INVENTION DISCLOSURE FORM FOR PATENTS

Applicant Name-Marwadi University

1. **Particulars of Inventors**

Mr./Ms/Dr.	Name (Full)	Department	Designation	Mobile No.	Email	Postal Address
Mr.	Aryan Dilipbhai Langhanoja	Information and Communication Technology	Student	9404806497	aryan.langhanoja119561@marwadiuniversity.ac.in	9-Shivdhara Duplex Row House Opp.Poonam Bakery Nr.Dharmanandan Society Nikol Naroda Road Nikol Ahmedabad 382350

2. **Provide title of the invention:** AI-Powered Train Track Monitoring and Emergency Maintenance System

3. **In 100 words or less, please provide an abstract or summary of the invention:**

- Broken tracks are indeed a very serious cause of railway train accidents that may pose risks to passengers and delay railway operations. This module suggests the use of an AI-based Train Track Maintenance Module aimed at solving such an imperative problem. Integrated with an AI camera, the module can be installed beside the wheels of the train in order to inspect tracks on a real-time basis. AI algorithms empowered by sophisticated computations detect cracks or even fractures in tracks with high precision. Immediately after the detection of a hazard, the module triggers a temporary welding system and ensures the safe movement of a train while preventing its derailment or accidents. At the same time, the system transmits accurate GPS coordinates of the damaged location to the railway authorities to permanently repair it. This technology not only ensures safety but also reduces the number of days for service availability. The module is transformative in the approach to railway infrastructure maintenance and accident prevention, combining real-time monitoring, AI-based detection, and emergency response.

4. **Detail description of the invention:(Answer to all below are required in detail)**

a. Problem the invention is solving

- Track defects, including cracks or breaks unnoticed are also an inducement for derailment catastrophes as well as associated train accidents. Current methods of inspections by human beings entail time consumption and labor. Automated surveillance systems also lack proper and immediate mechanisms of corrective action, leaving them vulnerable to accidents along the way. This invention fills these gaps with the real-time AI-based solution, enabling broken track detection, on-site temporary rectification to avoid accidents and authorities notified for permanent resolution. The invention, therefore, enhances railway safety, operational efficiency, and infrastructure monitoring while reducing the chance of accidents and associated economic and human losses.

b. General Utility/application of the invention

- **Railway Safety and Accident Avoidance**: Real-time tracking of railway tracks prevents derailments and accidents by correcting track fractures even before they become hazardous.
- **Efficient Infrastructure Management**: By providing precise GPS coordinates of track defects, it enables railway authorities to prioritize maintenance tasks.
- **Emergency Response**: The temporary welding mechanism is an immediate assurance of uninterruptible train operations, thereby ensuring the safe passage of passengers.
- **Scalable Application**: The device can be applied to both passenger and freight trains, making it a versatile solution for diverse railway systems.
- **Data-Driven Insights**: The AI system could collect and analyze track defect patterns for supporting long-term planning and predictive maintenance.

c. Advantages of the invention disclosing about the increased efficiency/efficacy

- Increased Efficiency: The system operates autonomously during train journeys, eliminating the need for frequent manual inspections.
- Real-Time Monitoring: Advanced AI algorithms ensure quick and accurate detection of track defects significantly reducing the period between defect detection and corrective action.
- Improved Safety: The temporary welding feature prevents accidents by immediately addressing track issues, buying time for permanent repairs.
- Cost-Effectiveness: The system helps prevent derailments and ensures optimal maintenance schedules, which minimize repair costs and service disruptions.
- Environmental Impact. The data-driven system reduces redundant inspections and involuntary train stoppages, therefore the fuel efficiency.
- Adaptability: The invention can be tailored for a variety of different railway systems and environmental conditions.

d. **Best way of using the invention as well as possible variants**

Ideal Applications:

- **Installation**: Install the module on trains running on high-risk routes or areas with high frequencies of track defects.
- **Integration**: Interconnect the module with the railway management systems in place to coordinate defect detection warnings and maintenance schedules.
- **Maintenance**: Update the AI algorithms periodically for better accuracy, adapting to the changing conditions of the tracks.

