Bytexl's guided project Final

Project report

Name of the educator	Guranna Gouda
Project title	AI Based Urban Planning
Tools / platforms used	Colab, VS-code, Python, TensorFlow, Keras, Scikit-learn, Streamlit

Title: AI Based Urban Planning

About the Project :

AI-Based Urban Planning uses smart technology like artificial intelligence (AI) to make cities better, safer, and more efficient. The project aims to use AI to help plan and manage city spaces in a way that solves problems like traffic, pollution, and overcrowding. By using data and smart systems, cities can grow in ways that make life easier and more enjoyable for everyone living there.

System Requirements:

- **Software:**
  - Programming Language: Python 3.8+
  - Key Libraries:
  - Machine Learning: Scikit-learn, TensorFlow/Keras, geopandas, osmnx, urbansprawl, streamlit ,pydeck ,reportlab,matplotlib, geopandas , folium
  - Data Visualization: Seaborn , Matplotlib, plotly.
  - Geospatial Data Analysis: geopandas
  - Web Framework: Streamlit (for API and deployment)
  - Development Tools: Visual Studio Code or PyCharm, Git for version control
- **Hardware:**
  - CPU: Multi-core processor (Intel i7/i9, AMD Ryzen 7/9)
  - RAM: 32 GB or more (64 GB recommended for large datasets)
  - Storage: 1 TB SSD (NVMe) + 2 TB HDD for data storage
  - Network: High-speed internet (1 Gbps or more)
  - Backup: External backup drives or cloud storage (AWS, Google Cloud)
  - (Optional) GPU: NVIDIA GPUs (RTX 3000 series or Tesla) for deep learning tasks

Functional Requirements:

- Data Collection & Integration: Collect real-time data from IoT devices, sensors, and city systems (e.g., traffic, pollution).
- Geospatial Analysis: Visualize and analyze city maps, zoning, and environmental data to aid urban planning.
- Machine Learning & Prediction: Use AI models to predict traffic patterns, energy usage, and future city needs.
- Real-Time Monitoring & Alerts: Track urban systems in real-time and send alerts for issues like traffic jams or pollution spikes.

- User Dashboard: Provide an interactive dashboard for displaying key metrics, insights, and reports.
- Security: Ensure data privacy and secure access to sensitive urban data.

User Interface Requirements:

The User Interface should provide an intuitive, interactive dashboard for real-time monitoring of drone-captured data, with easy access to visualizations, analysis reports, and alerts for critical urban areas. It should allow customizable views, historical data access, and role-based user controls for efficient decision-making.

Inputs and Outputs:

- **Inputs:** Users can input data via CSV uploads for historical data or real-time random generation for live data, with the option to manually enter parameters through the login page.
- **Outputs:** The system analyzes input data to identify patterns in areas like traffic, air quality, and water usage, providing insights for better city management. It calculates key statistics (mean, standard deviation) and visualizes **before-and-after AI impacts** On Urban Planning.geospatial analysis, showing improvements and optimizing city planning decisions.

List of Subsystems:

1. Data Collection: To gather real-time and historical data from various sources like IoT sensors, drones, and APIs.
2. Data Processing: To clean, preprocess, and prepare data for further analysis.
3. Machine Learning: To apply predictive models for urban trend forecasting and optimization.
4. Geospatial Analysis: To work with maps, spatial data, and geographic information for better urban planning.
5. Simulation & Optimization: To simulate various urban planning scenarios and find optimal solutions.
6. User Interface: To provide an easy-to-use dashboard for interacting with the system, viewing data, and reports.
7. Alert & Notification: To send notifications for any critical urban conditions, such as pollution or traffic issues.
8. Reporting: To generate reports and visualizations that help in decision-making.

Applications in Other Contexts:

AI-Based Urban Planning technologies can be applied across various fields like environmental monitoring, smart agriculture, disaster management, and healthcare by using drones, IoT sensors, and predictive analytics to optimize resources, improve efficiency, and make data-driven decisions. For example, AI can forecast traffic patterns, manage public health data, or optimize energy consumption in smart cities, offering solutions for diverse industries.

Designing of Test Cases:

Test Case: Data Upload (CSV Input**)**

- **Input**: A valid CSV file with traffic data (timestamps, traffic density).
- **Expected Output**: Data is successfully uploaded, parsed, and displayed without errors

Test Case: Real-Time Data Generation

- **Input**: Trigger random generation of real-time traffic and air quality data.
- **Expected Output**: The system generates valid, realistic data, which updates in real- time on the dashboard.

