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Jacek Nowakowski*, Daniel Kaczorowski*, Łukasz Tomczak*

Image Processing Algorithms Application for 3D Multi Phase Flow Model Reconstruction**

1. Introduction

The operations of images processing are used in a wide area of the scientific disciplines (tomography, medicine etc.) For variety of disciplines a different sequence of image processing algorithms are needed. These operations allow to select characteristic objects which are the subject of further processing. The results can be presented as the processed images or the list of objects. In the case of series of images which present the measurement during the certain time interval (for example flood of mixture through the pipe) the results can be the data source to create three dimensional model of flooding.

2. The data for process operations

To create 3D model of a flow the *PipeWithLiquid* program was developed (Fig. 1).

This program can process the series of images (in this case the ultrasound images of mixture of water and oil flood in the pipe shown in the Fig. 2). After performing series of image processing routines the three dimensional models are the results received from this application.

The process of creation the 3D model consists of the following steps:

1. To read the series of data from video source and process them.
2. To create the structure of transient data.
3. To create the vertex buffers from the generated data and render three dimensional scene.

The main aim of the first step is to apply an appropriate processing image algorithms to find the specific regions of the flow. These regions in this case are the stains of oil. The program performs the following of image processing operations: binary, median filter, erosion, dilatation, removal of small objects and filling the edge. The correct sequence of these operation allow to emphasize the regions which are the subject of research. After process operations the program displays the images (Fig. 3) which are the input data to the next step.

* Katedra Informatyki Stosowanej, Politechnika Łódzka

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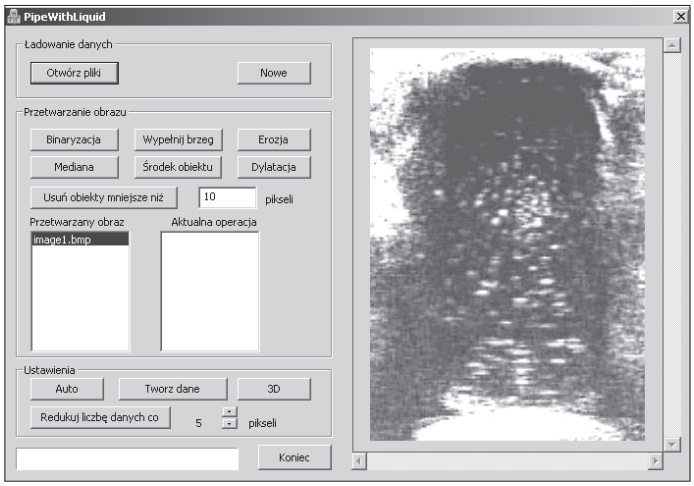

