1. **Title:** Autonomous Multi-Function Drone System for Versatile Applications
2. **Prior Art**
3. **Fully Autonomous Drone Flights (US20230350431)**

- This patent describes systems and methods for fully autonomous drone flights, which include taking off, navigating according to a flight plan, and landing autonomously. The system performs these tasks with minimal human intervention, relying on advanced AI algorithms for navigation and decision-making.
- **Key Features:**
  - Autonomous navigation and flight control.
  - Integration with image processing and messaging servers for data handling.
  - Real-time decision-making based on sensor inputs.
- **Distinguishing Aspects:**
  - Our invention includes modular payloads for various applications such as delivery, agriculture, and inspection, which is not a focus in this patent.
  - Enhanced user interface for remote operation and task configuration, which is more comprehensive than the system described in this patent.
- **Modular Autonomous Drone (US20200301427)**
  - This patent details a modular autonomous drone system designed for versatility in operation, including racing drones that can navigate through a predefined course. The system incorporates AI for autonomous flight and can switch between remote-control and autonomous modes.
- **Key Features:**
  - Modular design for different configurations and applications.

    - AI-controlled autonomous navigation.
    - Ability to operate in both remote-control and autonomous modes.
  - **Distinguishing Aspects:**
    - Our invention's focus on diverse applications such as delivery, agriculture, and infrastructure inspection sets it apart from the primary racing application described in this patent.
    - Our energy management system with renewable energy integration and efficient power usage optimization offers a unique advantage over the systems described in this patent.

4. **Delivery Drone Guiding System (US20220343775)**
   - This patent describes a system and method for guiding delivery drones to specific locations using a combination of location-determining modules, communication modules, and processors. The system includes a housing for the drone's components and integrates with external devices for monitoring and control.

- **Key Features:**
  - Location-determining and communication modules for precise delivery.
  - Integration with external devices and software for real-time monitoring and control.
  - Sensor and camera systems for capturing images and videos during delivery.
- **Distinguishing Aspects:**
  - Our invention's modular payload capability allows for applications beyond delivery, including agricultural spraying and infrastructure inspection.

- The advanced sensor array in our system, including LiDAR and ultrasonic sensors, provides comprehensive environment monitoring and obstacle avoidance, which enhances the versatility and safety of our drone system.

5. **Non-Patent Literature:**
6. **Recent Advances in Unmanned Aerial Vehicles: A Review** - This article provides a comprehensive overview of recent advancements in UAV technology, including autonomous navigation, sensor integration, and practical applications in various fields such as agriculture and industrial inspections (SpringerLink).
7. **Intelligent Autonomous Drones in Industry 4.0** - This chapter discusses the role of autonomous drones in Industry 4.0, including data collection, emergency response, and disaster management (SpringerLink).
8. **A Review on IoT Deep Learning UAV Systems** - This review article explores the use of deep learning techniques for real-time obstacle detection and collision avoidance in UAVs, highlighting the integration of UAVs with IoT applications (MDPI).
9. **Public Use or Sale:**
10. **Autonomous drones for emergency response** - Various instances of autonomous drones being used in real-world emergency response scenarios demonstrate their public use before the effective filing date (SpringerLink).
11. **DroneAlert** - A project utilizing autonomous drones for emergency response and disaster management, showing public deployment and usage (SpringerLink).
12. **Prior Public Disclosure:**
13. **Conference Presentations and Workshops** - Research and developments in UAV technology have been publicly disclosed in numerous conferences and workshops,

providing detailed insights into their functionalities and applications (SpringerLink) (SpringerLink).

14. Other Public Disclosures:

15. **Internet Publications and Trade Shows** - Information about autonomous drones has been widely disclosed on the internet and in trade shows, including detailed descriptions of their capabilities and technological advancements (MDPI) (SpringerLink).

16. Overcoming Prior Art:

17. **Versatility and Modular Design**:
    - Ability to interchange payloads for different applications, which is not commonly found in the prior art.
18. **Advanced Sensor Integration**:
    - Comprehensive sensor array, including advanced technologies like LiDAR and infrared sensors, which provide superior environment monitoring and obstacle detection capabilities.
19. **Energy Management and Sustainability**:
    - Efficient energy management system that includes battery swapping and renewable energy integration, enhancing operational sustainability and reducing downtime.
20. **User Interface and Remote Operation**:
    - User-friendly interface and remote operation capabilities, which allow for easy monitoring, task configuration, and control from a distance.

