plurality of rotor motors, and (b) the multi-tool module comprises a base, a hub which is rotatable relative to the base about an axis of rotation, a plurality of arms having respective first ends pivotably coupled to the hub, a plurality of tools mounted to respective second ends of respective arms of the plurality of arms, a motor operatively coupled to drive rotation of the hub, and a second motor operatively coupled to drive rotation of the plurality of arms relative to the hub. The hub comprises an inner cylinder which is rotatable relative to the base about the axis of rotation, a head affixed to the inner cylinder and pivotably coupled to the first ends of the plurality of arms, a ring which is disposed between the head and the base and is slidable along and translatable relative to the inner cylinder, and a plurality of links, each link having one end pivotably coupled to the ring and another end pivotably coupled to a respective arm of the plurality of arms.

Another aspect of the subject matter disclosed in detail below is an apparatus comprising an unmanned aerial vehicle and a tool pick-and-place module coupled to the unmanned aerial vehicle, wherein: (a) the unmanned aerial vehicle comprises a body frame, a plurality of rotor motors mounted to the body frame, and a plurality of rotors operatively coupled to respective rotor motors of the plurality of rotor motors; (b) the tool pick-and-place module comprises a platform comprising a plurality of tool stations, a tool pick-and-place robot mounted to the platform, and a plurality of tools positioned at respective tool stations; and (c) the tool pick-and-place robot comprises a base, a hub which is rotatable about the base, an arm having a first end fixedly coupled to the hub and a second end at a distance from the hub, and a tool holder mounted to the second end of the arm.

CLAIMS

1. An apparatus comprising an unmanned aerial vehicle and a multi-tool module coupled to the unmanned aerial vehicle, wherein:

the unmanned aerial vehicle comprises a body frame, a plurality of rotor motors mounted to the body frame, and a plurality of rotors operatively coupled to respective rotor motors of the plurality of rotor motors, and

the multi-tool module comprises a base, a hub which is rotatable relative to the base about an axis of rotation, a plurality of arms having respective first ends pivotably coupled to the hub, a plurality of tools mounted to respective second ends of respective arms of the plurality of arms, a first motor operatively coupled to drive rotation of the hub, and a second motor operatively coupled to drive rotation of the plurality of arms relative to the hub,

wherein the hub comprises:

an inner cylinder which is rotatable relative to the base about the axis of rotation;

a head affixed to the inner cylinder and pivotably coupled to the first ends of the plurality of arms;

a ring which is disposed between the head and the base and is slidable along and translatable relative to the inner cylinder; and

a plurality of links, each link having one end pivotably coupled to the ring and another end pivotably coupled to a respective arm of the plurality of arms.

2. The apparatus as recited claim 1, wherein:

the unmanned aerial vehicle further comprises a payload support frame pivotably coupled to the body frame;

the multi-tool module is attached to the payload support frame; and

the payload support frame comprises a plurality of surface attachment devices.

3. The apparatus as recited in claim 1 or 2, wherein the plurality of tools comprises a subtractive repair tool and an additive repair tool.

4. The apparatus as recited in claim 3, further comprising a control system which is configured to control the multi-tool module so that the subtractive repair tool subtracts material from the surface of the structure and thereafter the additive repair tool adds material to the surface of the structure.

5. The apparatus as recited in claim 1 or 2, wherein the plurality of tools comprises a cleaner and a dryer.

6. The apparatus as recited in claim 5, further comprising a control system which is configured to control the multi-tool module so that the cleaner cleans the surface of the structure and thereafter the dryer dries the surface of the structure.

7. The apparatus as recited in any one of claims 1 to 6, further comprising a vacuum adherence system configured to temporarily attach the multi-tool module in a stable position on the surface of the structure.

8. The apparatus as recited in claim 7, wherein the vacuum adherence system comprises a control valve comprising first and second ports, a vacuum pump in fluid communication with the first port of the control valve, a vacuum manifold assembly in fluid communication with the second port of the control valve, and a plurality of suction cups in fluid communication with the vacuum manifold assembly.