BRIEF DESCRIPTION OF THE DRAWINGS

The present description will be better understood from the following detailed description read in light of the accompanying drawings, wherein:

FIGs. 1 to 4 illustrate, as schematic flow diagrams, methods for detecting microscopic objects of foreign origins present in a fluid;

FIG. 5 illustrates, in the form of graphs 5(A) to 5(E), principles that are usable in providing filtered image data;

FIG. 6 illustrates relationship between concrete microscopic foreign objects and prepared and filtered hologram patterns resulting therefrom;

FIG. 7 illustrates the effect of scaling in patterns;

FIGs. 8 and 9 illustrate, as schematic block diagrams, apparatuses for detecting microscopic objects of foreign origins present in a fluid; and

Fig. 10 illustrates effects of filtering of hologram patterns.

DETAILED DESCRIPTION

The method 10 of FIG. 1 comprises obtaining, in operation 11, prepared image data originating from a hologram digital image frame captured by an image sensor receiving light propagated across a sample volume which may be lie within, or be defined by, a cuvette, which sample volume contains a fluid possibly comprising microscopic objects of foreign origin, while illuminating the sample volume by coherent light.

Being defined by a cuvette refers to the extension, i.e. the shape and the dimensions, of the sample volume being physically limited or restricted by the

cuvette. Such cuvette may have any appropriate shape and structure with one or more straight or curved walls which may determine the boundary of the sample volume. Alternatively, the sample volume may comprise only a part of an inner volume defined by the cuvette.

The expression “of foreign origin” refers to that the microscopic objects are not formed of the fluid itself. They may originate, for example, from the materials of pipes or containers in which the fluid at issue is conveyed or stored. Particles of the

spatially substantially constant or slowly changing base level. The amplitude of such intensity component, used in determining the size parameter(s) may be, for example, maximum or average peak or peak to peak amplitude, second largest peak or peak to peak amplitude, or any other appropriate amplitude related property of the intensity in the area of the prepared or filtered hologram pattern.

In those embodiments comprising determining one or more size parameters of the microscopic object, the correlation between the brightness of the interference fringes and the object size is utilized. The larger is the object, the higher is the intensity in the interference maxima of the interference fringes.

Any of the shape, position, and size parameters may be provided for further use or for storage as any appropriate electric data or signal form.

Further, in addition to the amplitude or brightness, also other parameters such as the spatial frequency of the interference fringes may be utilized in determining a size parameter of the microscopic object.

Identifying the prepared hologram patterns associated with the filtered hologram patterns may be based on comparison of the positions of the filtered hologram patterns and the prepared hologram patterns in the filtered image data and the prepared image data, respectively.

In an embodiment illustrated in FIG. 2, which may be in accordance with any of the previous embodiments, obtaining the prepared image data in operation 21 comprises obtaining, in sub-operation 211, initial image data of the hologram digital image frame, the initial

CLAIMS

1. A method for detecting microscopic objects of foreign origin present in a fluid, the method comprising:

obtaining prepared image data originating from a hologram digital image frame captured by an image sensor receiving light propagated across a sample volume, containing a fluid possibly comprising microscopic objects of foreign origin, while illuminating the sample volume by coherent light, whereby the possible microscopic objects scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects, the prepared image data comprising, for a microscopic object, a prepared hologram pattern with prepared spatially alternating intensity formed by the interference fringes;

providing filtered image data, comprising automatically filtering the prepared image data by an edge enhancing filter, the filtered image data comprising, for a prepared hologram pattern present in the prepared image data, a filtered hologram pattern; and

automatically detecting, on the basis of the filtered hologram pattern, the presence of the microscopic object associated with the filtered hologram pattern in the sample volume of the fluid.

2. A method as defined in claim 1, wherein the edge enhancing filter is a symmetric filter.

3. A method as defined in claim 1 or 2, wherein the prepared image data is filtered by the edge enhancing filter at least in two different directions.

