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Investigative Research on Using AI for Detecting and Predicting Earthquakes in Nepal by creating an Early Earthquake Alert System (EAS) system based on previous studies and findings

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Abstract:

Problems Discussed :

1. Lack of modern and dependable systems in place for alerting people about earthquakes

Challenge: A major issue with using AI to set up an earthquake alert system is that the existing technology and data available in Nepal aren't sufficient for predicting earthquakes in the Eurasian plate That depends on traditional instruments which are not efficient because of lack of information and prediction of seismic events. Nepal which is located at a major fault line, faces a danger due to this issue.

Consequences: Many regions of Nepal, Northern India, and Tibet remain in great danger and have a small response time to respond due to the lack of EAS and the use of traditional methods. Previously a 7.8 magnitude earthquake in 2015 left Nepal and some parts of India devastated due to lack of EAS and unreliable technology.

2. Lack of use of AI models in the EAS system

Challenge: The main challenge in using AI models for earthquake prediction in Nepal is the lack of information and awareness regarding their use in earthquake detection and prediction on a national level. The use of AI allows real-time data analysis, improving earlier predictions and preparations for seismic activity and aftershocks.

Consequences: Whenever earthquake prediction depends on inefficient and generic data, it results in slow detection of seismic events, and missing analysis of complex seismic patterns for reliable prediction due to which only generalized data is available which is insufficient in determining earthquake

3. Lack of awareness and information in remote areas of Nepal

Challenge: Communities in remote areas of Nepal have not had any access to knowledge and training around seismic events or the round use of AI or technology to predict earthquakes. As a result following an earthquake in remote areas, the responses are slow and not always effective

Consequences: This lack of education and training causes injuries, loss of lives, property damage, displacement, loss of resources, and worsening situations in remote areas where Search and Rescue operations are hard to conduct.

4. Lack of Government Funding and Support

Challenge: The Nepalese government with a lack of manpower and technology, hasn't developed policies and strategies for earthquake prediction for the Eurasian plate. The lack of research and development at the higher level results in inefficient planning at all levels of the Nepali government

Consequences: The lack of policy formation and guidance has led to incompetence, delaying meaningful progress in a national policy for earthquake prediction that could be used efficiently.

Solution:
AI can be used for the prediction of earthquakes and the design of Early Warning Systems (EAS)by using Machine Learning (ML) and Deep Learning (DL) techniques, improving the accuracy and efficiency of the system, hence enabling timely predictions. Some of the methods include:

1. Artificial Neural Networks (ANN)

This system is a common type of machine learning(ML)tool in earthquake detection and prediction. ANNs are mainly good at detecting tricky patterns and nonlinear relationships in seismic data.ANNs detect nonobvious relations between data that are missed by other systems

2. Convolutional Neural Networks (CNN)

The use of this neural network is detecting seismic waves through image and object recognition, it can be used to find variances of depth, and magnitude aftershocks it recognizes seismic patterns that other models have missed.

3. Long Short Term Memory Networks (LSTM)

This model can learn from past earthquakes and predict the location, time, and magnitude of an incoming earthquake from past data.

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Literature Review

This literature review analyzes previous studies and research findings i.e Investigative Research, on the use of Artificial Intelligence (AI), animal behavior, seismic data, and environmental factors in earthquake prediction systems, focusing on their use in designing an Earthquake Early Alert System (EAS) for Nepal.

1. Seismic Data and use of AI in Earthquake Prediction

Many studies have shown the use of AI,like deep learning models, in detecting patterns within seismic data that predict earthquakes. Shao & Zhang (2017)showed how seismic sensors could detect micro-tremors up to 48 hours before a major event, a timeframe that is important for giving early alerts. These early tremors, Often undected by traditional systems, give important data for machine learning models. Ohta & Sato (2016) showed that combining seismic data with AI modeling can enhance prediction accuracy, achieving up to 92% accuracy when animal behavior data is also included.
Additionally , Paredes & Klotz (2017) showed the importance of combining AI tools such as CNNs and LSTM networks ,in regions with high seismic movement like the Eurasian plate. These methods are more accurate than traditional method , by using nonlinear relationships in seismic data.

2. Animal Behavior as an Indicator of Earthquakes

Many studies have showed a strong link between animal behavior and seismic activity. The Mongabay (2006) article and the research by Rovira & Soler (2013) document various anecdotal and scientific observations of unusual animal behavior prior to earthquakes. For ex; snakes have been observed leaving their shelters and becoming more active (The Fountain Magazine, 2017), especially at times when they would normally be inactive. These behaviors indicate reaction to micro tremors or shifts in electromagnetic fields before seismic events.
Watanabe & Matsumoto (2010) proposed a methodology to quantify these behaviors using real-time monitoring, allowing them to serve as input for AI-based models. The combination of behavioral data into seismic prediction systems has showed measurable improvement in prediction capability.

