

CLAIMS

1. A computerized method of training a neural network system for anomaly detection, comprising:

obtaining a training dataset including a set of original images capturing a target object, and a set of random data vectors, wherein the set of original images
5 include a first subset of original images without presence of anomaly associated with the target object and a second subset of original images with presence of anomaly associated with the target object thereof;

constructing a neural network system comprising a generator neural network,
10 and a first discriminator neural network and a second discriminator neural network operatively connected to the generator neural network; and

training the generator neural network, the first discriminator neural network and the second discriminator neural network together based on the training dataset, such that: i) the generator neural network is trained using the original images from
15 the first subset and the set of random data vectors, at least based on evaluation of the first discriminator neural network, to generate synthetic images meeting a criterion of photo-realism as compared to corresponding original images, wherein at least part of the synthetic images contain a synthetic anomaly generated and associated with the target object thereof, and wherein the first discriminator neural network is trained to
20 discriminate the synthetic images from the corresponding original images; and ii) the second discriminator neural network is trained based on images with anomaly and images without anomaly from the set of original images including the first subset and the second subset and from the synthetic images wherein at least part thereof contains synthetic anomaly, to discriminate images with presence of anomaly from
25 images without presence of anomaly with a given level of accuracy, thereby giving rise to a trained neural network system.

2. The computerized method of claim 1, wherein the training is performed iteratively for one or more batches of original images from the first subset together with one or more batches of random data vectors from the set of random data
30 vectors.

3. The computerized method of claim 2, wherein the training comprises, for a given batch of original images and a corresponding batch of random data vectors:

generating, by the generator network, a batch of synthetic images based on the given batch of original images and the given batch of random data vectors,
5 wherein at least part of the batch of synthetic images each contains a synthetic anomaly generated and associated with the target object thereof;

training the first discriminator network and the second discriminator network based on the batch of original images and the batch of synthetic images using a first loss function associated with the first discriminator network and a second loss
10 function associated with the second discriminator network, and training the generator network using at least the first and second loss functions.

4. The computerized method of claim 3, wherein the first discriminator network and the second discriminator network are trained simultaneously, comprising:

providing the batch of original images and the batch of synthetic
15 images to be processed by the first discriminator network, and updating parameters of the first discriminator network according to the first loss function—~~such that the first discriminator network is trained to discriminate synthetic images from original images;~~ and

providing a batch of images with presence of anomaly and a batch of
20 images without presence of anomaly to be processed by the second discriminator network, and updating parameters of the second discriminator network according to the second loss function such that the second discriminator network is trained to discriminate images with presence of anomaly from images without presence of anomaly, wherein the batch of
25 images with presence of anomaly includes one or more original images from at least one of the second subset ~~and~~/or one or more synthetic images containing synthetic anomaly, and the batch of images without presence of anomaly includes one or more original images from at least one of the first subset ~~and~~/or one or more synthetic images not containing synthetic anomaly.

5. The computerized method of claim 3, wherein the training the generator network comprises updating parameters of the generator network according to at least the first and second loss functions such that the generator network is trained to generate photo-realistic synthetic images at least part of which contain photo-realistic synthetic anomaly.

6. The computerized method of claim 3, wherein the first discriminator network and the second discriminator network are trained sequentially, comprising:

providing the batch of original images and the batch of synthetic images to be processed by the first discriminator network, and updating parameters of the first discriminator network according to the first loss function ~~such that the first discriminator network is trained to discriminate synthetic images from original images;~~

updating parameters of the generator network according to the first loss function such that the generator network is trained to generate photo-realistic synthetic images;

providing a batch of images with presence of anomaly and a batch of images without presence of anomaly to be processed by the second discriminator network, and updating parameters of the second discriminator network according to the second loss function such that the second discriminator network is trained to discriminate images with presence of anomaly from images without presence of anomaly, wherein the batch of images with presence of anomaly includes one or more original images from at least one of the first subset ~~and~~/or one or more synthetic images containing synthetic anomaly, and the batch of images without presence of anomaly includes one or more original images from at least one of the second subset ~~and~~/or one or more synthetic images not containing synthetic anomaly; and

updating parameters of the generator network according to the second loss function such that the generator network is trained to generate photo-realistic synthetic images at least part of which contain photo-realistic synthetic anomaly.

7. The computerized method of claim 3, wherein the generator network is trained further using a third loss function associated with the generator network such that the batch of synthetic images generated therefrom meets a similarity criterion as compared to the corresponding batch of original images.

5 8. The computerized method of claim 1, further comprising validating the neural network system using one or more validation datasets to determine whether the neural network system is properly trained.

9. The computerized method of claim 1, further comprising generating one or more synthetic images with presence of anomaly using the trained neural network system.
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10. The computerized method of claim 1, further comprising detecting presence of anomaly in one or more input images using the trained neural network system.

11. The computerized method of claim 1, wherein the neural network system relates to Generative adversarial network (GAN).

15 12. The computerized method of claim 1, wherein the target object of the set of original images is a vehicle and the trained neural network is configured to detect anomaly associated with the vehicle.