Variant Possible Applications :

- **Mobile Inspection Vehicle:** This module can be modified for use on special track inspecting vehicles for scheduled inspections.
- **Multi-Sensor Integration:** Provide this module with additional sensors, like ultrasonic or infrared, to detect internal track defects.
- **High-Speed Adaptation**: Change the system for high-speed railways to utilize and activate more highly developed image processing capabilities for fast detection.
- **Modular Welding Units:** Develop detachable welding mechanisms that can be replaced or upgraded independently.

e. **Working of invention along with Drawing, schematics and flow diagrams if required with complete explanations**

System Components:

- **AI Integrated Camera:** Captures video feed of the track continuously and is fed to the AI for interpretation.
- **AI Algorithm:** Processes video data in real time, identifying cracks, fractures, or other anomalies.
- **Temporary welding unit:** the compact mechanism that could begin spot repairing once the defect has been identified.
- **GPS Module:** Records the location accurately when any problem is detected to be sent to railway authorities.
- Communication Module sends alerts with defect details and coordinates to a centralized maintenance system.

Working Process:

- **Step 1:** The camera with AI continuously captures track images.
- **Step 2:** The AI algorithm scans the images for defects such as cracks or breakage.
- **Step 3:** Upon detection of a defect, the system activates the temporary welding unit to weld the damaged section.
- **Step 4:** The GPS module records the location, and the communication module sends the details to the railway authority.
- **Step 5:** Upon this data, organizations deploy teams that could undertake permanent repair.

Algorithm: -

- **Start**
  - Initialize the system components:
    - AI-integrated camera.
    - AI algorithm for anomaly detection.
    - Temporary welding unit.
    - GPS and communication modules.
- **Track Monitoring**
  - Begin real-time video capture from the AI-integrated camera mounted near the train wheels.
  - Feed the video frames into the AI processing system.
- **Anomaly Detection**
  - Analyse the video frames using the AI algorithm to identify anomalies such as cracks or fractures in the track.
- **Decision Point: If Anomaly Detected?**
  - **Yes**:
    - **Step 4.1**: Trigger the temporary welding unit to initiate spot repair on the damaged section of the track.
    - **Step 4.2**: Record the GPS coordinates of the defect location.
    - **Step 4.3**: Use the communication module to send an alert with defect details and coordinates to railway authorities.
  - **No**:
    - Continue monitoring the track in real-time.
- **Loop Back**
  - Repeat steps 2–4 continuously as the train operates.
- **End**
  - Stop monitoring when the train journey concludes or if manually terminated.
  - Archive all defect data and logs for future analysis.

Schematic Diagram: A schematic could include:

- Train-mounted camera system positioned near wheels.
- Data flow from the camera to the AI processor.
- Output connections to the welding unit, GPS, and communication module.

5. **Have you conducted a Primary Patent Search? Yes / No (if yes, attach the patent search results) :- No**

6. **Existing state-of-the-art and prior arts: (Brief background of the existing knowledge/product/process in the market)**

1. Manual Inspection Methods

- **Process**: Railway personnel conduct visual inspections or use handheld devices to detect track defects.
- **Limitations**:
  - Time-consuming and labor-intensive.
  - Subject to human error and inefficiency, especially over long railway networks.
  - Reactive rather than preventive.

2. Automated Track Inspection Systems

- **Technology**: Automated systems mounted on dedicated inspection trains or vehicles use sensors (ultrasonic, infrared, or laser) to detect defects.
- **Features**:
  - High-precision defect identification.
  - Data collection for predictive maintenance.
- **Drawbacks**:
  - These systems are expensive and require separate inspection vehicles, leading to downtime for maintenance scheduling.
  - They lack real-time corrective actions such as emergency repairs.

3. Vision-Based Track Monitoring

- **Technology**: Cameras and computer vision algorithms are deployed to monitor and analyze track conditions.
- **Strengths**:
  - Real-time monitoring with AI-enabled pattern recognition.
  - Can be mounted on operational trains for continuous analysis.
- **Weaknesses**:
  - They primarily focus on detection and reporting but do not provide immediate solutions to prevent accidents.

