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TITLE PAGE

- **Problem Statement ID -** 25071
- **Problem Statement Title -** AI-Based Rockfall Prediction and Alert System for Open-Pit Mines
- **Theme -** Disaster Management
- **PS Category -** Software
- **Team ID -** 86157
- **Team Name (Registered on portal) -** TEAM-MANTHAN

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RockGuard AI

RockGuard AI is a predictive intelligence platform that transforms mine safety by identifying rockfall hazards before they happen.

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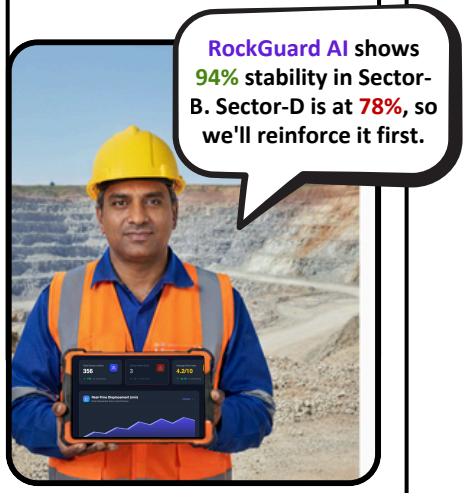
From Reactive Guesswork to Proactive Safety

The Disconnected Reality

High Risk, Unpredictable, Labor-Intensive.

RockGuard AI Solution



Predictive, Data-Driven, Automated.

- **AI-Powered Predictive Core:** An intelligent system that processes **multi-source data** to identify patterns preceding rockfall events. [👉 *Explained in Next Slide*]
- **Unified Dashboard:** An intuitive **web/mobile dashboard** for mine planners to visualize risk zones, forecasts, and sensor data.
- **Automated Alert Mechanism:** **Real-time alerts** sent via **SMS/Whatsapp** with suggested action plans to key personnel. [👉 *Shown in the right*]
- **Multi-Data Integration:** Seamlessly processes **Digital Elevation Models (DEM)**, **drone imagery**, **geotechnical sensor** data, and environmental factors. [👉 *Briefed in Next Slide*]

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TECHNICAL APPROACH

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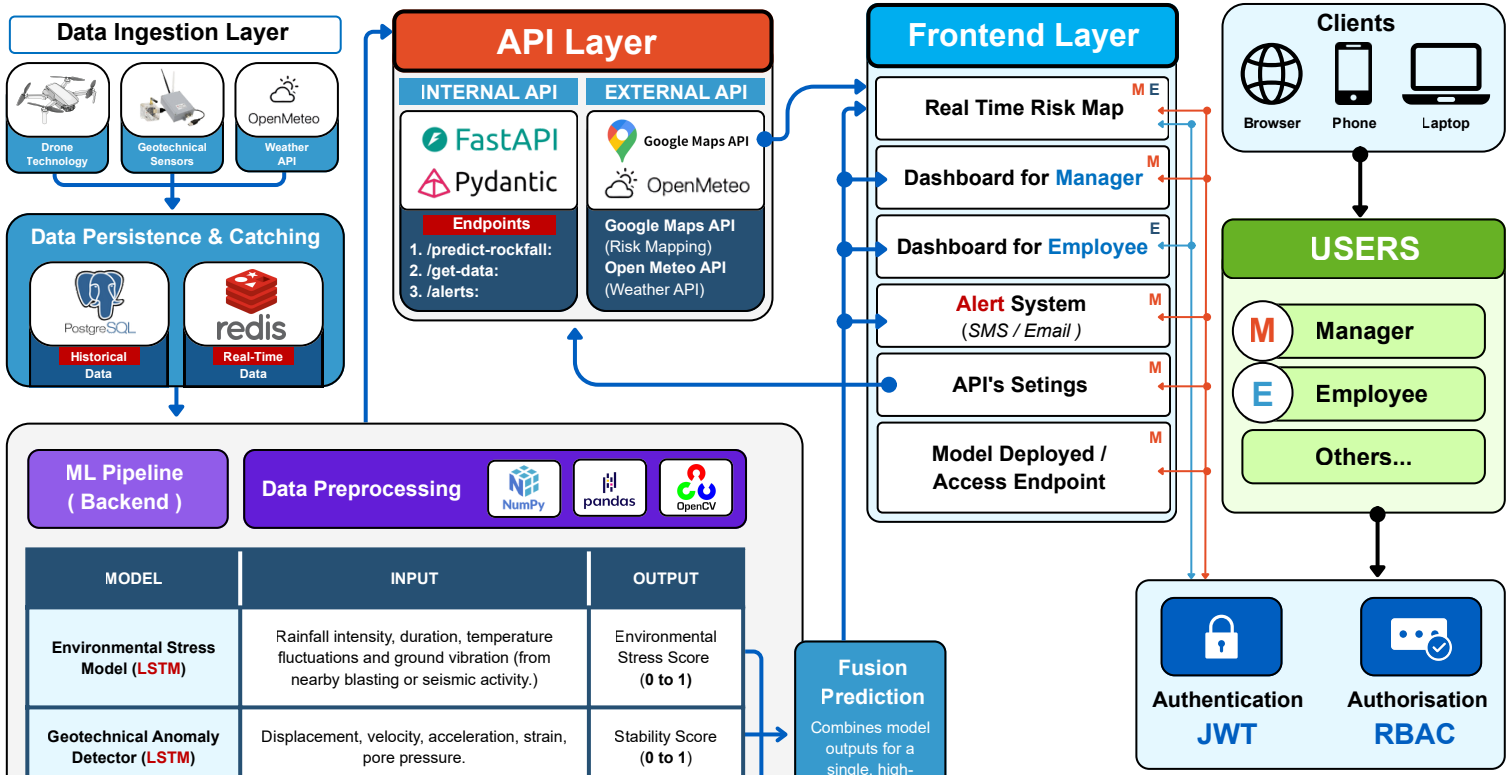
Technical Architecture



