Project Title: Pavement & Airfield Tactical Robotic On-site Locator (PATROL)

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Problem: Foreign Object Debris (FOD) and pavement anomalies on airport runways and taxiways pose a major threat to aviation safety, costing the global industry an estimated $22.7 billion annually. Even small objects can damage engines, puncture tires, or cause catastrophic accidents. Current practices rely on manual inspections that are labor-intensive, error-prone, and disruptive to operations, or prohibitively expensive automated systems deployed at only a few major airports. Neither approach provides continuous, real-time monitoring with actionable decision support.

Objectives: PATROL aims to develop an autonomous robotic inspection system that:

- Detects hazards in real time using multi-modal sensors.
- Classifies anomalies by type and severity, with confidence scores.
- Provides GPS-tagged alerts and actionable recommendations to operators.
- Enables proactive, continuous monitoring without disrupting airport operations.

Technical Approach: PATROL integrates low-cost sensors (HD cameras, LiDAR, thermal imaging) with AI analytics on a mobile quadruped robot (i.e., robot dog). This multi-sensor fusion ensures reliable detection under diverse weather and lighting. AI algorithms deliver FOD detection, classification, confidence, and recommended actions, keeping humans in the loop. PATROL will be trained, tested, and validated on a comprehensive dataset of real-world FOD and pavement anomalies at a Colorado airfield. Autonomous robotic deployment enables 24/7, all-weather and all-terrain inspections, delivering immediate hazard alerts and minimizing operational downtime, automating a high-cost, high-risk process in infrastructure management.

Commercialization and Transition: The plan outlines a practical and scalable path from prototype development to operational deployment. By utilizing commercially available quadruped platforms (e.g., Unitree or Boston Dynamics), hardware costs and development time are minimized, enabling the project to concentrate on advancing AI algorithms and multi-sensor integration. Initial pilot testing will be conducted at Christman Airfield, a decommissioned and CSU-operated facility that provides a safe, realistic environment for evaluating system performance without disrupting active airport operations. These pilot studies will establish baseline performance, validate feasibility in operationally relevant conditions, and generate the data needed to engage potential end users. Developed intellectual property, particularly the AI-driven detection and classification framework, can be transitioned to industry by similarly leveraging off-the-shelf hardware.

Impact: PATROL delivers transformative benefits across safety, efficiency, cost, and scalability. Continuous monitoring reduces FOD-related risks to both aircraft and personnel, while minimizing costly runway closures and inspection delays. By preventing damage to aircraft and lowering long-term infrastructure maintenance, the system provides significant cost savings. Its modular design ensures scalability, making it an affordable solution for airports ranging from regional facilities to large international hubs. By shifting inspections from periodic, reactive tasks to proactive, real-time safety assurance, PATROL directly supports U.S. Department of Transportation goals of safety, efficiency, and resilience.