REAL-TIME WORKER FATIGUE DETECTION

IIT(ISM), Dhanbad | MNC 306

OVERVIEW

"In high-risk work environments, even a moment of fatigue can lead to serious accidents, injuries, or costly downtime. Despite strict safety protocols, human alertness remains a critical—and often overlooked—factor. Our project, Real-Time Worker Fatigue Detection, addresses this issue by integrating wearable sensors and real-time video analysis powered by machine learning. By continuously monitoring physical and behavioral indicators, we aim to proactively identify signs of fatigue and alert supervisors before accidents happen. This not only enhances worker safety but also boosts productivity by ensuring that every team member stays alert and engaged on the job."

SELECTED FEATURES:

We chose these four key indicators because they provide a reliable and real-time reflection of a worker's physical and mental condition in challenging underground environments:

Breathing Rate

- Why: Indicates fatigue, stress, or respiratory issues due to poor air quality.
- Sensor: Piezoelectric chest belt – low-cost, wearable, and effective for respiration tracking.

Heart Rate

- Why: Reflects physical exertion, fatigue, or abnormal stress levels.
- Sensor: PPG sensor (smartwatch/wristband) – affordable, comfortable, and widely available.

Posture

- Why: Poor or slouched posture is a sign of fatigue or drowsiness.
- Sensor: IMU (Inertial Measurement Unit) – compact and wearable on the back, helmet, or belt.