21. **Technical Field**

22. This invention relates to drone technologies, specifically to an autonomous multi-function drone system designed for versatile applications. The system employs advanced sensors, artificial intelligence (AI), and modular payloads to perform a variety of tasks in different environments.

23. **Background of the Invention**

24. Drones have become increasingly popular in various industries, including agriculture, surveillance, delivery, and disaster response. However, most current drones are designed for specific tasks and lack the versatility needed to adapt to different applications and environments. There is a need for a multi-function drone system that can autonomously switch between tasks and efficiently operate in diverse conditions.

25. **Summary of the Invention**

26. The present invention is an autonomous multi-function drone system designed to perform a variety of tasks in different environments. The system features advanced sensors for real-time environment monitoring, AI for decision-making and task execution, and modular payloads for task-specific configurations. This innovation aims to enhance the versatility and efficiency of drone operations across multiple industries.

27. Brief Description of the Drawings

28. Fig. 1: Overall System Architecture:

29. This figure illustrates the overall architecture of the autonomous multi-function drone system, showcasing the central processing unit (CPU), advanced sensors, modular payloads, autonomous navigation system, energy management module, and user interface.

- **Central Processing Unit (CPU) (101):** The CPU is the core component of the drone system responsible for integrating AI algorithms for decision-making and task management. It processes data from various sensors and controls the modular payloads, navigation, and energy management.
- **Advanced Sensors (102):**
  - **Cameras (102a):** Capture real-time visual data for navigation and task execution.
  - **LiDAR (102b):** Provides precise distance measurements to detect obstacles and map the environment.
  - **Ultrasonic Sensors (102c):** Detect objects and measure distance using sound waves.
  - **Infrared (IR) Sensors (102d):** Capture thermal images to identify heat signatures.
  - **Environmental Sensors (102e):** Monitor environmental conditions such as temperature, humidity, and air quality.
  - **Solid Lines:** Indicate a direct connection to the CPU for real-time data processing.
- **Modular Payloads (103):**
  - **Camera Module (103a):** Used for surveillance and inspection tasks.
  - **Delivery Container (103b):** Facilitates the transportation of goods.
  - **Agricultural Sprayer (103c):** Used for crop monitoring and spraying.
  - **Inspection Tools (103d):** Employed for infrastructure inspection and maintenance.

    - **Solid Lines:** Show the integration of various payloads with the CPU for task-specific configurations.

- **Autonomous Navigation System (104):**
    - Utilizes GPS, inertial measurement units (IMUs), and computer vision for precise navigation and positioning.
    - **Solid Line with Arrow:**
    - Represents the flow of navigation data to the CPU for autonomous flight control.
- **Energy Management Module (105):**
    - Optimizes power usage and supports battery swapping and renewable energy integration.
    - **Solid Lines:** Indicate a direct connection to the CPU for efficient energy management.
- **User Interface (106):**
    - Allows operators to monitor system status, configure tasks, and receive alerts.
    - **Solid Line with Arrow:** Shows the flow of user commands and system feedback to and from the CPU.

30. Fig. 2: Detailed View of the Central Processing Unit (CPU):

31. This figure provides a detailed view of the central processing unit (CPU) highlighting the AI algorithms, task management, and data processing capabilities.

    - **Central Processing Unit (CPU) (201):** The CPU is the core component responsible for integrating AI algorithms for decision-making and task management. It processes data from various sensors and controls the modular payloads, navigation, and energy management.

- **AI Algorithms (202):**
  - These algorithms are designed to analyze sensor data and make real-time decisions.
  - **Solid Line:** Indicates a direct connection to the Task Management and Data Processing units within the CPU for coordinated operations.
- **Task Management (203):**
  - This module manages the execution of various tasks based on the AI algorithms' decisions.
  - **Solid Line:** Shows the interaction with the AI Algorithms and Data Processing units for task coordination.
- **Data Processing (204):**
  - This unit processes incoming data from sensors and other modules, preparing it for analysis by the AI algorithms.
  - **Solid Line:** Represents the data flow between the Data Processing unit and the AI Algorithms and Task Management modules.

32. **Fig. 3: Sensor Array Setup:**
33. This figure shows the setup of various sensors including cameras, LiDAR, ultrasonic sensors, infrared (IR) sensors, and environmental sensors used for comprehensive environment monitoring.

- **Central Processing Unit (CPU) (301):** The CPU processes data from various sensors and integrates it for decision-making and task execution.’
- **Cameras (302a):**
  - Capture real-time visual data for navigation and task execution.

