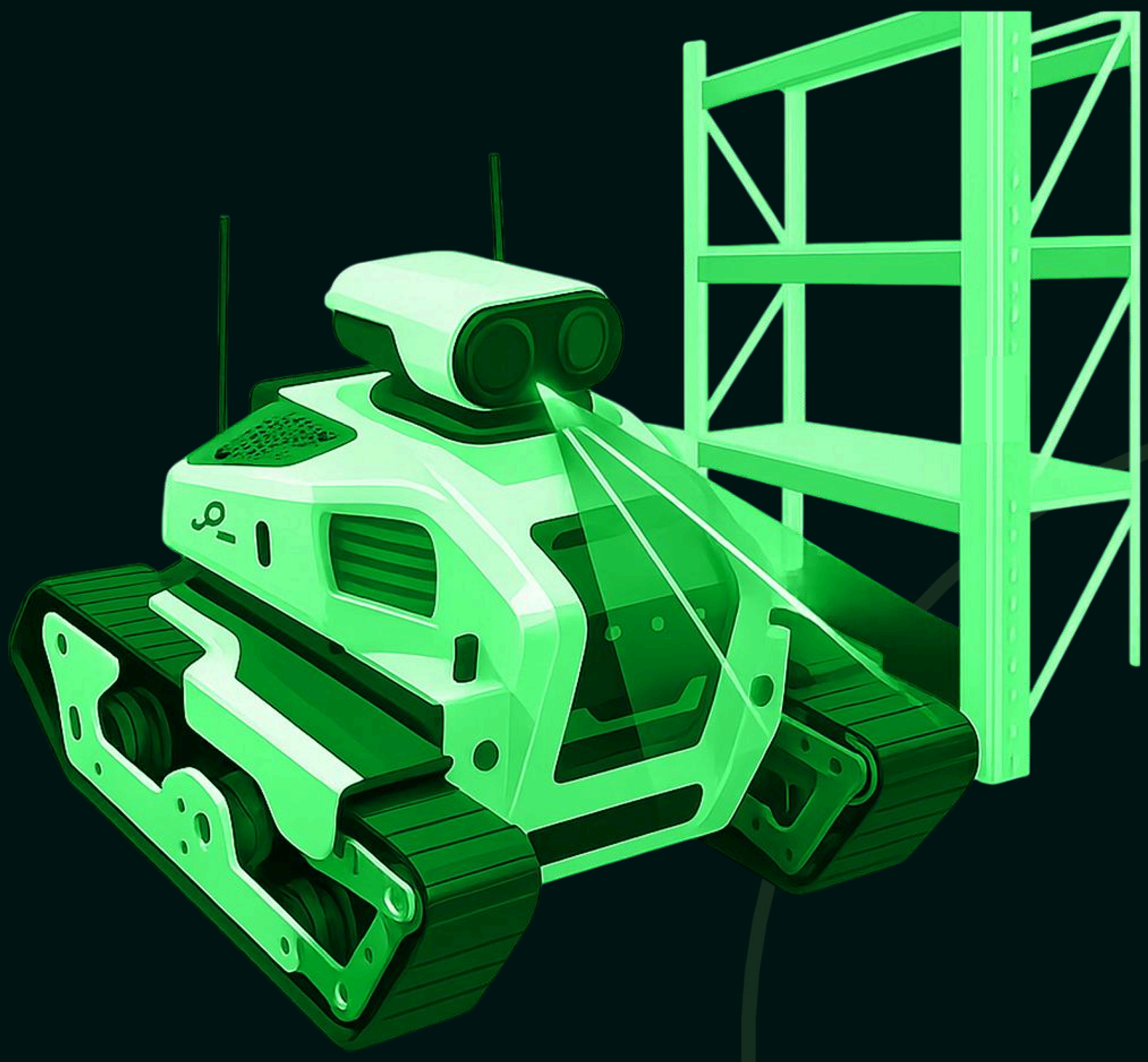
INTER IIT
TECH MEET 14.0

MID PREP



eternal

Autonomous Rover for Warehouse Rack Inventory Management

INTER IIT
TECH MEET 14.0

Introduction

Modern warehouses face significant challenges in inventory management, including time-consuming manual inspection processes, human error in stock counting, limited accessibility to high-altitude storage locations, and lack of real-time inventory visibility.

