Shape – detection of small particles (1µm – 3µm) via digital image processing

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The 3D - distribution of small particles within a defined measurement volume is stored via digital holography and subsequently plane-wise reconstructed. From these reconstructed planes information concerning shape (Template – Matching Method) and size are gained by using a specific designed software program.

1 Introduction

The subject of interest is to gain a realistic impression of the three - dimensional distribution of small particles e.g. fine dust, pollen, as well as their identification by size and shape. For this, the 3D - distribution of small particles within a defined measurement volume is stored via digital holography. The digitally stored hologram (Fig.1a) is plane-wise reconstructed along the z-axis (Fig.1b, 2).These reconstructed planes are scanned for particular shapes of particles of interest defined by templates (Fig.3).

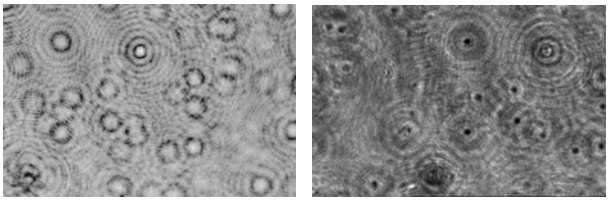

Fig. 1: *a) Hologram, b) One of the reconstructed planes*

This approach is called Template – Matching – Method. If a match is found in the reconstructed planes that corresponds to the template, the percentaged match with the template as well as the x- and y- position of the found shape are displayed (Fig.4). Information about the z – position is gained by the indices of the reconstructed planes.

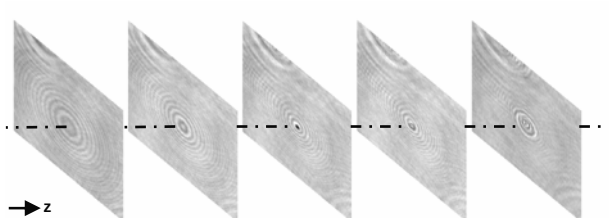

Fig. 2: *Reconstructed planes along the z-axis*

To specify the size of found shapes, the sum of pixels belonging to the shape of interest are determined and converted into area units.

In the following the operation of this program is exemplified on the basis of one particle.

Fig. 3: *Template*

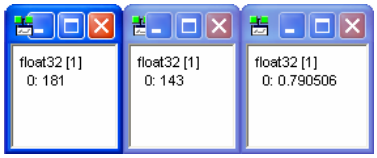

Fig. 4: *a)X- position in pixels, b) Y– position in pixels, c) Correlation with the template*

2 Shape determination

The reconstructed planes (Fig.5a) are scanned for particular shapes defined by templates (Fig.3). If a shape is found that matches with the template the correlation needs to be at least 55% for further investigation (specified threshold). If such a shape is detected the area around the found match is scanned again from the centre of the shape within a vicinity of 15 pixels to search for a better match with the template. Subsequently the centre of the found shape (Fig.5b) is marked and the position within the x-y- plane (Fig.4a, b) is visualised.

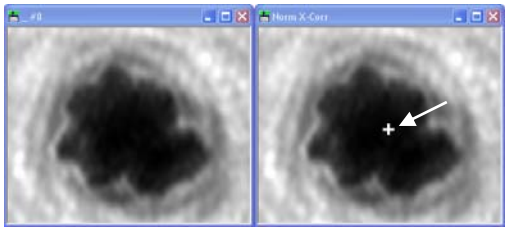

Fig. 5: *a) Extract of a reconstructed plane, b) Found shape within the reconstructed plane*

In addition, the percentaged degree of correlation between particle shape and template is displayed

(Fig.4c). In this example the found shape has a sufficient correlation of approx. 79% with the template. The necessary calculations are carried out by the designed software program, which has been developed by means of the image processing software WiT© (Fig.6):

