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LASER SIMULATION

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Abstract. The paper informs about starting project dealing with laser device. The task of the project is to develop a new kind of laser device, its control and simulation. The final equipment should be used for scientific physical experiments or for application purpose. The system will be able to burn vector and raster images, text or make a various kind of surface processing into various types of material (steel, ceramics, plastics…). Moreover, user will be able to set the priority of time or accuracy optimalization. This paper describes single parts of the project. The major part of the paper refers about the SW part and data preparations, there are also suggested simulation methods and process.

Key words. simulation, laser, visualization, application approach, 3D

Mathematics Subject Classification: 68Q85.

1 Introduction

About one year ago a project started in a cooperation of three departments of University of West Bohemia – the Department of Computer Science and Engineering, the Department of Physics and the Department of Cybernetics. Except these three university departments, also a hi-tech company – Lintech, participates in this project and supports it.

Our aim is to develop a real laser equipment (HW device) for burning any image or description into any kind of material. This device must have several SW parts, which control the laser and simulate its function. The development is divided among three university departments. Single parts of the whole project are more in detail described in the fig. 1.

The laser itself services the Department of Physics (the dashed part) and the Department of Cybernetics will develop HW control of the equipment (the dashed part). Laser would be used for broad range of functions starting from applications (e.g. electronic describing) to physical experiments. Results of these operations are not fully deterministic, that is why they sometimes need to be reoperated several times to obtain optimal result, which is money and time consuming.

From this reason, a laser simulation is desirable and the Department of Computer Science and Engineering was asked to provide IT support and simulation of the whole system (the solid part in fig. 1). The simulation should provide experiments quick and cheap as possible. Moreover, it enables optimalization and elimination of unexecutable experiments. As a part of the simulation there is also implemented an application for data visualization.