4. A method as defined in any of claims 1 to 3, further comprising automatically determining at least one shape

parameter of a detected microscopic object on the basis of shape of the associated filtered hologram pattern.

5. A method as defined in any of claims 1 to 4, further comprising automatically determining at least one position parameter of a detected microscopic object on the basis of position of the associated filtered hologram pattern in the filtered image data.

6. A method as defined in any of claims 1 to 5, further comprising automatically identifying, for a filtered hologram pattern, the associated prepared hologram pattern in the prepared image data, and automatically determining at least one size parameter of the associated microscopic object on the basis of amplitude of the prepared spatially alternating intensity of the associated prepared hologram pattern.

7. A method as defined in any of claims 1 to 6, wherein obtaining the prepared image data comprises obtaining initial image data of the hologram digital image frame, the initial image data comprising, for a microscopic object, an initial hologram pattern with initial spatially alternating intensity component; and automatically scaling down amplitude values of the initial spatially alternating intensity component of the initial hologram pattern exceeding a predetermined limit.

8. A method as defined in any of claims 1 to 7, wherein filtering the prepared image data by an edge enhancing filter comprises applying a convolution kernel to the prepared image data.

9. A method as defined in any of claims 1 to 8, wherein filtering the prepared image data by an edge enhancing

filter is carried out for at least two different spatial frequencies.

10. A method as defined in claim 3 or 9, wherein providing the filtered image data comprises providing a plurality of filtered image frames each comprising partial filtered image data, and combining the partial filtered image data of the plurality of filtered image frames into the filtered image data.

11. A method as defined in any of claims 1 to 10, the filtering the prepared image data initially producing, for a prepared hologram pattern, filtered spatially alternating intensity component with positive and negative values, wherein providing the filtered image data further comprises automatically converting the negative values into their absolute values.

12. A method as defined in claim 11, wherein providing the filtered image data further comprises automatically smoothing the filtered spatially alternating intensity component.

13. A method as defined in any of claims 1 to 12, the fluid flowing in the sample volume, wherein obtaining the prepared image data comprises:

obtaining initial image data of two hologram digital image frames captured sequentially in time;

automatically detecting, on the basis of the initial image data of the two hologram digital image frames, presence of any stationary scattering object on the basis of presence of stationary hologram patterns appearing similarly in the image data of the two hologram digital image frames; and

automatically generating the prepared image data on the basis of at least one of the initial image

data from which any stationary hologram detected is removed.

14. A method as defined in any of claims 1 to 13, wherein obtaining the prepared image data comprises:

providing coherent light;

illuminating a sample volume containing a fluid possibly comprising microscopic objects of foreign origin by the coherent light, whereby the possible microscopic objects scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects; and

capturing a hologram digital image frame by an image sensor receiving the light propagated across the sample volume.

15. An apparatus for detecting microscopic objects of foreign origin present in a fluid, the apparatus comprising a computing arrangement configured to perform the operations of the method as defined in any of claims 1 to 12.

16. An apparatus as defined in claim 15, further comprising a measurement arrangement comprising:

a cuvette defining a sample volume for receiving a fluid possibly comprising microscopic objects of foreign origin;

an illuminating arrangement configured to emit coherent light and illuminate fluid received in the sample volume by the coherent light, whereby the possible microscopic objects scatter part of the light, the scattered and non-scattered light interfering so as to form interference fringes behind the microscopic objects; and

an image sensor positioned and configured to capture a hologram digital image frame by receiving the light propagated across the sample volume;

the computing arrangement being connected to the measurement arrangement to receive image data of the hologram digital image frame.

17. An apparatus as defined in claim 16, wherein the cuvette is of flow-through type.

18. A computer program product comprising program code instructions which, when executed by a processor, cause the processor to perform the method according to any of claims 1 – 13.

19. A computer program product as defined in claim 18, stored on a computer-readable medium.