Calibration limited by available data; uncertainties in exposure estimates

Limitations of existing systems

1. **Survey Analysis:** Current solutions focus on city-level alerts; lack ward-level predictions, safe route planning, and real-time integration of rainfall, and waterlogging data.

2. **Problem Status:** Awareness exists, but practical, localized, real-time solutions are missing; no system combines prediction, visualization, and routing.

3. **Observations & Improvements:** ML models are accurate; GIS (Geographic Information System) dashboards are user-friendly; improvements needed include ward-level predictions, dynamic route planning.

4. **Technology :** Random Forest or Bayesian Networks and GIS mapping perform well; limitations include high computation, poor local adaptation, and lack of integrated routing.

Problem statement

Mumbai faces severe flooding every monsoon, with historical events like the 2005 and 2017 floods causing extensive loss of life and property. Current weather and flood alert systems provide city-wide warnings but lack ward-specific, real-time predictive information. Citizens and authorities cannot make informed decisions about travel, evacuation, or resource allocation at a localized level.

Problem Elaboration :

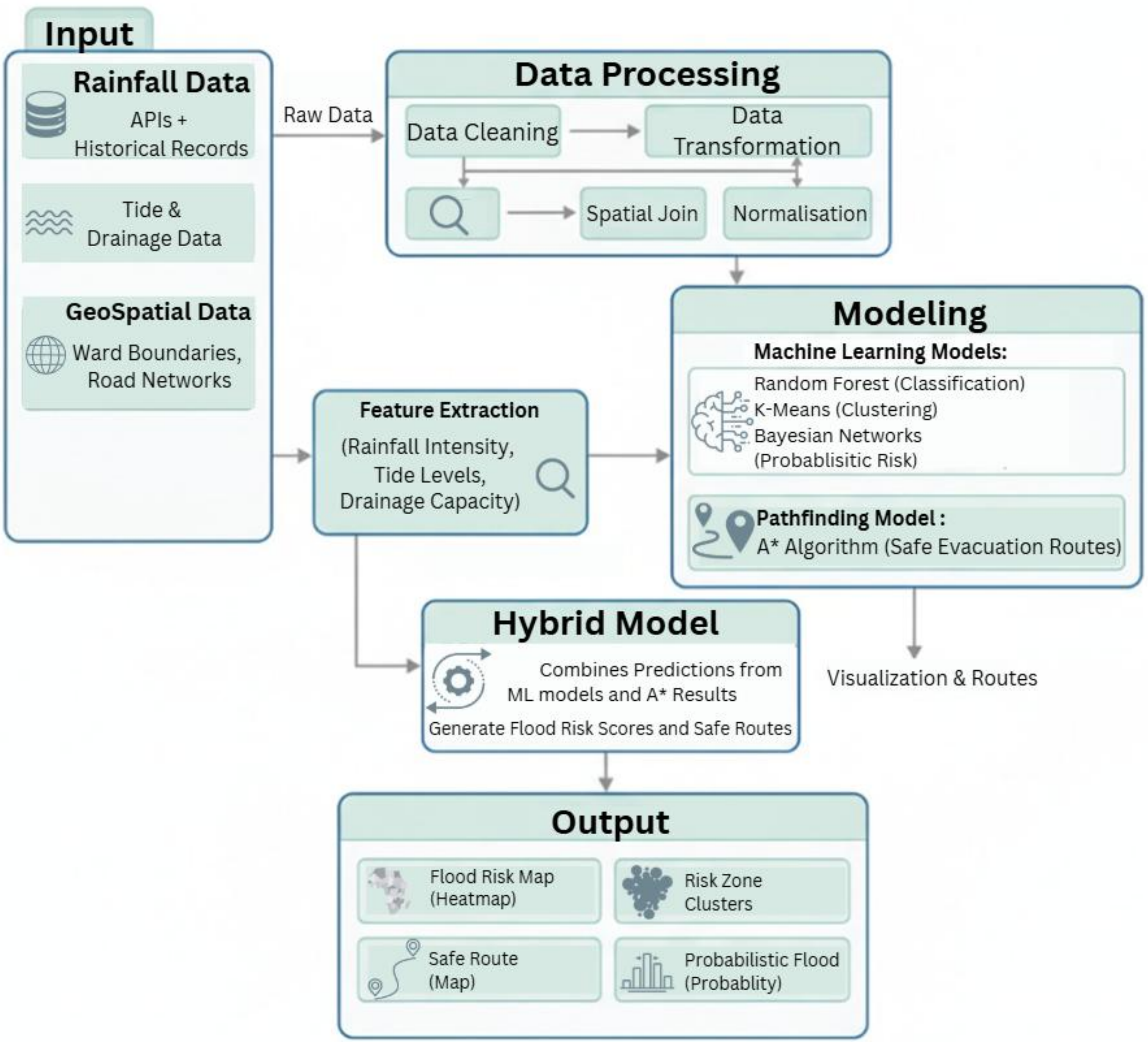
1. Lack of localized prediction – Alerts cover the entire city rather than specific wards or neighborhoods.

