Claims

1. A method for automated electroluminescence (EL) imaging of a PV array using an aerial vehicle, the PV array corresponding to a plurality of target points for the aerial vehicle, the method comprising:

positioning the aerial vehicle at a first target point of the plurality of target points corresponding to the PV array; and

controlling the aerial vehicle for automated manoeuvre between the first target point and a second target point of the plurality of target points to capture a visual dataset of the PV array, the automated manoeuvre performed by the aerial vehicle comprising:

aligning a field-of-view (FOV) of a camera of the aerial vehicle to a PV array subsection of the PV array;

locating, in the aligned FOV, a first target viewpoint of the PV array and corresponding to the first target point;

determining, based on an arrangement of the aerial vehicle relative to the PV array and with reference to the located first target viewpoint, a scanning direction for moving the aerial vehicle between the first and second target points; and

capturing, using the camera, the visual dataset of the PV array starting from the PV array subsection as the aerial vehicle moves along the scanning direction between the first and second target points.

2. The method according to claim 1, wherein the automated manoeuvre comprises determining, based on the arrangement of the aerial vehicle, camera, and PV array, the scanning direction to be:

a forward scanning direction, wherein the aerial vehicle and camera face perpendicular directions as the aerial vehicle moves forwardly along the forward scanning direction; or

a sideward scanning direction, wherein the aerial vehicle and camera face forward as the aerial vehicle moves laterally along the sideward scanning direction.

3. The method according to claim 1 or 2, wherein the automated manoeuvre comprises:

moving the aerial vehicle forwardly along the scanning direction from the first target point to the second target point; and

moving the aerial vehicle reversely along the scanning direction from the second target point to the first target point.

4. The method according to any one of claims 1 to 3, wherein aligning the FOV comprises detecting a polygonal outline of the PV array subsection.

5. The method according to claim 4, wherein:

aligning the FOV comprises calculating a pitch angle misalignment based on the detected polygonal outline; and

aligning the FOV optionally comprises adjusting a pitch angle of the camera by the pitch angle misalignment, such that the polygonal outline is centred to the FOV.

6. The method according to claim 4 or 5, wherein:

aligning the FOV comprises calculating a roll axis misalignment based on the angular difference between a current pitch angle of the camera and a desired pitch angle; and

aligning the FOV optionally comprises manoeuvring the aerial vehicle along a roll axis by the roll axis misalignment, such that an optical axis of the camera is perpendicular to the PV array.

7. The method according to any one of claims 4 to 6, wherein aligning the FOV comprises aligning a pair of guide lines of the FOV to the PV array subsection, the guide lines being offset from edges of the FOV.

8. The method according to claim 7, wherein:

aligning the FOV comprises calculating a rotational misalignment between the polygonal outline and the PV array subsection based on the offset guide lines and the polygonal outline; and

aligning the FOV optionally comprises adjusting a yaw angle of the camera by the rotational misalignment.

9. The method according to claim 7 or 8, wherein aligning the FOV comprises calculating a vertical misalignment based on the offset guide lines and the polygonal outline.

10. The method according to any one of claims 1 to 9, wherein the scanning direction is determined based on a pitch axis misalignment between the aligned FOV and the PV array subsection.

11. The method according to any one of claims 1 to 10, wherein the automated manoeuvre comprises calculating misalignment parameters as the aerial vehicle moves along the scanning direction and reducing movement speed of the aerial vehicle if the misalignment parameters breach predefined conditions.

12. The method according to any one of claims 1 to 11, further comprising:

receiving geolocation data of the aerial vehicle; and

returning the aerial vehicle to a previous position based on the geolocation data, wherein at the previous position, the PV array subsection was last visible in the FOV.

