

# PROFILEMETER SOFTWARE

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**Abstract:** The work is focused on development of software tool for Windows operating system. This tool has the ability to visualize the measured data in 3D. The software's input data is images taken by a digital camera that captures them by an optical microscope ocular. In this work, the basic principles, which are used to solve the main problem and design the proposed software, are described.

**Keywords:** Software with 3D output graph, image processing, measuring by optical methods.

## 1. INTRODUCTION

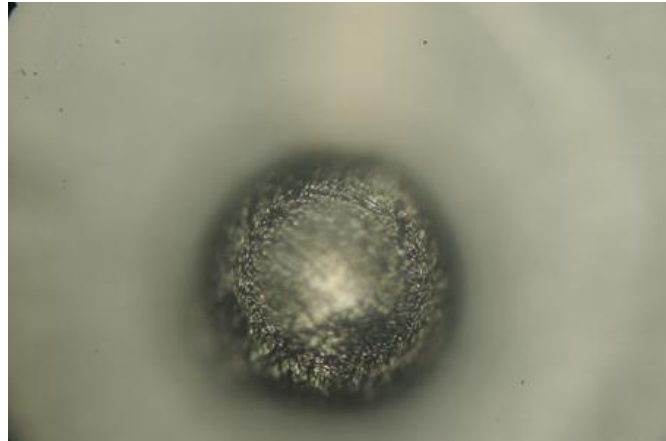
This work is dedicated for designing software, which allows examining a structure in microscope scale in the surrounding area. The design is focused on measuring a structure, which can be examined by optical method, however, this software can be used with other methods too. The main aim for developing the software was using the available resources for creating the nondestructive measure method in 3D. Today, many methods, which can generate 3D output data, are widely available. However, such devices are too expensive. The cost of microscope and digital camera is considerably less than that of a professional device for optical 3D inspection. Thus, using suitable software can achieve similar results with a greatly reduced cost. On the other hand, optical method has some negative aspects, such as limiting the measurement. The work describes a method for capturing images and their processing. This article presents the means, by which the measuring method limitations have been solved and the developed software has been tested.

## 2. ANALYSIS

The software's input data is images taken by a digital camera, which is placed on the ocular of an optical microscope (Figure 1). Images taken by this way are affected by an optical defect (Figure 2), which is used for plotting on 3D area. The measuring process is performed by taking a set (dose) of images with the same microscope approach step. At each height level, the captured images are sharp in a specific part, whereas the rest examined structure area is fuzzy. The focal length of the lens causes an image distortion, which creates the aforementioned fuzzy part in the captured images. If the projected object is near than infinitive distance, the sharp projection is moving (on converging lens) to larger distance from lens [1]. For each distance from lens, the images are sharp only for objects, which are located within that distance. Objects that are closer or further appears fuzzy and muddy, because their plain of focus is closer or further, respectively, from to the microscope lens.



**Figure 1:** A digital camera placed on a microscope ocular.



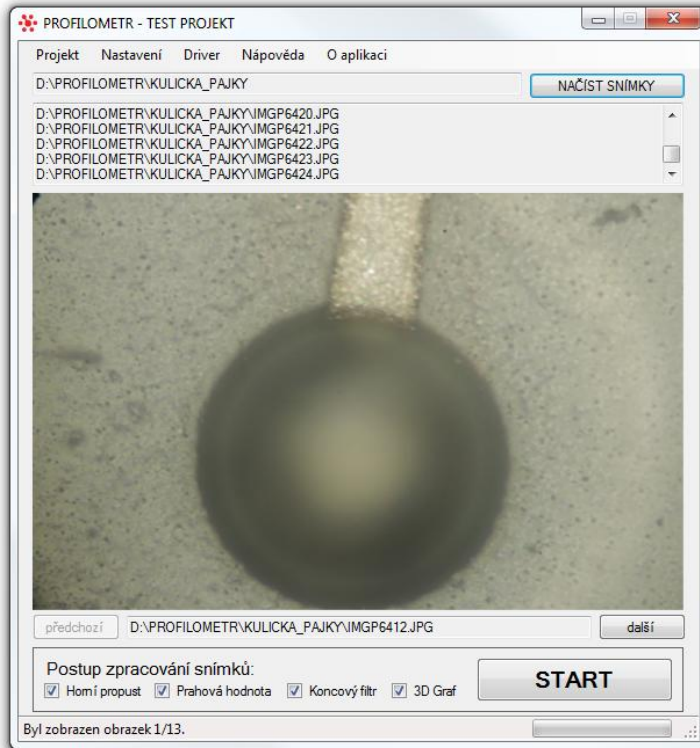
**Figure 2:** Fuzzy area in a captured image.

