Task 4: Summarize 3 Papers from SUAS 2022.

1. Aerial Robotics Club at NC State.

Technical Design Report for AUVSI Student UAS Competition 2022

ARC

Aerial Robotics Club
at
NC State
Technical Design Paper
AUVSI Student UAS Competition 2022

- ***Abstract:***

This technical design report outlines the development and specifications of the Akela 3 platform by the Aerial Robotics Club at NC State (ARC) for participation in the 2022 Student Unmanned Aerial Systems Competition (SUAS). The platform is engineered for fully autonomous flight, precise Unmanned Ground Vehicle (UGV) drop delivery, automatic target identification, mapping, and obstacle avoidance**.**

- ***Introduction:***
  The Aerial Robotics Club at NC State (ARC) has embarked on the development of the Akela 3 platform, building upon the success of the Fenrir 3 airframe previously used in SUAS 2019. This platform aims to execute a successful mission in the 2022 SUAS competition, focusing on enhancing payload capabilities and software suite while retaining the proven airframe design.

Platform Specifications:

- ***Autopilot System***

The Akela 3 is equipped with a PixHawk 2 autopilot running Ardupilot V4.1.6, an open-source software renowned for its effectiveness in UAV control. The PixHawk 2 interfaces with an array of avionics sensors, including a Matek digital airspeed sensor, a Here3 real-time kinematic (RTK) GPS, a digital magnetometer, a LightWare SF11/C LiDAR altimeter, and a digital air temperature sensor. It also features an onboard inertial measurement unit (IMU) and barometer. A real-time telemetry link is maintained with the ground station via a pair of 900MHz RFD900X telemetry radios, facilitating dynamic updates to the autopilot's mission parameters.

- ***Competition Task Involvement***

The autopilot system's capabilities align with the competition tasks:

1. ***Autonomous Flight:*** The platform performs fully autonomous flight with a waypoint accuracy of 10ft, including autonomous takeoff, landing, and dynamic re-tasking.
2. ***Obstacle Avoidance:*** The autopilot dynamically adjusts its waypoint course to avoid obstacles using input from the flight computer***.***
3. ***Object Detection, Classification, and Localization***: The system conducts ground object detection by flying the aircraft in a back-and-forth survey pattern, ensuring 50% image overlap. A custom convolutional neural network (CNN) classifies target-containing regions in images.
4. ***Mapping:*** High-resolution images are captured to create maps using the back-and-forth survey pattern at a higher altitude.
5. ***-Air Delivery:*** The autopilot directs the aircraft for precise delivery of payloads and transitions between mission stages.

- ***Ground Control Station (GCS)***
  The GCS operates Mission Planner V1.3.76 and communicates with Akela 3 via RFDesign RFD900X radio modems. It supports telemetry and waypoint re-tasking simultaneously, enabling real-time monitoring and mission adjustments.

- ***Obstacle Avoidance.***
  Obstacle avoidance is managed by the Sense, Detect and Avoid (SDA) system, comprising an auto-generation server and an in-flight avoidance system. The auto-generation server calculates optimal paths around obstacles, while the in-flight system intervenes to navigate the aircraft away from potential collisions.

- ***Imaging System***

ARC employs a LucidVision Phoenix GigE camera with a 24 MP CMOS sensor and a two-axis gimbal for image stabilization and off-axis tracking. Images are used for object detection, classification, and localization.

- ***Object Detection, Classification, Localization***

Manual object detection, classification, and localization are performed using the Shimmer server. A custom CNN is trained to classify target-containing regions, and duplicate target instances are filtered out.

- ***Mapping***

OpenDroneMap is used for stitching images together and creating high-resolution maps. The Stitcher service ensures map parameters such as aspect ratio and projection are met.

- ***Communications***

Communication links include an RC link for aircraft control, a payload link for data transmission via 5 GHz WiFi, and an autopilot link for real-time telemetry and sensor data exchange.

- ***Air Drop***

  The UGV drop system incorporates safety measures, including manual authorization, a custom parafoil system, and a controlled descent mechanism for the UGV.

  - ***Operational Excellence***

    Operational excellence is ensured through the team's extensive experience with the autopilot system, gained from hours of autonomous flight, enabling effective troubleshooting during missions.

Conclusion

The Akela 3 platform developed by ARC is designed to excel in the 2022 SUAS competition, combining robust hardware, sophisticated software, and operational expertise to tackle complex mission tasks with safety and precision.

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2. ATATÜRK UNIVERSITY ATA UAV TEAM.

ATA-UAV Technical Design Report

- **Abstract**

The Ataturk University Unmanned Aerial Vehicles (ATA-UAV) team, a division of the ATA-TEB club at Ataturk University, has embarked on the challenge of designing an Unmanned Aerial System (UAS) and an unmanned decision-making vehicle to participate in the AUVSI SUAS competition. The team comprises nine members,

including eight undergraduate students and a supervising lecturer from various engineering disciplines. The primary objectives are to develop a system capable of autonomous flight, obstacle avoidance, image processing, and payload delivery.

- **Introduction**

ATA-UAV's mission is to design and build a UAS that excels in the AUVSI SUAS competition. The team comprises students from diverse engineering backgrounds, ensuring a multidisciplinary approach to the project. The core principles guiding our development efforts are security and efficiency.

- **System Components**
  - **Flight Control**

The team utilizes DroneKit, a Python library, to send MAVLink commands from the Jetson Nano to the Pixhawk Cube flight controller. While DroneKit offers flexibility, the increasing complexity of multiple subsystems necessitates the introduction of the Robot Operating System (ROS) and the MAVROS package for enhanced functionality and compatibility.