  - **Solid Line:** Indicates a direct connection to the CPU for data processing.
- **LiDAR (302b):** Provides precise distance measurements to detect obstacles and map the environment.
  - **Solid Line:** Shows the data flow from the LiDAR to the CPU.
- **Ultrasonic Sensors (302c):**
  - Detect objects and measure distance using sound waves.
  - **Solid Line:** Represents the connection to the CPU for real-time data analysis.
- **Infrared (IR) Sensors (302d):**
  - Capture thermal images to identify heat signatures.
  - **Solid Line:** Indicates the data flow from the IR sensors to the CPU.
- **Environmental Sensors (302e):**
  - Monitor environmental conditions such as temperature, humidity, and air quality.
  - **Solid Line:** Shows the integration of environmental data with the CPU for comprehensive monitoring.

34. Fig. 4: Example of Modular Payloads:

35. This figure depicts different modular payloads such as a camera module, delivery container, agricultural sprayer, and inspection tools, which can be interchangeably used with the drone system.

- **Central Processing Unit (CPU) (401):** The CPU coordinates the operation of various modular payloads based on task requirements.
- **Camera Module (402a):**
  - Used for surveillance and inspection tasks.

  - **Solid Line:** Indicates a direct connection to the CPU for data exchange and control.
- **Delivery Container (402b):**
  - Facilitates the transportation of goods.
  - **Solid Line:** Represents the connection to the CPU for managing delivery tasks.
- **Agricultural Sprayer (402c):**
  - Used for crop monitoring and spraying.
  - **Solid Line:** Shows the integration with the CPU for precise application and monitoring.
- **Inspection Tools (402d):**
  - Employed for infrastructure inspection and maintenance.
  - **Solid Line:** Indicates the data flow and control interface with the CPU.

36. Fig. 5: Autonomous Navigation System Components:

37. This figure illustrates the components of the autonomous navigation system, including GPS, inertial measurement units (IMUs), and the computer vision setup used for precise navigation and positioning.

- **Central Processing Unit (CPU) (501):** The CPU processes data from various navigation components to enable autonomous flight and precise positioning.
- **GPS (502a):**
  - Provides location data for navigation.
  - **Solid Line:** Indicates a direct connection to the CPU for real-time location tracking.
- **Inertial Measurement Units (IMUs) (502b):**

  - Measure the drone's velocity, orientation, and gravitational forces.
  - **Solid Line:** Represents the data flow from the IMUs to the CPU for flight stabilization and control.
- **Computer Vision Setup (502c):**
  - Uses cameras and image processing algorithms to detect and avoid obstacles.
  - **Solid Line:** Shows the integration of visual data with the CPU for real-time navigation decisions.
- **Navigation and Positioning (502d):**
  - Integrates data from GPS, IMUs, and the computer vision setup to determine the drone's precise position and path.
  - **Solid Line:** Indicates the data flow to the CPU for autonomous navigation and path planning.

38. Fig. 6: User Interface Layout:

39. This figure shows the layout of the user interface, which includes system status monitoring, task configuration, alerts and notifications, and remote operation control.

- **Central Processing Unit (CPU) (601):** The CPU coordinates the data exchange between the user interface panels and the drone system.
- **System Status Monitoring (602a):**
  - Displays real-time information about the drone's operational status, battery levels, and system health.
  - **Solid Line:** Indicates a direct connection to the CPU for continuous status updates.
- **Task Configuration (602b):**

    - Allows the user to configure and schedule various tasks for the drone to execute.
    - **Solid Line:** Represents the flow of configuration data to the CPU for task management.
- **Alerts and Notifications (602c):**
    - Provides alerts and notifications about system events, errors, and important updates.
    - **Solid Line:** Shows the integration of alert data with the CPU for timely notifications.
- **Remote Operation Control (602d):**
    - Enables remote control and operation of the drone, allowing the user to manually override autonomous functions if necessary.
    - **Solid Line:** Indicates the data flow between the remote control interface and the CPU for real-time command execution.

40. Fig. 7: Energy Management Module:

41. This figure depicts the energy management module, highlighting power usage optimization, the battery swapping mechanism, renewable energy integration, and continuous operation capabilities.

- **Central Processing Unit (CPU) (701):** The CPU manages the energy resources and ensures efficient power distribution and usage.
- **Power Usage Optimization (702a):**
    - Optimizes the power consumption of the drone system to extend operational time.
    - **Solid Line:** Indicates a direct connection to the CPU for real-time power management.