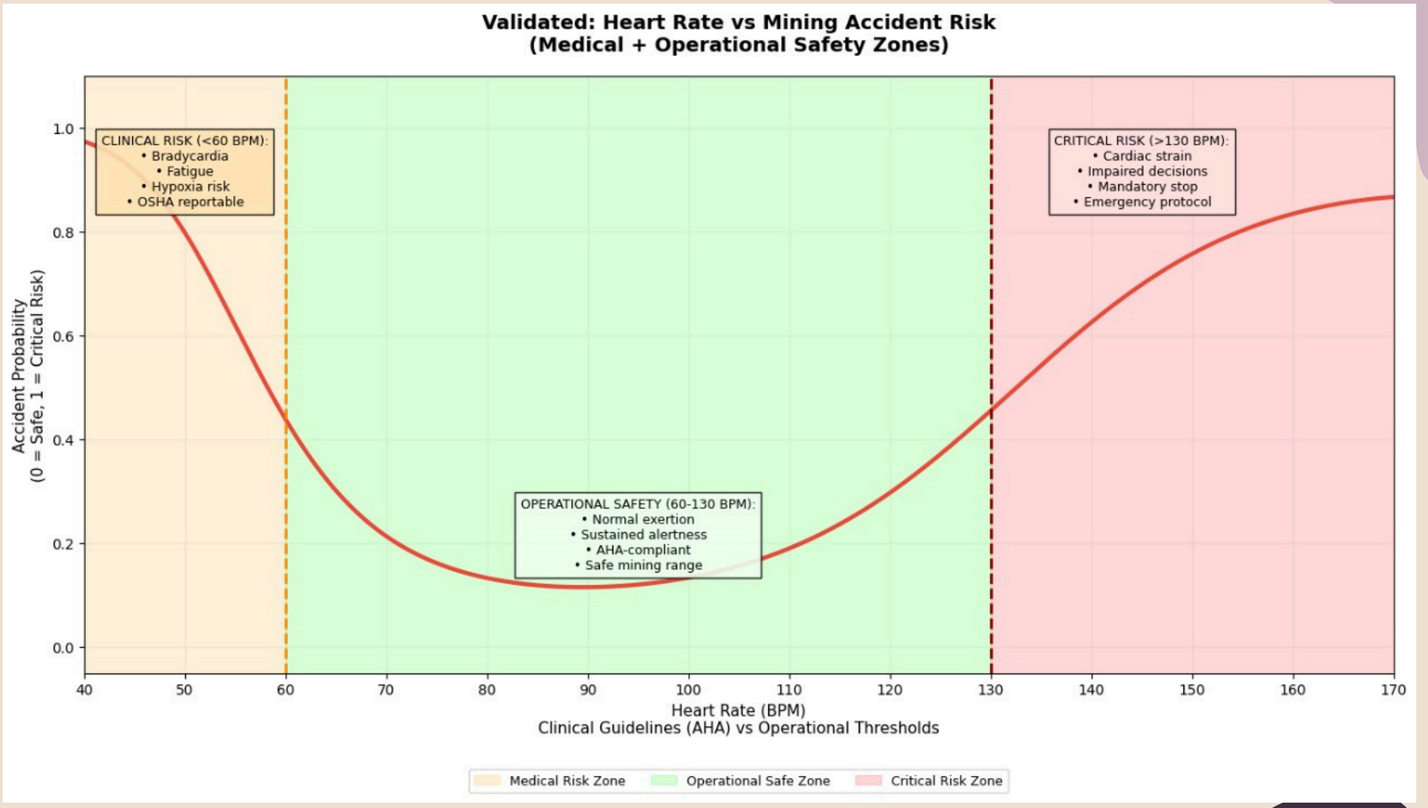
Ambient Temperature

- Why: High or low temperatures can lead to heat stress, fatigue, or reduced performance.
- Sensor: Digital temperature sensor (DS18B20) – very low-cost and easy to integrate into helmets or vests.

HEART RATE VS MINING ACCIDENT RISK

- **X-axis** (Heart Rate (BPM)): This axis represents the miner's heart rate, measured in beats per minute. The range is from 40 BPM to 170 BPM.
- **Y-axis** (Accident Probability (0 = Safe, 1 = Critical Risk)): This axis represents the probability of a mining accident. It's a normalized scale, where 0 indicates a safe condition (low accident probability) and 1 indicates a critical risk (high accident probability).

- **High Risk at Low Heart Rates:** The curve starts high on the left side, showing a high accident probability at low heart rates.
- **Decreasing Risk to an Optimal Range:** The curve then slopes downwards, reaching a minimum in the middle. This indicates a decrease in accident probability as heart rate increases to a certain optimal range.
- **Increasing Risk at High Heart Rates:** After the minimum, the curve slopes upwards again, showing increased accident probability at high heart rates.



BREATHING RATE VS MINING ACCIDENT RISK

- **X-axis (Respiration Rate (breaths/minute)):** This axis represents the miner's breathing rate, measured in breaths per minute. The range is from 10 breaths/minute to 60 breaths/minute.
- **Y-axis (Accident Probability Prediction (0 = Safe, 1 = Critical Risk)):** This axis represents the predicted probability of a mining accident. It's a normalized scale, where 0 indicates a safe condition (low accident probability) and 1 indicates a critical risk (high accident probability).