  - **Flight Simulation**

For flight simulation, the team employs the Gazebo environment, which has yielded successful results in testing and validation.

  - **Imaging System**

Camera

The selected camera for the UAV is the Sony A6000 mirrorless camera, chosen for its compact size, high quality, and resolution. It offers optimal price-to-performance ratio for the current mission objectives.

Gimbal

To ensure clear image capture, a Brushless Yuntai 3-Axis CNC Metal Camera Gimbal with a STORM32BGC driver card is used. Ongoing development efforts focus on gimbal optimization.

- **Object Detection, Classification, and Localization**

The team initially experimented with OpenCV-Python and a CNN algorithm for letter detection but later transitioned to the Yolo algorithm for improved object detection. The algorithm detects letters and shapes simultaneously, providing more robust results.

- **Avionics and Power Dispatch System Design**

Thorough calculations were conducted to determine propulsion requirements based on material weights. The team selected appropriate engines, batteries, and propellers to maximize efficiency. The Pixhawk Cube flight controller was chosen for its advanced capabilities, including ADS-B integration for collision avoidance.

- **Communication**

The communication system comprises three key components:
- Ground station communication with the aircraft via telemetry (RFD900x).
- Pilot's communication with the aircraft using AT9SS (2.4GHz).
- Image transfer from the drone to the ground station via a Ubiquiti Bullet M5 5GHz module.

Additionally, software communication is facilitated through the MAVLink library, enabling communication between the Jetson Nano and Pixhawk Cube.

- **Ground Control Station**

To ensure the security of telemetry communication, the team has implemented encryption to establish unique channel frequencies and transmission rates, preventing unauthorized access.

- **Conclusion**

The ATA-UAV team is committed to the development of a highly capable and efficient UAS for the AUVSI SUAS competition. Through careful selection of components, robust system integration, and a focus on security, the team aims to excel in the competition and contribute to the field of unmanned aerial systems.

3. Team UAS-DTU (Delhi Technological University)

Team UAS-DTU Technical Design Report

Team UAS-DTU
Delhi Technological University
AUVSI-SUAS 2022
Technical Design Paper

- **Abstract**

Team UAS-DTU, an undergraduate team from Delhi Technological University, has dedicated itself to developing innovative and indigenous solutions for Unmanned Aerial Vehicles (UAVs). Over the past two years, the team has successfully created High Endurance UAV solutions for the Indian Air Force, equipped with features like Human Detection, GPS Denied Navigation, and Swarming capabilities for Humanitarian Aid & Disaster Relief operations. Building on this experience, the team aims to maximize platform autonomy while prioritizing safety and property protection in their pursuit of the AUVSI SUAS 2022 competition. This document outlines and discusses the design, testing, and development of various subsystems, including Autopilot, Avionics, Imaging System, Communication Architecture, Obstacle Avoidance, ODLC, Mapping, and the Ground Control Station.

- **Autopilot**

The team utilizes the ProfiCNC Pixhawk 2 (Hex Cube orange) paired with the open-source firmware, ArduCopter, for their UAV's autopilot system. The autopilot parameters are meticulously modified to align with mission requirements, optimizing mission time, accuracy, and efficiency. The Pixhawk Cube offers built-in vibration-damped IMUs (ICM 20602 and ICM 20948) with a magnetometer, MS5611 barometer, and compatibility with external sensors. Two Here2+ GPS modules provide reliable localization, and a servo rail controls actuators through PWM signals. Autotuning and further stabilization enhance flight stability.

- **Avionics Box**

To simplify system integration and reduce setup time, the team designed a 3D printed modular avionics box, making it a "Plug and Play" subsystem. This approach also streamlines compass calibration and pre-flight checks.

- **Imaging System**

The imaging system incorporates YOLO detection and CNN classification, ensuring accurate object recognition. The Tarot TL3T05 three-axis gimbal provides stability, and the Git2P Action Camera is chosen for its suitability in ODLC tasks.

- **Communication Architecture**

Communication involves three key links: wireless data link, RC link, and autopilot telemetry link. The team uses Microhard 'PMDDL2450' and RFD900x for data transmission and FrSky Taranis QX7 for RC control. Encryption ensures secure communication.

- **Obstacle Avoidance**

Obstacle avoidance is primarily achieved through collision-free trajectory planning in Mission Planner software. Exclusion geofences are implemented as a failsafe measure to prevent deviations from the planned path.

- **ODLC (Object Detection, Classification, and Localization)**

The team has developed an ODLC algorithm that autonomously detects, classifies, and localizes targets in aerial images. Shape detection, character classification, color recognition, and character orientation are all part of this system.

- **Mapping**

Mapping involves stitching together multiple images to create a larger, comprehensive map. Key points, invariant descriptors, and homography matrices are utilized to achieve this. Robust gain compensation and image blending enhance the stitched map's quality.

- **Ground Control Station**

The Ground Control Station (GCS) is designed for efficient interfacing with the autopilot operator. It comprises terminals for Flight Control, interop communication, and imagery processing control. Mission Planner and custom GCS software facilitate telemetry data monitoring, decision-making, and the display of detected objects.

- **Conclusion**

In summary, Team UAS-DTU has meticulously designed a high-endurance UAV system equipped with advanced features for humanitarian and disaster relief missions. Their report highlights a well-thought-out subsystem design, emphasizing safety, efficiency, and autonomy. Notable elements include secure communication, obstacle avoidance, precise object detection, and mapping capabilities. Overall, Team UAS-DTU's UAV system is a testament to their innovation and dedication, setting them up for success in the AUVSI SUAS 2022 competition.