expensive equipment such as high spatial resolution cameras, expensive transponders, and advanced computers. Other factors that contribute to the cost associated with expensive imaging satellites are the launch cost and maintenance. Expensive high spatial resolution imaging satellites must be monitored from a ground facility, which requires expensive manpower. These satellites are also susceptible to damage or costly downtimes. The high launch and development costs of expensive imaging satellites leads to a slowdown in the introduction of new or upgraded satellite imagery and communication services for object detection.

[0004] Cheaper low spatial resolution imaging satellites may be used for capturing images. However, such satellites and provide unclear images. In low-resolution imagery, objects such as containers or tanks are typically not clearly identifiable and often appear as blobs containing a few adjacent pixels. In other instances, such as in infrared band imagery, the images may be completely invisible to humans.

SUMMARY

[0004a] In a first aspect, the present disclosure provides a method for processing images from an aerial imaging device, the method comprising: detecting by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest, the machine learning model configured to differentiate features corresponding to the cloud cover from background features and features corresponding to the object of interest; responsive to the amount of cloud cover present in the image of the object of interest being less than a cloud detection threshold, extracting, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device; generating, from the parameters, idealized images of the object of interest, wherein each idealized image corresponds to a distinct filled volume of the object of interest; matching the image of the object of interest to

each idealized image to determine a filled volume of the object of interest; and transmitting information corresponding to the determined filled volume of the object of interest to a user device.

[0004b] In a second aspect, the present disclosure provides a method for processing images from an aerial imaging device, the method comprising: detecting by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest; responsive to the amount of cloud cover present in the image of the object of interest being less than a threshold, extracting, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device; determining, from the parameters, a filled volume of the object of interest; and transmitting information corresponding to the determined filled volume of the object of interest to a user device.

[0004c] In a third aspect, the present disclosure provides a non-transitory computer-readable storage medium comprising instructions executable by a processor, the instructions when executed by the processor cause the processor to: detect by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest; responsive to the amount of cloud cover present in the image of the object of interest being less than a cloud detection threshold, extract, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device; determine, from the parameters, a filled volume of the object of interest; and transmit information corresponding to the determined filled volume of the object of interest to a user device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The disclosed embodiments have advantages and features which will be more readily apparent from the detailed description, the appended claims, and the accompanying figures (or

drawings). A brief introduction of the figures is below.

[0006] Figure (FIG.) 1 illustrates a block diagram of an example system environment in which a remote container analysis system operates, in accordance with an embodiment.

[0007] FIG. 2 illustrates a block diagram of an example system architecture for the remote container analysis system, in accordance with an embodiment.

[0008] FIG. 3A illustrates an example positive training set for the remote container analysis system, in accordance with an embodiment.

[0009] FIG. 3B illustrates an example negative training set for the remote container analysis

CLAIMS

1. A method for processing images from an aerial imaging device, the method comprising:

detecting by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest, the machine learning model configured to differentiate features corresponding to the cloud cover from background features and features corresponding to the object of interest;

responsive to the amount of cloud cover present in the image of the object of interest being less than a cloud detection threshold, extracting, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device;

generating, from the parameters, idealized images of the object of interest, wherein each idealized image corresponds to a distinct filled volume of the object of interest;

matching the image of the object of interest to each idealized image to determine a filled volume of the object of interest; and

transmitting information corresponding to the determined filled volume of the object of interest to a user device.

2. The method of claim 1, further comprising:

creating training sets comprising labeled images of a geographical area, the labeled images of the geographical area comprising distinct amounts of cloud cover; and

configuring the machine learning model, based on the training sets, to detect an amount of cloud cover present in an unlabeled image by differentiating features in the

unlabeled image corresponding to the cloud cover present in the unlabeled image from background features present in the unlabeled image.

3. The method of claim 1, further comprising extracting a feature vector from the image of the object of interest, the feature vector comprising features representing attributes of pixels in the image of the object of interest, wherein the detecting of the amount of cloud cover present in the image of the object of interest comprises transmitting the feature vector to the machine learning model.

4. A method for processing images from an aerial imaging device, the method comprising:

detecting by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest;

responsive to the amount of cloud cover present in the image of the object of interest being less than a threshold, extracting, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device;

determining, from the parameters, a filled volume of the object of interest; and

transmitting information corresponding to the determined filled volume of the object of interest to a user device.

5. The method of claim 4, further comprising:

creating training sets comprising labeled images of a geographical area, the labeled images of the geographical area comprising distinct amounts of cloud cover; and

configuring the machine learning model, based on the training sets, to detect an amount of cloud cover present in an unlabeled image by differentiating features in the

unlabeled image corresponding to the cloud cover present in the unlabeled image from background features present in the unlabeled image.

