Intelligent Systems for Multiple UAV Operations

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The objective of this paper is to demonstrate the powerful impact of an innovative intelligent autonomous mission planner/controller for networked multiple manned/unmanned autonomous vehicles which is applicable to the Future Combat System (FCS), Future Force Warrior (FFW), Future Special Operations Forces (SOF) systems, Land Warrior, and Homeland Defense. For the intelligent vehicles, which consist of multiple heterogeneous unmanned vehicles, the autonomous mission planner/controller includes navigation, obstacle detection and avoidance, waypoint tasking planner, mission trajectory planner, vehicle formation control and wireless communication network. The navigation subsystem is implemented by fusion of the AGNC's coremicro® Palm Navigator, monocular/stereo vision, Doppler radar, and ranging sensors. The intelligent system is designed to guide, navigate, and control each vehicle using multiple control techniques. The intelligent controller guides and navigates each UAV to follow the trajectory generated from the command station according to the mission to properly adapt to the new environment. The implemented intelligent system complies with the ARDEC Multiple Platform Coordination (MPC) Architecture standard. This system is also adaptable to the commercial and industrial applications, such as, Traffic Monitoring, Air Traffic Management, Law Enforcement, Border Patrol, and Search and Rescue missions, etc.

Autonomous UAV applications are currently becoming increasingly important. Multiple UAVs operation is very important, especially in applications dangerous for humans, such as, search and rescue operations at a fire site or in a collapsed building. Small multiple UAVs can get into the dangerous area and help expedite search and rescue operations to save valuable lives. This paper introduces an intelligent system for the multiple UAVs operation. The intelligent system is designed to guide, navigate, and control each vehicle involved with multi-UAV operations using multiple control techniques, such as, fuzzy hybrid system and optimal control.

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The intelligent controller guides and navigates each UAV to follow the trajectory generated from the command station according to the mission based artificial intelligence such as fuzzy logic reasoning and neural network based learning system to properly adapt to the new environment and control the vehicle according to the mission plan.

The developed intelligent controller is implemented using AGNC's coremicro® Palm Navigator (CPN) embedded with the coremicro® AHRS/INS/GPS Integration Unit, monocular/stereo vision, ranging sensors, speed sensor, etc. AGNC's coremicro® Helicopter (rotary wing UAV) and Fixed-wing UAV which are low cost, lightweight, high performance, and electric powered air vehicles have been demonstrated to be very easy to handle and operate with little maintenance and cost. For individual vehicle control, the autopilot system has been developed using the AGNC coremicro® Palm Navigator (CPN) as the flight computer for its guidance, navigation, and control. The CPN includes sensor array and GPS unit to measure dynamics of the UAV and a communication unit to communicate with a command station. Also, an integrated radio link transmits a video stream from the gimbaled camera, vehicle status, and location, and receive commands from the command station.

AGNC's coremicro® Helicopter (rotary wing UAV): The coremicro® Helicopter is an ideal vehicle for executing in hover sustained surveillance of an area with a vision system and offers an efficient navigation capability for flight through openings, such as, gates, doors, and windows. The coremicro® Helicopter is also ideal for accommodating the viewing conditions for target identification by AGNC's vision system and can readily carry out autonomous flight. The simulation model for this coremicro® Helicopter is constructed based on the flight test. The CPN is also installed on the helicopter to send the real-time measurement of the helicopter dynamics to the ground computer for the system identification purposes. The coremicro® Helicopter autopilot is designed using the simulation model and fuzzy logic hybrid system.

AGNC's Fixed-wing UAV: To achieve automatic precision flight of the fixed wing UAV, AGNC's coremicro® Palm Navigation (CPN) is used as a flight control computer for the guidance, navigation, control, and communication. The autopilot is designed using optimal and fuzzy hybrid control and has the ability to guide, navigate, and control the fixed wing UAV. This innovative control design can be used for many of the conventional small UAVs. The simulation model also includes the weather effects to ensure versatile operation capability in many different weather conditions.

AGNC's innovative command station has the capability to control multiple vehicles at the same time. The command station automatically generates each trajectory to perform a teamed mission. The trajectory consists of 4D information which is position (x, y, and z) and time (t). The generated trajectory is then fed into each vehicle's autopilot to follow.

The simulation results showed excellent results not only for the trajectory tracking performance but also for robustness against adverse weather conditions, such as, moderate constant wind, and wind gust. This innovative intelligent multiple UAV control system for networked unmanned vehicles finds a large market in many areas. It has immediate use for vehicles and robotic control, as well as guidance and navigation systems related applications. Moreover, the technology is suitable to any commercial application where intelligent autonomous control is required, particularly where a low cost, flexible and reconfigurable module is desirable.