By choosing these sharp parts, a set of values for coordinate system in two axis  $x$  and  $y$  is obtained. Image indexing can be determined according to the height level of points, and thus, the value of the third axis  $z$  in the surrounding area, is assigned. Measuring accuracy strongly depends on the ability of precisely adjusting the focal length of microscope lens. Therefore, it is appropriate to apply automate microscope adjustment, hence reducing human factor errors.

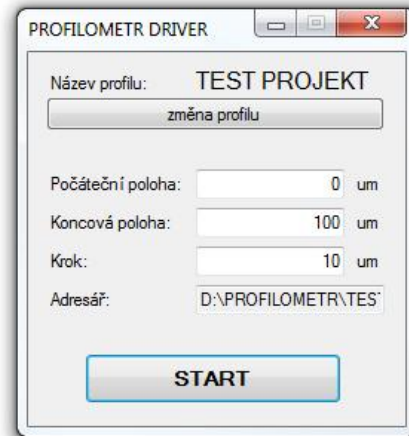
## 2.1. MEASURE AUTOMATION

The developed software can be used as a tool, which can process a set of images with a given indexing in chronological order (Figure 3). This software can also control a device for automatic adjustment of the microscope (Figure 4). The microscope is initially focused on a defined level, and it gradually increases the focal length of the lens. Changing the focal length is done by rotating the focusing screw. The device's software establishes the communication with software installed on PC via a communication protocol. This protocol allows to interchange information about the focusing position, the end state and errors. The software for automated measuring is able to run independently. Thus, the control software generates an executable file that contains information about the required measurements. The measuring process has the following steps:

- creating a new project for measuring and setting the work directory path,
- setting start position, end position and the length of focusing step,
- moving the focusing from the start to the end position based on the length of focusing step,
- after each focusing step, an image of the actual structure is captured and saved in the selected work directory.



**Figure 3:** Application main window.



**Figure 4:** Software for automated microscope adjustment.

## 2.2. SOFTWARE FOR IMAGE PROCESSING

The developed application (Figure 3) is designed for Windows operating system and is written in C# programming language. The software is divided into five main parts:

- the “Projekt” menu – creating a new project, opening an existing project,
- the control software – measure automation,
- the “Nastavení” menu – filters settings, settings of area raster,
- the application’s main window – loading images, filter selection, start image processing,
- the application’s graphic output – 2D and 3D graphs.

### The “Projekt” menu

In this case, a project means a definition file containing information corresponding to the captured images and their processing, such as information about the images locations, their order and the location of work directory. Moreover, the project combines the information connected to the settings of the control software and image processing software. The project also defines the selection of used filters. Saving these definitions leads to user’s ability for simple reproduction of previous measures and store those results.

### **The control software**

The control software is able to run as an independent application, which has the possibility to launch from the image processing software. The application form is designed to provide a user's ability to simply and quickly capturing images of the examined structure, and to get good information of the actual processes.

### **The “Nastavení” menu for image processing**

This is the most important part of the software, in terms of processing the measured data. The first part of menu sets the behavior of the primary filter for image processing. In this part, the user can select the required settings for filter matrix [2] from a combobox (such as high-pass, Sobel operator, Laplace operator, etc.), threshold of the scanned pixels intensity and rules for generating plot data. These rules have a strong influence on the resolution of the output graph.

### **The application's main window**

This window is located in such a way to make the user clearly informed about the chosen images and filters for processing. The processing progress is shown via a graphical and a text form, and is displayed on the status bar, too. The graphical form can also be used as a feedback of the applied filters. After applying each filter, is the affected (filtered) image displayed.

