SNOWSENTRY: AVALANCHE PREDICTION SYSTEM

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ABSTRACT

An avalanche can be described as a mass of snow, rocks, ice and soil that slide down a mountainside and cause immense destruction and loss of life and property. Snow Sentry has been conceived with the aim of developing a robust AI oriented approach towards the prediction and mitigation of avalanches.

The advent of Deep Learning can truly revolutionize disaster aversion and mitigation strategy. Timely forecasts of impending natural calamities can save lives and minimize damage. In this project we propose a comprehensive Deep learning approach that can automate the prediction of avalanches and alert users in advance. Our project leverages three Deep Learning models (timeseries model, computer vision model, and a classification model) to accurately predict the time and location of avalanche occurrence. This helps in accurately pinpointing the accurate location, time and nature of the avalanche.

The system also entails a SMS alert system that alerts users in case the model has detected the probability of a avalanche occurrence

INTRODUCTION

Avalanches pose a growing risk, demanding precise and real-time solutions. Current approaches lack accuracy, impacting safety decisions.

The Snow Sentry project addresses this gap by integrating machine learning models for personalized, location-specific avalanche risk assessments. Our aim is to empower individuals, resorts, and authorities with reliable information, fostering better-informed decision-making and improving safety outcomes in avalanche-prone areas.

The proposed Snow Sentry system is a sophisticated and user-centric solution designed for the early detection and mitigation of avalanches.

Leveraging cutting-edge ML models, including timeseries forecasting, classification, and computer vision, the system offers personalized avalanche risk assessments based on individual user locations. The integration of weather data, satellite imagery, and user-specific details ensures a comprehensive and accurate evaluation of avalanche hazards.

Users, ranging from individuals engaging in outdoor activities to mountain resorts, transportation agencies, emergency responders, and researchers, will benefit from the system's ability to provide real-time, location-specific information on avalanche risks. The user interface, implemented through a Flask-based website, offers an intuitive and accessible platform for users to access tomorrow's predicted weather, receive timely avalanche warnings via SMS notifications, and view areas predicted to be affected by avalanches.

The system's core features include robust database management, periodic retraining of machine learning models, and seamless integration with external services such as Twilio for SMS notifications and satellite imagery providers. Snow Sentry aims to set a new standard in avalanche risk management, contributing to the safety and well-being of individuals and organizations operating in avalanche-prone environments.

LITERATURE SURVEY

1. “A neural network model for automated prediction of avalanche danger level”

In this paper, Singh et. al explores neural networks and Random forests method for accurately predicting the occurrence of an avalanche. They achieved 79.75% accuracy.

2. Choubin, Bahram, et al. "Snow avalanche hazard prediction using machine learning methods." Journal of Hydrology 577 (2019): 123929.

Snow avalanche modeling in this study was done using three main categories of data, including avalanche occurrence locations, meteorological factors, and terrain characteristics.

3. Iordache, George, et al. "Algorithms and parameters for avalanche prediction-a review." 2021 13th International Conference on Electronics, Computers and Artificial Intelligence (ECAI).

This paper gives an overview of the various AI paradigms, avalanche prediction parameters and reviews the already present approaches.

4. Kaur, Prabhjot, Jagdish Chandra Joshi, and Preeti Aggarwal. "A multi-model decision support system (MM-DSS) for avalanche hazard prediction over North-West Himalaya." Natural Hazards

This paper introduces a new multi-model system (MM-DSS) combines four models for improved accuracy in the Himalayas.MM-DSS shows promising results with high detection rates and moderate skill scores for up to 3-day forecasts.

5. Hendrick, Martin, et al. "Automated prediction of wet-snow avalanche activity in the Swiss Alps." Journal of Glaciology (2023):

This study tackles the challenge of predicting wet-snow avalanches, which lack sufficient understanding for traditional process-based models, by implementing a data-driven random forest model based on real-world data and observations. The model demonstrates strong performance in both nowcast and 24-hour forecast modes, offering valuable decision-making tools for avalanche risk management.

6. Yang, Jinming, Qing He, and Yang Liu. "Winter–spring prediction of snow avalanche susceptibility using optimisation multi-source heterogeneous factors in the Western Tianshan Mountains, China."

In this paper, Support Vector Machine, Random Forest, and K-Nearest Neighbour models are built to predict avalanche hazard based on these factors. It separates and analyzes the impact of factors like terrain, snow depth, and weather on avalanches in winter and spring.

7. Aaron, Jordan, et al. "Probabilistic prediction of rock avalanche runout using a numerical model." Landslides 19.12 (2022)

This research analyzes 49 Canadian rock avalanches, identifies key factors (volume, fall height, topography) influencing runout, and develops a computer tool (PRE-RA) for estimating impact probability aiding in risk mitigation.

8. Pérez-Guillén, Cristina, et al. "Data-driven automated predictions of the avalanche danger level for dry-snow conditions in Switzerland."

This research developed data-driven random forest models using weather data and simulations to objectively predict avalanche danger in the Swiss Alps. This study demonstrates the promise of data-driven approaches in improving avalanche forecasting by bridging the gap between objective data and subjective expert judgment.

