GEO-FIDUCIALS FOR UAV NAVIGATION

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is based on U.S. Application No. 16/360,952, filed March 21, 2019, the contents of which are incorporated herein by reference in their entirety.

TECHNICAL FIELD

[0002] This disclosure relates generally to unmanned aerial vehicles (UAVs), and in particular but not exclusively, relates to UAV navigation systems and methods for navigating UAVs.

BACKGROUND INFORMATION

[0003] A UAV is a vehicle capable of air travel without a physically-present human operator. UAVs may be provisioned to perform various different missions, including payload delivery, exploration/reconnaissance, imaging, public safety, surveillance, or otherwise. The mission definition will often dictate a type of specialized equipment and/or configuration of the unmanned vehicle.

[0004] Safe and efficient UAV navigation relies upon the UAV having an accurate and precise navigation solution (for example, a latitude, longitude, and altitude). For example, a UAV may rely on a global positioning system (GPS) to generate a navigation solution in wide open environments; however, GPS navigation may lack the precision necessary to navigate a UAV in confined or crowded environments (such as an indoor UAV base having numerous UAVs). In addition, weather and other contingencies may degrade GPS signal strength, which may compromise the ability of a UAV to generate an accurate navigation solution by GPS. Some environments may experience degraded GPS performance, for example due to multipath, and others may be completely GPS-denied, i.e., may lack GPS signal altogether. These are merely exemplary scenarios, as other challenges characterize UAV navigation. Ultimately, the ability to generate a reliable, accurate, and precise navigation solution is important to efficient and safe UAV navigation.

SUMMARY OF THE INVENTION

[0004a] According to a first aspect of the present invention, there is provided an unmanned aerial vehicle (UAV) navigation system, comprising:

a UAV charging pad positioned at a storage facility;

a plurality of fiducial markers positioned at the storage facility, each fiducial marker of the plurality being associated with a fiducial dataset storing a position of the fiducial marker, each fiducial dataset being stored in a fiducial map; and

a UAV having a power source, a propulsion unit operably coupled with the power source, and a navigation system coupled to the propulsion unit, the navigation system including a camera, a fiducial navigation sub-system, a non-fiducial navigation sub-system, and logic that when executed causes the UAV to perform operations including:

imaging a first fiducial marker of the plurality with the camera;

transitioning from a non-fiducial navigation mode in which the UAV navigates without aid of the fiducial navigation sub-system, to a fiducial navigation mode in which the UAV navigates at least partially based upon the fiducial navigation sub-system;

accessing, from the fiducial map, the fiducial dataset storing the position of the first fiducial marker; and

navigating, based upon the fiducial dataset storing the position of the first fiducial marker, into alignment with and landing on the UAV charging pad.

[0004b] According to a second aspect of the present invention, there is provided an unmanned aerial vehicle (UAV) navigation method, comprising:

positioning a plurality of fiducial markers around a UAV charging pad in a storage facility, each fiducial marker of the plurality being associated with a fiducial dataset storing a position of the fiducial marker;

imaging a first fiducial marker of the plurality using a fiducial navigation sub-system of a UAV, the UAV having a navigation system including the fiducial navigation sub-system and a non-fiducial navigation sub-system;

transitioning the UAV from a non-fiducial navigation mode in which the UAV does not navigate based upon the fiducial navigation sub-system, to a fiducial navigation mode in which the UAV navigates at least partially based upon the fiducial navigation sub-system;

accessing, from a fiducial map stored onboard the UAV, the fiducial dataset storing the position of the first fiducial marker; and

navigating the UAV, based upon the fiducial dataset storing the position of the first fiducial marker, into alignment with and landing on the UAV charging pad.