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 a first 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 each tracking parameter indicates an ease of determining a location of the UAV using one or more images captured by the camera with respect to a respective section; and

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

[0003b] According to a second aspect of the present invention, there is provided computer program instructions that, when executed by one or more processors of a UAV, cause the UAV to:

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

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

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

control a propulsion system of the UAV 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 each tracking parameter indicates an ease of determining a location of the UAV using one or more images captured by the camera with respect to a respective section; 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. The UAV of any preceding claim, wherein determining the route includes planning the route with a preference for passing the route over first sections of the map deemed easier, as indicated by the tracking parameters, to determine the location of the UAV using the images, while avoiding second sections of the map deemed more difficult, as indicated by the tracking parameters, to determine the location of the UAV using the images.

12. Computer program instructions that, when executed by one or more processors of a UAV, cause the UAV to:

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

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

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

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

13. The computer program instructions of claim 12, wherein determining the route includes planning the route with a preference for passing the route over first sections of the map deemed easier, as indicated by the tracking parameters, to determine the location of the UAV using the images, while avoiding second sections of the map deemed more difficult, as indicated by the tracking parameters, to determine the location of the UAV using the images.

14. The computer program instructions of claims 12 or 13, wherein the instructions cause the UAV 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.

15. The computer program instructions of any of claims 12 to 14, 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.