Seismic Globe: 3D Visualization of Global Earthquake Activity (2020–2024)

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Abstract

Seismic Globe is an interactive 3D visualization tool that maps global earthquake activity from 2020 to 2024. The system fetches near-real-time seismic data from the USGS Earthquake API, processes it using Python's scientific stack, and renders an animated globe with magnitude-scaled markers color-coded by depth. The project serves as both an educational tool for geoscience and a template for geospatial data visualization.

1 Technical Overview

The system architecture comprises three core components:

1.1 Data Acquisition

- Fetches M5.0+ earthquakes from USGS API (2020–2024)
- Implements automatic retry logic for API failures
- Caches data locally as CSV for offline analysis

1.2 Visualization Engine

- Plotly-based 3D globe rendering
- Dynamic marker scaling: $size = 2^{magnitude}$
- Depth-based colormap (0-700km: blue to red gradient)

1.3 Animation Pipeline

- 360° rotation at 12 frames per second
- Imageio-based MP4 encoding
- Configurable resolution (default 1920×1080)

2 Installation

2.1 Prerequisites

Listing 1: System requirements

```
Python >= 3.8
GPU with WebGL support (recommended)
```

2.2 Setup

Listing 2: Installation commands

```
git clone https://github.com/zafariabbas68/Seismic-Globe.git
cd Seismic-Globe
pip install -r requirements.txt
```

3 Usage Workflow

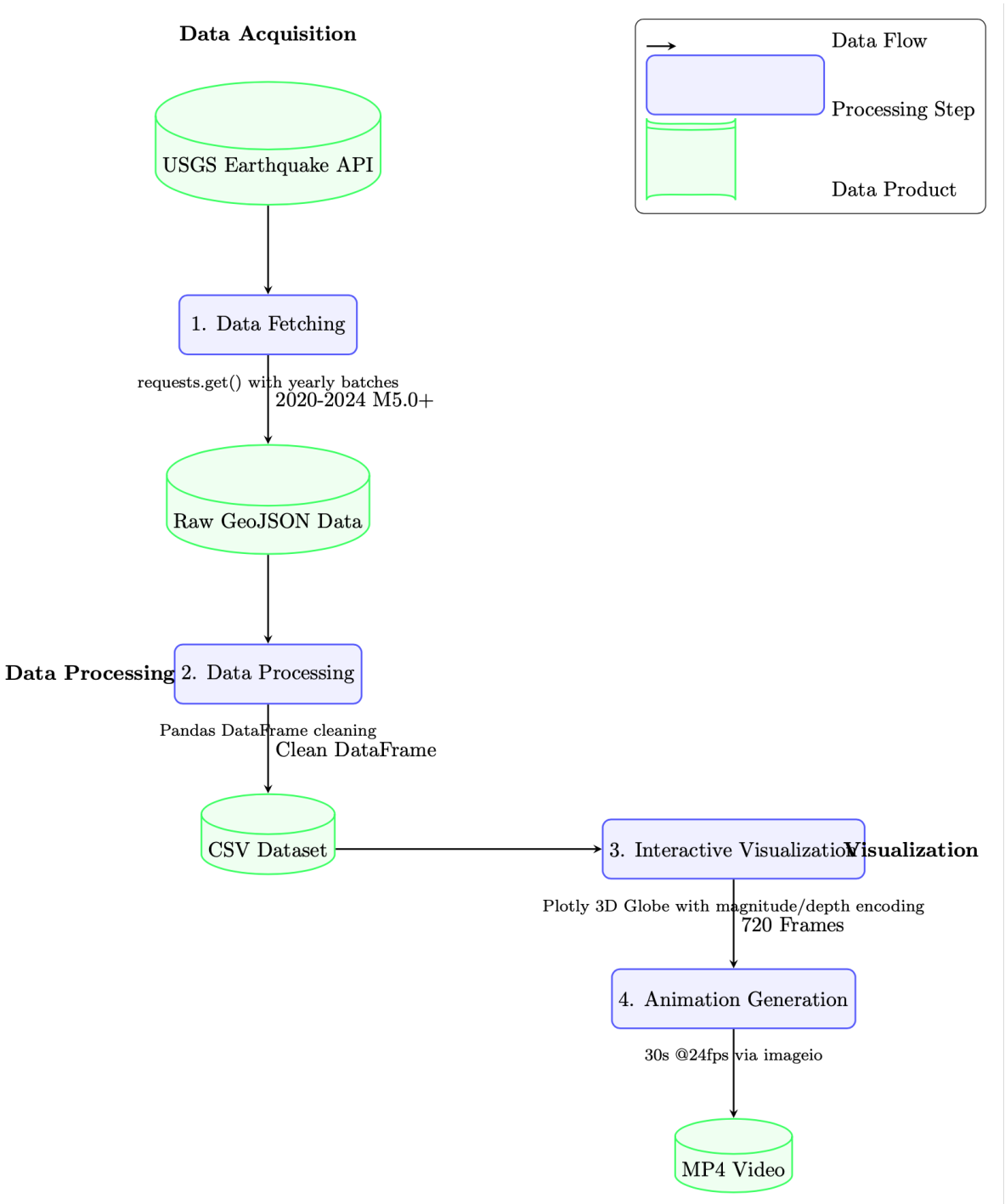

Figure 1: Workflow diagram

Figure 2: Seismic Globe data processing pipeline

3.1 Data Fetching

Listing 3: USGS API query

```python
import requests

url = "https://earthquake.usgs.gov/fdsnws/event/1/query"
params = {
    "format": "geojson",
    "starttime": "2020-01-01",
    "endtime": "2024-12-31",
    "minmagnitude": 5.0
}
response = requests.get(url, params=params)
```