- **High Risk at Low Breathing Rates: T**he curve starts high on the left side, showing a high accident probability at low breathing rates.
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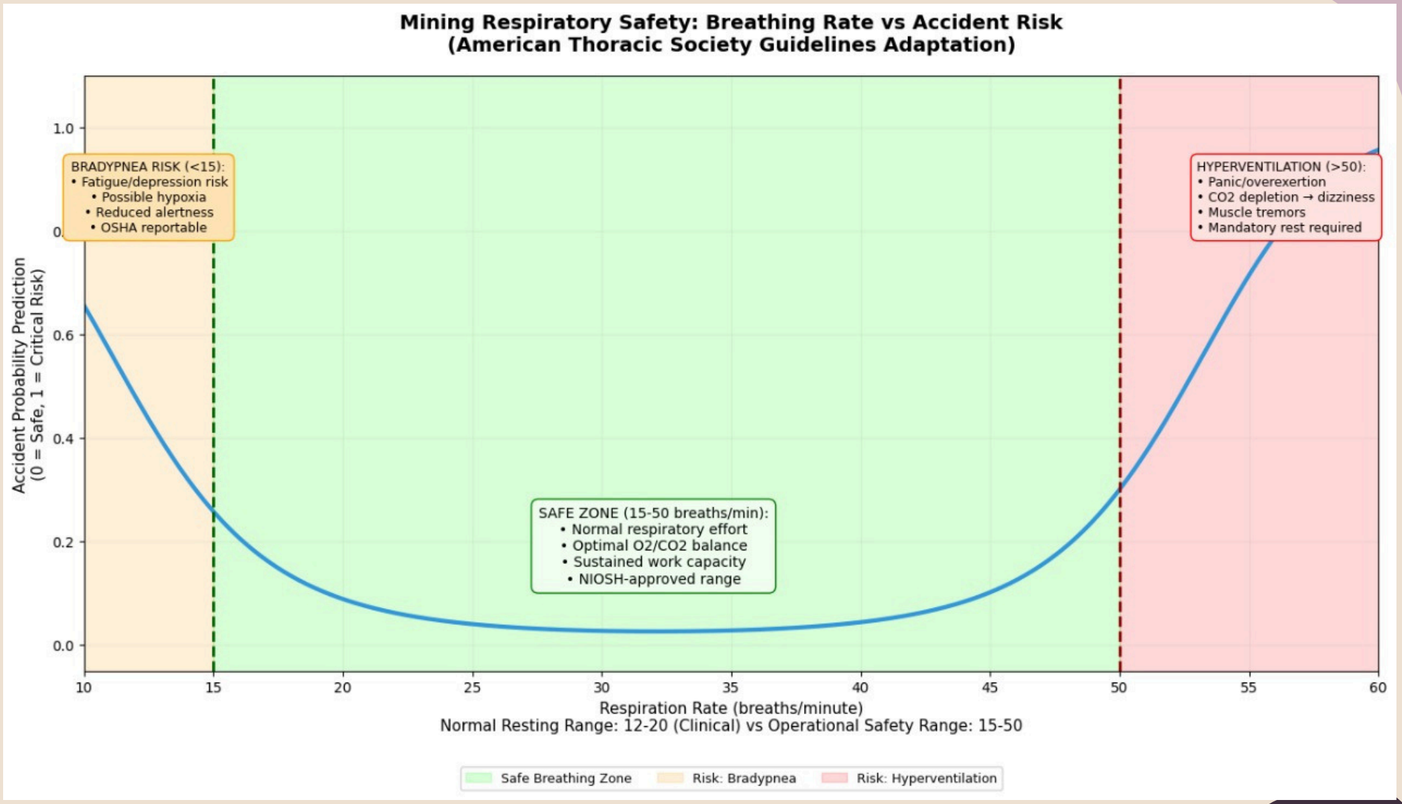
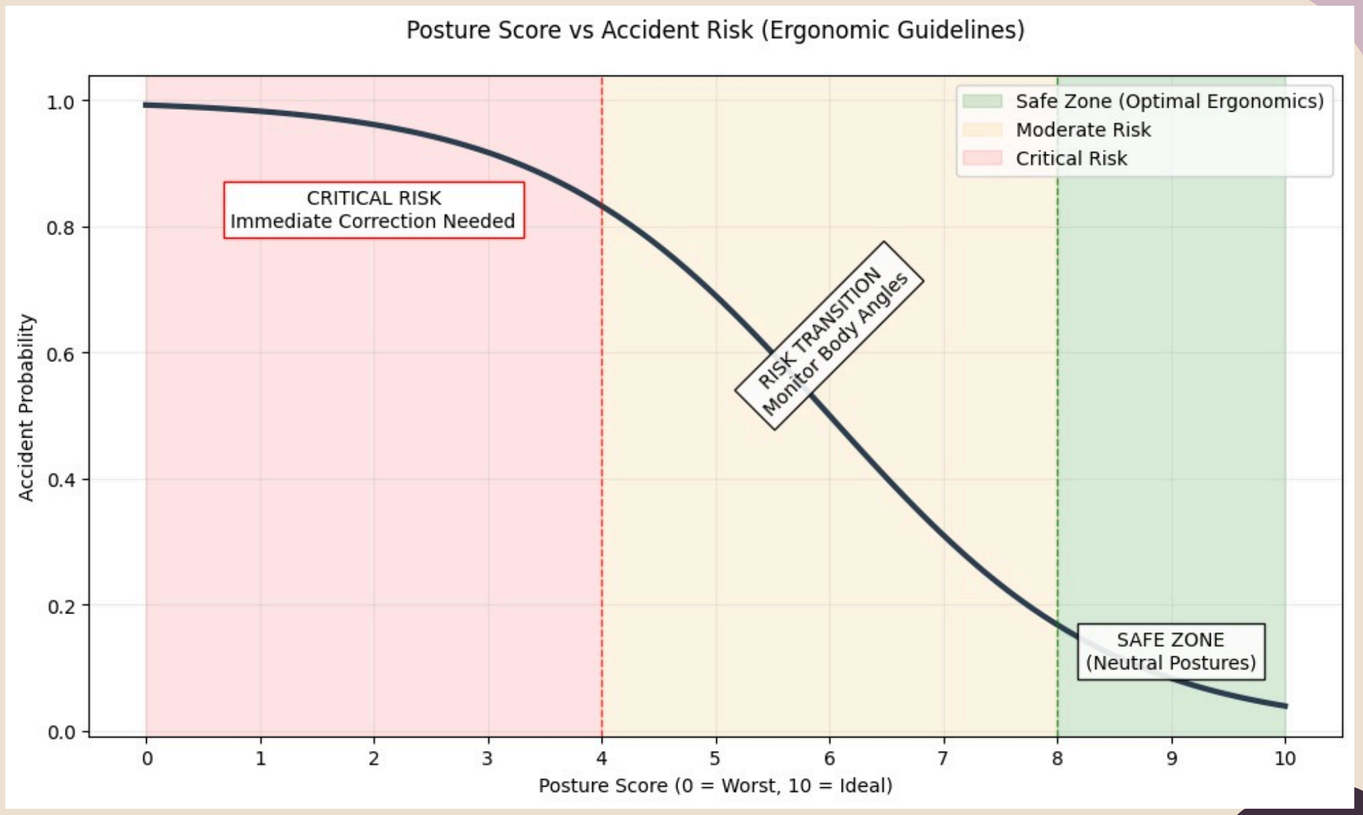