9. Joshi, Jagdish Chandra, et al. "HIM-STRAT: a neural network-based model for snow cover simulation and avalanche hazard prediction over North-West Himalaya.“

This novel system simulates snowpack characteristics like hardness, strength, and temperature using weather data collected in the Chowkibal-Tangdhar region. HIM-STRAT demonstrates good accuracy and reliability in both snowpack simulation and avalanche prediction, offering a valuable tool for risk management.

10. Akay, Hüseyin. "Spatial modeling of snow avalanche susceptibility using hybrid and ensemble machine learning techniques."

The study identified key factors for avalanche susceptibility using statistical models and combined them into susceptibility maps. This research highlights the valuable role of data and statistical models in mapping avalanche susceptibility and provides practical tools for managing risk

11. Wen, Hong, et al. "Application of machine learning methods for snow avalanche susceptibility mapping in the Parlung Tsangpo catchment, southeastern Qinghai-Tibet Plateau.“

This paper highlights the effectiveness of machine learning in mapping avalanche susceptibility and provides actionable insights for risk management in the Qinghai-Tibet Plateau and beyond. SVM emerges as the most robust model, and the maps pinpoint high-risk zones along key roads and valleys.

12. Mosavi, Amirhosein, et al. "Towards an ensemble machine learning model of random subspace based functional tree classifier for snow avalanche susceptibility mapping."

This study introduces a novel machine learning model, RSFT, to map avalanche susceptibility and compare it to established models. RSFT outperforms standard models, achieving high sensitivity, specificity, and accuracy in predicting avalanche zones and offers valuable insights for targeted mitigation efforts in Karaj Watershed and other mountainous regions.

13. Viallon-Galinier, Léo, Pascal Hagenmuller, and Nicolas Eckert. "Combining modelled snowpack stability with machine learning to predict avalanche activity.“

This research combines advanced snow simulations and stability analysis with a machine learning model to improve prediction accuracy.

14. Tiwari, Anuj, G. Arun, and Bramha Dutt Vishwakarma. "Parameter importance assessment improves efficacy of machine learning methods for predicting snow avalanche sites in Leh-Manali Highway, India”

This study utilizes a "Parameter Importance Assessment" technique to select the most relevant factors from extensive sensor data, leading to improved prediction accuracy compared to using all available parameters. This approach offers a valuable technique for optimizing machine learning methods in avalanche forecasting for saving lives.

15. Chawla, Manesh, and Amreek Singh. "A data efficient machine learning model for autonomous operational avalanche forecasting."

This paper proposes a data-efficient Random Forest model that requires less training data compared to other models. This research shows promise in advancing avalanche forecasting by incorporating objective data analysis while maintaining operational practicality.

EXISTING WORK / SYSTEM

While there isn't a single system that replicates the exact functionality of SnowSentry, there are existing systems that utilize some of the same concepts:

Machine Learning for Avalanche Forecasting: Research is ongoing in applying machine learning to avalanche forecasting. Studies explore using historical data and weather observations to train models that predict avalanche risk with improved accuracy. (https://nhess.copernicus.org/articles/23/2523/2023/nhess-23-2523-2023.pdf)

Satellite Imagery and Avalanche Detection: Satellite imagery analysis plays a role in some avalanche forecasting systems. Techniques involve identifying features like snowpack depth and slope angle in satellite images to assess avalanche risk zones. (https://www.usgs.gov/centers/norock/science/remote-sensing-tools-advance-avalanche-research)

Alert and Notification Systems: Avalanche forecasting agencies often have notification systems in place to disseminate avalanche warnings. These may involve public bulletins, targeted alerts to specific user groups, or even automated warning systems in high-risk areas.

PROPOSED WORK / SYSTEM

SnowSentry goes beyond these existing efforts by offering a more comprehensive and user-centric approach. The key points which sets SnowSentry apart are:

Real-time, User-Specific Predictions: Existing systems often rely on general forecasts for entire regions. SnowSentry personalizes the risk assessment by using a user's specific location and real-time data to predict weather and potential avalanche occurrence.