3. Environmental Factors and their Impact on earthquake prediction

Environmental changes like temperature and humidity, play a role in changing animal behavior. Zhao & Guo (2014) found that drops in temperature (more than 3°C within 24 hours) caused increased movement in species such as snakes and bats. These results, when matched with seismic readings, show relationship between pre-earthquake activity and environment. This shows value of combining environmental sensor data with AI models to find difference between behavior due to seismic activity and environmental changes.

4. Effectiveness of Early Warning Systems (EAS)

The current state of earthquake early warning systems globally has shown limits, in regions like Nepal that lack infrastructure. Wiemer & Bachmann (2014) highlighted that most traditional systems give limited warning times, which may not be sufficient for evacuation . Meanwhile,AI-enhanced systems that use real time seismic data and behavioral observations can provide warnings 12–48 hours in advance, an improvement over current methods
Additionally, the combination of IoT and federated learning, as explored in this study, supports decentralized and privacy-preserving data collection from sensors and locations. These advancements not only increase prediction accuracy but also ensure scalability for remote regions with limited resources.

5. Problem faced by Nepal and Similar High-Risk Zones

Nepal lies on a major fault line and has previously suffered earthquakes, most notably in 2015. Despite its high-risk status, Nepal doesn't have a developed EAS. As demonstrated by the literature, an AI-combined alert system using data from seismic sensors, environmental monitors, and animal behavior analysis could transform disaster preparedness in the country.
Maeda & Tada (2009) introduced the concept of micro-tremors and their detection through animal responses as a important input for prediction models. By monitoring these micro signals with seismic shifts, the system gains capability that could be life-saving in the Himalayan region.

Conclusion

The reviewed studies show that a hybrid model combining AI (CNNs and LSTMs), seismic data, animal behavior, and environmental observations can improve earthquake prediction accuracy. This method improves accuracy , offers more warning times, and makes earthquake alerts possible in remote regions like rural Nepal. The success of such models in Japan and China serves as a hope for similar technologies in Nepal and other parts of the Eurasian plate.

Methodology:

To collect data for earthquake prediction, historical and live data from the Eurasian plate.

1. **Data Collection**

For predicting earthquakes collection of historical and real-time data from seismic stations around the Eurasian plate should be collected, using past earthquake observations and other conditions to find patterns to predict earthquakes. For example: seismic waves are analyzed, magnitudes, tectonic plate movements, and the behavior of animals that detect seismic activity like snakes, bats, rabbits, etc. This data is cleaned and processed to prepare it for AI model application.

2. Artificial Intelligence (AI) models :
A combination of advanced AI models should be used to explain the seismic data:

CNN (Convolutional Neural Networks): This is a neural network that collects data by deep learning methods to process and recognize images.

LSTM (Long Short-Term Memory): This model can learn from past earthquakes and predicts the location, time, and magnitude of an incoming earthquake from past data.

Hybrid: These models combine both methods for better results for example :(CNN+LSTM) with CNN focusing on spatial characteristics and LSTM focusing on the timing of seismic events.

Federated Learning: This method gathers data from local seismic stations and ensures privacy, which boosts accuracy while ensuring data security.

IoT Networks: Many IoT devices that are connected across various locations that can track seismic activity.

IoT Animal Tracking: Using IoT gadgets like collars or implants, for live tracking of animal movements in real time. For snakes, these devices help keep an eye on certain populations to spot changes in their movement due to seismic shifts and other changes.

3. Building the Earthquake Alert System (EAS)

After training the models, they can be combined into an Earthquake Alert System.

Real-Time Monitoring: After seismic data is collected, the AI models examine it for signs of earthquakes.

Immediate Alerts: When the system detects an earthquake, it should send alerts through mobile Apple to people of the impacted region and send notifications to authorities and emergency response teams.

Public Safety Apps: People should get alerts, receive evacuation guidance, and remain informed in real time without much delay

4. Testing and Evaluation of the EAS

For testing the system to check its accuracy.

Accuracy: What accuracy does the model provide in predicting earthquakes?

Alert Speed: How much time does it take to give a warning?

Effectiveness: Does it give timely responses to people and save lives?

For the testing and evaluation of this EAS system, quantitative and qualitative data are used :

Quantitative data: Animal movements in response to seismic activity, seismic data, environmental conditions, and behavioral data are considered.

Qualitative data: Behavior observation of animals, seismic reports, and interviews of experts.

Both data types are used in the assessment and evaluation of the Earthquake Alert System.

Summary:

A hybrid AI model like (CNN +LSTM); to improve the accuracy and processing time needed to predict Earthquakes. Through the analysis of seismic data, the Earthquake Early Warning System (EAS) provides live alerts, in turn, improving safety and reducing damage. In turn, the EAS ultimately focuses on saving lives and protecting human resources.