2. Absence of real-time updates – Current systems are often delayed and do not account for fast-changing rainfall or tide conditions.

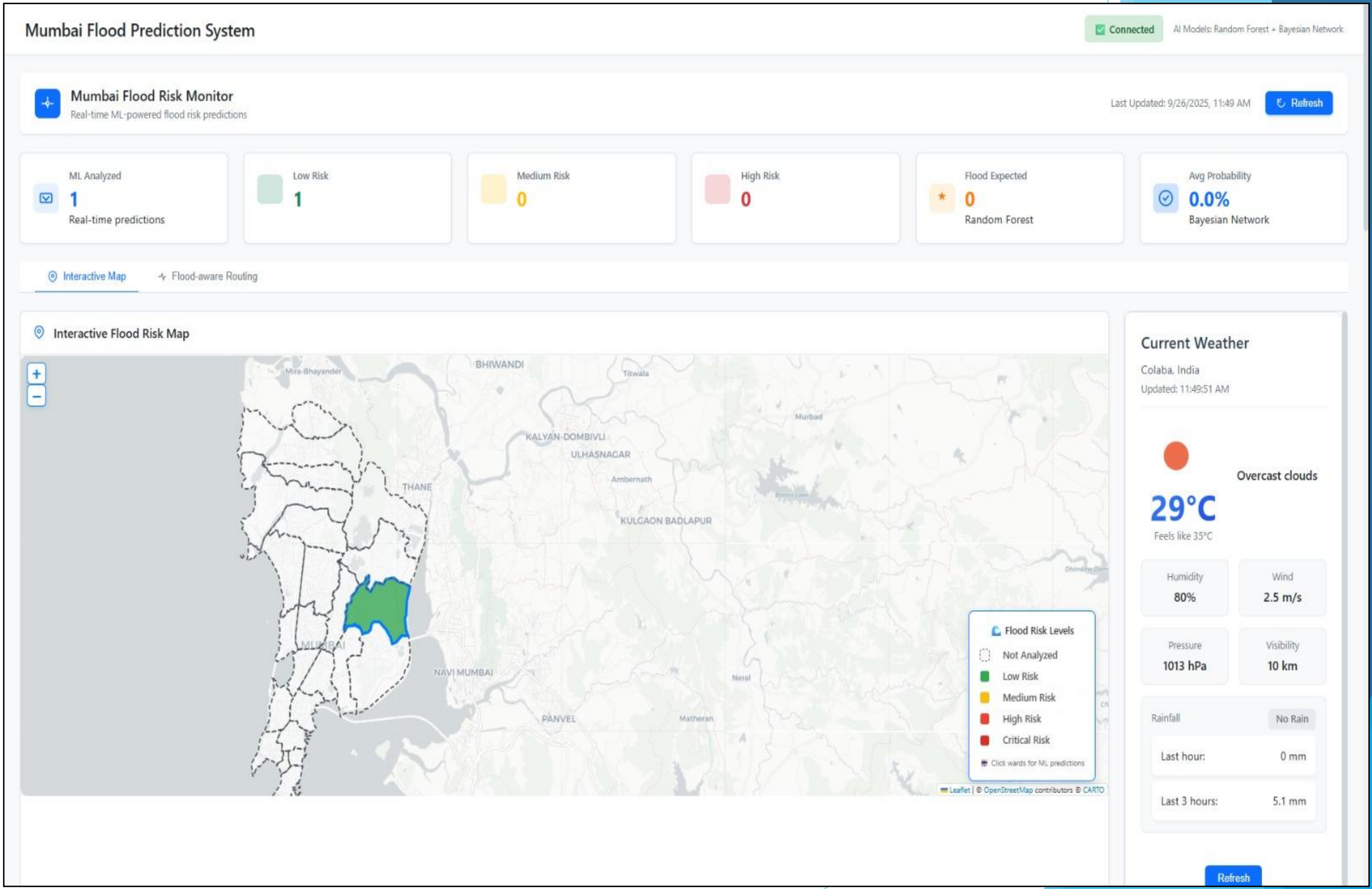
3. No predictive intelligence – Systems fail to combine rainfall, tide, elevation, and historical patterns into a probabilistic flood model.