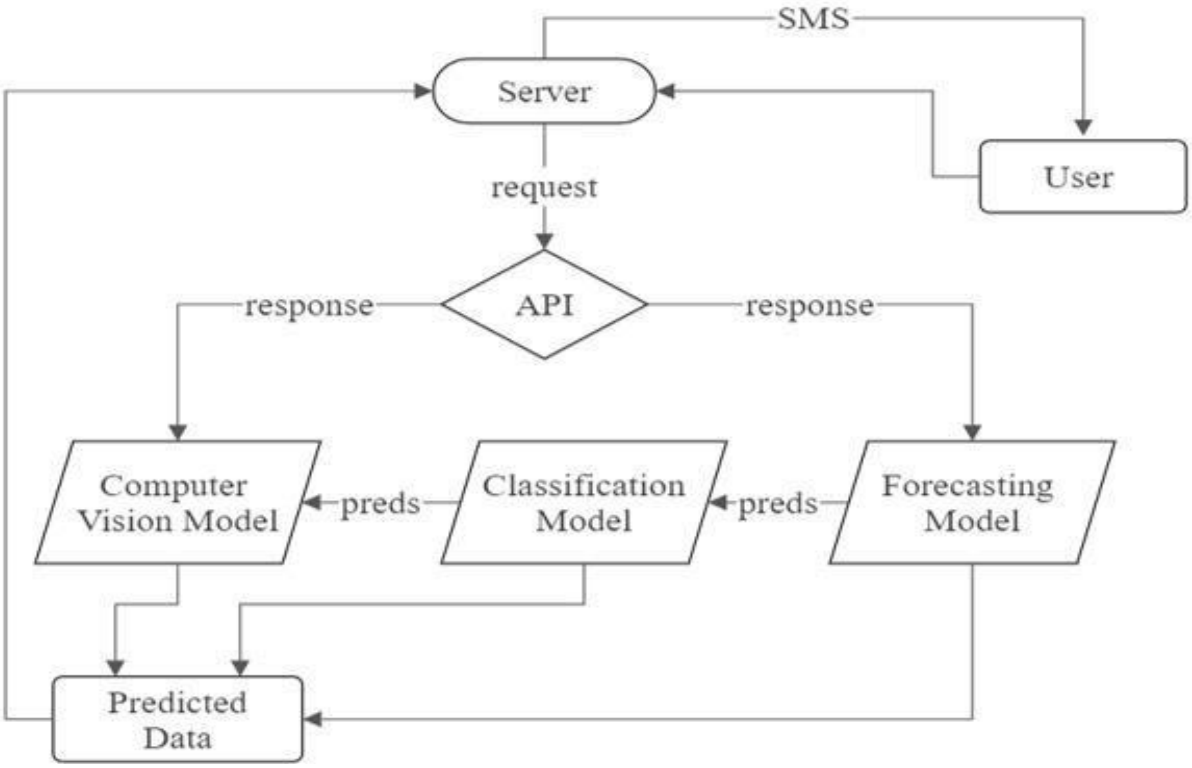
Multi-Model Analysis: SnowSentry integrates three machine learning models, each tackling a different aspect of the problem. This provides a more robust and nuanced risk assessment compared to systems that rely on a single data source or analysis method.

Impact Zone Identification: While some systems might assess avalanche risk, SnowSentry goes a step further by utilizing computer vision to identify potential areas that might be affected by an avalanche. This provides crucial information for users and rescue teams to take necessary precautions.

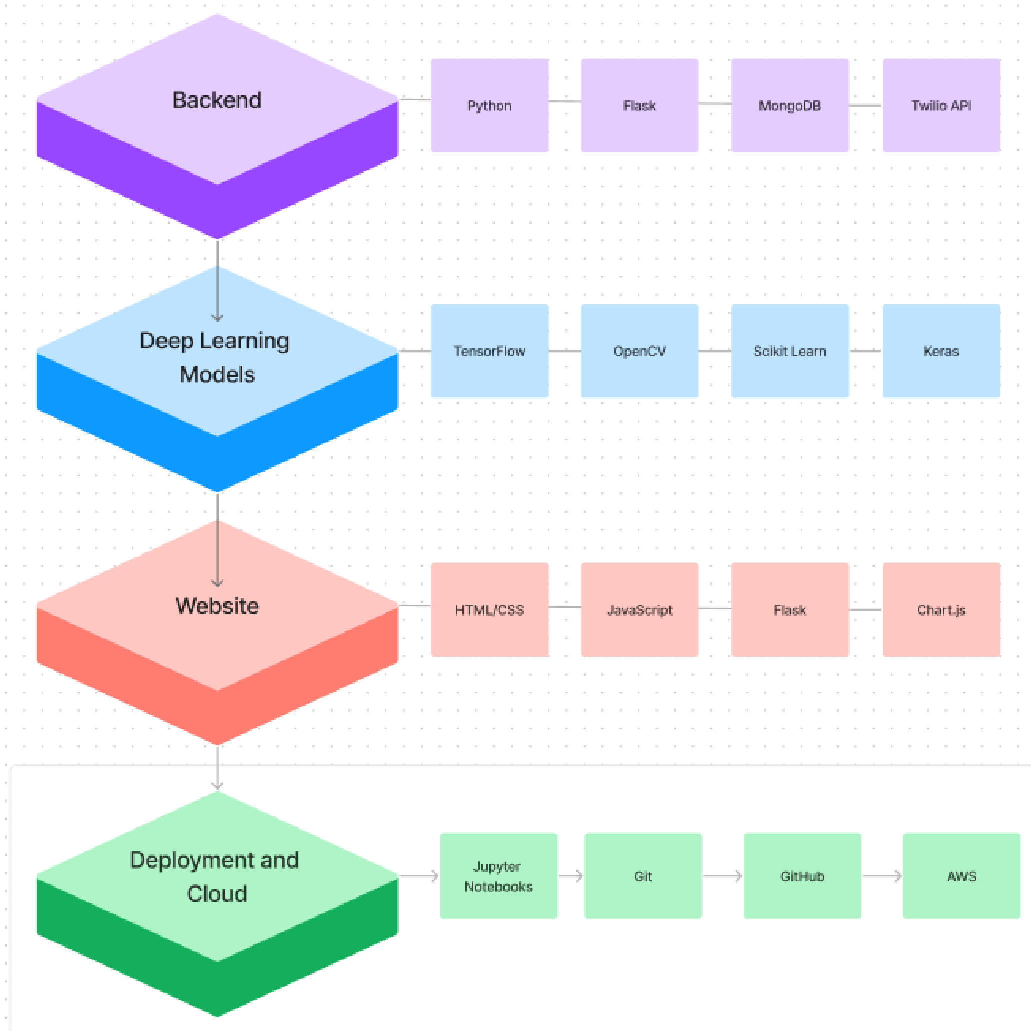
Integrated Notification System: SnowSentry seamlessly integrates real-time risk assessment with user and rescue team notification. This allows for faster and more targeted interventions in case of high avalanche risk.