- **Battery Swapping Mechanism (702b):**
    - Allows for quick and easy swapping of batteries to minimize downtime.
    - **Solid Line:** Represents the data flow to the CPU for monitoring battery status and managing the swapping process.
- **Renewable Energy Integration (702c):**
    - Integrates renewable energy sources, such as solar panels, to supplement the drone's power supply.
    - **Solid Line:** Shows the connection to the CPU for efficient energy utilization and management.
- **Continuous Operation (702d):**
    - Ensures that the drone can operate continuously by managing power sources and usage.
    - **Solid Line:** Indicates the data flow between the continuous operation module and the CPU for seamless energy management.

42. Fig. 8: Safety Features:

43. This figure illustrates the safety features of the drone system, including emergency landing protocols, collision avoidance, and fail-safe mechanisms.

- **Central Processing Unit (CPU) (801):** The CPU is responsible for processing data from safety features and making real-time decisions to ensure the safe operation of the drone.
- **Emergency Landing Protocols (802a):**
    - Manages the drone's behavior in emergency situations, ensuring a safe and controlled landing.

    - **Solid Line:** Indicates a direct connection to the CPU for executing emergency landing procedures.

- **Collision Avoidance (802b):**
    - Uses sensor data to detect and avoid obstacles in real-time.
    - **Solid Line:** Represents the data flow to the CPU for processing and making immediate adjustments to the flight path.
- **Fail-Safe Mechanisms (802c):**
    - Provides backup systems and procedures to ensure the drone's operation remains safe in case of system failures.
    - **Solid Line:** Shows the integration with the CPU for continuous monitoring and activation of fail-safe measures when necessary.

44. **Detailed Description of the Invention**

45. Clear and Complete Explanation:

46. The "Autonomous Multi-Function Drone System for Versatile Applications" comprises several key components: the central processing unit (CPU), advanced sensors, modular payloads, autonomous navigation system, energy management module, and user interface. Each component is integrated to provide a comprehensive solution for various applications such as delivery, agriculture, and infrastructure inspection.

47. **System Architecture:**

- The drone system comprises a central processing unit (CPU), multiple sensors, modular payloads, and a user interface.
- The CPU integrates AI algorithms for decision-making and task management.
- **Advanced Sensors:**

  - The system includes various sensors such as cameras, lidar, ultrasonic, infrared (IR), and environmental sensors for comprehensive environment monitoring.
  - Sensor data is processed in real-time to detect obstacles, identify objects, and assess environmental conditions.
- **Artificial Intelligence:**
  - AI algorithms analyze sensor data to make real-time decisions and execute tasks.
  - Machine learning models enable the system to learn from past experiences and improve performance over time.
- **Modular Payloads:**
  - The system features interchangeable payloads, including cameras, delivery containers, agricultural sprayers, and inspection tools which can be easily swapped to perform different tasks.
  - Payloads are designed for specific functions such as surveillance, delivery, crop monitoring, and infrastructure inspection.
- **Autonomous Navigation:**
  - The system uses GPS, inertial measurement units (IMUs), and computer vision for precise navigation and positioning.
  - Autonomous flight capabilities include waypoint navigation, obstacle avoidance, and dynamic path planning.
- **Task Adaptation:**
  - The system can dynamically adjust its actions based on real-time sensor data and AI analysis.

  - Adaptation includes changing payloads, altering flight paths, and adjusting flight parameters according to task requirements.

- **User Interface:**
  - A user-friendly interface allows operators to monitor system status, configure tasks, and receive alerts.
  - The interface supports remote operation and programming, enabling users to control the drone from a distance.
- **Energy Management:**
  - The system includes an efficient energy management module that optimizes power usage and supports battery swapping for continuous operation.
  - Renewable energy options such as solar charging are integrated to enhance sustainability.
- **Safety and Compliance:**
  - The system is equipped with safety features including emergency landing protocols, collision avoidance, and fail-safe mechanisms.
  - Compliance with industry standards and regulations ensures safe operation in various environments.

48. Best Mode:

49. The best mode of carrying out the invention involves the integration of advanced AI algorithms in the CPU for real-time decision-making and task management. The system is designed to be modular, allowing for the easy interchange of payloads depending on the specific application.

50. Embodiments:

- **Primary Embodiment:** The primary embodiment includes a drone equipped with a CPU, multiple advanced sensors (cameras, LiDAR, ultrasonic, infrared, and environmental sensors), modular payloads (camera module, delivery container, agricultural sprayer, and inspection tools), an autonomous navigation system, an energy management module, and a user interface.
- **Alternative Embodiments:** Alternative embodiments may include variations in the sensor types, additional payload configurations, and alternative energy management strategies such as solar panels or fuel cells.

