CLAIMS

1. A method for training a neural network to identify cracks on a surface, the method including the steps of:

(a) training a neural network to detect a crack; and

(b) refining the trained neural network using a direction of the crack~~.~~,

~~2. A method according to claim 1,~~ wherein (a) training a neural network comprises:

(a1) receiving at least one training image, each said training image comprising a plurality of pixels; and

(a2) classifying each pixels as either a crack pixel, indicating presence of a potential crack, or a non-crack pixel, indicating no crack present~~.~~,

~~3. A method according to claim 2,~~ wherein, for each training image of one or more of said at least one training image, (a) training a neural network comprises:

(a3) selecting a first predetermined number of said crack pixels (selected crack pixels);

(a4) for each selected crack pixel, generating a patch of crack centred of said selected crack pixel;

(a5) determining whether to retain the patch based on a number of crack pixels in the patch; ~~and~~

(a6) adding the patch to a training data set if it is determined the patch should be retained; and

(a7) training a neural network using the training data set,

wherein the neural network comprises:

at least one convolutional layer;

a latent feature space layer for receiving an output of the at least one convolutional layer;

an output layer for outputting a binary output of crack detected or crack not detected; and

a latent label layer for labelling patches with one or more latent labels based on one or more features identified in the latent feature space layer; and

wherein (a7) training a neural network using the training data set comprises:

applying the at least one convolutional layer and latent feature space layer to the training data set, including extending a convolutional neural network (CNN) to a refined convolutional neural network (R-CNN) for crack patch detection; and

applying the output layer to a first output of the latent feature space layer.

42. A method according to claim 31, wherein:

(a3) further comprises selecting a second predetermined number of said non-crack pixels (selected non-crack pixels); and

(a4) further comprises, for each selected non-crack pixel, generating a patch of non-crack centred of said selected non-crack pixel.

53. A method according to claim 3 or 41 or 2, further comprising rotating the at least one image by an angle, and repeating steps (a3) to (a6).

64. A method according to claim 53, wherein the angle is a random angle.

~~7. A method according to any one of claims 3 to 6, wherein (a) training a neural network further comprises:~~

~~(a7) training a neural network using the training data set.~~

~~8. A method according to claim 7, wherein the neural network comprises~~:

~~at least one convolutional layer;~~

~~a latent feature space layer for receiving an output of the at least one convolutional layer;~~

~~an output layer for outputting a binary output of crack detected or crack not detected; and~~

~~a latent label layer for labelling patches with one or more latent labels based on one or more features identified in the latent feature space layer; and~~

~~wherein (a7) training a neural network using the training data set comprises:~~

~~applying the at least one convolutional layer and latent feature space layer to the training data set, including extending a convolutional neural network (CNN) to a refined convolutional neural network (R-CNN) for crack patch detection; and~~

~~applying the output layer to a first output of the latent feature space layer.~~

~~9~~5. A method according to ~~claim 8~~any one of claims 1 to 4, wherein (b) refining the trained neural network using a direction of the detected crack comprises applying the latent label layer to a second output of the latent feature space layer.

~~10~~6. A method according to claim ~~9~~5, wherein the second output is generated using only patches in which a crack is detected.

~~11~~7. A method according to claim ~~9~~5, wherein the second output is generated using only patches determined based on a said selected crack pixel.

~~12~~8. A method according to any one of claims ~~8~~ 1 to ~~11~~7, further comprising:

(c) identifying a crack by applying a Bayesian model for computing the probability of a true crack based on labels obtained from (a) and (b).

~~13~~9. A method for identifying a crack, comprising:

(d) receiving at least one further image of a surface; and

(e) identifying a crack by:

(e1) applying a neural network trained according to the method of any one of claims 1 to ~~12~~ 8 to the at least one further image; and

(e2) applying a Bayesian model for computing the probability of a true crack based on labels obtained from (a) and (b).

~~14~~10. A method according to claim ~~12~~ 8 or ~~13~~9, wherein the Bayesian model determines crack orientation consistency.

~~15~~11. A method according to any one of claims ~~12~~ 8 to ~~14~~10, wherein (c) identifying a crack comprises identifying a string of partially overlapping patches in which a crack is detected.

~~16~~12. A method according to any one of claims 1 to ~~15~~11, wherein each said surface is a surface of at least one of:

a building;

a construction;

an aircraft; and

a vessel.

~~17~~13. An apparatus for training a neural network to identify cracks on a surface, the apparatus including:

memory; and

at least one data processor, the memory comprising instructions that, where executed by the at least one processor, cause the at least one processor to:

perform the method of any one of claims 1 to ~~11~~7, or claim ~~16~~ 12 when dependent on any one of claims 1 to ~~11~~7.

~~18~~14. An apparatus for detecting cracks on a surface, the apparatus including:

memory; and

at least one data processor, the memory comprising instructions that, where executed by the at least one processor, cause the at least one processor to:

perform the method of any one of claims ~~12~~ 8 to ~~16~~12.

~~19~~15. A non-transitory computer readable storage medium embodying thereon a program of computer readable instructions which, when executed by at least one data processor of an apparatus for training a neural network to identify cracks on a surface, cause the apparatus to carry out a method according to any one of claims 1 to ~~11~~7, or claim ~~16~~ 12 when dependent on any one of claims 1 to ~~11~~7.

~~20~~16. A non-transitory computer readable storage medium embodying thereon a program of computer readable instructions which, when executed by at least one data processor of an apparatus for detecting cracks on a surface, cause the apparatus to carry out a method according to any one of claims ~~12~~ 8 to ~~16~~12.