**Amrita Immersion Program Batch 03**

## **Project Statement-V**

Worker Posture and Location Tracking in Mining Operations

**Sensors:** MPU6500 (1), GPS (1)

**Problem Description:**

Safety in mining depends on real-time worker tracking. MPU6500 motion

sensors and GPS tracking, movement and location. Data is uploaded to the cloud for ML-

based anomaly detection, such as irregular motion or falls. Analytics tools provide

heatmaps of worker activity zones, posture trends, and incident patterns. The system

supports quick emergency response and continuous safety improvement through data-

driven insights.

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| **Stage/Activity** | **Tool** | **Outcome** | **Metrics/Rubics** |
| **Stage Ⅰ: Brainstorm** | **Group Discussion: on** the requirements and Solution Model |  |  |
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**Brainstorming:**

**Challanges:** Mining environments pose several challenges for posture and location tracking systems. GPS becomes unreliable underground, necessitating alternatives like UWB or BLE for accurate positioning. Sensor drift due to equipment vibration, device durability, and battery longevity are also concerns. Additionally, ensuring worker privacy and minimizing false alarms is crucial to gaining trust and making the system usable in real-world operations.

**Opportunity:** Despite these challenges, the system offers major safety and efficiency benefits. Fall detection can enable quick emergency responses, while fatigue monitoring can reduce accidents through proactive sleep. Heatmaps and posture trend analysis help identify risk zones and prevent long-term injuries. Anomaly detection and proximity alerts further enhance safety by flagging unusual behavior and keeping workers out of danger zones.

**Ideas:** To implement this effectively, key ideas include integrating UWB/BLE for indoor positioning, adding barometers for altitude tracking, and using ML models to classify posture, estimate fatigue, and identify risk areas. Edge computing ensures real-time alerts even without the internet, and a centralized dashboard gives supervisors a live overview of worker status and safety risks.

**Abstract :**  
Worker safety is a major challenge in mining areas. This project aims to enhance safety using real-time posture and location tracking. An MPU6500 motion sensor monitors body movements, while a GPS module tracks location. Abnormal activities like falls or lack of motion are detected and sent to the cloud. Machine learning analyzes data to identify patterns, highlight risky zones, and trigger alerts, ensuring faster emergency response and long-term safety improvements.

**Questionaries:**

1. What are the biggest safety challenges your mining site currently faces?
   1. Common challenges include poor visibility, equipment-related hazards, fall risks, communication issues, and difficulty in quickly locating injured workers in large or underground areas.
2. How do you currently keep track of workers' locations during their shifts?
   1. Most sites rely on manual check-ins, shift logs, and occasional radio communication. Some use RFID or basic location tracking, but real-time tracking is rare.
3. Have you faced any incidents where workers were lost or unreachable?
   1. Yes. In many mining sites, there have been cases where workers were unreachable due to being in remote or communication-dead zones, especially underground.
4. How quickly are you able to respond to accidents or falls when they occur?
   1. Response time can vary. In open areas, it's usually fast, but in underground or isolated sections, locating the person and reaching them often causes delays.
5. What delays or gaps exist in your current emergency response process?
   1. Key delays include difficulty in identifying the precise location of the incident, communication breakdowns, and navigating through complex mine layouts.
6. Do you think real-time posture monitoring could reduce such incidents?
   1. Yes, posture monitoring could help detect falls, signs of fatigue, or unsafe behavior early, allowing for preventive action or immediate alerts during emergencies.
7. Frequent emergencies occurring in areas?
   1. Accidents tend to occur more in deep shafts, tunnel intersections, areas with moving equipment, slopes, and poorly lit or ventilated sections of the mine.
8. Are there any blind spots or areas where GPS or communication is poor?
   1. Yes, most underground zones are out of GPS range, and wireless communication (Wi-Fi, GSM, BLE) often struggles without infrastructure like repeaters or mesh networks.
9. How do you usually respond to emergencies in confined or deep mining areas?
   1. Typically, response involves radio communication, manual searching by nearby teams, and coordination with safety officers. The process can be time-consuming and risky.
10. Do you think musculoskeletal injuries due to poor posture are a problem in your operations?
    1. Yes, long shifts involving repetitive, awkward, or strenuous postures often lead to chronic back pain, joint issues, and fatigue among workers.
11. Have you tried using wearable technology for worker safety?
    1. In most cases, no advanced wearables are in regular use. Some sites may use ID badges or smart helmets, but full-body posture tracking wearables are rare.
12. Are you currently using any tracking systems (RFID, GPS, BLE, etc.)? If yes, what are their limitations?
    1. RFID is used at checkpoints but lacks real-time tracking. GPS is ineffective underground. BLE offers promise but requires a network of beacons that may not yet be deployed.
13. What concerns do you have about using wearables in tough environments like mines (e.g., dust, water, temperature)?
    1. Main concerns include durability (resistance to dust, heat, water), comfort, interference with daily tasks, battery life, and whether the device can survive rugged usage.

Stage VI: Design of Modules (Phased Manner – Workforce Identification)

Phase: Ideate

Activity: Design of Modules

Description:

The overall solution is broken down into well-defined, manageable modules for structured development. For this project, the modules include:

Sensing Module – integration of MPU6500 for posture and motion tracking

Location Module – GPS for surface tracking and BLE/UWB alternatives for underground

Edge Computing Unit – real-time analysis and alert system

Cloud and Dashboard Module – central monitoring, ML-based analytics, and heatmaps

Workforce and roles are identified for each module such as sensor integration, embedded system development, ML model training, and UI/UX for the dashboard.

Stage VII: Resources Identification (Identification of Requirements)

Phase: Ideate

Activity: Resources Identification

Description:

Here, all hardware, software, and human resources needed for each module are identified. This includes:

Sensors: MPU6500, GPS modules, barometers

Computing Devices: Microcontrollers (e.g., ESP32), edge processing units

Connectivity: BLE/UWB modules, Wi-Fi modules

Cloud Platform: For data upload, analysis, and dashboard deployment

Personnel: Embedded developers, ML engineers, UI/UX designers, safety consultants

A budget estimation and procurement plan are also formed.

Stage VIII: Planning (Project Schedule)

Phase: Ideate

Activity: Project Planning

Description:

A clear timeline is developed outlining start and end dates for each phase of the project. Key milestones include:

Sensor integration and baseline data collection

Edge alert system and anomaly detection

Dashboard prototype and data visualization

System testing and refinement

Dependencies, buffer time, and deliverables are clearly charted. Tools like Gantt charts or project tracking software may be used.

Stage IX: Re-Design (Checklist)

Phase: Ideate

Activity: Re-Design

Description:

A final checklist-driven review is conducted to verify technical, logistical, and ethical feasibility:

Is underground tracking resolved through UWB/BLE?

Are false positives from posture classification minimized?

Is edge computing reliable in offline conditions?

Are all emergency use cases covered?

Is the design durable for mining conditions (dust, moisture, ruggedness)?

Based on this checklist, minor redesigns or refinements are made before transitioning to the prototyping phase.

Stage X: Execution Framework (Modules)

Phase: Prototype

Activity: Execution Framework

Description:

With design finalized, an execution framework is constructed for each module. It defines input/output data flow, interaction between hardware/software components, and execution logic. For instance:

Sensor module sends IMU and GPS data at regular intervals

Edge unit preprocesses and classifies posture anomalies locally

Communication layer handles data transfer and local buffering in case of connection loss

Cloud system receives and logs data, updating the dashboard in real time

All modules are integrated for synchronized functionality and tested for interdependency and failover behavior./