Test Case: Geospatial Visualization

- **Input**: Load geospatial data (city zoning, roads, land use).
- **Expected Output**: Map displays with accurate overlays; users can zoom, pan, and filter areas.

Test Case: Machine Learning Prediction

- **Input**: Historical traffic data for a city (traffic density over time).
- **Expected Output**: AI generates accurate traffic predictions with low error margins when compared to actual traffic data.

Test Case: User Role Access Control

- **Input**: Login as Admin, Planner, and Analyst with different permissions.
- **Expected Output**: Admin has full access, while Planner and Analyst have restricted access to reports and data.

Test Case: Alert Notification System

- **Input**: Simulate traffic congestion exceeding a threshold.
- **Expected Output**: System sends an instant alert to the user dashboard and via email.

Test Case: Report Generation

- **Input**: Select traffic and pollution data for the past month and generate a report.
- **Expected Output**: A report is generated with accurate data visualizations and analysis.

Test Case: System Performance Under Load

- **Input**: Upload multiple large datasets or simulate high-frequency real-time data.
- **Expected Output**: The system processes data without crashes or significant lag

Future Work:

The future work for the AI-Based Urban Planning project will focus on expanding data integration, including real-time sources like smart sensors and external APIs, to enhance decision-making. Key developments will include improving AI models for more accurate traffic and environmental predictions, adding mobile app support for easier access, and implementing predictive maintenance to monitor city infrastructure. The system will also introduce citizen engagement tools for public feedback, ensure scalability to handle data from large cities, and explore collaborations with governments and NGOs to promote sustainable urban planning.

References:

1. Zhou, Y., & Yang, Y. (2021). Artificial Intelligence in Urban Planning: A Review. *Journal of Urban Technology*, 28(1), 1-18. https://doi.org/10.1080/10630732.2021.1878405
Kumar, A., & Singh, P. (2020). Predictive Analytics for Smart Urban Mobility. *Transportation Research 2. 2. Part C: Emerging Technologies*, 118, 102769. https://doi.org/10.1016/j.trc.2020.102769
3. Boulanger, P., et al. (2019). AI for Smart Cities: Applications and Challenges. *IEEE Access*, 7, 118481-118494. https://doi.org/10.1109/ACCESS.2019.2932411
4. Jiang, X., & Zhang, L. (2022). Integrating Machine Learning into Urban Air Quality Management. *Environmental Science & Technology*, 56(12), 7535-7545. https://doi.org/10.1021/acs.est.1c05895
5. Gonzalez, A., et al. (2020). Urban Green Spaces: An AI-Driven Approach. *Urban Forestry & Urban Greening*, 56, 126843. https://doi.org/10.1016/j.ufug.2020.126843
6. Li, H., & Wu, J. (2021). Data-Driven Approaches to Urban Density Management. *Sustainability*, 13(4), 2147. https://doi.org/10.3390/su13042147
7. Patel, R., & Gupta, S. (2018). Smart Transportation Systems: Leveraging AI Technologies. *Journal of Transportation Engineering*, 144(9), 04018066. https://doi.org/10.1061/JTEPBS.0000190
8. Niu, S., & Zhou, H. (2020). AI and Crime Prevention in Urban Areas. *Criminal Justice Review*, 45(3), 263-284. https://doi.org/10.1177/0734016818801545
9. Wang, T., et al. (2022). Optimizing Waste Management through AI. *Waste Management*, 137, 106-114. https://doi.org/10.1016/j.wasman.2021.11.010
10. Chen, L., & Huang, M. (2021). Enhancing Urban Resilience with AI

Reflection of the Project Creation:

1. Technical Challenges Encountered:
   - Data Integration and Quality: Managing diverse data sources with varying formats and incomplete information was challenging.
   - Real-Time Data Processing: Ensuring the system could handle and process continuous data streams efficiently.

2. How Existing Software Engineering Knowledge Helped Me:
   - Problem Solving and Debugging: My troubleshooting skills allowed me to quickly identify and fix issues with data consistency and model accuracy.
   - Version Control: Git helped me manage code changes, track progress, and collaborate smoothly.

3. Benefits Gained from the Project:
   - Practical Application of Knowledge: The project allowed me to apply AI and data analysis tools like GeoPandas, OSMnx, and UrbanSprawl for urban planning tasks.
   - Enhanced Spatial Analysis Skills: Working with geospatial libraries improved my ability to manipulate and visualize geographic data effectively.

4. Additional Knowledge I Gained While Working with this Project:
   - Advanced Geospatial Analysis: A deeper understanding of GIS would have enhanced map integration and spatial analysis.