3.2 Interactive Visualization

Key visualization parameters:

- `marker_size`: $base\_size \times 2^{magnitude-5}$
- `color_scale`: Viridis gradient normalized to 0-700km depth
- `rotation_speed`: 0.5° per frame

4 Output Samples

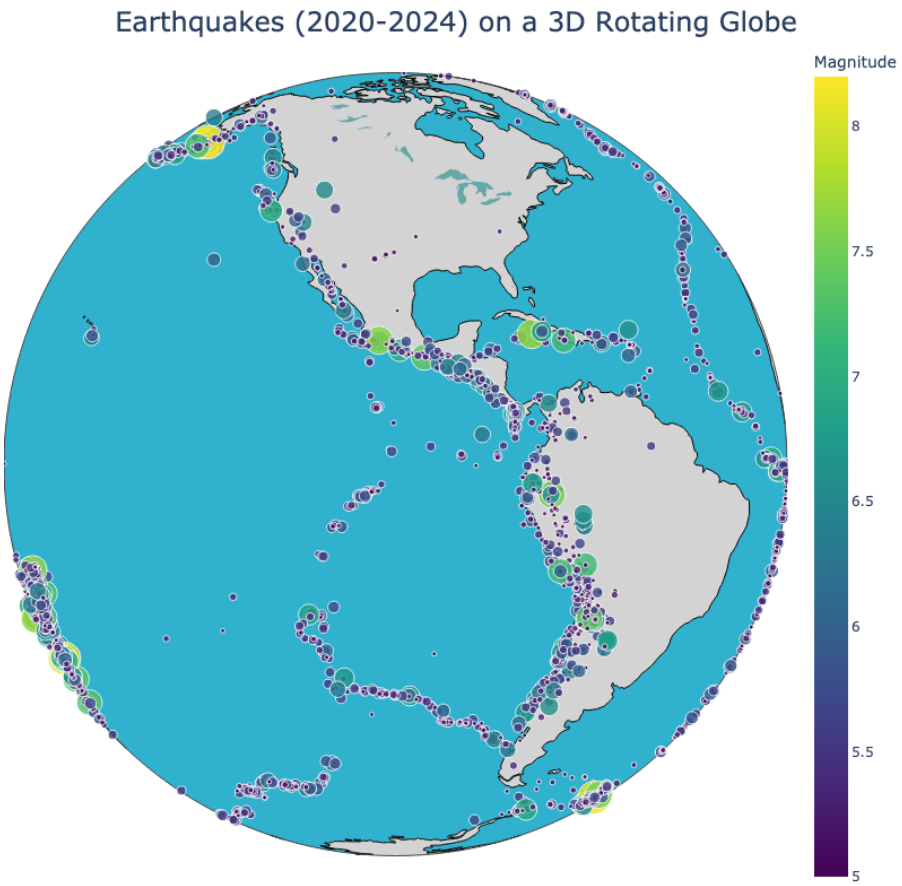

Figure 3: Enter Caption

5 Performance Metrics

Metric	Value
Data fetch time (2020–2024)	2.3s ± 0.4s
Globe render time (initial)	1.8s
Animation generation (30s @24fps)	4m22s
Final MP4 filesize	18.7MB

Table 1: System performance characteristics

6 Technical Specifications

6.1 Data Schema

- `time`: ISO 8601 timestamp
- `latitude`/longitude: WGS84 coordinates
- `depth`: km (0–700)
- `mag`: Richter scale (5.0–9.5)
- `place`: Nearest geographical feature

6.2 File Structure

```
Seismic-Globe/
 data/                    # Raw GeoJSON backups
 frames/                  # Animation frames (PNG)
 outputs/                 # Rendered videos
 src/
    api_handler.py       # USGS data fetcher
    globe_builder.py     # Plotly visualization
    animation.py         # Frame rendering
 earthquake_data.csv      # Processed dataset
```

7 Applications

- **Seismology Education**: Visualizing plate tectonics
- **Disaster Preparedness**: Identifying high-risk zones
- **Journalism**: Interactive data stories
- **Research**: Spatial-temporal pattern analysis

8 Extensions and Future Work

- Real-time data streaming
- Historical comparison mode
- Tsunami risk overlay
- VR/AR compatibility

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- Python Scientific Computing Ecosystem

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