MAP INCLUDING DATA FOR ROUTING AERIAL VEHICLES DURING GNSS FAILURE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on U.S. Application No. 16/689,872, filed November 20, 2019, the contents of which are hereby incorporated by reference in its entirety.

BACKGROUND

[0002] An unmanned aerial vehicle (UAV), which may also be referred to as an autonomous vehicle, is a vehicle capable of travel without a physically-present human operator on board.

[0003] Position and orientation of the UAV should be known for a variety of reasons, for example, for maintaining the required flight path of the UAV, for avoidance of obstructions, for avoidance of the flight path of the commercial aircraft, for precise delivery of the payload, for precise coverage of certain ground area when the UAV is used in telecommunication, etc. In practice, unmanned aerial vehicles (UAVs) typically carry a global navigation satellite system (GNSS) sensor-based primary navigation system onboard to determine the UAV's location. For various reasons, however, the GNSS-based navigation system may fail, rendering the UAV inoperable. For example, the GNSS signal may be erroneous or too weak to be used by the UAV. Furthermore, the GNSS equipment of the UAV may also fail, thus making the UAV, at a minimum, incapable of fulfilling its tasks.

SUMMARY OF INVENTION

[0003a] According to an aspect of the present invention, there is provided an unmanned aerial vehicle (UAV) comprising:

a propulsion system;

a global navigation satellite system (GNSS) sensor;

a camera; and

a controller including logic that, in response to execution by the controller, causes the UAV to:

in response to detecting a loss of tracking by the GNSS sensor:

determine an estimated location of the UAV on a map based on a location image captured by the camera;

determine a route to a destination using tracking parameters embedded in the map, wherein the map is divided into a plurality of sections and the tracking parameters indicate an ease of determining a location of the UAV using images captured by the camera with respect to each of the sections; and

control the propulsion system to cause the UAV to follow the route to the destination.

DESCRIPTION OF THE DRAWINGS

[0004] Many of the attendant advantages of embodiments of the present disclosure will become more readily appreciated as the same become better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0005] Figure 1A is a top isometric view of a UAV in accordance with an embodiment of the present technology;

[0006] Figure 1B is a bottom isometric view of a UAV in accordance with an embodiment of the present technology;

CLAIMS

What is claimed is:

1. An unmanned aerial vehicle (UAV) comprising:

a propulsion system;

a global navigation satellite system (GNSS) sensor;

a camera; and

a controller including logic that, in response to execution by the controller, causes the UAV to:

in response to detecting a loss of tracking by the GNSS sensor:

determine an estimated location of the UAV on a map based on a location image captured by the camera;

determine a route to a destination using tracking parameters embedded in the map, wherein the map is divided into a plurality of sections and the tracking parameters indicate an ease of determining a location of the UAV using images captured by the camera with respect to each of the sections; and

control the propulsion system to cause the UAV to follow the route to the destination.

2. The UAV of claim 1, wherein determining the estimated location of the UAV on the map based on the image captured by the camera includes:

determining the estimated location of the UAV on the map based on the image captured by the camera and a last tracked location of the UAV from the GNSS sensor.

3. The UAV of claim 1, wherein the logic further causes the UAV to, in response to detecting the loss of tracking by the GNSS sensor, control the propulsion system to cause the UAV to ascend before the location image is captured by the camera.

4. The UAV of claim 1, wherein the tracking parameters are numerical values.

5. The UAV of claim 4, wherein determining the route to the destination using the tracking parameters embedded in the map includes determining the route such that the

route does not pass through a section of the map having a tracking parameter that does not meet a threshold value.

6. The UAV of claim 4, wherein the controller further includes logic to determine the route based on an average tracking parameter of sections of the map in the route.

7. The UAV of claim 4, wherein the controller further includes logic to determine the route such that the UAV travels through fewer than a threshold number of areas related to sections of the map with a tracking parameter that does not meet a threshold value when following the route.

8. The UAV of claim 1, wherein the map is a three-dimensional map, wherein the three-dimensional map includes a plurality of two-dimensional layers, and wherein different two-dimensional layers of the three-dimensional map correspond to different heights of the UAV.

9. The UAV of claim 8, wherein determining the route includes determining a route that includes a change in height of the UAV.

10. The UAV of claim 1, wherein determining the estimated location of the UAV on the map based on the location image captured by the camera includes:

extracting features of interest from the location image;

matching the features of interest to features on the map; and

estimating a location of the UAV based on the matched features of interest.

~~11. A method comprising:~~

~~obtaining at least one image of an area;~~

~~determining a quantity of features and a feature uniqueness in the at least one image;~~

~~generating a map of the area;~~

~~dividing the map into map sections; and~~

assigning a tracking parameter to each of the map sections based on the quantity of features and the feature uniqueness in the at least one image.

12. The method of claim 11, wherein the map sections form a grid.

13. The method of claim 11, wherein the map is a three-dimensional map with a plurality of two-dimensional layers together forming the three-dimensional map, wherein each of the two-dimensional layers is divided into the map sections, and wherein each two-dimensional layer of the map corresponds to a UAV at a different height.

14. The method of claim 13, wherein each two-dimensional layer of the map has sections has a different size, and wherein the quantity of features and feature uniqueness in the at least one image is determined for each two-dimensional layer of the map.

15. The method of claim 11, wherein the tracking parameter of each section of the map is a numerical value.

16. The method of claim 11, further comprising identifying temporary and permanent features in the at least one image, wherein the determining the quantity of features and the feature uniqueness in the at least one image is performed on the permanent features.

17. The method of claim 11, wherein at least one of the at least one image is taken from a first height and another of the at least one image is taken at a second height.

18. The method of claim 11, further comprising transmitting the map to an unmanned aerial vehicle (UAV) for autonomous navigation.

19. The method of claim 11, wherein the features include roads, intersections, and buildings.

~~20. A non-transitory computer-readable medium having computer-executable instructions stored thereon that, in response to execution by a computer, cause the computer to:~~

~~obtain at least one image of an area;~~

~~determine a quantity of features and a feature uniqueness in the at least one image;~~

~~generate a map of the area;~~

~~divide the map into map sections; and~~

~~assign a tracking parameter to each of the map sections based on the quantity of features and the feature uniqueness in the at least one image.~~