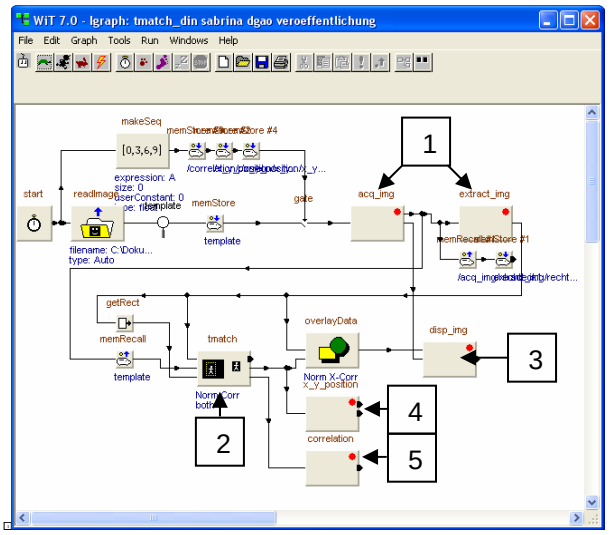

Fig. 6: *Screenshot of the designed program*

At first the template and all reconstructed planes are imported and prepared for investigation (Fig.6, No.1). Subsequently, the reconstructed planes are scanned for particular shapes defined by templates (Fig.6, No.2). Icon No.3 in Fig.6 is responsible for displaying the results of investigation. Icon No.4 (Fig.6) extracts the information of the x- and y-position of the found shape, whereas icon No.5 (Fig.6) points out the percentaged correlation with the template.

3 Sizing of shapes

At first, the reconstructed planes (Fig.7a) are transformed into binary images (Fig.7b) to size found shapes.

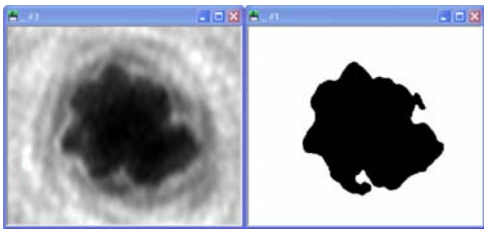

Fig. 7: *a) Extract of a reconstructed plane, b) Binary image*

To get information about size of found shapes all pixels that are different from zero are summed up (Fig.8a) and by means of this the area in µm is calculated (Fig.8b).

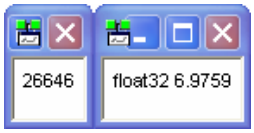

Fig. 8: *a) Number of pixels of found shape, b) Area in µm*

If more than one shape of interest is found in a reconstructed hologram plane, they can be distinguished by their coordinates and evaluated in the same manner as described above.

In addition edge detection can be carried out (Fig.9).

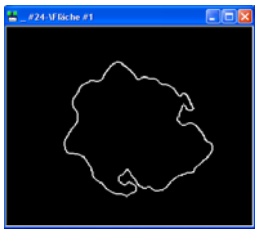

Fig. 9: *Additional information: Edge detection*

4 Results

The designed program determines information about position of particles within the measurement volume stored via digital holography as well as shape and size.

Furthermore, these determined parameters (coordinates, size, shape) are visualised by means of an additional designed software program to gain a realistic three-dimensional impression of particle distribution.

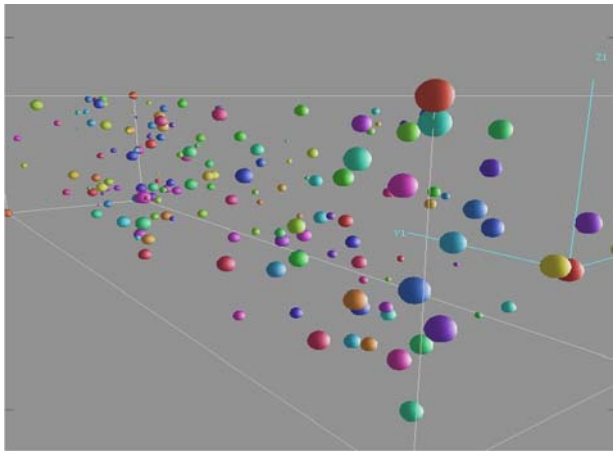

Fig. 10: *Three - dimensional distribution of particles within the measurement volume gained by evaluation of digital hologram*

Literature

[1] "Methoden der digitalen Bildsignalverarbeitung" by Zamperoni; 2. überarbeitete Auflage; published by Vieweg; 1991

[2] „Bildverarbeitung und optische Messtechnik" by Bernd Breukmann; published by Franzis; 1993