AESS ENSIT STUDENT BRANCH CHAPTER

IEEE Robotics & Automation Society
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How to train your drones 2.0

DRONATHON

The Rescue

Specification book

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Introduction:

In emergency and disaster situations, timely response can save lives. However, human responders often face accessibility challenges, hazardous conditions, and limited real time information. Leveraging autonomous systems, particularly rescue drones, can dramatically enhance efficiency, speed, and safety during such critical operations.

Problematic:

In traditional rescue operations, human intervention is often limited by harsh environmental conditions, geographical barriers, and a lack of real-time situational awareness. During emergencies such as earthquakes, floods, or drowning incidents, responders face delays due to difficult access, unstable terrain, and communication breakdowns. Moreover, resource allocation and coordination between rescue teams become increasingly complex in dynamic and unpredictable environments.

These limitations highlight the urgent need for intelligent and autonomous aerial systems capable of operating in diverse and challenging situations. The challenge lies in designing drones that can independently analyze their surroundings, make real-time navigation and detection decisions, communicate securely with ground or maritime teams, and assist in locating and rescuing victims efficiently and safely.

The key question is: How can we integrate advanced technologies such as AI, cyber security , and autonomous flight control to create a robust, reliable, and efficient drone system that enhances the speed and safety of modern rescue missions, both on land and in water?

Concept:

The idea is to design and implement rescue drones that can operate autonomously or semi-autonomously in disaster scenarios. These drones should be able to:

- Navigate complex environments using real-time data.
- Identify victims or hazards via sensors and computer vision.
- Communicate and coordinate with rescue teams and other drones.
- Adapt to dynamic constraints such as weather, terrain, and resource

Challenge:

1. Hardware (50 points total)

1.1 Drone Conception & Design (20 pts)

Criteria: Structural efficiency, weight vs. durability, adaptability to harsh conditions, and energy efficiency.

Scoring Questions:

(4 pts) Is the drone designed using lightweight yet strong materials (e.g., carbon fiber, Kevlar, composites)?

(4 pts) Does the frame balance aerodynamics and payload capacity effectively?

(4 pts) Has the team considered energy efficiency and endurance in the design?

(4 pts) Can the design withstand harsh rescue environments (rain, dust, rubble, high winds)?

(4 pts) Is portability and ease of field deployment demonstrated?

1.2 Flight Control & Navigation (20 pts)

Criteria: Stability, agility, autonomy, energy efficiency, and robustness in rescue scenarios.

Scoring Questions:

(4 pts) Does the drone demonstrate stable flight under dynamic conditions (wind, obstacles)?

(4 pts) Are path-planning algorithms (A*, RRT*, swarm intelligence, etc.) integrated for autonomous navigation?

(4 pts) Are sensor fusion systems (IMU, GPS, LiDAR, barometer) correctly implemented?

(4 pts) How well does the drone avoid collisions and navigate obstacles in real time?

(4 pts) Is energy consumption optimized (e.g., through efficient flight patterns)?

1.3 Hardware Reliability & Resilience (10 pts)

Criteria: Hardware fault tolerance, modularity, repairability in the field.

Scoring Questions:

(3 pts) Can the drone continue to function with partial system failures (redundant systems, fail-safes)?

(3 pts) Is the hardware modular and field-repairable under rescue constraints?

(4 pts) Does the drone design demonstrate resilience against harsh terrains/weather conditions?

2. Software & Cybersecurity (50 points total)

2.1 Human Detection & AI (15 pts)

Criteria: Accuracy, real-time performance, robustness under rescue conditions.

Scoring Questions:

(3 pts) Does the system achieve high detection accuracy in challenging conditions (smoke, low light)?

(3 pts) Are multi-modal sensors (thermal, RGB, IR, LiDAR) used effectively for human detection?

(3 pts) Is real-time processing latency acceptable for emergency operations?

(3 pts) Does the AI model minimize false positives/negatives in victim recognition?

(3 pts) Is multi-drone coordination for detection well integrated?

2.2 System Integration & Autonomy (15 pts)

Criteria: Coordination between hardware, AI, and secure communication.

Scoring Questions:

(3 pts) Do drones demonstrate multi-agent coordination (swarm-based or centralized control)?

(3 pts) Is the system capable of autonomous decision-making without constant human input?

(3 pts) Is fail-safe mode included (return to base, hover, or emergency landing)?

(3 pts) Is the UI/dashboard intuitive for rescue teams to interact with drones?

(3 pts) Does the system support real-time updates and adaptability to changing rescue environments?

2.3 Secure Communication :

Criteria: Ensure confidentiality, integrity and availability of satellite and long-range communications so the autonomous drone cannot be attacked, spoofed, or issued unauthorized commands. Prioritize authenticated command channels, tamper resistant key management, robust anomaly detection, and safe-fail behaviours that protect people and property.

Scoring questions

• (5 pts) Threat model & mitigation: Has the team produced a clear threat model focused on satellite/long-range comms (e.g., remote command injection, MITM, replay, certificate compromise, jamming, GNSS spoofing) and provided concrete mitigations?

• (6 pts) Authenticated commands & integrity: Are all commands, mission updates and control messages cryptographically signed and verified on the drone (e.g., signatures over command + nonce + mission ID)? Is replay protection enforced (nonces / monotonic counters / sequence numbers)?

• (5 pts) Strong encryption & mutual authentication: Is telemetry and any command traffic encrypted end-to-end (authenticated encryption) and is mutual authentication used between drone and gateway/satellite endpoint (device certificates / PKI)? Are secure key lifecycle practices documented (provisioning, rotation, revocation)?
• (4 pts) Secure boot & firmware protection: Does the drone enforce secure boot and accept only signed firmware images (prevents remote code injection or replacement)? Are OTA updates signed and authenticated with rollback protection?• (3 pts) Redundancy & failover policies: Are fallback communications planned
(e.g., alternate satellite provider, LoRa/mesh/cellular relays) and is there automatic, tested failover behavior on link loss or suspected compromise?
• (2 pts) Anomaly detection & incident response: Is there on-board anomaly detection for telemetry/command anomalies and a documented safe-fail incident response (hover/loiter, mission abort, return-to-safe-zone, surface/land, deploy marker)?
• (2 pts) Anti-jamming / anti-spoofing & navigation checks: Are GNSS spoofing/jamming mitigations included (multi-source checks, IMU/visual odometry cross-checks) and is the drone able to detect and react to positioning inconsistencies?
• (1 pt) Physical & supply-chain security: Are protections present for physical tamper, key storage (HSM/TPM or equivalent), and supply-chain measures for critical components?

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Dataset Requirements

Participants are required to utilize datasets for training and validating their AI models, particularly for human detection and navigation tasks.

Main Dataset (Required):

https://www.kaggle.com/datasets/rgbnihal/c2a dataset?fbclid=IwY2xjawNJHt1leHRuA2FlbQIxMABicmlkETFmVFdkRG1ve U43OW9lemNaAR5H7blfWlwZIcTYZI2dFQR-Zckj6j3YVl_qLAjT4YT-08F1Lt6HCCeVavGb0A_aem_ubbEszKQWjXlg7dgLHQ9VQ

This dataset should serve as the primary source for training core detection and classification models.

Bonus Datasets (Optional):

• Participants are encouraged to incorporate additional datasets to improve model robustness and generalization. Examples include:

o https://ieee-dataport.org/
o https://www.kaggle.com/
o https://roboflow.com/

Scoring Consideration:• Teams that use larger or more diverse datasets may receive extra points in the Software & AI section, as this demonstrates a commitment to improving model accuracy, reducing bias, and enhancing real-world performance under varied conditions

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