By combining these elements, SnowSentry offers a more comprehensive and user-friendly system for avalanche detection and mitigation. It empowers users with personalized risk assessments and facilitates timely action by rescue teams, potentially saving lives in these dangerous situations.

SYSTEM DESIGN WORK / ARCHITECTURE OF PROPOSED SYSTEM



TECHNOLOGY STACK



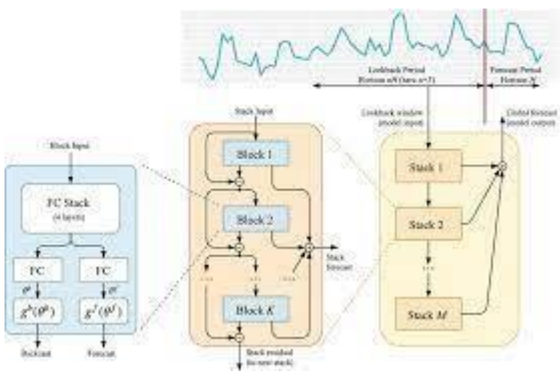
WORKING MODULES

1. Data Collection and Processing Module:

- **Sub-modules:**
  - **Location Data Collection:**
    - **Description:** Collects the user's location data through an API call from a data provider.
    - **Technology:** Python, API
  - **Weather Data Collection:**
    - **Description:** Gathers weather data for the user's location to train the timeseries forecasting model.
    - **Technology:** Python, API
  - **Satellite Image Data Collection:**
    - **Description:** Collects satellite image data with different bands to train the computer vision model.
    - **Technology:** Python, Satellite Imaging API
- **Output:** Location data, weather data, satellite image data

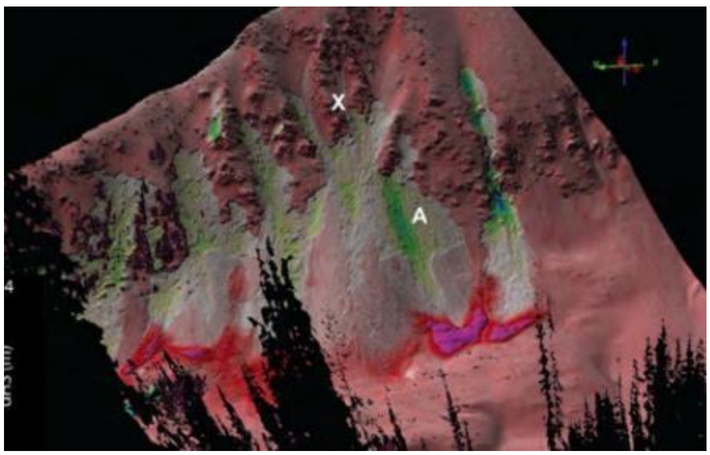
2. Timeseries Forecasting Model Module:

- **Description:** Trains the timeseries forecasting model to predict the next day's weather conditions at the user's location.
- **Technology:** Python, TensorFlow, Keras
- **Input:** Weather data
- **Output:** Predicted weather conditions



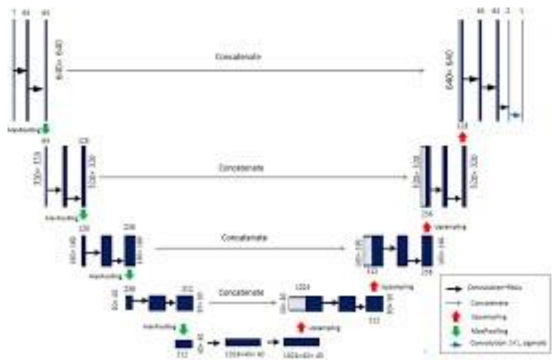
3. Classification Model Module:

- **Description:** Trains the classification model to predict whether the given weather conditions can cause an avalanche.
- **Technology:** Python, TensorFlow, Keras
- **Input:** Weather data
- **Output:** Prediction (Avalanche or No Avalanche)