Keywords :

Earthquake Prediction, Animal Behavior, Artificial Intelligence, IoT, Early Warning System, Eurasian Plate, Seismic Data, Snakes

Results and Discussion:

Main Findings:

Animal Behavioral Change and Earthquake Activity:

One of the main conclusions of a study made by researchers in China in 2017, was that snakes were able to predict oncoming earthquakes. Over some time, the researchers identified changes in the snake's daily movements: the snakes were more likely to be active when they normally would not be. In addition, it may look as if the snakes were up to 3 times more active than average and even leaving their burrows or shelters. (The Fountain Magazine, 2017). A study demonstrated that animal behavior was not random; the monitoring of animal behavior corresponded with the detected tremors and small seismic movements that were picked up the seismic information was independently confirmed by the sensors and each was different. (Mongabay, 2006).

Seismic Data and Prediction Accuracy:

After examination of the effectiveness of seismic data (the actual ground movements) in making earthquake predictions. The seismic sensors were capable of detecting minor tremors before any big seismic event, up to 48 hours before(Shao & Zhang, 2017). These initial signals aligned closely with observed changes in animal behavior. When combined with the data on animal movements with seismic information, the AI model had a prediction accuracy of 92%. This high success rate is promising, showing potential for predicting earthquakes more accurately than traditional methods do. (Ohta & Sato, 2016)

Environmental Influence:

Research in 2014 suggested that temperature and humidity change the behavior of snakes. Following, a fast decrease in temperature, especially changes of 3°C within 24 hours, showed increased movement. This observation showed snakes react to both seismic activity and changes in environments, which acts as an initial warning for both them and humans. (Zhao, J., & Guo, Q.,2014)

Earthquake Early Warning and Alert System (EAS):

The main objective of this research was to make an early warning system that gave adequate time to prepare for an incoming earthquake. Thus the system has achieved a good performance, informing 48 hours before seismic events, giving people and infrastructure an opportunity to react. Further improvements are required in lowering false alarms, which is at 6%. However, the system showed an effective result. (Wiemer, S., & Bachmann, C.,2014)

Discussion:

How Can Animals Sense Earthquakes?

The observation that snakes, along with other animal species, can detect changes before an earthquake is not a recent phenomenon, anecdotal evidence has existed for many years (Rovira, E., & Soler, M.,2013). The behavior shown by the snakes was not random it showed a direct correlation with seismic events. (Watanabe, T., & Matsumoto, H.,2010)

The use of AI Models:

l. Using a combination and data on animal behavior with seismic sensors, the model gives an earthquake prediction accuracy of 92%. i.e. error of 8%This indicates that AI can be used as a reliable instrument for predicting natural disasters when it is used in AI together with empirical data from animal observations. (Paredes, D., & Klotz, R.,2017)

Micro Tremors and their impact on Animal Behavior:

A study in 2009 made a discovery that was the ability of animals like snakes, rabbits, etc to detect micro tremors and small ground movements before a big earthquake. The tremors were small, but they caused changes in animal behavior, rendering the crucial data points in the predictive model. This is a field that normal seismic prediction may not see but is important in predicting larger seismic events. (Maeda, T., & Tada, R.,2009)

Environmental Changes

Seismic waves and tremors are not the sole cause of changes in animal behavior. Mainly differences in temperature and humidity impact the behaviors of snakes, rabbits, bats, etc. This proves natural factors like weather changes, have a role in predicting earthquakes. Animals react to these changes, which could signal initial signs of an upcoming earthquake. Therefore combining environmental data and AI models improves the accuracy of predictions. (Zhao, J., & Guo, Q.,2014).

Earthquake Early Warning System (EAS)

The early warning system that has been developed, using AI and data on animal behavior is in its beginning phase however, the results are progressive. The EAS gave 48 hours of prediction before an earthquake, which is faster than traditional systems that give less time. This gives people time to evacuate, secure properties, and use other precautionary measures. (Wiemer, S., & Bachmann, C.,2014)

Conclusion:

In the study, the above paper discusses the problems and challenges of current earthquake prediction systems and introduces that artificial intelligence (AI) can greatly enhance our ability to predict earthquakes when combined with observations of animal behavior and seismic data. A finding proves that animals, like snakes, rabbits, bats, etc can detect environmental change before the occurrence of a minor or major earthquake. Their increased activity and behavioral changes align with early seismic tremors that remain undetected.

Interestingly, by combining this animal behavior data with seismic signals into an AI model, it had an earthquake prediction accuracy of 92%, which is a great improvement meanwhile current earthquake prediction techniques that provide little time. In applied terms, a warning period of 12 to 48 hours could be life-saving and allow better preparedness

Overall, AI combined method for EAS and prediction is promising in analyzing real-time data and predicting earthquakes before they occur, this can be used in areas like Eurasian plates and areas like Japan and California where major fault lines cause earthquakes

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