POSTURE VS MINING ACCIDENT RISK

- **X-axis (Posture Score (0 = Worst, 10 = Ideal)):** This axis represents the posture score. A score of 0 indicates the worst possible posture, while a score of 10 represents the ideal, most ergonomic posture.
- **Y-axis (Accident Probability):** This axis represents the probability of an accident, ranging from 0 (no risk) to 1 (high risk).

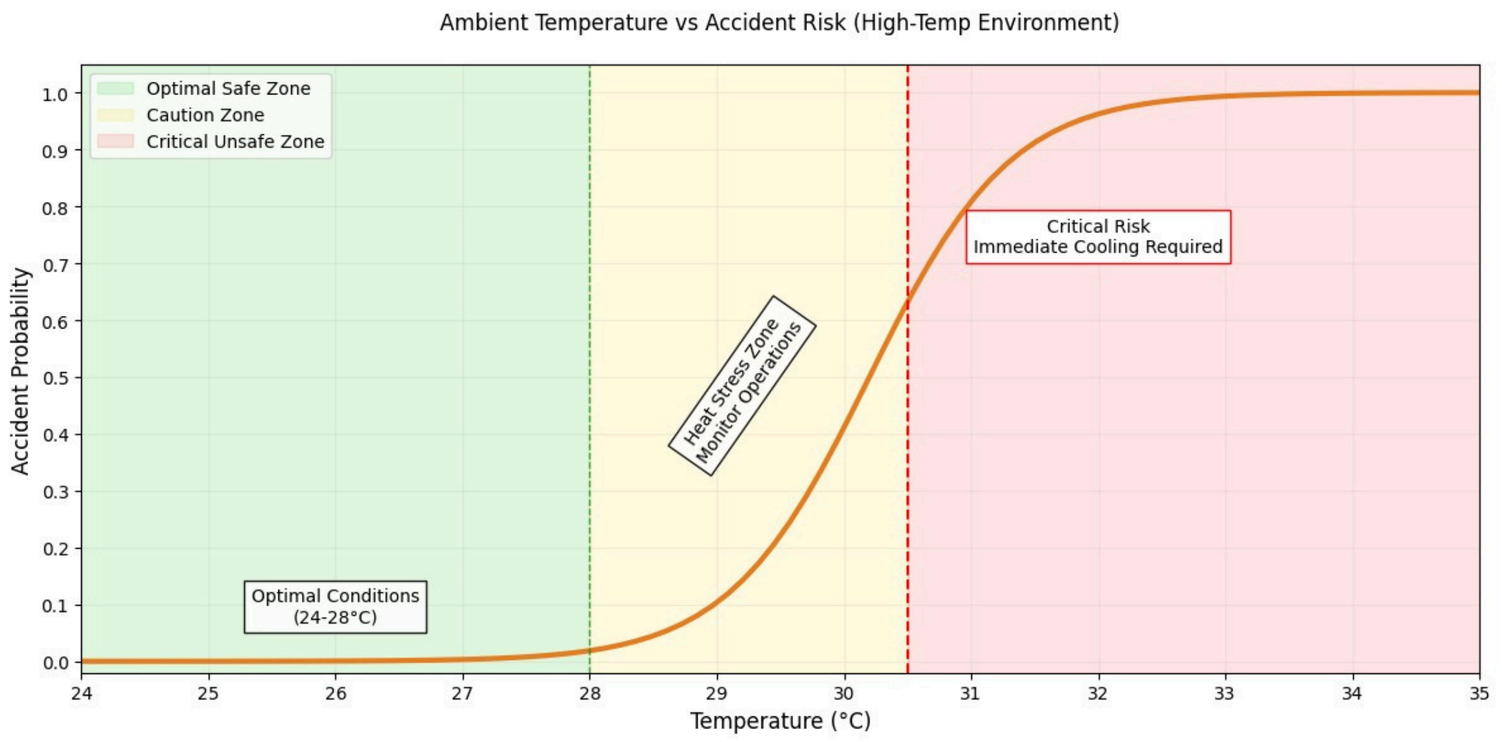
- **High Risk at Low Posture Scores:** At lower posture scores (worse postures), the accident probability is high.
- **Decreasing Risk with Better Posture:** As the posture score increases (better postures), the accident probability decreases.



AMBIENT TEMPERATURE VS MINING ACCIDENT RISK

- **X-axis (Temperature (°C)): T**his axis represents the ambient temperature, measured in degrees Celsius. The range is from 24°C to 35°C.
- **Y-axis (Accident Probability):** This axis represents the probability of an accident, ranging from 0 (no risk) to 1 (high risk).

- **Low Risk at Lower Temperatures:** At lower temperatures, the accident probability is low and relatively constant.
- **Rapid Increase in Risk at Critical Temperature:** As the temperature approaches a critical point (around 30-31°C), the accident probability increases rapidly.
- **High Risk at Higher Temperatures:** At higher temperatures, the accident probability plateaus at a high level.



IMPLEMENTING OUR MACHINE LEARNING MODEL(XG BOOST)

Advantages of XGBOOST for this project:

- Handles Mixed Data Types:
  - Works seamlessly with continuous features (e.g., heart rate, temperature) and ordinal data (e.g., posture score 0–10) without manual scaling.
  - Captures non-linear interactions (e.g., high heart rate + high temperature → heat stress).
- Robust to Noise:
  - Regularization (L1/L2) prevents overfitting to sensor outliers common in harsh mining environments.
- Feature Importance:
  - Identifies critical risk drivers (e.g., "posture contributes 30% to failure risk"), aiding safety audits.
- Speed & Scalability:
  - Processes large datasets efficiently (1M+ samples) and runs on edge devices (e.g., Raspberry Pi) for real-time predictions.

IMPLEMENTING OUR MACHINE LEARNING MODEL(XG BOOST)

Output of the Model:

Model Output:

- Probability (0-1): Accident risk.
- Binary: Fail/Safe (adjustable threshold).

Usage:

- Real-time alerts: Tiered warnings, automated shutdowns.
- Safety dashboards: Risk visualization.
- Prevention: Prioritize interventions via feature importance.
- Incident analysis: Audit past failures.
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THANK YOU

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