Autonomous mobile robots can achieve speeds of up to 4 m/s and operate in temperatures ranging from 0°C to 40°C, making them ideal for warehouse environments. This solution addresses these pain points by providing consistent, accurate, and efficient rack monitoring capabilities.

About Us

Eternal isn't just a name. It's a mission statement. At the heart of Eternal's success lies the synergy between our group companies. Each brand under the Eternal umbrella embodies the principles of innovation, adaptability, and excellence. Zomato connects millions to their favourite restaurants, offering convenience, discovery, and exceptional dining experiences. Blinkit delivers groceries and essentials in minutes, redefining convenience with instant delivery solutions. District delivers immersive retail experiences, marketing solutions, and community-driven projects. Hyperpure helps restaurants source fresh, high-quality, and sustainable products to deliver culinary excellence. Eternal envisions a future where adaptability, innovation, and sustainability form the foundation of enduring success. We foster excellence and trust, empowering our companies to lead industries and impact society.

INTER IIT
TECH MEET 14.0

Problem Statement Description

Develop a comprehensive autonomous mobile robot system capable of navigating warehouse environments and performing vertical scanning operations on storage racks up to 2 meters in height. The system must capture high-resolution visual data from bottom to top (or vice versa), process the information, and store it for real-time inventory analysis and management.

Solution Requirements

Specifics of the components choice and integration strategy is left to the participating teams.

Following are the requirements for the features of the solution:

1. Navigation and Positioning
    a. Horizontal positioning accuracy: ±10 cm
    b. Vertical positioning accuracy: ±2cm
    c. Obstacle detection range: 5 meters
    d. Path planning time: <3 seconds
    e. Emergency stop response time: <500 ms
2. Scanning Performance
    a. Vertical scanning speed: Complete each rack in <3 minutes
    b. Image resolution: Minimum 1920×1080 pixels
    c. Image quality: Sharp focus, minimal motion blur
    d. Scanning repeatability: >95% consistency
    e. 5cmx5cm size QR detection rate: >90%

3. Mechanical Chassis Features
    a. Length: <600 mm
    b. Width: <450 mm
    c. Weight: <25 kg
    d. Low center of gravity design
    e. Anti-tip base geometry
    f. Emergency stop mechanism

Constraints and Assumptions

1. Technical Constraints:
    a. Maximum rack height: 1.8 meters
    b. Operating environment: Indoor warehouse with WiFi/4G
    c. Floor type: Smooth, flat surface
    d. Power source: Battery-powered (no external power during operation)
2. Components Constraints:
    a. Preference for COTS (Commercial Off-The-Shelf) components
    b. Open-source software wherever possible
3. Safety Requirements:
    a. Emergency stop functionality
    b. Collision avoidance system
    c. Safe maximum speed limits
    d. Compliance with warehouse safety standards
4. Assumptions:
    a. Warehouse racks are stationary and standardized
    b. Network connectivity available (WiFi/4G)
    c. Racks have visible QR codes
    d. Smooth warehouse floor without major obstacles

INTER IIT TECH MEET 14.0

Deliverables

1. Hardware Deliverables
    a. Functional autonomous rover prototype
    b. Complete mechanical assembly with tested vertical scanning mechanism
    c. Integrated sensor suite and navigation system
    d. Robust chassis with safety features
2. Software Deliverables
    a. Storing the information from the scanned QR code
3. End Term Submission
    a. Documentation
        i. Detailed system architecture diagram
        ii. Software architecture and flowcharts
        iii. User manual and maintenance guide
        iv. Testing and validation reports
        v. Bill of Materials (BOM) with cost breakdown
        vi. Circuit schematics and PCB designs
        vii. 3D CAD models and assembly drawings
    b. Code files
    c. Videos
4. Presentation
5. Live Hardware Demonstration

