

MULTI-UAV MANAGEMENT

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application is a continuation of U.S. Application No. 15/953,831, filed on April 16, 2018, entitled MULTI-UAV MANAGEMENT, the disclosure of which is hereby incorporated herein by reference.

BACKGROUND

[0002] Delivery services, also known as courier services, mail services, and shipping services, such as those offered by the U.S. Postal Service and commercial carriers, provide delivery of letters, packages, and parcels to and from residences and businesses across the country. As the number of deliveries increases, alternative methods of such delivery services are becoming more and more popular. For instance, unmanned aerial vehicle (UAV) may be used to perform various tasks relating to delivery services, including, for instance, picking up and dropping off packages for “last mile” deliveries. These UAVs can be controlled by a remote human operator and/or autonomously to complete such tasks. UAVs can therefore be efficient tools for providing such services but can also be subject to problems, such as battery failures and other conditions, which are difficult for human operators to identify while the UAV is in flight.

BRIEF SUMMARY

[0002a] According to a first aspect of the present invention, there is provided a system for identifying and responding to problem conditions for a plurality of aerial vehicles, the system comprising one or more processors configured to:

receive, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;

input the sensor feedback into a model that outputs, for each of a plurality of possible problem conditions, a corresponding likelihood of the aerial vehicle experiencing the respective possible problem condition;

identify a problem condition of the plurality of possible problem conditions based on the outputted likelihoods;

determine a mitigation response for the identified problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and

send the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the identified problem condition.

[0002b] According to a second aspect of the present invention, there is provided a method of identifying and responding to problem conditions for a plurality of aerial vehicles, the method comprising:

receiving, by one or more processors of one or more server computing devices, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;

inputting the sensor feedback into a model that outputs, for each of a plurality of possible problem conditions, a corresponding likelihood of the aerial vehicle experiencing the respective possible problem condition;

identifying, by the one or more processors, a problem condition of the plurality of possible problem conditions based on the outputted likelihoods;

determine, by the one or more processors, a mitigation response for the identified problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and

send, by the one or more processors, the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the identified problem condition.

[0003] ~~Aspects of the present disclosure provide~~ There is provided a system for identifying and responding to problem conditions for a plurality of aerial vehicles. The system includes one or more processors configured to receive, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback; identify a problem condition using the sensor feedback; determine a mitigation response for the problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and send the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the problem condition.

[0004] In one example, the one or more processors are part of one or more server computing devices remote from the aerial vehicle. In this example, the system also includes the aerial vehicle, and wherein the aerial vehicle is an unmanned aerial vehicle. In addition, the system also includes the plurality of aerial vehicles, and wherein the server computing devices are configured to identify one or more problem conditions of one or more other aerial vehicles of the plurality of aerial vehicles. In another example, the one or more processors are further configured to use the problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response. In another example, the one or more processors are further configured to use the problem condition to estimate a remaining flight distance for the aerial vehicle, and wherein the estimated remaining flight distance is used to determine the mitigation response. In another example, the problem condition corresponds to a current problem with the aerial vehicle. In another example, the problem condition corresponds to an expected future problem with the aerial vehicle. In another example, identifying the problem condition includes determining whether the sensor feedback meets a threshold value for the problem condition. In another example, identifying the problem condition

includes determining whether the sensor feedback meets a combination of two or more threshold value for the problem condition. In another example, identifying the problem condition includes inputting the sensor feedback into a model that outputs the problem condition. In another example, the one or more processors are further configured to, after identifying the problem condition, flagging the aerial vehicle for inspection. In another example, the one or more processors are further configured to determine the mitigation response further based on a severity of the problem condition. In another example, the problem condition corresponds to a broken propeller. In another example, the problem condition corresponds to a battery failure. In another example, the problem condition corresponds to a motor failure.