4. Limited support for decision-making – Citizens and emergency services do not have tools for safe route planning or targeted resource allocation.

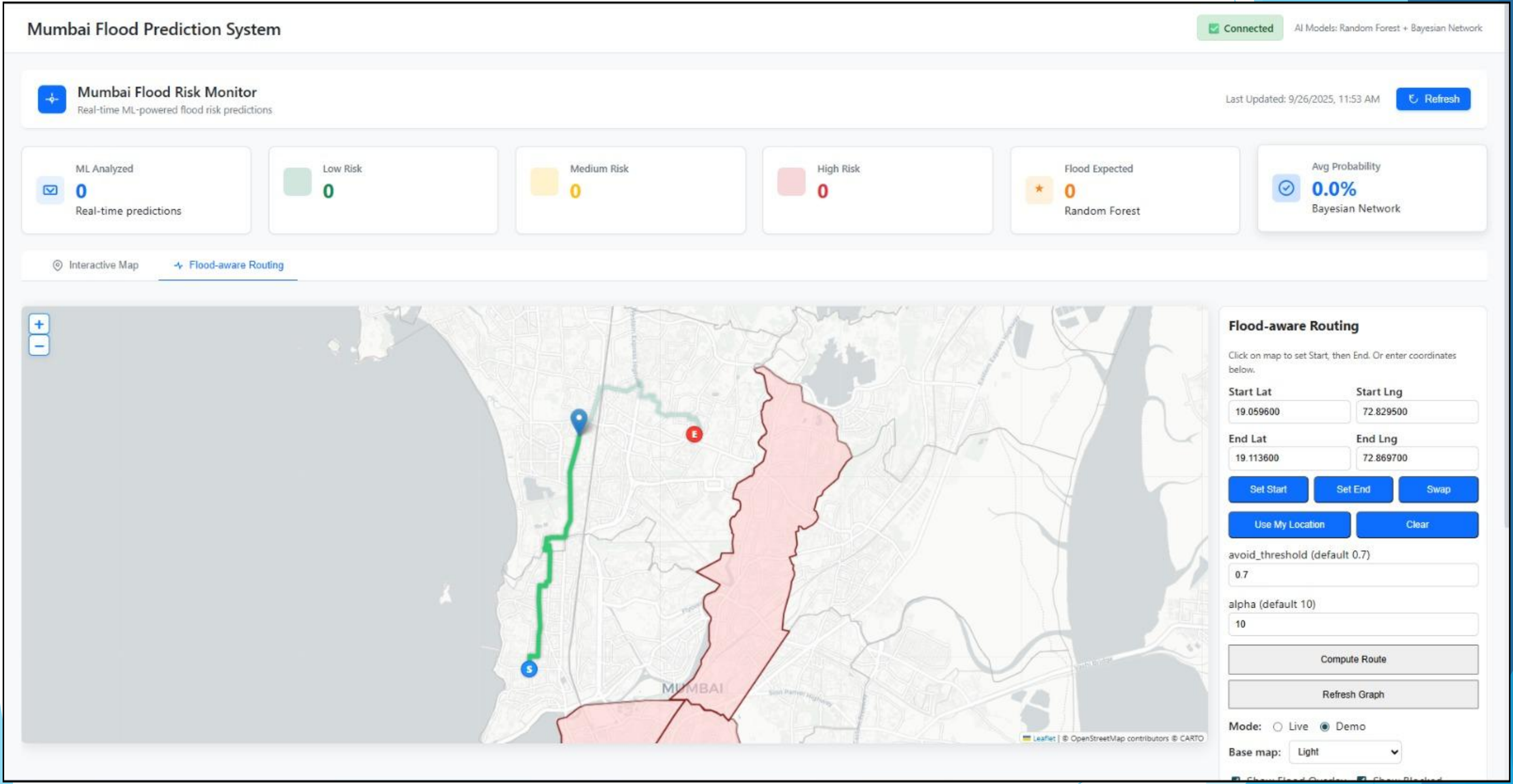
System Design – Architecture Diagram



Implementation – Main Dashboard



Implementation – Flood Aware Routing



Technologies and methodologies

Frontend:

• React.js: Builds dynamic, component-based UI.

• Leaflet.js: Displays interactive maps for flood-prone areas.

• Charts.js: Shows rainfall, water levels, and prediction trends.

Backend:

• FastAPI / Flask: Handles API requests, serves data, supports real-time processing.

• Scikit-learn: Machine learning models for flood risk prediction.

Methodology:

• Data Collection & Preprocessing: Rainfall, water levels, geographic data.

• Modeling: Train flood prediction models with Scikit-learn.

• API Development: FastAPI/Flask serves predictions and RESTful APIs.

• Frontend Visualization: React + Leaflet for maps, Charts.js for trends.

• Integration: Real-time data flow from backend to frontend.

Technologies and methodologies

Algorithms

- Random Forest (Classification): Predict flood risk levels.
- KMeans (Clustering): Identify high-risk zones.
- Bayesian Network: Model dependencies between rainfall, tides, and flooding.