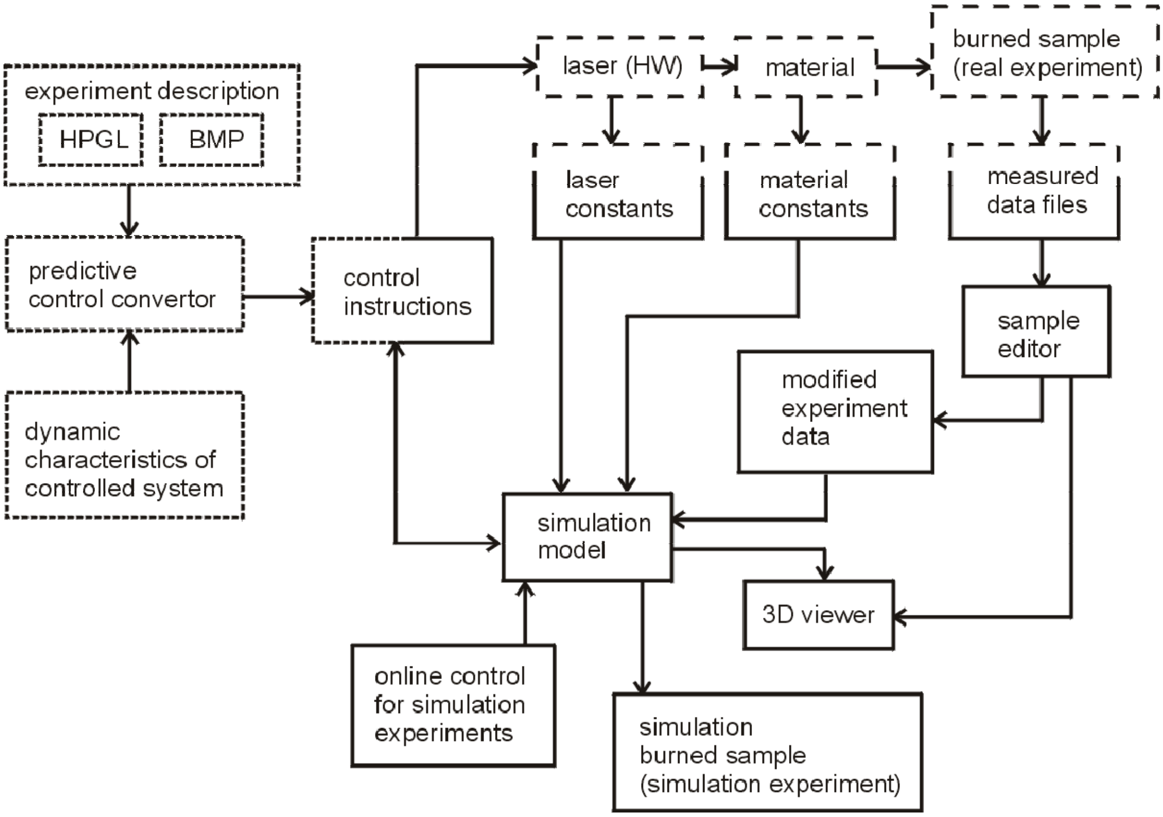


Fig. 1: Detail view of single parts of the project.

The paper is divided into several chapters. Chapter 2 describes parts of the whole system; in Chapter 3 methods of laser burning simulations are presented. Our result and future plans are described in Chapter 4; Chapter 5 concludes the paper.

2 Parts of the System

The whole system enables to burn predefined patterns into the chosen material. The basic function of system parts shown in the fig. 1 and the sequences of the device work are described in this chapter.

The laser device enables burning raster and vector graphics, text, etc. Anything we want to burn has to be described in HPGL (Hewlett-Packard Graphics Language) language or in the form of BMP image. This experiment description goes to predictive control convertor. The convertor uses knowledge of dynamic characteristics of controlled system and creates from the description the set of control instruction for the laser. Instructions contain information where to burn, which intensity use and so on. These instructions are sent to the laser to control the burning process into real material – the real experiment.

To provide simulation of the burning process, we have to know characteristics of the laser and material. These are described in the laser and material constants. The real sample has to be measured and the result saved into the data file. The file is loaded into the sample editor, where it is processed (e.g. overflowing parts of the sample are cropped). All files with necessary data are taken and loaded into the simulation model. The simulation of the burning process can be online controlled to get the best results, where the criterion such as speed of burning or quality of result can be taken into account. The simulator also enables to view all samples in 3D viewer or to possibly optimalize control instruction for the laser (especially intensity of the laser). Finally we have the burned sample obtained by the simulation process (the simulation experiment).

Both real experiment and simulation experiment can be compared, which helps in verification of the simulation model.

3 Methods

Let us speak about simulation itself, because that is what we are working on. It is possible to simulate the real situation on the basis of analytical methods or create simulation model with using application approach.

3.1 Analytical methods

Simulation using analytical approach comes from knowledge of physical equations, mathematical descriptions, procedures and dependencies. Of course, the analytical methods can be discretize and results can be get numerically. Such a simulation model can be general enough but in the case of concrete equipment it is difficult to find the right combination of parameters to describe it exactly. Nevertheless, the analytical approach is a good way how to model lasers. We do not have to model only lasers, we can also describe melting processes of the material (e.g. the Stefan problem [1]).

3.2 Application methods

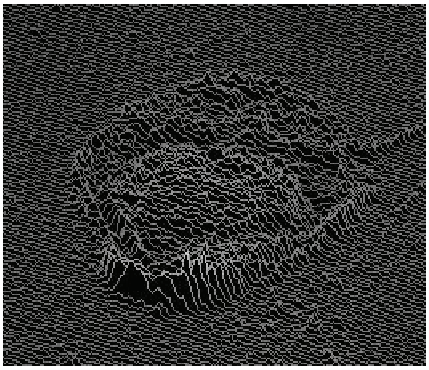
We decided to select another way to simulate laser burning – the application approach which is combined with software simulation. We started from experiments and make use of knowledge of concrete lasers and materials. Because we deal with real data from concrete type of laser pulses measured in a given material, we can achieve more accurate results in comparison with analytical method mentioned above.