[0005] ~~Another aspect of the disclosure provides~~ There is provided a method of identifying and responding to problem conditions for a plurality of aerial vehicles. The method includes receiving, by one or more processors of one or more server computing devices, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback; identifying, by the one or more processors, a problem condition using the sensor feedback; determining, by the one or more processors, a mitigation response for the problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and sending, by the one or more processors, the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the problem condition.

[0006] In one example, the method also includes using, by the one or more processors, the problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response. In another example, identifying the problem condition includes determining whether the sensor feedback meets a threshold value for the identified problem condition. In another example, identifying the problem condition includes determining whether the sensor feedback meets a combination of two or more threshold value for the identified problem condition.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIGURES 1A-1E are examples of UAVs in accordance with aspects of the present disclosure.

[0008] FIGURE 2 is an example functional diagram of a UAV in accordance with aspects of the disclosure.

[0009] FIGURE 3A is an example functional diagram of a management system for managing a group of UAVs in accordance with aspects of the disclosure.

[0010] FIGURE 3B is an example pictorial diagram of a management system for managing a group of UAVs in accordance with aspects of the disclosure.

[0011] FIGURE 4 is an example representation of a UAV flying a mission in accordance with aspects of the disclosure.

[0012] FIGURE 5 is an example of status information for UAVs of a fleet of UAVs in accordance with aspects of the disclosure.

CLAIMS

1. A system for identifying and responding to problem conditions for a plurality of aerial vehicles, the system comprising one or more processors configured to:
 - receive, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;
 - identify a problem condition using the sensor feedback;
 - determine a mitigation response for the problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and
 - send the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the problem condition.
2. The system of claim 1, wherein the one or more processors are part of one or more server computing devices remote from the aerial vehicle.
3. The system of claim 2, further comprising the aerial vehicle, and wherein the aerial vehicle is an unmanned aerial vehicle.
4. The system of claim 3, further comprising the plurality of aerial vehicles, and wherein the server computing devices are configured to identify one or more problem conditions of one or more other aerial vehicles of the plurality of aerial vehicles.
5. The system of claim 1, wherein the one or more processors are further configured to use the problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response.
6. The system of claim 1, wherein the one or more processors are further configured to use the problem condition to estimate a remaining flight distance for the aerial vehicle, and wherein the estimated remaining flight distance is used to determine the mitigation response.
7. The system of claim 1, wherein the problem condition corresponds to a current problem with the aerial vehicle.
8. The system of claim 1, wherein the problem condition corresponds to an expected future problem with the aerial vehicle.
9. The system of claim 1, wherein identifying the problem condition includes determining whether the sensor feedback meets a threshold value for the problem condition.

~~10. The system of claim 1, wherein identifying the problem condition includes determining whether the sensor feedback meets a combination of two or more threshold value for the problem condition.~~

~~11. The system of claim 1, wherein identifying the problem condition includes inputting the sensor feedback into a model that outputs the problem condition.~~

~~12. The system of claim 1, wherein the one or more processors are further configured to, after identifying the problem condition, flagging the aerial vehicle for inspection.~~

~~13. The system of claim 1, wherein the one or more processors are further configured to determine the mitigation response further based on a severity of the problem condition.~~

~~14. The system of claim 1, wherein the problem condition corresponds to a broken propeller.~~

~~15. The system of claim 1, wherein the problem condition corresponds to a battery failure.~~

~~16. The system of claim 1, wherein the problem condition corresponds to a motor failure.~~

~~17. A method of identifying and responding to problem conditions for a plurality of aerial vehicles, the method comprising:~~

~~receiving, by one or more processors of one or more server computing devices, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;~~

~~identifying, by the one or more processors, a problem condition using the sensor feedback;~~

~~determine, by the one or more processors, a mitigation response for the problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and~~

~~send, by the one or more processors, the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the problem condition.~~

~~18. The method of claim 17, further comprising using, by the one or more processors, the problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response.~~

~~19. The method of claim 17, wherein identifying the problem condition includes determining whether the sensor feedback meets a threshold value for the identified problem condition.~~

20. The method of claim 17, wherein identifying the problem condition includes determining whether the sensor feedback meets a combination of two or more threshold value for the identified problem condition.

