

CLAIMS

What is claimed is:

1. A computer-implemented method for detecting an environmental change to a delivery zone via an unmanned aerial vehicle (UAV), the method comprising:
obtaining an anchor image and an evaluation image, each representative of the delivery zone, and wherein a first timestamp of the anchor image is earlier than a second timestamp of the evaluation image;
providing the anchor image and the evaluation image to a machine learning model to determine an embedding score associated with a distance between representations of the anchor image and the evaluation image within an embedding space, and wherein the distance is proportional to a degree of similarity between the anchor image and the evaluation image; and
determining an occurrence of the environmental change to the delivery zone when the embedding score is greater than a threshold value.
2. The computer-implemented method of claim 1, wherein the delivery zone corresponds to a predetermined geographic area, wherein the anchor image and the evaluation image respectively provide a first perspective and a second perspective, each including, at least in part, the predetermined geographic area, and wherein the first perspective is different than the second perspective.
3. The computer-implemented method of claim 2, wherein the first perspective provided by the anchor image and the second perspective provided by the evaluation image differ by at least one of altitude, orientation, or GPS coordinates when captured.
4. The computer-implemented method of claim 1, wherein the anchor image and the evaluation image are point cloud images.
5. The computer-implemented method of claim 1, wherein the machine learning model incorporates metadata associated with at least one of the anchor image or the evaluation image to determine the embedding score.

6. The computer-implemented method of claim 5, wherein the metadata includes at least one of altitude, orientation, GPS coordinates, point-cloud information, or timestamp.

7. The computer-implemented method of claim 5, further comprising:
providing first metadata and second metadata, each included in the metadata, to the machine learning model, wherein the first metadata is associated with the anchor image, and wherein the second metadata is associated with the evaluation image;
generating a first combined representation of the first metadata and the anchor image with the machine learning model; and
generating a second combined representation of the second metadata and the evaluation image with the machine learning model.

8. The computer-implemented method of claim 7, further comprising:
determining a first embedding value associated with the anchor image based, at least in part, on the first combined representation with the machine learning model;
determining a second embedding value associated with the evaluation image based, at least in part, on the second combined representation with the machine learning model,
wherein the first embedding value and the second embedding value correspond to respective positions within the embedding space.

9. The computer-implemented method of claim 8, wherein the embedding space is an m-dimensional Euclidean space, and wherein the embedding score corresponds to a squared Euclidean distance between the respective positions.

10. The computer-implemented method of claim 1, further comprising:
determining a first embedding value associated with the anchor image with the machine learning model;
segmenting the evaluation image into subimages that are provided to the machine learning model to determine corresponding embedding values for the subimages, wherein the first embedding value and the corresponding embedding values correspond to respective positions within the embedding space;

determining embedding scores for the subimages based on a difference in position between the corresponding embedding values and the first embedding value of the anchor image; and

mapping the embedding scores to the evaluation image to determine whether the environmental change has occurred in one or more regions of the delivery zone represented by the subimages.

11. The computer-implemented method of claim 1, further comprising:
assigning the evaluation image to correspond to the anchor image when the embedding score is greater than the threshold value such that a next occurrence of the environmental change of the delivery zone is determined with respect to the evaluation image.

12. The computer-implemented method of claim 1, wherein the environmental change corresponds to an obstruction impeding delivery of a parcel to the delivery zone via the UAV.

13. The computer-implemented method of claim 12, further comprising:
adjusting a flight path of the UAV to avoid the obstruction when delivering the parcel to the delivery zone; or
identifying a secondary delivery zone, different than the delivery zone, for delivering the parcel; or
aborting the delivery of the parcel.

14. The computer-implemented method of claim 1, further comprising:
providing the evaluation image to a second machine learning model that provides semantic segmentation of the evaluation image to identify which regions of the delivery zone have changed.

15. The computer-implemented method of claim 14, further comprising:
searching a database of images representative of the delivery zone for a secondary anchor image, wherein the secondary anchor image is selected from the database based on similarity in field of view to the anchor image and the evaluation image determined, at

least in part, by metadata associated with the images included in the database, the anchor image, and the evaluation image.

16. The computer-implemented method of claim 15, further comprising:
comparing the evaluation image to the secondary anchor image based on the semantic segmentation provided by the second machine learning model to identify the regions of the delivery zone that have changed.

17. A non-transitory computer-readable storage medium having instructions stored thereon that, in response to execution by one or more processors of a computing system, cause the computing system to perform actions comprising:

obtaining an anchor image and an evaluation image, each representative of a delivery zone, and wherein a first timestamp of the anchor image is earlier than a second timestamp of the evaluation image;

providing the anchor image and the evaluation image to a machine learning model to determine an embedding score associated with a distance between representations of the anchor image and the evaluation image within an embedding space, and wherein the distance is proportional to a degree of similarity between the anchor image and the evaluation image; and

determining an occurrence of an environmental change to the delivery zone when the embedding score is greater than a threshold value.

18. The non-transitory computer-readable storage medium of claim 17, wherein the delivery zone corresponds to a predetermined geographic area, wherein the anchor image and the evaluation image respectively provide a first perspective and a second perspective, each including, at least in part, the predetermined geographic area, and wherein the first perspective is different than the second perspective.

19. The non-transitory computer-readable storage medium of claim 17, wherein the machine learning model incorporates metadata associated with at least one of the anchor image or the evaluation image to determine the embedding score.

20. The non-transitory computer-readable storage medium of claim 19, wherein the actions further comprise:

providing first metadata and second metadata, each included in the metadata, to the machine learning model, wherein the first metadata is associated with the anchor image, and wherein the second metadata is associated with the evaluation image;

generating a first combined representation of the first metadata and the anchor image with the machine learning model; and

generating a second combined representation of the second metadata and the evaluation image with the machine learning model.

21. The non-transitory computer-readable storage medium of claim 20, wherein the actions further comprise:

determining a first embedding value associated with the anchor image based, at least in part, on the first combined representation with the machine learning model;

determining a second embedding value associated with the evaluation image based, at least in part, on the second combined representation with the machine learning model,

wherein the first embedding value and the second embedding value correspond to respective positions within the embedding space.

22. The non-transitory computer-readable storage medium of claim 17, wherein the actions further comprise:

determining a first embedding value associated with the anchor image with the machine learning model;

segmenting the evaluation image into subimages that are provided to the machine learning model to determine corresponding embedding values for the subimages, wherein the first embedding value and the corresponding embedding values correspond to respective positions within the embedding space;

determining embedding scores for the subimages based on a difference in position between the corresponding embedding values and the first embedding value of the anchor image; and

mapping the embedding scores to the evaluation image to determine whether the environment change has occurred in one or more regions of the delivery zone represented by the subimages.

23. The non-transitory computer-readable storage medium of claim 17, wherein the actions further comprise:

assigning the evaluation image to correspond to the anchor image when the embedding score is greater than the threshold value such that a next occurrence of the environmental change of the delivery zone is determined with respect to the evaluation image.

24. The non-transitory computer-readable storage medium of claim 17, wherein the anchor image and the evaluation image are point cloud images.