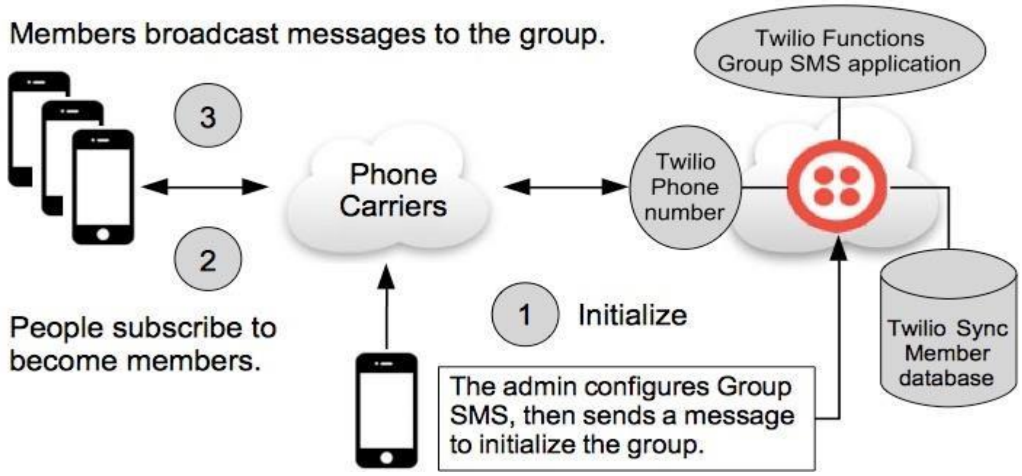
4. Computer Vision Model Module:

- **Description:** Trains the computer vision model to predict the areas that might get affected in case of an avalanche.
- **Technology:** Python, TensorFlow, Keras, OpenCV
- **Input:** Satellite image data
- **Output:** Predicted affected areas



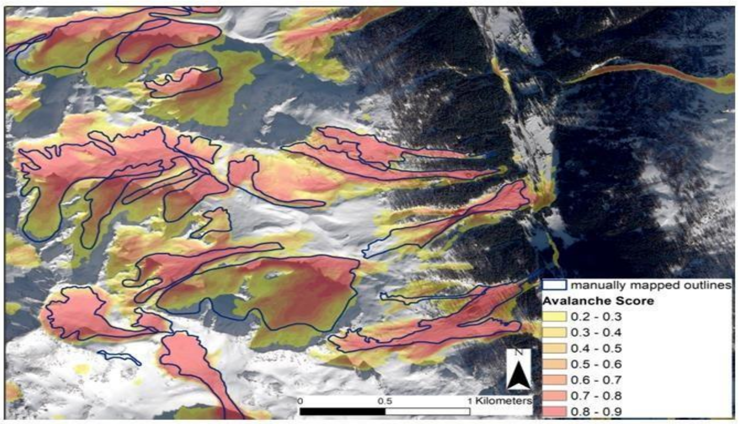
5. **Backend Module:**

- **Description:** Develops the backend services using Flask, handles user sign-in, and database management.
- **Sub-modules:**
  - **User Authentication:**
    - **Description:** Allows users to sign in using their name, phone number, and location.
    - **Technology:** Flask, MongoDB
  - **Database Management:**
    - **Description:** Stores user information and avalanche data.
    - **Technology:** MongoDB
  - **SMS Notification:**
    - **Description:** Sends SMS notifications to users and rescue teams if the models predict an avalanche.
    - **Technology:** Twilio API, Flask
- **Output:** Backend services, user authentication, database management