At the beginning of the simulation we need clearly defined real experiment. It means we have to get data from samples burned into the concrete material by the real laser. For example, we need with the concrete laser do following burnings into concrete material: one laser pulse singly, two, five, ten pulses into one point. All these burnings should be done several times. Now a question could arise, where these numbers came from. Let us call the set of burnings an experiment. One of our tasks is to find the optimal experiment which would represent the result of burning with concrete laser into defined material. We have to decide, how many burnings we have to make to obtain enough full-range and representative spectrum of pulses. Of course we try not to do many burnings uselessly, because it is obvious that experiments with real material cost money and time.

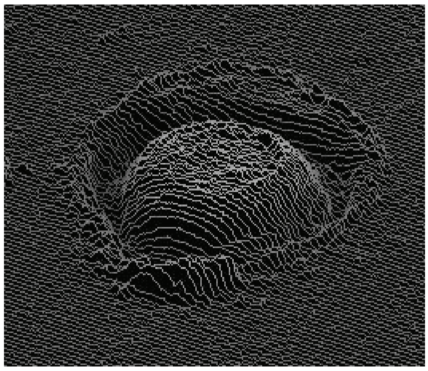
For different materials the experiments can differ. With data from well defined experiment, the simulation model would be able to realize arbitrary kind of simulation experiment (e.g. one hundred pulses into one point and immediately see the result on 3D viewer).

Results from such real experiment burned into a steel material are visible in the 3D views in fig. 2. After burning, the burned samples has to be measured, scanned by the microscope and saved in the proper format (currently we use the format of height map). These files are further processed by the sample editor and then by the simulator. This described experiment is really very small, but it is sufficient for our imagination.

After defining the experiment, it is important to create and validate the simulation model and to enable users to control simulation experiments online or to prepare bat-oriented simulation. User can apply single laser pulses into the material pulse after pulse. The system also enables user to simulate burning, for example, thirty pulses into one point in automatical mode or set the whole simulation experiment (e.g. for verification or optimalisation).



a)



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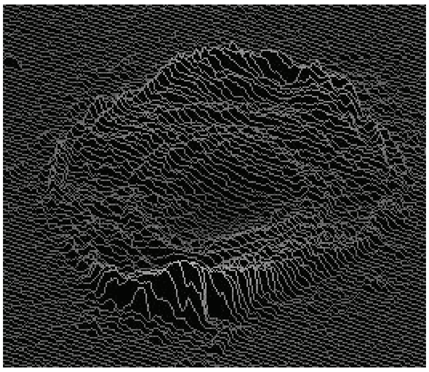
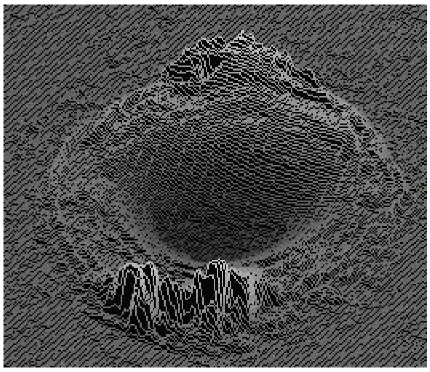


c)



d)

Fig. 2: 3D views of material burned with laser a) 1x b) 2x, c) 5x, d) 10x into one point.

Each measured real experiment or generated simulation experiment can be visualized and further processed, scanned, metered or saved for verification. For visualization we use OpenGL [2], [3] and because the whole simulation system is implemented in Java, for cooperating OpenGL and Java we use JOGL [4].

4 Results and Future Plans

At this time we are in the opening phase of the project. The sample editor is already implemented. We are also preparing data for simulation and data representation.