### **The application's graphic output**

A window for viewing the 3D-graph is automatically launched as soon as the plot data is generated. If data is generated, the software can show the cross-section through the examined structure. This type of plot seems to be better in some cases, such as 2D-graphs, because viewing the structure's shape and its dimensions will be much easier.

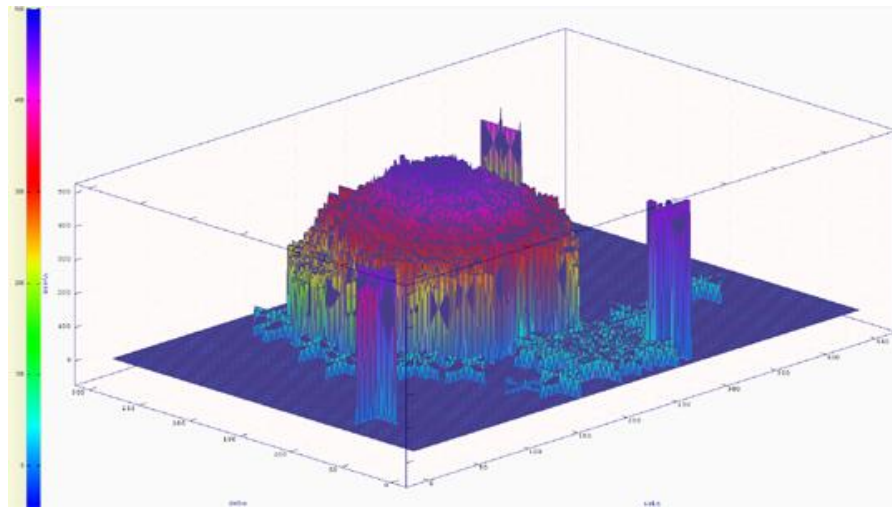
## **2.3. THE PRINCIPLE OF IMAGE PROCESSING**

The main aim of this project is determining the sharp area of a captured image and showing this area in a 3D-graph at a corresponding height level. Determining the sharp area can be realized by couple ways [3]. In the presented software, a method for generating individual points, which are found in the target area, was used. Suitable points are used for surface rastering. Rastering is a necessary component for generating a meaningful 3D-graph, because the number of points obtained from the sharp areas, when compared with the image resolution, is relatively small. If only the suitable points are plotted, then the graph will be created out of peaks, which are very far apart, thus it is not possible to estimate the result shape of the surface. Rastering is a mathematical method for calculating the height level of undefined points. Around a suitable point, an area with the height level corresponding to the value of z axis of that point is created. A correct choice of the shape and its size will enlarge the resolution of the 3D-graph.

## **2.4. TESTING AND REAL RESULTS**

Designing the presented software started at providing an ability to plot simple 3D-shapes. The main aim of testing was to create a set of images, which correspond to the cross-sections through the shapes in defined height levels from a fixed view point. According to the testing image set, a limitation of the used measuring method is obvious. This limitation flows from the impossibility to view the shapes that are hidden by a certain object's shadows. These shadows are created by objects, which stand-out the surface

and prevent focusing on the areas below. This problem is solved by structure rotation and capturing images from another angle of view. After this step, the user is able to evaluate if the 3D-graph contains a shadow or not. However, in some cases, this shadow detection is impossible. The result of a real structure testing is shown on figure 5.



**Figure 5:** 3D-graph of a real structure.

### 3. CONCLUSION

The designed software is alternative for 3D optical inspection devices, which can greatly reduce the cost. The proposed software can also be used with images captured by methods other than optical ones. The uncovered main deficiencies of the optical method were solved (totally eliminated or reduced). The 3D output graphs have demonstrable characters of the measured structures. The measuring shows the necessity to eliminate the human factor in image capturing process. A further software development can be focused on preparing better filters and raster methods, reducing shadows or generating 3D-graphs without shadows in case of using other image capturing methods.

### ACKNOWLEDGMENT

This work was supported by grant project F1a no. 1005/2011 „Komplexní inovace systému výuky výrobních technologií mikroelektronických systémů”.

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