4. Intelligent Maintenance Platforms

- **Technology**: Predictive maintenance platforms analyze historical data and AI algorithms to predict when a track might fail.
- **Advantages**:
  - Preventive maintenance reduces overall downtime and costs.
- **Disadvantages**:
  - These systems are heavily reliant on historical data, which might not account for sudden or immediate track failures.

5. Temporary Track Repair Solutions

- **Product**: Some tools exist for manual, temporary track repairs, such as welding kits carried by maintenance personnel.
- **Challenges**:
  - Repairs are reactive and require the presence of maintenance teams, leading to delays.

Contact Details: Aayush Gupta, Email:mu@ennobleip.com, Phn- +91 92891 50390

7. **List out the known ways about which others have tried to solve the same or similar problems? Indicate the disadvantages of these approaches. In addition, please identify any prior art documentation or other material that explains or provides examples of such prior art efforts.**

S. No.	Existing state of art	Drawbacks in existing state of art	Overcome (how your invention is overcoming the drawback)
1	Manual Inspection Methods	- Labor-intensive and time-consuming. - Prone to human errors. - Cannot detect microscopic or hidden defects. - Reactive, not preventive.	- Fully autonomous system eliminates human error. - Continuous monitoring ensures no track section is missed. - Real-time detection.
2	Ultrasonic Track Testing (UTT)	- Requires dedicated testing vehicles, causing delays in train operations. - High operational costs. - Ineffective for emergency responses.	- Operates on active trains without requiring separate inspection vehicles. - Immediate temporary repair prevents accidents.
3	Rail Grinding and Maintenance Machines	- Designed for regular track maintenance, not for detecting or repairing emergency defects. - Bulky and expensive equipment.	- Compact and cost-effective system capable of both defect detection and emergency repairs. - Suitable for real-time applications.

8. **List the Technical features and Elements of the invention along with the Description of your invention from start to end.**

1) AI-Integrated Camera System:
- Captures high-resolution images or video of the railway track in real time.
- Mounted near the train wheels for optimal track visibility.
- Equipped with low-light and weather-resistant capabilities for uninterrupted operation.

2) AI-Powered Anomaly Detection Algorithm:
- Processes video frames to identify defects like cracks, fractures, or misalignments.
- Trained on a large dataset of track defect images for high accuracy.
- Capable of real-time processing to minimize delays.

3) Temporary Welding Unit:
- Compact welding mechanism mounted on the train.
- Automatically initiates spot repairs for detected cracks to ensure the train can proceed safely.
- Uses quick-cooling welding materials for efficiency.

4) GPS Module:
- Records the precise location (latitude and longitude) of detected defects.
- Ensures accurate reporting to railway authorities for permanent repair.

5) Communication and Alert System:
- Sends defect details, including type, severity, and GPS coordinates, to the railway control center.
- Alerts maintenance teams in real-time via a cloud-based platform or SMS/email.

6) Power Supply Unit:
- Powered by the train's electrical system or a dedicated battery pack.
- Ensures continuous operation during the train's journey.

7) Data Storage and Reporting:
- Stores detected defect data locally and uploaded it to a central database.
- Enables data analysis for predictive maintenance and long-term planning.

9. List out the features of your invention which are believed to be new and distinguish them over the closest technology.

1) Real-Time Defect Detection and Repair:
- Combines AI-based anomaly detection with an onboard temporary welding unit to immediately repair track defects.
- Existing technologies focus solely on defect detection, lacking integrated corrective measures.

2) Seamless Integration with Active Trains:
- Operates while the train is in motion without requiring separate inspection vehicles or interrupting train schedules.
- Closest technologies like Ultrasonic or Vision-based systems often require standalone vehicles or manual inspection pauses.

3) Emergency Response Mechanism:
- Instantly addresses critical defects by applying temporary welds, allowing the train to proceed safely until permanent repairs are made.
- Other technologies only report defects, leading to delays in repairs and increased accident risks.

4) Precise GPS-Tagged Reporting:
- Records the exact location of detected defects and sends real-time alerts with GPS data to railway authorities.
- Static monitoring systems lack dynamic location tracking, making them unsuitable for comprehensive railway networks.

5) Cost-Effectiveness and Scalability:
- Compact design that leverages existing trains, reducing the need for expensive dedicated inspection vehicles or static sensors.
- Scalable to various train types and track conditions, unlike fixed-location systems.

