FireFly Guardian

Technical Specifications Document

NASA Space Apps Challenge 2023

Managing Fire: Increasing Community-based Fire Management Opportunities

TUNSA Space Robotics: Task Force 1

Overview

Our quadcopter drone is designed to perform autonomous fire verification and monitoring missions using various sensors and communication modules. It can fly in different modes, such as gliding, hovering, or propelling, depending on the environmental conditions and the mission objectives. It can also rotate its thermal and optical camera modules 180° to capture images and videos from different angles. In addition, it uses solar panels and a wind generator to extend its battery life and flight time. This drone aims to enhance the speed and efficiency of firefighting efforts while ensuring the safety of both responders and affected communities.

Components

Our proposed list of components is as follows:

- **Flight controller**: This is the brain of the drone that controls its flight behavior and communicates with the sensors and the communication modules. It also receives commands from the satellite, the central station, or the emergency control center. It can be based on a microcontroller or a microprocessor, depending on the computational requirements and the power consumption. The option we suggest is the T-Motor F7 PRO flight controller, which has built-in wifi and Bluetooth capabilities. It also supports various RF protocols, such as SBUS, IBUS, DSMX, CRSF, and FPort. It has a high-performance processor, a low-power mode, a USB-C interface, and various peripherals.
- **Motors**: These are brushless DC motors that spin the propellers to generate thrust and torque. They are rated by their size, weight, voltage, current, power, and KV value (which indicates how fast they spin per volt). The option we propose is the T-Motor F40 Pro IV motor, which has a KV value of 1950.

- **Electronic speed controllers (ESCs)**: These are devices that regulate the speed and direction of the motors by converting the DC voltage from the battery into three-phase AC voltage. They also provide feedback to the flight controller about the motor speed and current. We recommend the T-Motor V45A 4-in-1 as a 4-in-1 ESC that can control four motors simultaneously. It supports DShot1200 protocol and has a current rating of 45A per channel. It also has a built-in current sensor and a 10V/2A BEC. It is also compatible with the T-Motor F7 PRO flight controller and the T-Motor F40 Pro IV motors. A possible option for firmware is the BLHeli_32, which supports the ESC hardware and protocols.
- **Propellers**: These are blades that convert the rotational motion of the motors into lift and thrust. They are characterized by their diameter, pitch, material, shape, and number of blades. A possible option is the Xoar PJT 18x8 propeller, which has a diameter of 18 inches, a pitch of 8 inches, and two blades. It is made of carbon fiber composite material, which is light, strong, and durable.
- **Battery**: This is the power source of the drone that provides electricity to all the components. Since we are not looking for speed, but rather longer flight times, we chose to go with Lithium-ion as an alternative type of battery that has higher energy density and longer cycle life than LiPo batteries. We recommend a combination of four Panasonic NCR18650B battery cells, each of which has a voltage of 3.6V, a capacity of 3400mAh, a discharge rate of 6.8A, and a weight of 48g.
- **Thermal camera**: This is a device that captures infrared radiation emitted by objects and converts it into visible images that show the temperature distribution of the scene. A possible option is the FLIR Lepton 3.5 camera, which has a resolution of 160x120 pixels, a frame rate of 9 Hz, a field of view of 57°x44°, and a weight of 5g.
- **Optical telephoto camera**: This is the device that captures visible light images with high magnification and resolution. The option we recommend is the Insta360 Sphere camera, which can capture up to 5.7K video and 6K HDR stills without any appearance of the drone in your shot. The camera securely mounts onto your drone without impeding the GPS signal or balance of the drone. It features two 7.2mm ultra-wide-angle lenses, 360° reframing, and FlowState stabilization for smooth motion footage, allowing you to create a variety of creative shots such as dolly zoom, tiny planet, FPV, etc. *Note: We used a different camera in our 3D model because we didn't find an open-source model for the Insta360 Sphere.*
- **GPS**: This is a device that receives signals from satellites and calculates the position, velocity, and time of the drone. A possible option is the BN-220 GPS module, which has a sensitivity of -167 dBm, an accuracy of 2.5 m, and a weight of 10g.

- **Gyroscope**: This is a device that measures the angular velocity of the drone around its three axes. We recommend the MPU-9250 module, which has a gyroscope with a range of ±250, ±500, ±1000, or ±2000 °/s, an accuracy of 0.01 °/s, and a weight of 1g.
- **Accelerometer**: This is a device that measures the linear acceleration of the drone along its three axes. The previously mentioned MPU-9250 includes an accelerometer module, which has a range of ±2, ±4, ±8, or ±16 g, an accuracy of 0.5 mg, and a weight of 1g.
- **Smoke sensor**: This is a device that detects the presence and concentration of smoke particles in the air. We chose the MQ-2 smoke sensor module, which has a sensitivity range of 300 to 10000 ppm, an output voltage range of 0 to 5V, and a weight of 5g.
- **Temperature sensor**: This is a device that measures the ambient temperature around the drone. We suggest the GY-906 MLX90614ESF contactless temperature sensor module, which uses infrared thermopile detection to measure the surface temperature of an object. It has a resolution of 0.02°C, a field of view of 35°, and an I2C interface. It can measure temperatures from -70°C to +380°C1.
- **Pressure sensor**: This is a device that measures the atmospheric pressure around the drone. One of the best options is the BMP280 pressure sensor module, which has a range of 300 to 1100 hPa, an accuracy of ±1 hPa, and a weight of 1g.
- **GSM 3G modem**: This is a device that enables cellular communication between the drone and the central station or the emergency control center using GSM or UMTS networks. The go-to option is the SIM800L GSM module, which supports quad-band GSM/GPRS/EDGE and single-band UMTS/HSDPA networks, has an output power of 2W at GSM850/900 MHz and 1W at DCS1800/PCS1900 MHz or UMTS2100 MHz, and has a weight of 15g.
- **LoRa module**: This is a device that enables long-range low-power communication between the drone and the central station or the emergency control center using LoRa technology. It can also be used to transmit low-bandwidth data such as GPS coordinates or sensor readings. The option we suggest is the RAK811 LoRa module, which supports LoRaWAN protocol, has a frequency range of 433/470/868/915 MHz, has an output power of +20 dBm, and has a weight of 5g.