MODEL	INPUT	OUTPUT
Environmental Stress Model (LSTM)	Rainfall intensity, duration, temperature fluctuations and ground vibration (from nearby blasting or seismic activity.)	Environmental Stress Score (0 to 1)
Geotechnical Anomaly Detector (LSTM)	Displacement, velocity, acceleration, strain, pore pressure.	Stability Score (0 to 1)
Structural Vulnerability Model (DNN)	Drone-captured imagery or images of Location. Static Data: slope angle, aspect, slope direction.	Detect features like cracks, joints, faults, erosion pattern

Technical Stack

Frontend: React, Node.js, Typescript, Tailwind, Material UI, Recharts

Backend: FastAPI, Uvicorn, Pydantic

Database & Catching: PostgreSQL, Redis

ML & Data Processing: Tensorflow, PyTorch, Fast.ai, NumPy, Pandas, Scikit Learn, OpenCV

External API: Google Maps API, Open Meteo

Data Visualization: Matplotlib

Key Features

- **Role-Based Access:** Secure login for Managers & Employees with custom dashboards (e.g., Risk Maps, Task Lists).
- **AI Fusion Engine [DNN + LSTM] :** Accepts input automatically via drones, sensors, and environmental APIs or manually through the dashboard, then combines three AI models into a single, highly accurate prediction.
- **Automated Alerts:** Triggers real-time SMS & WhatsApp notifications based on AI predictions.
- **Data Architecture:** Uses PostgreSQL for core data and Redis for high-speed, real-time caching.

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FEASIBILITY AND VIABILITY

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- **Accuracy Through Data Fusion:** By combining multiple data types, our model overcomes the limitations of any single source, increasing predictive accuracy to over 90%.
- **Time-Series Analysis:** Analyzing data as continuous frames (e.g., daily sensor readings) rather than static points allows our model to detect developing trends, boosting accuracy significantly.
- **Diverse Training Data:** The model will be trained on a robust dataset (real or synthetic) covering various geological conditions, weather patterns, and mine types to ensure it is widely applicable.

Environmental Data

Geotechnical Sensors

Potential Challenges and Our Solutions:

Challenge: Real-time Data Processing Latency.

Solution: Convert the trained model to an optimized format (like TensorFlow Lite or ONNX). Use a message queuing system (e.g., RabbitMQ) and background processing threads to ensure the dashboard remains responsive.

Challenge: Scarcity of Real-World Rockfall Data.