6. **Website Module:**

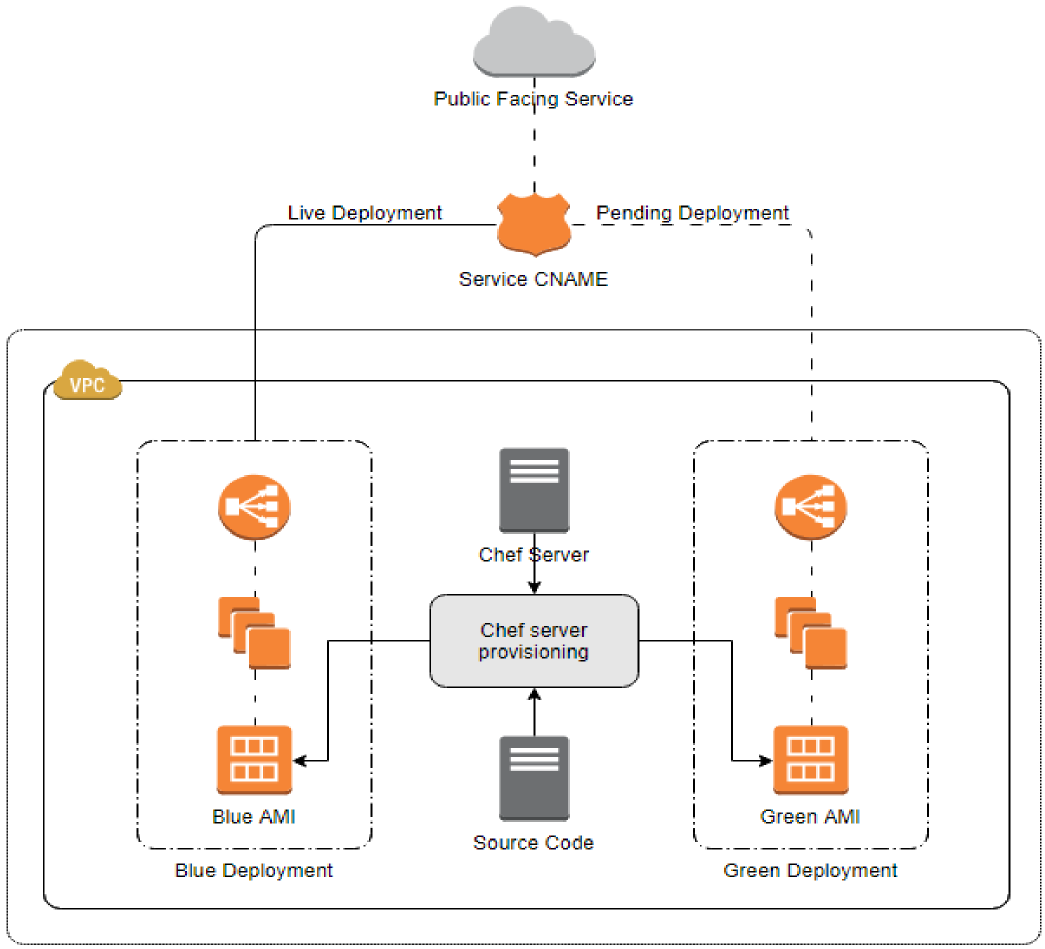
- **Description:** Develops the website to display predicted weather, emergency contact information, and avalanche-affected areas.
- **Sub-modules:**
  - **Web Interface:**
    - **Description:** Provides a user interface for accessing the system.
    - **Technology:** HTML, CSS, JavaScript, Flask
  - **Weather Display:**
    - **Description:** Displays tomorrow's predicted weather.
    - **Technology:** Chart.js, Flask
  - **Emergency Contact Information:**
    - **Description:** Displays emergency contact information.
    - **Technology:** HTML, CSS, Flask
  - **Avalanche-Affected Areas Display:**
    - **Description:** Displays the image of the avalanche-affected areas predicted by the computer vision model.
    - **Technology:** Leaflet.js, Flask



- **Output:** Deployed website with integrated functionalities

7. Deployment & Cloud Module:

- **Description:** Deploys the Flask application, machine learning models, and storage on the cloud.
- **Sub-modules:**
  - **Model Deployment:**
    - **Description:** Deploys the machine learning models on the cloud.
    - **Technology:** AWS / Google Cloud Platform / Microsoft Azure, Flask
  - **Website Deployment:**
    - **Description:** Deploys the Flask application and website on the cloud.
    - **Technology:** Heroku, AWS / Google Cloud Platform / Microsoft Azure
  - **Database Deployment:**
    - **Description:** Deploys MongoDB on the cloud.
    - **Technology:** MongoDB, AWS / Google Cloud Platform / Microsoft Azure
- **Output:** Deployed application, models, and database on the cloud platform.


Public Facing Service
Live Deployment
Pending Deployment
Service CNAME
VPC
Chef Server
Chef server provisioning
Blue AMI
Source Code
Green AMI
Blue Deployment
Green Deployment

CONCLUSION

SnowSentry presents a novel approach to avalanche detection and mitigation, leveraging the power of machine learning and real-time data analysis. By integrating three distinct machine learning models, it tackles the problem from multiple angles, offering a more comprehensive risk assessment compared to existing systems. The user-specific nature of SnowSentry provides a significant advantage, allowing it to predict avalanche risk based on an individual's location and real-time weather data.

Furthermore, SnowSentry's ability to identify potential avalanche impact zones using computer vision offers a valuable tool for both users and rescue teams. Visualizing the areas at risk can significantly aid in evacuation efforts and targeted deployment of resources in the event of an avalanche. The integrated notification system ensures timely alerts are sent to users and rescue teams, facilitating a faster response during high-risk situations. While SnowSentry demonstrates a promising advancement in avalanche detection, it's important to acknowledge the need for continuous development and refinement. Integrating additional data sources like real-time snowpack measurements and seismic activity can provide a more holistic understanding of avalanche risk.

In conclusion, SnowSentry offers a significant step forward in avalanche detection and mitigation. Its user-centric design, multi-model approach, and integration of real-time data provide a comprehensive risk assessment system. With continuous development and collaboration, SnowSentry has the potential to become a vital tool for saving lives in avalanche-prone areas. The future of SnowSentry lies in ongoing research, data integration, and collaboration, ultimately empowering users and facilitating a more coordinated response to avalanches, leading to a safer winter experience for everyone.

FUTURE WORK

SnowSentry has a strong foundation, but there's always room for improvement. Future work could focus on expanding its capabilities in several ways. Integrating additional data sources like real-time snowpack measurements and seismic activity could provide a more holistic understanding of avalanche risk. Real-time snowpack data, collected from automated sensors in avalanche-prone areas, could offer valuable insights into the stability of the snowpack, a crucial factor in avalanche forecasting. Seismic activity data could also be integrated, as tremors can sometimes trigger avalanches. By incorporating these diverse data sources, SnowSentry's machine learning models could learn to identify complex patterns and make more accurate predictions.

