CLAIMS

What is claimed is:

1. An autorotating aerial device comprising:

a housing member having disposed thereon an actuator and a controller configured to control the actuator; and

a wing member coupled to the actuator, the wing member comprising a main wing portion and a flap portion adjustable with respect to the main wing portion,

wherein the controller is configured to control the actuator to switch the autorotating aerial device between a diving mode of operation and an autorotating mode of operation based on adjusting an angle of attack of the flap portion, the angle of attack being with respect to a lateral axis along the main wing portion,

wherein said control the actuator to switch the autorotating aerial device between the diving mode of operation and the autorotating mode of operation comprises adjusting the angle of attack of the flap portion beyond a critical angle of attack for the diving mode of operation and adjusting the angle of attack of the flap portion below the critical angle of attack for the autorotating mode of operation, and

wherein the controller is further configured to control the actuator to adjust the angle of attack of the flap portion to an angle in a range of 70° to 90° for a positive angle with respect to the lateral axis along the main wing portion or in a range of -60° to -90° for a negative angle with respect to the lateral axis along the main wing portion to initiate the diving mode of operation of the autorotating aerial device.

2. The autorotating aerial device of claim 1, wherein the critical angle of attack is about 70° for a positive angle with respect to the lateral axis along the main wing portion and about -60° for a negative angle with respect to the lateral axis along the main wing portion.

3. The autorotating aerial device of claim 1 or 2, wherein in the autorotating mode of operation, the controller is further configured to control the actuator to control a pitch angle of the flap portion based on a square cyclic control.

4. The autorotating aerial device of any one of claims 1 to 3, wherein the main wing portion comprises a leading edge and a trailing edge, wherein the flap portion is arranged along a length of the trailing edge of the main wing portion.

5. The autorotating aerial device of claim 4, wherein the flap portion is arranged along an entire length of the trailing edge of the main wing portion.

6. The autorotating aerial device of any one of claims 1 to 5, wherein the main wing portion is formed of wood and the flap portion is formed of a solid foam material.

7. The autorotating aerial device of any one of claims 1 to 6, wherein the actuator is a servo configured to adjust the angle of attack of the flap portion with respect to a lateral axis along the main wing portion.

8. The autorotating aerial device of any one of claims 1 to 7, wherein the actuator is further configured to be removably coupled to a coupling hub, wherein the coupling hub is configured to couple respective housing members of two or more autorotating aerial devices for collaborative autorotation.

9. The autorotating aerial device of any one of claims 1 to 8, wherein the housing member further has disposed thereon a magnetometer, a global positioning system, a receiver, a voltage regulator, an inertial measurement unit and a battery.

10. The autorotating aerial device of any one of claims 1 to 9, wherein the housing member further comprises a memory, and the controller is communicatively coupled to the memory and configured to control the actuator to switch the autorotating aerial device between the diving mode of operation and the autorotating mode of operation based on adjusting the angle of attack of the flap portion.

11. An autorotating aerial system, the system comprising:

two or more autorotating aerial devices, each autorotating aerial device according to any one of claims 1-10 coupled together at a coupling hub; and

wherein for said each autorotating aerial device, the actuator of the autorotating aerial device is configured to release the autorotating aerial device from the coupling hub in response to a trigger.

12. The autorotating aerial system of claim 11, wherein the actuator is configured to release the two or more autorotating aerial devices from the coupling hub simultaneously.

13. The autorotating aerial system of claim 11 or 12, wherein the coupling hub comprises a spring loaded mechanism disposed on the housing member of said each autorotating aerial device, respectively, for interlocking corresponding housing members of the two or more autorotating aerial devices.

14. A method of forming an autorotating aerial device, the method comprising:

providing a housing member having disposed thereon an actuator and a controller configured to control the actuator;

providing a wing member comprising a main wing portion and a flap portion adjustable with respect to the main wing portion; and

coupling the wing member to the actuator,

wherein the controller is configured to control the actuator to switch the autorotating aerial device between a diving mode of operation and an autorotating mode of operation based on adjusting an angle of attack of the flap portion, the angle of attack being with respect to a lateral axis along the main wing portion,

wherein said control the actuator to switch the autorotating aerial device between the diving mode of operation and the autorotating mode of operation comprises adjusting the angle of attack of the flap portion beyond a critical angle of attack for the diving mode of operation and adjusting the angle of attack of the flap portion below the critical angle of attack for the autorotating mode of operation, and

wherein the controller is further configured to control the actuator to adjust the angle of attack of the flap portion to an angle in a range of 70° to 90° for a positive angle with respect to the lateral axis along the main wing portion or in a range of -60° to -90° for a negative angle with respect to the lateral axis along the main wing portion to initiate the diving mode of operation of the autorotating aerial device.

15. The method of claim 14, wherein said providing a wing member comprises:

decomposing the flap portion into a plurality of blade elements;

determining, for each blade element of the plurality of blade elements, an optimized chord length, optimized chord width and optimized flap angle based on a multi-component objective optimization function including a plurality of components relating to a drop speed of the autorotating aerial device, a rotation rate of the autorotating aerial device and undesired oscillations of the autorotating aerial device and using genetic algorithm optimization; and

forming the flap portion based on the optimized chord length and optimized chord width of each blade element and the optimized flap angle.

16. The method of claim 15, wherein the plurality of components of the multi-component objective optimization function comprise a first component relating to the rotation rate of the autorotating aerial device, a second component relating to the drop speed of the autorotating aerial device, a third component relating to a penalty function for the undesired oscillations of the autorotating aerial device, and a fourth component relating to a distance deviation of the autorotating aerial device in a time interval.

17. The method of any one of claims 14 to 16, wherein the critical angle of attack is about 70° for a positive angle with respect to the lateral axis along the main wing portion and about -60° for a negative angle with respect to the lateral axis along the main wing portion.

18. The method of any one of claims 14 to 17, wherein in the autorotating mode of operation, the controller is further configured to control the actuator to control a pitch angle of the flap portion based on a square cyclic control.

19. The method of any one of claims 14 to 18, wherein the main wing portion comprises a leading edge and a trailing edge, wherein the flap portion is arranged along a length of the trailing edge of the main wing portion.

20. The method of claim 19, wherein the flap portion is arranged along an entire length of the trailing edge of the main wing portion.

21. The method of any one of claims 14 to 20, wherein the main wing portion is formed of wood and the flap portion is formed of a solid foam material.