- A* Seach Algorithm : Find optimal evacuation routes during floods.

Datasets

- Rainfall Data: opendatacity.in
- Rainfall Live Data: OpenWeatherMap API
- Ward Boundaries: GeoJSON files for mapping and zoning.

Conclusion

The **SmartFlood Mumbai: AI Risk Mapping using Bayesian Network** provides real-time, ward-level flood predictions and safe route guidance. By combining live data, machine learning, and predictive analytics, it helps citizens, emergency services, and planners make informed decisions, improving flood preparedness and urban resilience.

References

[1] Tripathy, S.S., Chaudhuri, S., Murtugudde, R., Mhatre, V., Parmar, D., Pinto, M., Zope, P.E., Dixit, V., Karmakar, S., & Ghosh, S. (2024). **"Analysis of Mumbai floods in recent years with crowdsourced data."** *Journal of Hydrology and Hydromechanics*, 72(1), 95-108. https://www.sciencedirect.com/science/article/abs/pii/S2212095524000117

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[6] OpenCity, "Mumbai Wards Map," Mumbai Open Data Portal. [Online]. Available: https://data.opencity.in/dataset/mumbai-wards-map. [Accessed: Dec. 26, 2024].

[7] OpenCity, "Mumbai Rainfall Data," Mumbai Open Data Portal. [Online]. Available: https://data.opencity.in/dataset/mumbai-rainfall-data. [Accessed: Dec. 26, 2024].

Thank You...!!