Fig. 1. The interface of the PipeWithLiquid program

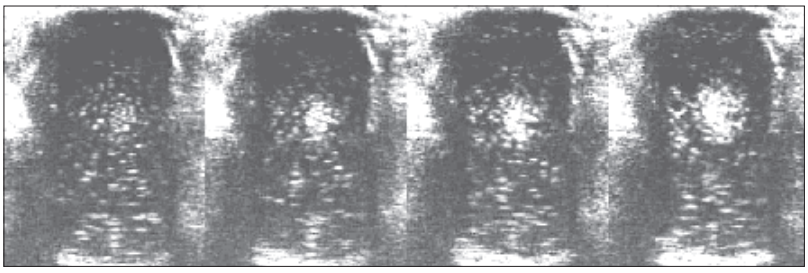

Fig. 2. The series of ultrasound images

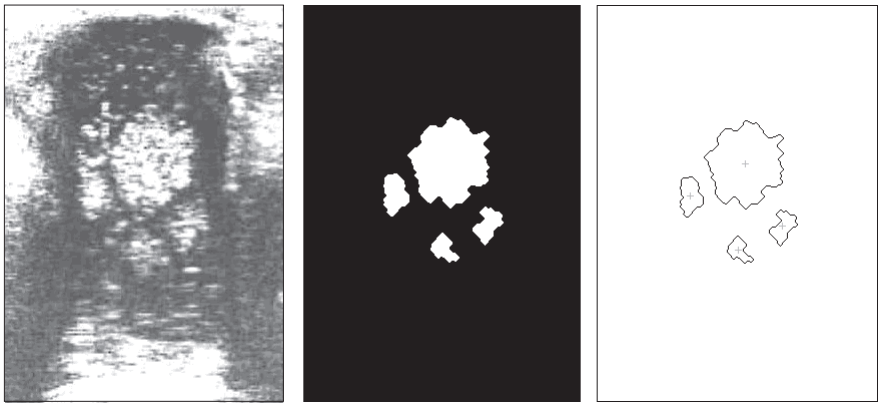

Fig. 3. Original image and processed image

The second step of generating the results in three dimensional model is to create an appropriate structure which keeps the temporary data. These data which in this step are input data has recurrent sequence of data. Each image is one of the parallel plane in three dimensional space. On these planes irregular close objects are reconstructed. Their edges and the centre point were determined during processing image algorithms. The best structure which keeps this data has the diagram which is presented below:

Layer 1
    Object 1: the edge, the centre point
    Object 2: the edge, the centre point
    …
    Object n: the edge, the centre point
Layer 2
    Object 1: the edge, the centre point
    Object 2: the edge, the centre point
    …
    Object n: the edge, the centre point
…
Layer n
    Object 1: the edge, the centre point
    Object 2: the edge, the centre point
    …
    Object n: the edge, the centre point

Each layer represents one image. On each layer a few objects are generated (reconstructed). Each object has the points which represent the edge and the centre point (center of the gravity) of this object. The structure is dynamic so it can be used for different number of input data (images).

The last step before building three dimensional model is to build appropriate vertex and index buffers. These buffers store the vertices of all objects on the images (in our case the stains of oil found in the images). The edges of objects on the each layer have various length. This is a problem for render stream. In three dimensional graphics all models are rendered from strip triangles so to create correct buffers the program increases the number of points on edges to the longest edge. In order to decrease the number of data the program creates the index buffers. Additionally these buffers allow to decrease the quantity of system memory space which is used by vertex buffers.

3. Reconstruction of three dimensional flooding

The third step in graphical data processing is generating 3D model. The program allows to display the results in three forms. The first one displays points which are created in the second step of our algorithm. The second one is to display the contours of each object placed on the layers. The last one is displaying the three dimensional objects as a wireframe model. The exemplary results are shown in the Figure 4.

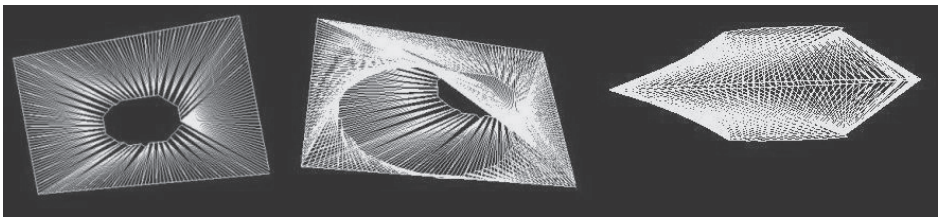

Fig. 4. The exemplary result in three dimensional graphics

4. Conclusion

The *PipeWithLiquid* is the program which was built and tested for analysis of flooding of the mixture of water and oil through the pipe which was represented as a series of ultrasound images. This program can be used for another series of data.

Having the possibility to present the flow measurement result in three dimensional models, the program will allow to calculate overall flow of different media, mean percentage of different flow components. The research is currently focused on automation of image processing algorithms, allowing optimal reconstruction of frames, corresponding to different cross-sections of a flow.

References

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[2] Wojnar L., Majorek M.: *Komputerowa analiza obrazu.* Fotobit Design, Kraków 1994
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