

CLAIMS:

1. A fluid quality measurement device, comprising:
at least one processor; and
at least one memory including computer program
5 code;
the at least one memory and the computer program
code configured to, with the at least one processor,
cause the fluid quality measurement device to:
obtain a plurality of holograms, wherein each hol-
10 ogram in the plurality of holograms represents a micro-
scopic object in a fluid sample;
produce a latent space representation of each hol-
ogram in the plurality of holograms using a trained
autoencoder neural network;
15 assign each hologram in the plurality of holograms
to a class in a plurality of classes based on the latent
space representation of the hologram, wherein each class
in the plurality of classes corresponds to a partition
of the latent space; and
20 produce a fluid sample fingerprint based on the
assignment of the plurality of holograms into the plu-
rality of classes, wherein the fluid sample fingerprint
comprises an indication of a concentration of micro-
scopic objects in the fluid sample for each class in the
25 plurality of classes.

2. The fluid quality measurement device according to claim 1, wherein the at least one memory and the computer program code are further configured to, with

the at least one processor, cause the fluid quality measurement device to:

provide the fluid sample fingerprint for transmission to a server; and/or

5 provide the fluid sample fingerprint to a user.

3. The fluid quality measurement device according to claim 1 or claim 2, wherein the autoencoder neural network comprises a variational autoencoder neural network or a convolutional variational autoencoder neural network.

4. The fluid quality measurement device according to any preceding claim, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the fluid quality measurement device to:

provide a sample hologram from the plurality of holograms for at least one class in the plurality of classes for transmission to a server; and/or

provide a sample hologram from the plurality of holograms for at least one class in the plurality of classes to a user.

5. The fluid quality measurement device according to any preceding claim, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the fluid quality measurement device to provide a sample latent space rep-

resentation of a hologram from the plurality of holograms for at least one class in the plurality of classes for transmission to a server.

5 6. The fluid quality measurement device according to any preceding claim, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the fluid quality measurement device to:

10 assign each hologram in the plurality of holograms to a class in a second plurality of classes using a trained convolutional neural network, wherein the second plurality of classes comprises at least one class of interest; and

15 compute an indication of a concentration of microscopic objects corresponding to the at least one class of interest in the fluid sample based on the assignment of the plurality of holograms into the second plurality of classes.

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 7. The fluid quality measurement device according to claim 6, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the fluid quality measurement device to:

25 provide the indication of the concentration of microscopic objects corresponding to the at least one class of interest in the fluid sample for transmission to a server; and/or

provide the indication of the concentration of microscopic objects corresponding to the at least one class of interest in the fluid sample to a user.

5 8. The fluid quality measurement device according to any preceding claim, further comprising an imaging unit configured to produce the plurality of holograms using digital holographic microscopy.

10 9. A server comprising:
 at least one processor; and
 at least one memory including computer program code;
 the at least one memory and the computer program
15 code configured to, with the at least one processor, cause the server to:
 receive a fluid sample fingerprint from a fluid quality measurement device, wherein the fluid sample fingerprint comprises an indication of a concentration
20 of microscopic objects in a fluid sample for each class in a plurality of classes;
 compare the fluid sample fingerprint to at least one preconfigured criterion;
 in response to the fluid sample fingerprint not
25 meeting the preconfigured criterion, provide an anomaly notification.

 10. The server according to claim 9, wherein the at least one memory and the computer program code are further
30 configured to, with the at least one processor,

cause the server to compare the fluid sample fingerprint to at least one preconfigured criterion by performing:

5 produce a feature space representation of the fluid sample fingerprint, wherein each dimension of the feature space corresponds to a class in the plurality of classes; and

 compare the feature space representation of the fluid sample fingerprint to a feature space representation of at least one reference fingerprint.

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11. The server according to claim 10, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the server to compare the feature space representation of the fluid sample fingerprint to a feature space representation of the at least one reference fingerprint by calculating a distance metric between the fluid sample fingerprint and the at least one reference fingerprint.

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12. The server according to claim 11, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the server to:

25 compare the calculated distance metric to a preconfigured maximum distance metric; and

 in response to the calculated distance metric being greater than the preconfigured maximum distance metric, provide the anomaly notification.

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13. The server according to claim 9, wherein the at least one memory and the computer program code are further configured to, with the at least one processor, cause the server to compare the fluid sample fingerprint to at least one preconfigured criterion by performing:

5 compare the indication of the concentration of microscopic objects in the fluid sample of each class in the plurality of classes to a corresponding preconfigured maximum value; and

10 in response to the indication of the concentration of microscopic objects being greater than the corresponding preconfigured maximum value in at least one class, provide the anomaly notification.

15 14. A fluid monitoring system comprising at least one fluid quality measurement device according to any of claim 1 - 8 and a server according to any of claims 9 - 13.

20 15. A method for fluid quality measurement, the method comprising:

 obtaining a plurality of holograms, wherein each hologram in the plurality of holograms represents a microscopic object in a fluid sample;

25 producing a latent space representation of each hologram in the plurality of holograms using a trained autoencoder neural network;

 assigning each hologram in the plurality of holograms to a class in a plurality of classes based on the latent space representation of the hologram, wherein

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each class in the plurality of classes corresponds to a partition of the latent space; and

producing a fluid sample fingerprint based on the assignment of the plurality of holograms into the plurality of classes, wherein the fluid sample fingerprint comprises an indication of a concentration of microscopic objects in the fluid sample for each class in the plurality of classes.

10 16.A method for fluid quality monitoring, the method comprising:

receiving a fluid sample fingerprint from a fluid quality measurement device, wherein the fluid sample fingerprint comprises an indication of a concentration of microscopic objects in a fluid sample for each class in a plurality of classes;

comparing the fluid sample fingerprint to at least one preconfigured criterion;

in response to the fluid sample fingerprint not meeting the preconfigured criterion, providing an anomaly notification.

17.A computer program product comprising program code configured to perform the method according to claim 15 or claim 16 when the computer program product is executed on a computer.