6) AI-Powered Efficiency:
- Utilizes deep learning algorithms trained on a diverse dataset for accurate anomaly detection in varying environmental conditions.
- Outperforms conventional vision or sensor-based systems limited by pre-defined defect parameters.

7) Data Logging and Predictive Insights:
- Captures defect data in a centralized database for future analysis, enabling predictive maintenance planning.
- Most existing systems lack a comprehensive data-driven approach for preventive measures.

10. **Has the invention been built or tested or implemented? If yes please provide the Efficiency/Efficacy details of the invention :- No**

11. **Briefly state when and how you first conceived this idea?**

- The concept behind this invention was developed in the light of studying the frequent train crashes arising from failures in the railway track, especially hidden cracks or breaks. The motivation behind this was spurred by some reports indicating defected delay as regards defect detection and repair, then also the heavy reliance on point-to-point inspection and high monetary costs of independent monitoring systems.

- Combining real-time monitoring with AI-based detection and an onboard repair mechanism, I realized that such a system could not only identify issues instantly but be engineered to provide a temporary remedy to prevent accidents. Building on the concept, along with research into advancements in AI, robotics, and welding technologies, integration of these solutions in one cost-effective and scalable product was desired.

- This notion was born out of research into railway safety innovation, with the intent of filling the gap that exists between detection and immediate corrective action to enhance safety for both passengers and operators.

12. **Have you sold, offered for sale, publicly used or published anything related to this invention? If yes, please briefly explain the dates and circumstances. List those individuals to whom you have revealed your invention. Were non-discloser documents signed prior to discloser in each case? Please state any deadlines of which you may be aware for filing an application on this invention. :- No**

13. **Include any reasons that your invention would not have been obvious to someone of average skill in the art.**

- **Integration of Multiple Technologies**: The invention integrates a combination of advanced technologies: AI-based defect detection, real-time welding, GPS tracking, and automated reporting, into a streamlined system for the maintenance of train tracks. Each of these components already exists independently, but it is not an obvious notion to integrate all these into one complete autonomous solution. This integration needs solid exposure and knowledge of AI, robotics, welding techniques, and real-time data communication, thus the overall invention is not obvious to anyone with merely basic knowledge in one area of the art.

- **Real Time Welding Mechanism**: Although the technology of track welding is well known, it would not be very apparent to add a direct and real-time onboard welding unit, which automatically engages based on detected defects. Most systems were designed around detection, allowing for repair by a human rather than trying to create a self-repairing system during the journey of the train.

- **AI for Dynamic and Continuous Monitoring**: Another uniqueness of the invention is the use of AI to continuously and dynamically monitor train tracks while the train is in motion. Stationary solutions for track monitoring systems often use AI, but this solution utilized real-time analysis from a mobile platform-the train itself-for track safety. Such a mobile application of AI to track safety was not immediately obvious from initial signs in the field of railway maintenance.

