CLAIMS

What is claimed is:

1. An aircraft, comprising:

an airframe having a lifting surface;

a longitudinal-thrust engine;

a plurality of modular articulated electric rotors attached to the airframe, each rotor being a rotor assembly including a respective electric motor and respective propeller rotated thereby, each rotor being nominally aligned with a respective vertical axis perpendicular to a longitudinal axis of the aircraft, at least some of the rotors being variable-position rotors having variable orientations about their nominal alignment based on rotor position signals supplied thereto;

a source of electrical power for powering the electric rotors;

control circuitry configured and operative to independently control thrust of the longitudinal-thrust engine and rotor thrust and rotor orientation of each of the variable-position rotors, relative to the aircraft lifting surface and longitudinal thrust engine, to provide for commanded thrust-vectoring maneuvering of the aircraft during vertical takeoff and landing (VTOL), fixed wing flight, and intermediate transitional states, including maintenance of a desired pose of the lifting surface independent of the rotor orientations when hovering the aircraft in windy conditions; and

a flight and navigation control system that automates flight maneuvers autonomously or through human-in-the-loop augmentation and is capable of maintaining the desired aircraft system pose and position relative to static or dynamic global coordinates that are autonomously or operator defined when the aircraft is executing station keeping, tracking, avoidance, or convergence maneuvers,

wherein the variable-position rotors are compound-articulated electric rotors having variable orientations in both pitch and roll based on the rotor position, and wherein the control circuitry provides the independent control of the compound-articulated electric rotors to maintain the desired pose of the lifting surface independent of the rotor orientations when hovering the aircraft in crosswind conditions,

the aircraft being further configured and operative in both a lateral-translation case and a longitudinal-translation case, wherein in the lateral-translation case the rotors are articulated in

roll to assist while managing a substantially horizontal attitude of the lifting surface to reduce adverse and variable effects of wind-induced lifting and to maintain control authority, and wherein in the longitudinal-translation case the rotors are articulated in pitch to assist while managing the substantially horizontal attitude of the lifting surface to reduce adverse and variable effects of wind-induced lifting components and maintain control authority,

wherein the control circuitry includes a model-based controller incorporating an aircraft physical plant model taking into account aerodynamic forces experienced by the aircraft including (1) in the lateral-translation case due to airflow laterally and longitudinally across the lifting surface, and (2) in the longitudinal-translation case due to airflow over the lifting surface, including forces induced by wind from the environment, and the model-based controller (1) uses the model to determine required response of the rotors to thereby provide reduced energy demand and time to transition to and from fixed-wing flight.

2.. The aircraft of claim 1, wherein the control circuitry and flight and navigation control system are co-operative to provide for thrust vectoring propulsion with control in six dimensions, including (a) rotational speed and blade pitch of the longitudinal-thrust engine, and (b) rotor assembly longitudinal tilt-angle, rotor assembly lateral tilt-angle, rotor rotational speed, and rotor blade pitch for the rotors.

3. The aircraft of claim 2, wherein each of the rotors is independently controlled.

4. The aircraft of claim 1, wherein the lifting surface is formed by wings extending laterally from a central longitudinal fuselage.

5. The aircraft of claim 4, wherein the horizontal-thrust engine is located on the fuselage and is arranged to provide rearward horizontal thrust.

6. The aircraft of claim 4. further including two elongated booms attached to the wings, and wherein the rotors are attached at respective ends of the booms.

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7. The aircraft of claim 1, wherein the rotors include front rotors oriented upward and having tractor propellers, and rear rotors oriented downward and having pusher propellers.

8. The aircraft of claim 1, having a symmetric propulsion configuration including variable-orientation front rotors and variable-orientation rear rotors.

9. The aircraft of claim 1, having an asymmetric propulsion configuration including variable-orientation front rotors and constrained-orientation rear rotors, the constrained-orientation rotors having a more limited range of motion than the variable-orientation rotors.

10. The aircraft of claim 1, having an asymmetric propulsion configuration including variable-orientation front rotors and fixed-orientation rear rotors.

11. The aircraft of claim 1, wherein at least some of the rotors include a variable-pitch mechanism by which the pitch of the rotor propeller is dynamically adjusted to provide a corresponding aspect of flight control.

12. The aircraft of claim 1, wherein the aircraft physical plant model includes a propeller airflow model, servo torque and latency model, motor power and latency model, and actuator feedback model.

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