13. A computerized method of anomaly detection, comprising:

receiving an input image capturing a target object; and

20 determining presence of anomaly associated with the target object in the input image using a discriminator neural network, wherein the discriminator neural network is trained together with a generator neural network operatively connected to the discriminator neural network and an additional discriminator neural network operatively connected to the generator neural network, ~~such that:~~ i) the generator
25 neural network is trained based on a training dataset, the training dataset including a set of original images capturing the target object, and a set of random data vectors, wherein the set of original images include a first subset of original images without presence of anomaly associated with the target object and a second subset of original images with presence of anomaly associated with the target object thereof, such that:
30 i) the generator neural network is trained using the original images from the first

subset and the set of random data vectors, at least based on evaluation of the additional discriminator neural network, to generate synthetic images meeting a criterion of photo-realism as compared to corresponding original images, wherein at least part of the synthetic images contain a synthetic anomaly generated and associated with the target object thereof, and wherein the additional discriminator neural network is trained to discriminate the synthetic images from the corresponding original images; and ii) the discriminator neural network is trained based on images with anomaly and images without anomaly from the set of original images including the first subset and the second subset and from the synthetic images wherein at least part thereof contains synthetic anomaly, to discriminate images with presence of anomaly from images without presence of anomaly with a given level of accuracy.

14. The computerized method of claim 13, wherein the target object is a vehicle.

15. A computerized method of anomaly generation, comprising:

receiving an input image capturing a target object and a random data vector;
15 and

generating a photo-realistic synthetic image containing photo-realistic synthetic anomaly generated and associated with the target object using a generator neural network, wherein the generator neural network is trained together with a first discriminator neural network and a second discriminator neural network operatively connected to the generator neural network, ~~such that: i) the generator neural network is trained~~ based on a training dataset, the training dataset including a set of original images capturing the target object, and a set of random data vectors, wherein the set of original images include a first subset of original images without presence of anomaly associated with the target object and a second subset of original images with presence of anomaly associated with the target object thereof, such that: i) the generator neural network is trained using the original images from the first subset and the set of random data vectors, at least based on evaluation of the first discriminator neural network, to generate synthetic images meeting a criterion of photo-realism as compared to corresponding original images, wherein at least part of the synthetic images contain a synthetic anomaly generated and associated with the target object thereof, and wherein the additional discriminator neural network is

trained to discriminate the synthetic images from the corresponding original images;
and ii) the second discriminator neural network is trained based on images with
anomaly and images without anomaly from the set of original images including the
first subset and the second subset and from the synthetic images wherein at least part
5 thereof contains synthetic anomaly, to discriminate images with presence of anomaly
from images without presence of anomaly with a given level of accuracy.

16. The computerized method of claim 15, wherein the target object is a vehicle.

~~17. A computerized system of training a neural network system for anomaly
detection, the system comprising a processor and memory circuitry (PMC)
10 configured to perform method steps of any of claims 1-12.~~

~~18. A computerized system of anomaly detection, the system comprising a
processor and memory circuitry (PMC) configured to perform method steps of any of
claims 13-14.~~

~~19. A computerized system of anomaly generation, the system comprising a
15 processor and memory circuitry (PMC) configured to perform method steps of any of
claims 15-16.~~

~~20. A non-transitory computer readable medium comprising instructions that,
when executed by a computer, cause the computer to perform method steps of any of
claims 1-12.~~

~~20 21. A non-transitory computer readable medium comprising instructions that,
when executed by a computer, cause the computer to perform method steps of any of
claims 13-14.~~

~~22. A non-transitory computer readable medium comprising instructions that,
when executed by a computer, cause the computer to perform method steps of any of
25 claims 15-16.~~

~~23.~~17. A non-transitory computer readable medium storing a discriminator neural
network trained to detect anomaly using a method comprising:

receiving an input image capturing a target object;

determining presence of anomaly associated with the target object in the input image using a discriminator neural network, wherein the discriminator neural network is trained together with a generator neural network operatively connected to the discriminator neural network and an additional discriminator neural network operatively connected to the generator neural network, ~~such that: i) the generator neural network is trained~~ based on a training dataset, the training dataset including a set of original images capturing the target object, and a set of random data vectors, wherein the set of original images include a first subset of original images without presence of anomaly associated with the target object and a second subset of original
images with presence of anomaly associated with the target object thereof, such that:
i) the generator neural network is trained using the original images from the first subset and the set of random data vectors, at least based on evaluation of the additional discriminator neural network, to generate synthetic images meeting a criterion of photo-realism as compared to corresponding original images, wherein at least part of the synthetic images contain a synthetic anomaly generated and associated with the target object thereof, and wherein the additional discriminator neural network is trained to discriminate the synthetic images from the corresponding original images; and ii) the discriminator neural network is trained based on images with anomaly and images without anomaly from the set of original images including the first subset and the second subset and from the synthetic images wherein at least part thereof contains synthetic anomaly, to discriminate images with presence of anomaly from images without presence of anomaly with a given level of accuracy.