DC Presentation

Natural Disaster Prediction Using ML Techniques

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Introduction

Natural disasters such as floods, tornadoes, earthquakes, and forest fires pose significant threats to human life, infrastructure, and economic stability. In response to the growing frequency and severity of these events, our project aims to develop robust AI-based prediction models to enhance early warning systems and disaster preparedness.

Machine learning (ML) enables pattern recognition and predictive analytics through the analysis of large-scale historical and real-time data. By leveraging these capabilities, we can forecast the likelihood, intensity, and location of natural disasters, allowing authorities to plan and respond more effectively.

We have trained and evaluated machine learning models tailored to each disaster type, achieving promising results:

- **Flood Prediction**: 71.95% accuracy
- **Wildfire Detection**: 84% accuracy
- **Tornado Prediction**: 83% accuracy
- **Earthquake Prediction**: 78.53% accuracy

These models leverage multi-source data including weather patterns, satellite imagery, geophysical indicators, and temporal trends to enable real-time risk assessment. Our system demonstrates the potential of AI in mitigating the socio-economic impacts of natural disasters by enabling timely evacuations, reducing casualties, and minimizing property losses. This work underscores the critical role of predictive technologies in building disaster-resilient communities and supporting sustainable development in high-risk regions.

This is Our GitHub repository, where you can find codes for these models.

1. Impacts of Natural Disasters

Natural disasters pose severe threats to human life, infrastructure, and economies across the globe. Our project focuses on four high-impact natural disasters: **floods**, **tornadoes**,

earthquakes, and **forest fires**. Each of these disasters has caused significant loss of life and economic disruption in recent decades. Understanding their impact emphasizes the importance of developing advanced prediction systems.

1.1 Floods

Social Impact: Floods displace millions each year, destroy homes, contaminate water supplies, and spread waterborne diseases. Vulnerable populations often suffer the most due to lack of resilient infrastructure.

Economic Impact: According to the World Bank, floods account for 43% of all recorded disaster events and cause nearly **$40 billion** in annual global economic losses.

Real-world Example:

- **2014 Southeast Europe floods** affected Bosnia, Serbia, and Croatia, displacing over half a million people.
- **2022 Pakistan floods** submerged a third of the country, affecting 33 million people and causing damages exceeding **$30 billion**.

1.2 Tornadoes

Social Impact: Tornadoes often strike with little warning, resulting in high fatalities and injuries. Communities face trauma, homelessness, and long-term mental health issues.

Economic Impact: Tornadoes cost the U.S. alone an average of **$10 billion annually**, mainly due to property and infrastructure damage.

Real-world Example:

- **Joplin, Missouri (2011):** An EF5 tornado killed 158 people and caused **$2.8 billion** in damages — one of the deadliest tornadoes in U.S. history.
- **Kentucky tornado outbreak (2021):** A rare December event killed 90+ and devastated multiple counties.

1.3 Earthquakes

Social Impact: Earthquakes cause sudden, massive casualties and infrastructure collapse, often leaving survivors in dire conditions. The societal disruption may take years to recover.

Economic Impact: Global earthquake-related losses in the past two decades have averaged over **$14 billion annually**, with some events causing far greater damage.

Real-world Example:

- **2010 Haiti Earthquake:** Over 220,000 dead, 300,000 injured, and **$8 billion** in damages.
- **2011 Japan Tōhoku Earthquake & Tsunami:** Magnitude 9.0 quake killed 15,000+, and led to the Fukushima nuclear disaster, costing over **$235 billion**.

1.4 Forest Fires

Social Impact: Wildfires destroy homes, forests, and biodiversity, release harmful smoke affecting respiratory health, and cause mass evacuations.

Economic Impact: In 2020, wildfire damages in the U.S. alone surpassed **$16.5 billion**, with global losses rising due to climate change.

Real-world Example:

- **Australia Bushfires (2019-2020):** Burned 18 million hectares, killed 3 billion animals, and caused **$100+ billion** in losses.
- **California Wildfires (2020):** Over 4 million acres burned, thousands of homes destroyed, and **$12 billion** in insured losses.

2. Need for Predictive Models

With climate change increasing the frequency and intensity of natural disasters, **predictive models have become essential** tools for disaster preparedness and risk mitigation.

2.1 Flood Prediction Models

Justification: AI-driven flood prediction models utilize real-time weather data, satellite imagery, and hydrological parameters to forecast flood events. These models enable:

- **Timely evacuations**
- **Infrastructure protection**
- **Smart water management**

Benefits:

- In 2022, early warning systems in Bangladesh reduced flood-related deaths to one-tenth compared to similar events in the 1980s.
- Google's Flood Forecasting Initiative now covers 60+ countries and issues alerts to millions.

2.2 Tornado Prediction Models

Justification: Tornadoes develop rapidly, often within minutes. AI models using Doppler radar, atmospheric data, and image recognition can provide faster, more accurate warnings.

Benefits:

- Machine learning systems can now reduce false alarms and detect tornadoes **minutes earlier**, improving survival chances.
- In a recent NOAA trial, AI-enhanced forecasts provided a 5–7 minute earlier warning lead time compared to traditional models.

2.3 Earthquake Detection Models

Justification: Although precise long-term prediction is still elusive, **early warning systems** based on AI seismology can detect P-waves seconds before destructive shaking (S-waves) arrive.

Benefits:

- In Japan, the **EEW (Earthquake Early Warning)** system sends alerts seconds before strong shaking, saving thousands of lives annually.
- AI models trained on seismic waveforms can now **differentiate between real quakes and false signals** with >95% accuracy.

2.4 Forest Fire Detection Models

Justification: AI models using satellite imagery, temperature data, and vegetation indices can detect hotspots and predict fire spread dynamics.

Benefits:

- AI-powered platforms like **FireGuard** and **FIRMS** help detect fires in early stages, often before they spread uncontrollably.
- In California, predictive modeling helped PG&E cut power preemptively, preventing further wildfire ignitions.

3. Models and Its Results

Models	Accuracy
Flood Prediction	71.95%
Tornado Prediction	83%
Earthquake Prediction	78.53%
Wildfire detection	84%

3.1 Model Overview and Justification

Each disaster type required a unique modeling approach:

- **Flood Prediction**: Support Vector Regressor (SVR) and Decision Tree Regressor were used due to their strength in handling continuous input variables like rainfall and river flow.
- **Tornado Prediction**: A combination of Logistic Regression, Decision Tree, Random Forest, and K-Nearest Neighbors (KNN) helped classify atmospheric conditions to predict tornado formation.
- **Earthquake Prediction**: SVM, Multiple Linear Regression, Naive Bayes, and Random Forest were applied to seismic waveform and geolocation data to improve early detection.
- **Wildfire Detection**: Convolutional Neural Networks (CNNs) processed satellite imagery to identify heat signatures, dryness index, and vegetation patterns for hotspot detection.

Our model selection focused on balancing accuracy with interpretability, ensuring that emergency services can trust and act upon predictions.

4. Conclusion

Developing AI-based predictive models for floods, tornadoes, earthquakes, and forest fires is **not only scientifically valuable but socially imperative**. These models:

- Save lives through early warning systems
- Enable informed decision-making for emergency services
- Protect infrastructure and minimize economic losses

- Enhance global resilience to the growing threat of natural disasters

As climate risks intensify, **investing in and deploying predictive technologies at scale is our strongest line of defense**.