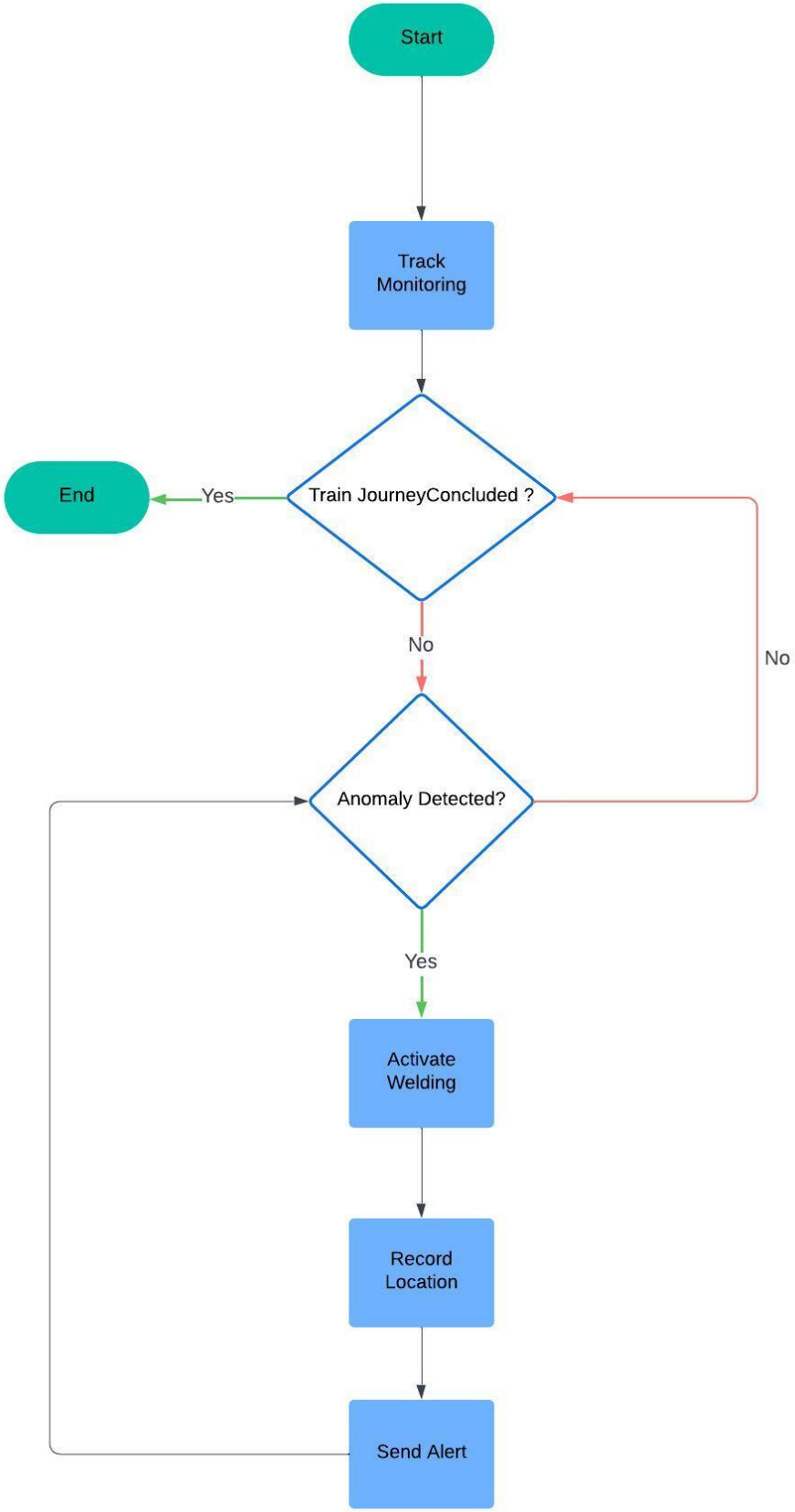
- **Real-Time Response to Critical Defects:** The innovation lies in it being able to instantly repair detected defects with a temporary welding mechanism. Conventional solutions for defect detection are currently reported, but this causes delay in repairs and can also lead to accidents. The built feature of the invention to address critical defects autonomously would have been obvious to a person of ordinary skill in the field because it combines defect detection with rapid corrective action, which is not typically found in existing systems.

- **Comprehensive Data Logging for Predictive Maintenance**: Existing monitoring systems may detect or report defects but hardly offer predictive maintenance insights. The novelty is in the addition of continuous data logging feeding into predictive analytics to anticipate future issues. This long-term, data-driven approach to avoiding defects is not a common practice in the existing track monitoring solutions focusing mainly on reactive maintenance.

- **Cost-Effective and Scalable Design:** Traditional track monitoring systems often involve high operational costs, such as dedicated inspection vehicles or static sensors. The invention's use of existing train infrastructure to monitor and repair tracks makes it both cost-effective and scalable, offering a solution that can be applied to various railway networks without significant infrastructure changes. This scalability and cost-efficiency are not obvious solutions in a field typically focused on high-cost, specialized equipment.

14. **Additional comments by inventor (if you want to give more details out of scope of this IDF).**

15. **Drawings/Flowchart/Table**



Contact Details: Aayush Gupta, Email:mu@ennobleip.com, Phn- +91 92891 50390