

What is claimed is:

1. A system for operating a remotely operated vehicle (ROV) comprising:

a database module of 3D elements operable to represent objects disposed in an operation environment of the ROV;

a virtual video generating module operable to generate a virtual video incorporating the 3D elements;

a video camera mounted to the ROV operable to generate a real video of the operation environment of the ROV;

a synchronizing module operable to synchronize an angle and position of a virtual camera with an angle and position of the video camera mounted to the ROV;

a visualization engine operable to superimpose the real video on the virtual video to create hybrid 3D imagery; and

a threat detection engine operable to detect an integrity threat in a structure from the hybrid 3D imagery and segment the structure in the hybrid 3D imagery, the threat detection engine comprising:

~~a dataset module;~~

a convolutional neural network (CNN) training module comprising a semi-supervised dataset and a supervised dataset, wherein the semi-supervised dataset includes at least a portion of the real video, and wherein the supervised dataset includes at least a portion of the real video and at least a portion of the virtual video;

~~a segmentation map module; and~~

~~an efficiency module.~~

2. The system ~~according to~~ of claim 1, wherein the CNN training module includes a timestamp for an image with an anomaly from the real video. ~~dataset module includes annotations detailing at what timestamps one or more anomalies are visible.~~

3. The system ~~according to~~ of claim 2, wherein the CNN training module analyzes the ~~accepts an input~~ image and either outputs a logic high if ~~a visible the~~ anomaly is detected ~~or~~ and outputs a logic low otherwise.

4. The system ~~according to~~ of claim 3, wherein the CNN training module comprises a plurality of stacked convolutional layers, wherein each subsequent stacked convolutional layer of the plurality of stacked convolutional layers includes a larger region of the input image.

5. The system ~~of~~ according to claim 4, wherein the CNN training model further comprises a coarse structure segmentation map.

6. The system ~~of~~ according to claim 5, further comprising a ~~wherein the~~ segmentation map module that generates ~~a the course structure~~ segmentation map ~~dataset~~ using pixel-level segmentations.

7. The system ~~of~~ according to claim 6, wherein the segmentation map module generates the pixel-level segmentations by projecting a 3D model of a visible structure into the ROV's virtual camera.

8. The system ~~of~~ according to claim 7, wherein the CNN training module trains a CNN model to minimize a loss function.

9. The system ~~of~~ according to claim 8, wherein the CNN training module (i) uses a loss function L for data that contains both segmentation data and anomaly ground-truth data and (ii) uses a loss function L_a for data that contains anomaly ground-truth data but not segmentation data.

10. The system ~~of~~ according to claim 9, further comprising an efficiency module, and wherein the efficiency module computes a binary mask m and, when all of m 's elements are close to zero, the efficiency module stops the threat detection engine from making further computations and generate an output that there are not ~~structure~~ structural anomalies.

11. A system for undersea exploration comprising:
a remote operated vehicle (ROV) comprising a camera for acquiring a real video;

a networked operating system comprising a computer and computer executable software comprising a visualization engine and a threat detection engine;

a database module of 3D elements operable to represent objects disposed in an operation environment of the ROV;

a virtual video generating module operable to generate a virtual video incorporating the 3D elements;

a video camera mounted to the ROV operable to generate a real video of the operation environment of

the ROV;

a synchronizing module operable to synchronize an angle and position of a virtual camera with an angle and position of the video camera mounted to the ROV;

wherein the visualization engine is operable to superimpose the real video on the virtual video to create hybrid 3D imagery; and

wherein the threat detection engine is operable to detect an integrity threat in a structure from the hybrid 3D imagery and segment the structure in the hybrid 3D imagery, the threat detection engine comprising:

~~a dataset module;~~

a convolutional neural network (CNN) training module comprising a semi-supervised dataset and a supervised dataset, wherein the semi-supervised dataset includes at least a portion of the real video, and wherein the supervised dataset includes at least a portion of the real video and at least a portion of the virtual video;

~~a segmentation map module;~~

~~an efficiency module; and~~

a navigation interface configured to display the hybrid 3D imagery, the navigation interface comprising at least one networked monitor.

12. The system ~~of~~according to claim 11, wherein CNN training module includes a timestamp for an image with an anomaly from the real video.~~the dataset module includes annotations detailing at what timestamps one or more anomalies are visible.~~

13. The system ~~of~~according to claim 12, wherein the

CNN training module analyzes the~~accepts an input~~ image and outputs a logic high if a visible anomaly is detected and outputs a logic low otherwise.

14. The system of~~according to~~ claim 13, wherein the CNN training module comprises a plurality of stacked convolutional layers, wherein each subsequent stacked convolutional layer of the plurality of stacked convolutional layers includes a larger region of the input image.

15. The system of~~according to~~ claim 14, wherein the CNN training model further comprises a coarse structure segmentation map.

16. The system of~~according to~~ claim 15, further comprising a ~~wherein the~~ segmentation map module that generates the coarse structure a ~~segmentation map dataset~~ using pixel-level segmentations.

17. The system of~~according to~~ claim 16, wherein the segmentation map module generates the pixel-level segmentations by projecting a 3D model of a visible structure into the ROV's virtual camera.

18. A method of operating a remotely operated vehicle (ROV) comprising:

obtaining 3D data from the ROV's operation environment;

storing 3D elements in a database module, the 3D elements representing objects disposed in the ROV's operation environment and comprising the 3D data;

generating a virtual video of the 3D elements;
 synchronizing an angle and position of a virtual camera with an angle and position of a video camera mounted to the ROV; and

aligning and superimposing a virtual video element with a real video element to create hybrid 3D imagery;

segmenting a structure from the hybrid 3D imagery;

~~and~~

training a CNN model with a semi-supervised dataset and a supervised dataset, wherein the semi-supervised dataset includes at least a portion of the real video, and wherein the supervised dataset includes at least a portion of the real video and at least a portion of the virtual video; and

detecting an integrity threat in the structure from the hybrid 3D imagery.

19. The method of claim 18, wherein detecting an integrity threat further includes:

~~training a CNN model; and~~

generating segmentation maps.

20. The method of claim 19, wherein detecting an integrity threat further includes:

generating a segmentation map dataset using pixel-level segmentations; ~~and~~

computing a binary mask m ; and

stopping further computations when all of m 's elements are close to zero.

21. A computer program product comprising instructions which, when the program is executed by a

computer, cause the computer to carry out the steps of the method of claim 20.