Further development of the computer vision model could allow it to not only identify potential impact zones but also predict the size and severity of an avalanche. This would be a significant leap forward, as it would provide crucial information for emergency responders. Imagine a scenario where SnowSentry not only alerts about an impending avalanche but also predicts its destructive path and potential force. This would allow rescue teams to prioritize areas at risk and deploy resources more effectively. Advanced computer vision techniques, such as 3D modelling and image segmentation, could be explored to achieve this level of sophistication.

A user feedback system could be implemented to refine the machine learning models over time, allowing them to learn from real-world data and improve their accuracy. Users could be prompted to provide feedback after receiving avalanche alerts, indicating whether the avalanche actually occurred and the severity if it did. This feedback data would be invaluable for training the models and ensuring their continued effectiveness. Additionally, gamification elements could be introduced to incentivize user participation in the feedback process.

Finally, exploring communication protocols with avalanche forecasting agencies could enable SnowSentry to share its predictions and contribute to broader avalanche risk assessments. Avalanche forecasting agencies play a vital role in winter safety, and SnowSentry's real-time, user-specific predictions could be a valuable asset to their operations. By establishing a two-way communication channel, SnowSentry could not only receive official avalanche bulletins but also share its own risk assessments with relevant authorities. This collaborative approach would lead to a more comprehensive understanding of avalanche risk across a wider geographical area.

By continuously refining the models, incorporating new data sources, and fostering collaboration with established organizations, SnowSentry can evolve into an even more powerful tool for avalanche detection and mitigation, ultimately enhancing winter safety for backcountry users and professionals alike.