51. Terminology and Definitions:

- **Central Processing Unit (CPU):** The main control unit of the drone, responsible for processing data and managing tasks.
- **Advanced Sensors:** Includes cameras, LiDAR, ultrasonic sensors, infrared sensors, and environmental sensors for comprehensive monitoring.
- **Modular Payloads:** Interchangeable components that allow the drone to perform various tasks.
- **Autonomous Navigation System:** Utilizes GPS, IMUs, and computer vision for navigation.
- **Energy Management Module:** Manages power usage and supports battery swapping and renewable energy integration.
- **User Interface:** Allows operators to monitor and control the drone remotely.

52. Function and Operation:

53. The drone operates by using its CPU to process data from its sensors and execute tasks using the appropriate modular payload. The autonomous navigation system ensures precise positioning and obstacle avoidance, while the energy management module optimizes power usage for extended operation. The user interface provides real-time monitoring and control capabilities.

54. Advantages and Improvements:

- **Versatility:** The modular design allows the drone to be used in multiple applications, enhancing its utility.
- **Advanced Sensors:** The comprehensive sensor array provides superior environment monitoring and obstacle detection.
- **Energy Efficiency:** The energy management system, including battery swapping and renewable energy integration, extends operational time and reduces downtime.
- **User-Friendly Interface:** The remote operation capabilities and intuitive interface make it easy to monitor and control the drone.

55. Alternative Configurations:

- **Sensor Configurations:** Variations in sensor types and placements to suit different operational environments.
- **Payload Variations:** Additional payloads such as firefighting equipment, medical supply containers, and more.
- **Energy Sources:** Alternative energy sources such as fuel cells or hybrid systems to enhance operational efficiency.

56. **Detailed Examples:**

- **Example 1: Delivery Application**

  - The drone is equipped with a delivery container payload.
  - It uses GPS and computer vision to navigate to the delivery location.
  - The energy management module ensures efficient power usage, and the user interface allows the operator to monitor the delivery process in real-time.

- **Example 2: Agricultural Application**
  - The drone is fitted with an agricultural sprayer payload.
  - It uses LiDAR and environmental sensors to monitor crop health and deliver precise amounts of pesticides or fertilizers.
  - The user interface provides real-time feedback and allows for task configuration.
  - These examples illustrate the practical applications of the drone system, demonstrating its versatility and advanced capabilities.

57. **Conclusion**

58. In conclusion, the "Autonomous Multi-Function Drone System for Versatile Applications" represents a significant advancement in drone technology. It combines a highly capable central processing unit with a comprehensive array of advanced sensors and modular payloads, enabling it to perform a wide range of tasks from delivery to agricultural monitoring and infrastructure inspection. The system's autonomous navigation capabilities and robust energy management ensure efficient and reliable operation, while the user-friendly interface provides operators with real-time control and monitoring. This innovative system's versatility, advanced functionality, and operational efficiency position it as a pioneering solution in the field of autonomous drones.

Claims

1. An autonomous multi-function drone system for versatile applications comprising:

    A central processing unit (CPU) with integrated AI algorithms for decision-making and task management;

    Multiple sensors for real-time environment monitoring including cameras, lidar, ultrasonic, infrared, and environmental sensors;

    Modular payloads including interchangeable cameras, delivery containers, agricultural sprayers, and inspection tools for performing different tasks;

    Autonomous navigation using GPS, IMUs, and computer vision for precise navigation and positioning;

    A user interface for system monitoring, task configuration, and remote operation;

    An energy management module optimizing power usage and supporting renewable energy options.

2. The drone system of claim 1, wherein the AI algorithms analyze sensor data to make real-time decisions and execute tasks.
3. The drone system of claim 1, wherein the modular payloads are designed for specific functions such as surveillance, delivery, crop monitoring, and infrastructure inspection.
4. The drone system of claim 1, wherein the system dynamically adjusts its actions based on real-time sensor data and AI analysis including changing payloads, altering flight paths, and adjusting flight parameters.
5. The drone system of claim 1, wherein the user interface supports remote operation and programming.

6. The drone system of claim 1, wherein the energy management module optimizes power usage and includes battery swapping and renewable energy integration.
7. The drone system of claim 1, wherein the safety features include emergency landing protocols, collision avoidance, and fail-safe mechanisms.

Abstract

1. An autonomous multi-function drone system designed to perform a variety of tasks in different environments. The system features advanced sensors for real-time environment monitoring, AI for decision-making and task execution, and modular payloads for task-specific configurations. Autonomous navigation, task adaptation, a user-friendly interface, efficient energy management, and robust safety mechanisms enhance the versatility and efficiency of drone operations across multiple industries.