**Synthetic City: Simulating Urban Growth and Dynamics.**

**Project Overview**

**Objective**: Create a Python-based simulation to generate synthetic data representing the growth and dynamics of a virtual city. Use the data to visualize urban development, population movement, and infrastructure expansion in an engaging way.

### **Project Components**

#### **1. Data Generation: City Growth Simulation**

* **Generate a City Map**: Creating a grid or geospatial map where each cell represents a city block.
  + Using **NumPy** to create a matrix for land type (residential, industrial, commercial, parks, etc.).
  + Simulate terrain (e.g., rivers, hills, and flatlands) using **Perlin noise** from the noise library.
* **Population Growth**:
  + Initializing starting populations for residential blocks.
  + Simulate population growth using random factors (birth rates, migration) and events (economic booms, natural disasters).
* **Infrastructure Expansion**:
  + Add transportation networks (roads, railways).
  + Using graph libraries like **NetworkX** to model and optimize traffic flow.

#### **2. Dynamic Events**

* Add real-world-inspired dynamic events:
  + Randomized economic changes (e.g., gentrification, industrial booms).
  + Natural disasters (e.g., floods, earthquakes).
  + Policy decisions (e.g., building parks, zoning regulations).

#### **3. Data Storage**

* Storing simulation data over time using:
  + **Pandas** DataFrames for tabular data.
  + JSON/CSV for exporting simulation states.

### **Data Visualization**

#### **1. Animated City Map**

* Using **Matplotlib** and **Seaborn** to visualize city maps at different time intervals.
* Incorporate animations using **Matplotlib.animation** or **Plotly** for interactive maps.

#### **2. Interactive Dashboards**

* Creating an interactive dashboard with **Dash** or **Streamlit**:
  + Display key metrics (e.g., population, pollution, GDP).
  + Show graphs of population growth, traffic density, etc.
  + Include a slider to explore historical data over time.

#### **3. Data Insights**

* Visualizing correlations:
  + Heatmaps of land usage vs. population density.
  + Trends of city growth over time.
* Analyzing the effects of policy changes or disasters on city dynamics.

**Unique Features**

1. **Customizable City Parameters**: Which allows users to tweak variables (e.g., initial population, land distribution).
2. **Random Seeds**: Generating unique cities every time based on random seeds.

### **My Stretched Goals**

* **Machine Learning**: Train models to predict future city growth or optimize infrastructure placement.
* **Augmented Reality**: Visualize the city in 3D using **PyVista** or Unity (via Python bindings).
* **Integration with Real Data**: Combine synthetic data with real-world city data for comparison.

**Made By**

***Muhammad Nafiu***