SAR

CPG - 268

Search & Rescue Rover

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PROJECT OVERVIEW

- Autonomous UGV designed for disaster zone operations
- Equipped with **LiDAR** for obstacle detection and terrain mapping
- **Thermal cameras** for detecting human presence through heat signatures
- Environmental sensors for hazard detection
- Sensor fusion for accurate situational awareness
- Real-time **3D** map generation for navigation assistance
- Machine learning for path optimization and automated navigation
- Real-time dashboard displaying terrain maps and hazard information

NEED ANALYSIS

01 Rescue operations face challenges like unstable structures, poor visibility, and hazardous conditions in disaster zones, risking human responders' safety.

02 An AI-driven UGV equipped with LIDAR, thermal imaging, and computer vision automates navigation, fire detection, and survivor identification.

03 The UGV's real-time 3D mapping and sensor integration help gather crucial environmental data for faster and informed decision-making.

04 A centralized dashboard supports real-time analytics, efficient coordination, resource management, task tracking, and enhanced operational effectiveness during critical rescue missions.

LITERATURE SURVEY

Survey and analysis of existing literature, research advancements, and previous works relevant to the current project or study domain.

- Liu et al. [1] enhanced LiDAR-inertial SLAM for UGVs in search and rescue by using a particle swarm filter and loop closure, improving localization accuracy. Tested in real-world environments, the system showed high efficiency and robustness.
- Zade et al. [2] developed a deep learning system for real-time survivor detection in UAV thermal imagery, improving search and rescue efficiency with high human detection accuracy.
- Hasan et al. [3] introduced an explainable AI-enhanced YOLOv8 model for fire detection, achieving 98% fire accuracy and 99.1% mAP, ensuring reliable hazard recognition.
- Surmann et al. [4] reviewed lessons from German rescue robotics deployments, emphasizing real-world testing and collaboration to improve disaster response readiness.

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- Li et al. [5] proposed the TAD-RRT*-Smart algorithm for UGV path planning, optimizing route selection for efficient and stable maneuverability in disaster scenarios.
- Huang et al. [6] explored FPGA-based AI for UAV and UGV search and rescue, achieving 90% survivor detection accuracy and 1.7–1.9× faster processing speeds.
- Murcia et al. [7] introduced a 3D scene reconstruction method using a 2D moving LiDAR. Their approach efficiently generated accurate 3D maps, validated through real-world experiments, offering a cost-effective solution for robotics and autonomous navigation.
- Yan and Ma [8] developed a real-time obstacle avoidance algorithm using 2D LiDAR. Their method enabled autonomous systems to navigate dynamic and unstructured environments effectively, proving valuable for applications like search and rescue operations.

PROBLEM STATEMENT

Disaster response is challenging due to unpredictable environments; there's a need for autonomous systems to map terrains, detect hazards, and assist rescue teams in real-time.

OBJECTIVE

- To design and develop an unmanned ground vehicle (UGV) capable of navigating hazardous terrains using LIDAR.
- To enhance autonomous navigation by incorporating intelligent obstacle avoidance and optimized route planning for efficient movement in disaster zones.
- To leverage LIDAR technology to generate 3D maps, assisting rescue teams in disaster-stricken areas.
- To integrate thermal imaging and vision-based AI models to detect and locate survivors efficiently.

ASSUMPTIONS

- Disaster-Affected Sites are Accessible
- Sensors and AI Processing Units Exist

CONSTRAINTS

- Harsh Environmental Conditions
- Obstacles & rough terrain
- Real-time data transmission might be delayed due to poor network coverage

METHODOLOGY

RESEARCH & HARDWARE INTEGRATION

- Identify disaster challenges & UGV applications.
- Research AI, LiDAR, thermal.
- Design UGV for optimal sensor placement & integration.

MODEL TRAINING

- Train CNN & YOLO for human/object detection.
- Implement SLAM for mapping & localization.

SENSOR DATA PROCESSING & FUSION

- Process thermal, LiDAR sensor.
- Fuse data for accurate 3D mapping & obstacle detection

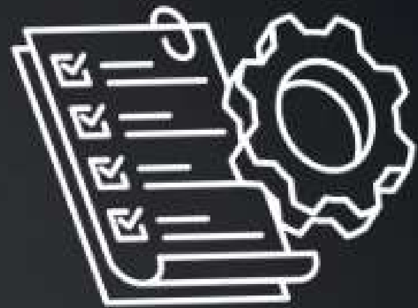
AUTONOMOUS NAVIGATION & OBSTACLE AVOIDANCE

- Developed SLAM-based algorithms for real-time mapping and path planning in dynamic environments
- Implemented strategies to detect and bypass obstacles, ensuring safe UGV operation without human intervention.

REAL-TIME MONITORING & ALERTS

- Build a dashboard for live UGV tracking.
- Display sensor data, maps & critical alerts.
- Enable quick decision-making for rescue teams

PROJECT REQUIREMENTS



HARDWARE

- Computing Power: Raspberry Pi 4, ESP32 (Edge AI Processing)
- Smart Sensors: LiDAR (3D Mapping), Thermal Camera (Human Detection)
- Actuation System: High-precision motor drivers for autonomous navigation

SOFTWARE

- Programming: Python (ML & Automation)
- AI & Data Processing: TensorFlow, OpenCV, ROS (Robot Operating System)
- Security: End-to-end encryption

PROJECT OUTCOMES

- Autonomous navigation, obstacle avoidance, rugged terrain adaptability, SLAM integration, path optimization.
- 3D environmental mapping, cave exploration, disaster site visualization, sensor fusion, LIDAR usage.
- Real-time detection, human identification, thermal imaging, vision-based AI, survivor tracking.
- Performance testing, disaster simulation, rugged terrain validation, data accuracy, system stress testing.
- Usability assessment, navigation efficiency, mapping precision, detection accuracy, user feedback.