1. A system for identifying and responding to problem conditions for a plurality of aerial vehicles, the system comprising one or more processors configured to:

receive, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;

input the sensor feedback into a model that outputs, for each of a plurality of possible problem conditions, a corresponding likelihood of the aerial vehicle experiencing the respective possible problem condition;

identify a problem condition of the plurality of possible problem conditions based on the outputted likelihoods;

determine a mitigation response for the identified problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and

send the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the identified problem condition.

2. The system of claim 1, wherein the model is used to estimate a remaining flight metric for the aerial vehicle, and wherein the processors are further configured to use the remaining flight metric to determine the mitigation response for the identified problem condition.

3. The system of claim 1, wherein the one or more processors are part of one or more server computing devices remote from the aerial vehicle.

4. The system of claim 3, further comprising the aerial vehicle, and wherein the aerial vehicle is an unmanned aerial vehicle.

5. The system of claim 4, further comprising the plurality of aerial vehicles, and wherein the server computing devices are configured to identify one or more problem conditions of one or more other aerial vehicles of the plurality of aerial vehicles.

6. The system of claim 1, wherein the one or more processors are further configured to use the identified problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response.

7. The system of claim 1, wherein the one or more processors are further configured to use the identified problem condition to estimate a remaining flight distance for the aerial vehicle, and wherein the estimated remaining flight distance is used to determine the mitigation response.

8. The system of claim 1, wherein the identified problem condition corresponds to a current problem with the aerial vehicle.

9. The system of claim 1, wherein the identified problem condition corresponds to an expected future problem with the aerial vehicle.

10. The system of claim 1, wherein the one or more processors are further configured to, after identifying the problem condition, flag the aerial vehicle for inspection.

11. The system of claim 1, wherein the one or more processors are further configured to determine the mitigation response further based on a severity of the identified problem condition.

12. The system of claim 1, wherein the identified problem condition corresponds to a broken propeller.

13. The system of claim 1, wherein the identified problem condition corresponds to a battery failure.

14. The system of claim 1, wherein the identified problem condition corresponds to a motor failure.

15. The system of claim 1, wherein the identified problem condition corresponds to a motor anomaly, an improperly secured propeller, an improperly tuned motor, a stuck propeller, a worn or broken aerodynamic surface, a loose structural member, or a board failure or anomaly.

16. A method of identifying and responding to problem conditions for a plurality of aerial vehicles, the method comprising:

receiving, by one or more processors of one or more server computing devices, from an aerial vehicle of the plurality of aerial vehicles, sensor feedback;

inputting the sensor feedback into a model that outputs, for each of a plurality of possible problem conditions, a corresponding likelihood of the aerial vehicle experiencing the respective possible problem condition;

identifying, by the one or more processors, a problem condition of the plurality of possible problem conditions based on the outputted likelihoods;

determine, by the one or more processors, a mitigation response for the identified problem condition, the mitigation response relating to a mission assigned to the aerial vehicle; and

send, by the one or more processors, the mitigation response to the aerial vehicle in order to cause the aerial vehicle to maneuver according to the mitigation response and thereby automatically respond to the identified problem condition.

17. The method of claim 16, further comprising using, by the one or more processors, the identified problem condition to estimate a remaining flight time for the aerial vehicle, and wherein the estimated remaining flight time is used to determine the mitigation response.

18. The method of claim 16 or the system of claim 1, wherein identifying the problem condition includes determining whether the sensor feedback meets a threshold value for the identified problem condition.

19. The method of claim 16 or the system of claim 1, wherein identifying the problem condition includes determining whether the sensor feedback meets a combination of two or more threshold value for the identified problem condition.