6. The method of claim 4, further comprising extracting a feature vector from the image of the object of interest, the feature vector comprising features representing attributes of pixels in the image of the object of interest, wherein the detecting of the amount of cloud cover present in the image of the object of interest comprises transmitting the feature vector to the machine learning model.

7. The method of claim 4, wherein the parameters further describe one or more of:

a time of capture of the received image;

an elevation angle of the sun; and

an azimuth angle of the sun.

8. The method of claim 4, wherein the determining of the filled volume of the object of interest comprises:

generating, from the parameters, idealized images of the object of interest, wherein each idealized image corresponds to a distinct filled volume of the object of interest; and

matching the image of the object of interest to each idealized image to determine the filled volume of the object of interest.

9. The method of claim 8, further comprising rescaling each idealized image by:

setting pixels corresponding to shadows and inner surfaces of the object of interest in the idealized image to negative values; and

setting pixels corresponding to a roof of the object of interest in the idealized image to positive values.

10. The method of claim 8, wherein the generating of each idealized image comprises:

generating a first circle corresponding to a top rim of the object of interest using the parameters;

generating a second circle corresponding to an arc of a shadow on an inner surface of the object of interest using the parameters;

generating a third circle corresponding to a roof of the object of interest using the parameters; and

synthesizing the idealized image by performing a convolution on the three circles.

11. The method of claim 10, wherein the performing of the convolution comprises performing unions and intersections between the first circle corresponding to the top rim, the second circle corresponding to the arc of the shadow, and the third circle corresponding to the roof.

12. The method of claim 8, wherein the matching of the image of the object of interest to each idealized image comprises:

superimposing the idealized image on different locations of the image of the object of interest;

performing a dot product between pixels of the image of the object of interest and pixels of the idealized image at each of the different locations to determine a maximum value of the dot product at each of the different locations.

13. The method of claim 8, wherein the matching of image of the object of interest to each idealized image comprises:

performing edge analysis on the idealized image to obtain an outline of a top rim of the object of interest in the idealized image; and

performing a dot product between pixels of an image gradient of the image of the object of interest and pixels of the outline of the top rim.

14. The method of claim 8, wherein the matching of the image of the object of interest to each idealized image comprises:

performing edge analysis on the idealized image to obtain an outline of a shadow on an inner surface of the object of interest in the idealized image; and

performing a dot product between pixels of an image gradient of the image of the object of interest and pixels of the outline of the shadow.

15. The method of claim 8, wherein the matching of the image of the object of interest to each idealized image comprises:

performing a dot product between pixels of the image of the object of interest and pixels of the idealized image to obtain a first response map;

performing a dot product between pixels of an image gradient of the image of the object of interest and pixels of an outline of a top rim of the object of interest in the idealized image to obtain a second response map;

performing a dot product between pixels of the image gradient and pixels of an outline of a shadow on an inner surface of the object of interest in the idealized image to obtain a third response map; and

summing up the three response maps.

16. A non-transitory computer-readable storage medium comprising instructions executable by a processor, the instructions when executed by the processor cause the processor to:

detect by a machine learning model, using an image of an object of interest, an amount of cloud cover present in the image of the object of interest;

responsive to the amount of cloud cover present in the image of the object of interest being less than a cloud detection threshold, extract, from the image of the object of interest, parameters describing at least an azimuth angle of the aerial imaging device;

determine, from the parameters, a filled volume of the object of interest; and

transmit information corresponding to the determined filled volume of the object of interest to a user device.

17. The non-transitory computer-readable storage medium of claim 16, the instructions further causing the processor to:

create training sets comprising labeled images of a geographical area, the labeled images of the geographical area comprising distinct amounts of cloud cover; and

configure the machine learning model, based on the training sets, to detect an amount of cloud cover present in an unlabeled image by differentiating features in the unlabeled image corresponding to the cloud cover present in the unlabeled image from background features present in the unlabeled image.

18. The non-transitory computer-readable storage medium of claim 16, the instructions further causing the processor to extract a feature vector from the image of object of interest, the feature vector comprising features representing attributes of pixels in the image of the object of interest, wherein the detecting of the amount of cloud cover present in the image of the object of interest comprises transmitting the feature vector to the machine learning model.

19. The non-transitory computer-readable storage medium of claim 16, wherein the determining of the filled volume of the object of interest comprises:

generating, from the parameters, idealized images of the object of the interest, wherein each idealized image corresponds to a distinct filled volume of the object of interest; and

matching the image of the object of interest to each idealized image to determine the filled volume of the object of interest.

20. The method of claim 19, wherein the generating of each idealized image comprises:

generating a first circle corresponding to a top rim of the object of interest using the parameters;

generating a second circle corresponding to an arc of a shadow on an inner surface of the object of interest using the parameters;

generating a third circle corresponding to a roof of the object of interest using the parameters; and

synthesizing the idealized image by performing a convolution on the three circles.