13. An aerial vehicle for automated electroluminescence (EL) imaging of a PV array, the aerial vehicle comprising:

a propulsion device for actuating movement of the aerial vehicle;

a camera for capturing a visual dataset of the PV array, the PV array corresponding to a plurality of target points for the aerial vehicle; and

a controller communicatively connected to the camera and the propulsion device and configured for:

positioning the aerial vehicle at a first target point of the plurality of target points corresponding to the PV array; and

controlling the aerial vehicle for automated manoeuvre between the first target point and a second target point of the plurality of target

points to capture the visual dataset of the PV array, the automated manoeuvre performed by the aerial vehicle comprising:

aligning a field-of-view (FOV) of a camera of the aerial vehicle to a PV array subsection of the PV array;

locating, in the aligned FOV, a first target viewpoint of the PV array and corresponding to the first target point;

determining, based on an arrangement of the aerial vehicle relative to the PV array and with reference to the located first target viewpoint, a scanning direction for moving the aerial vehicle between the first and second target points; and

capturing, using the camera, the visual dataset of the PV array starting from the PV array subsection as the aerial vehicle moves along the scanning direction between the first and second target points.

14. A method for automated flight of an aerial vehicle to perform imaging of a set of PV arrays, the method comprising:

determining flight paths between target points for capturing visual datasets of the PV arrays, each PV array corresponding to a plurality of the target points;

controlling the aerial vehicle for automated flight along the flight paths to a respective first target point of the respective plurality of target points corresponding to each PV array; and

controlling the aerial vehicle for automated manoeuvre between the respective first target point and a respective second target point of the respective plurality of target points to capture the visual datasets of each PV array using a camera of the aerial vehicle,

wherein the automated manoeuvre performed by the aerial vehicle comprises moving the aerial vehicle between the respective first and second target points along a scanning direction determined based on an arrangement of the aerial vehicle relative to the PV array and with reference to a first target viewpoint of the PV array in a field-of-view (FOV) of the camera, the first target viewpoint corresponding to the respective first target point.

15. The method according to claim 14, wherein the scanning direction is determined, based on the arrangement of the aerial vehicle, camera, and PV array, to be:

a forward scanning direction, wherein the aerial vehicle and camera face perpendicular directions as the aerial vehicle moves forwardly along the forward scanning direction; or

a sideward scanning direction, wherein the aerial vehicle and camera face forward as the aerial vehicle moves laterally along the sideward scanning direction.

16. The method according to claim 14 or 15, wherein the automated manoeuvre comprises:

moving the aerial vehicle forwardly along the scanning direction from the respective first target point to the respective second target point; and

moving the aerial vehicle reversely along the scanning direction from the respective second target point to the respective first target point.

17. The method according to any one of claims 14 to 16, wherein:

each flight is calculated using a 3D spline function;

the length of each flight path is minimized by adjusting positions of knots of the 3D spline function, wherein the flight path does not intersect with any obstacle and is above a predefined minimum height; and

the number of knots is optionally iteratively increased to determine the flight path that does not intersect with any obstacle and is above the predefined minimum height.

18. The method according to any one of claims 14 to 17, wherein:

controlling the aerial vehicle for automated flight comprises controlling the camera to always face the PV array corresponding to the next target point as the aerial flies along the respective flight path to the next target point;

each flight path to a respective target point optionally comprises an orbiting path circling around and towards the target point; and

the orbiting path optionally comprises a target turning circle tangential to the target point.

19. The method according to claim 18, wherein the aerial vehicle is controlled to fly along an outer tangent of the target turning circle, and wherein controlling the aerial vehicle for automated flight comprises reducing flight speed of the aerial vehicle as the aerial vehicle approaches the target point, such that the radius of the target turning circle decreases and the orbiting path forms a shorter spiral path.

20. The method according to claim 18, wherein the aerial vehicle is controlled to fly along an inner tangent of the target turning circle and over the PV array, and wherein the camera is configured to change from forward-facing to backward-facing as the aerial vehicle flies over the PV array.

21. The method according to any one of claims 14 to 20, further comprising:

determining a reference point on a PV array subsection of the PV array, the PV array subsection visible in a field-of-view (FOV) of the camera as the aerial vehicle approaches the PV array;

optionally determining, upon losing the PV array subsection from the FOV, a last reference point of the PV array subsection that was last visible in the FOV; and

optionally transforming the last reference point into a corrected target point and recalculating the flight path from a current position of the aerial vehicle to the corrected target point.