Evaluation Parameters

The problem statement is divided into four parts:

INTER IIT TECH MEET 14.0

1. **<u>X-Y Motion Hardware:</u>**
    a. The rover must demonstrate smooth and precise movement in the X-Y plane.
    b. Evaluation will consider:
        i. Accuracy and repeatability of horizontal movement.
        ii. Efficiency and response time during navigation.
        iii. Stability and control during acceleration and deceleration.
        iv. Robustness to minor surface irregularities.
        v. Integration of obstacle detection and emergency stop functionality.
2. **<u>Z Motion Hardware:</u>**
    a. The rover (or camera mounting system) must demonstrate reliable and controlled vertical motion.
    b. Evaluation will consider:
        i. Smoothness and precision of Z-axis movement.
        ii. Range of motion and mechanical stability (no wobble or drift).
        iii. Time taken for full vertical traversal.
        iv. Safety mechanisms to prevent collision or over-extension.
3. **<u>Camera Scan and Data Registration:</u>**
    a. The system must successfully perform scanning operations and data logging.
    b. Evaluation will consider:
        i. Coverage: The camera must be able to scan the entire 1.8-meter rack (bottom to top or vice versa).
            1. Image Quality: Sharp focus, minimal motion blur, and sufficient lighting.
        ii. Data Accuracy:
            1. QR code detection and decoding performance.
            2. Successful extraction and storage of scanned data.
        iii. Data Management:
            1. Proper recording and organization of scanned information.
            2. Real-time display or logging capability.

4. **SLAM (Simultaneous Localization and Mapping) and Navigation:**
    a. The system must be capable of autonomous navigation within the defined environment.
    b. Evaluation will consider:
        i. Localization accuracy and map consistency.
        ii. Ability to detect racks and align position for scanning.
        iii. Path planning between racks and within aisles.
        iv. Collision avoidance and dynamic obstacle handling.
        v. Restart and recovery capability (from predefined restart points).
5. **Code and Video Presentation Quality:**
    a. The clarity, structure, and presentation of the codebase and videos will be assessed.
    b. Evaluation will consider:
        i. Code readability (indentation, variable naming, and commenting).
        ii. Folder structure and modularity.
        iii. Presence of a detailed README including:
            1. Setup instructions.
            2. Explanation of file structure and purpose.
            3. Execution steps for replication.
        iv. Video quality:
            1. Clear demonstration of working features.
            2. High visual quality and stable recording.
            3. Proper narration or labeling of functionalities demonstrated.
6. **Presentation**
7. **Live Hardware Demonstration:**
    a. Teams will demonstrate the complete functioning of their prototype.
    b. Evaluation will consider:
        - Integration of all subsystems (motion, scanning, SLAM).
        - Execution of autonomous navigation and scanning across multiple racks (number to be disclosed later).
        - Accuracy and reliability under real-time conditions.
        - Proper execution of restart scenarios from designated points.
        - Adherence to safety protocols and emergency stop functionality.

INTER IIT TECH MEET 14.0

Judging Criteria

End Term Submission

1. X-Y Motion Hardware (10%)
2. Z Motion Hardware (20%)
3. Camera Scan and Data Registration (15%)
4. SLAM and Navigation (15%)
5. Code and Video Presentation Quality (10%)

**For the first four points, participants will be evaluated based on the achievability and accuracy of the stated objectives, the quality of the documentation, and the structure and clarity of the codebase.*

Offline Evaluation

1. Presentation (10%)
2. Live Hardware Demonstration (20%)

**The breakdown for the live hardware demonstration would be shared later*

Resources

1. Image of rack: https://drive.google.com/file/d/14HChWrIIzFpBQg57AQaXxCGrojJyNvAH/view?usp=sharing

   ** The image above is for reference only and may differ from the actual arena.*

2. Link of rack : https://amzn.in/d/gPfmsqX
3. ISO 3691-4: Safety of industrial trucks - Driverless trucks
4. RIA R15.08: Mobile robots and safety