Solution: Utilize synthetic data generation techniques by simulating rockfall events in a physics engine (e.g., using DEMs). Augment existing data by adding noise and variations to train a more robust model.

Drone Imagery

Visual Data representation

IMPACT AND BENEFITS

IMPACT

Towards a Zero-Fatality Workplace: Designed to reduce rockfall-related incidents by over 95%.

Boosts Operational Uptime by 20%: Proactive stabilization prevents catastrophic failures, saving an estimated ₹5-10 crores annually per mine site.

Data-Driven Compliance: Provides an auditable, real-time data trail for regulatory bodies like DGMS.

COMPETITIVE ANALYSIS TABLE:

Feature / Focus Area	Traditional Methods (Visual Inspection)	Proprietary Hardware (Radar Systems)	RockGuard AI (Our Solution)
Predictive Accuracy	Low/Subjective	High (Limited Scope)	✓ Very High (Fused AI)
Real-Time Alerting	✗	✓	✓ (Instant SMS/WhatsApp)
Cost-Effectiveness	High Labour Cost	Very High Capex	✓ High ROI (SaaS Model)
Data Source Fusion	✗	✗	✓ Sensor , Drone , Weather
Scalability	Poor	Low (Vendor Lock-in)	✓ High (Software-based)

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RESEARCH AND REFERENCES

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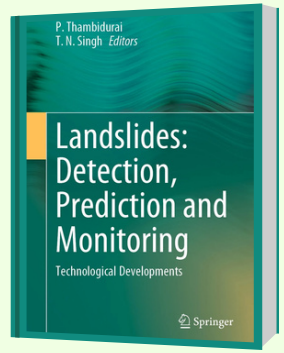
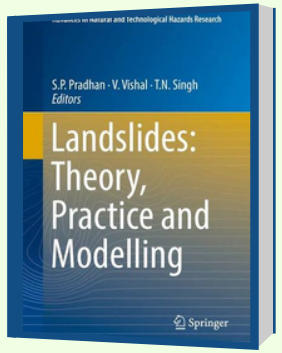
REFERENCES	KEY FINDINGS	RELEVANCE TO ROCKGUARD AI
Deep learning-based C-LSTM for landslide displacement prediction	• A combined DNN-LSTM model is highly effective for predicting landslide displacement. • The DNN extracts spatial features while the LSTM captures temporal patterns.	• This validates our core architecture of fusing a DNN (for drone imagery) with LSTMs (for sensor data).
Application of machine learning for landslide susceptibility, hazard, and prediction	• The review confirms that using a wide range of input factors, such as geology and environmental data, significantly improves the accuracy of machine learning predictions for landslides.	• This supports our multi-source data approach, justifying the integration of geotechnical, environmental, and visual data to create a more robust prediction model.
Application of deep learning in landslide disaster assessment: A review	• The paper highlights that DNNs are excellent for extracting features like cracks from images, while LSTMs are well-suited for processing time-series data from monitoring sensors.	• This reinforces the specific roles of our Structural Vulnerability Model (DNN) and our Geotechnical Anomaly Detector (LSTM).
A hybrid deep learning model for forecasting landslide displacement	• This research shows that pre-processing time-series data with a Wavelet Transform to de-noise it can significantly improve a model's predictive accuracy.	• This provides a clear path for future enhancement of our LSTM-based models by incorporating a data pre-processing layer to increase accuracy.
Integration of UAV photogrammetry and deep learning for rockfall source identification	• The study details the successful use of drone (UAV) imagery to create 3D models and train a DNN to automatically identify rockfall source areas.	• This directly validates the methodology of our Structural Vulnerability Model (Model III), which uses drone-captured imagery as a primary input for its DNN.
The role of antecedent rainfall and seismic activity in triggering deep-seated landslides...	• The paper confirms that preceding rainfall and seismic vibrations are critical triggers for landslides and that machine learning can effectively model these complex relationships.	• This justifies the entire purpose of our Environmental Stress Model (Model I), confirming that rainfall and ground vibration are crucial predictive features.

REF. BOOKS



Landslides: Detection, Prediction and Monitoring: Editors – Springer, 2023.



Landslides: Theory, Practice and Modelling Editors – Springer, 2018.

Github Repository : Click Here

Live Project Demo : Click Here

Video Walkthrough: Click Here