22. An aerial vehicle for automated flight to perform imaging of a set of PV arrays, the aerial vehicle comprising:

a propulsion device for actuating movement of the aerial vehicle;

a camera for capturing visual datasets of the PV arrays; and

a controller communicatively connected to the camera and the propulsion device and configured for:

determining flight paths between target points for capturing the visual datasets of the PV arrays, each PV array corresponding to a plurality of the target points;

controlling the aerial vehicle for automated flight along the flight paths to a respective first target point of the respective plurality of target points corresponding to each PV array; and

controlling the aerial vehicle for automated manoeuvre between the respective first target point and a respective second target point of the respective plurality of target points to capture the visual dataset of each PV array using a camera of the aerial vehicle,

wherein the automated manoeuvre performed by the aerial vehicle comprises moving the aerial vehicle between the respective first and second target points along a scanning direction determined based on an arrangement of the aerial vehicle relative to the PV array and with reference to a first target viewpoint of the PV array in a field-of-view (FOV) of the camera, the first target viewpoint corresponding to the respective first target point.

23. A method for automated flight of an aerial vehicle and automated electroluminescence (EL) imaging of a set of PV arrays using the aerial vehicle, the method comprising:

determining flight paths between target points for capturing visual datasets of the PV arrays, each PV array corresponding to a plurality of the target points;

controlling the aerial vehicle for automated flight along the flight paths to a respective first target point of the respective plurality of target points corresponding to each PV array; and

controlling the aerial vehicle for automated manoeuvre between the respective first target point and a respective second target point of the respective plurality of target points corresponding to each PV array to capture the visual dataset of the PV array using a camera of the aerial vehicle, the automated manoeuvre performed by the aerial vehicle comprising:

aligning a field-of-view (FOV) of the camera to a PV array subsection of the PV array;

locating, in the aligned FOV, a first target viewpoint of the PV array and corresponding to the respective first target point corresponding to the PV array;

determining, based on an arrangement of the aerial vehicle relative to the PV array and with reference to the located first target viewpoint, a scanning direction for moving the aerial vehicle between the respective first and second target points corresponding to the PV array;

determining the scanning direction to be a forward scanning direction or a sideward scanning direction based on arrangement of the aerial vehicle, camera, and PV array; and

capturing, using the camera, the visual dataset of the PV array starting from the PV array subsection as the aerial vehicle moves along the scanning direction between the first and second target points.

24. The method according to claim 23, wherein the automated manoeuvre comprises determining, based on the arrangement of the aerial vehicle, camera, and PV array, the scanning direction to be:

a forward scanning direction, wherein the aerial vehicle and camera face perpendicular directions as the aerial vehicle moves forwardly along the forward scanning direction; or

a sideward scanning direction, wherein the aerial vehicle and camera face forward as the aerial vehicle moves laterally along the sideward scanning direction.

25. The method according to claim 23 or 24, wherein the automated manoeuvre comprises:

moving the aerial vehicle forwardly along the scanning direction from the respective first target point to the respective second target point; and

moving the aerial vehicle reversely along the scanning direction from the respective second target point to the respective first target point.

26. An aerial vehicle for automated flight to perform automated electroluminescence (EL) imaging of a set of PV arrays, the aerial vehicle comprising:

a propulsion device for actuating movement of the aerial vehicle;

a camera for capturing visual datasets of the PV arrays; and

a controller communicatively connected to the camera and the propulsion device and configured for:

determining flight paths between target points for capturing the visual datasets of the PV arrays, each PV array corresponding to a plurality of the target points;

controlling the aerial vehicle for automated flight along the flight paths to a respective first target point the respective plurality of target points corresponding to each PV array; and

controlling the aerial vehicle for automated manoeuvre between the respective first target point and a respective second target point of the respective plurality of target points corresponding to each PV array to capture the visual dataset of the PV array using a camera of the aerial vehicle, the automated manoeuvre performed by the aerial vehicle comprising:

aligning a field-of-view (FOV) of the camera to a PV array subsection of the PV array;

locating, in the aligned FOV, a first target viewpoint of the PV array and corresponding to the respective first target point corresponding to the PV array;

determining, based on an arrangement of the aerial vehicle relative to the PV array and with reference to the located first target viewpoint, a scanning direction for moving the aerial vehicle between the respective first and second target points; and

capturing, using the camera, the visual dataset of the PV array starting from the PV array subsection as the aerial vehicle moves along the scanning direction between the first and second target points.