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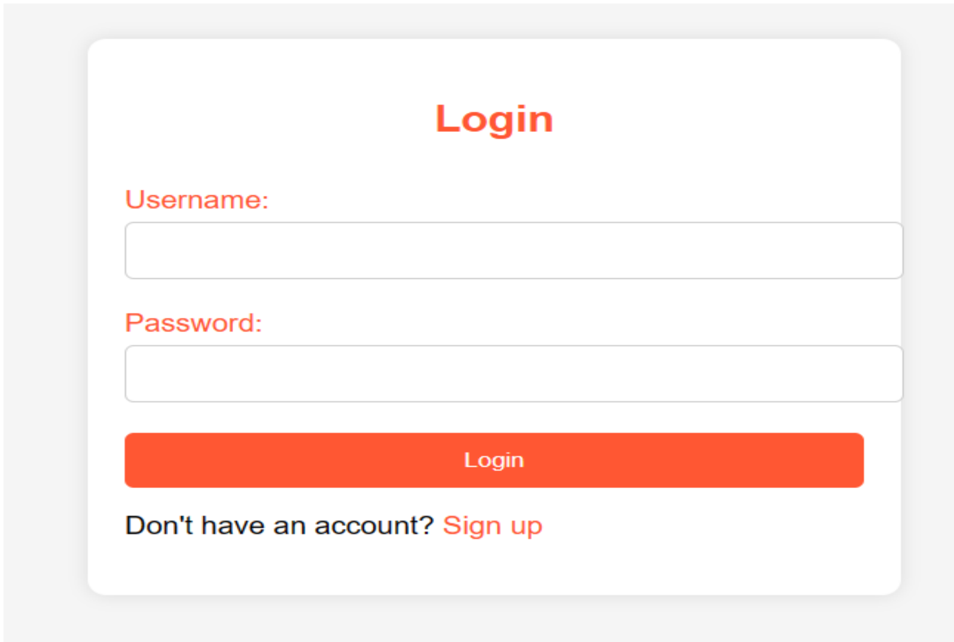
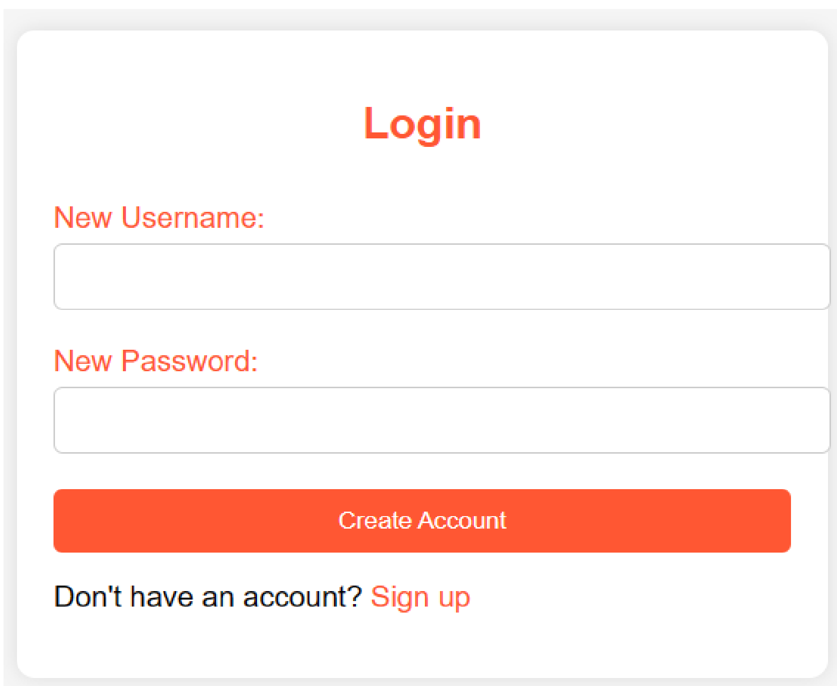
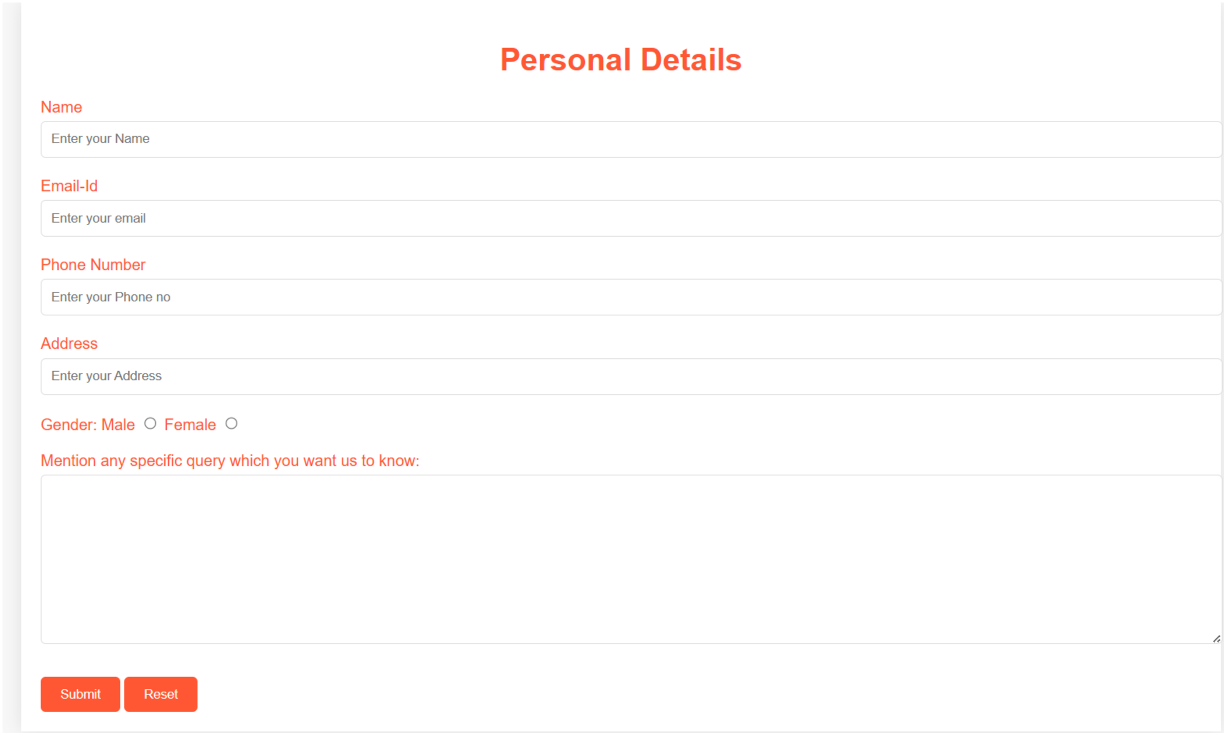
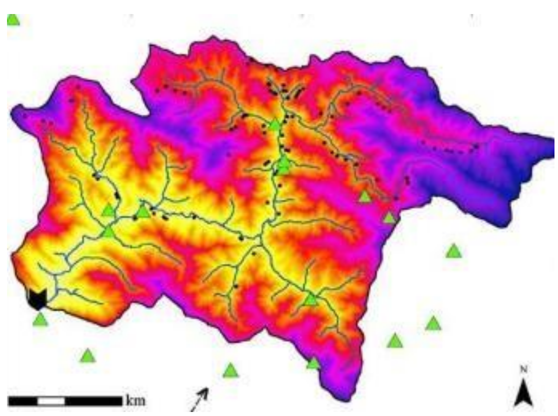
COMPLETE IMPLEMENTATION







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About
Avalanche forecaster forecastes avalanche strikes using a combination of factors and artificial intelligence and save lives and damage loss caused by this strikes.As a user of our application you can use our application to access your location and following inputs from our data collectors,we enable you with the power to foresee the chances of an avalanche occurring.
Forecasting Techniques
Disaster management is a critical use case and as responsible innovators we aim to use a number of calculations and techniques which includes a number of geographical information collected from our highly reliable and accurate sensors and satellites.After collecting these information in a secure encrypted way,it is given as input to our state of the art artificial Intelligence model which not only forecasts these parameters for the future but also classifies whether a avalanche might or might not happen for that day with a probability value.
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