All measured samples we get from the microscope are saved in text format. Samples surfaces are described as height maps in cvs (comma-separated values) files. The square grid of saved files is uniform and really fine. E.g. sample displayed in fig. 3 consists of 1024×768 decimals. The real size of the measured sample is 256×192μm. It means that one grid step measures 0.25μm. The simulation tools works with height maps, visualizes them and the simulation itself corresponds to the height map modification.

Presently, the tool for viewing measured data files with number of additional functions is ready. It enables 2D and 3D viewing of the whole samples and also of intersections in horizontal and vertical direction. User can measure size of burned pulses, depth of the face. Samples can be cropped and resaved, editor can figure out statistics of the sample, etc. The main window of the editor you can see in fig. 3, 3D visualization of the same sample in fig. 4.

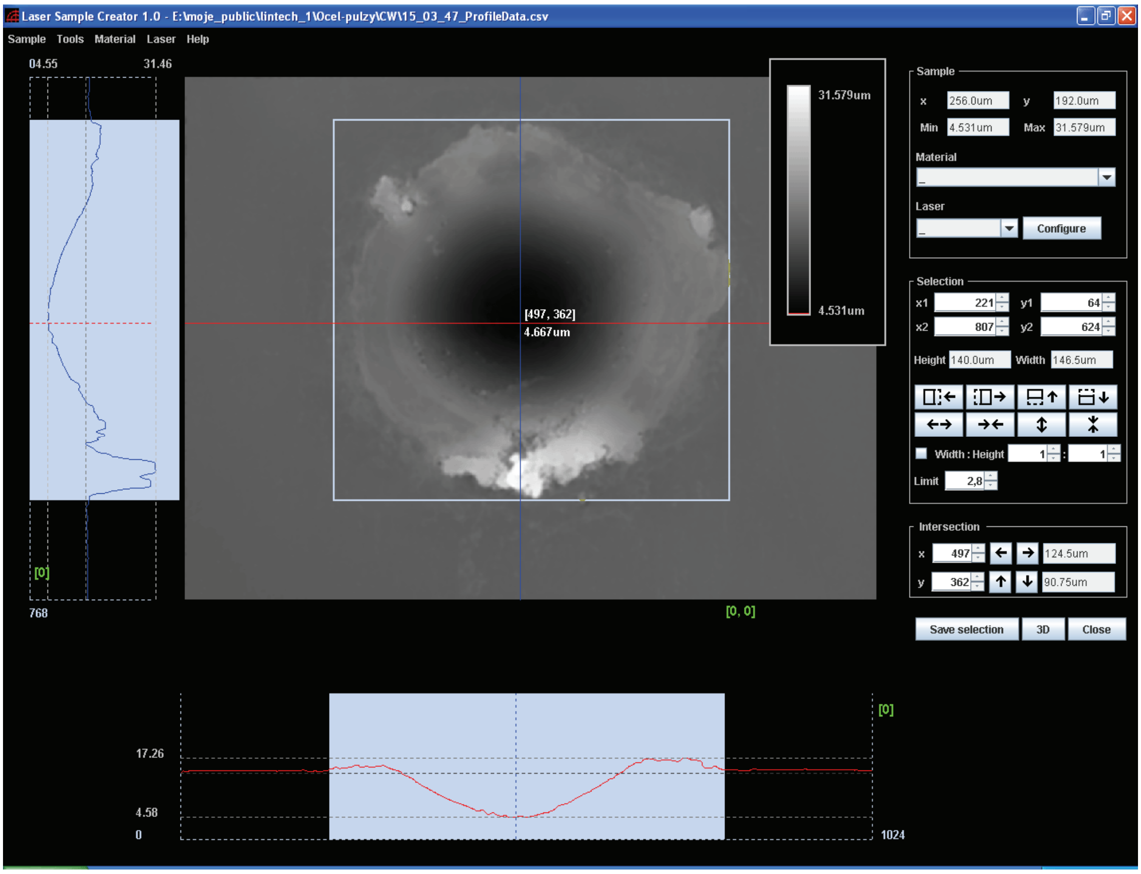
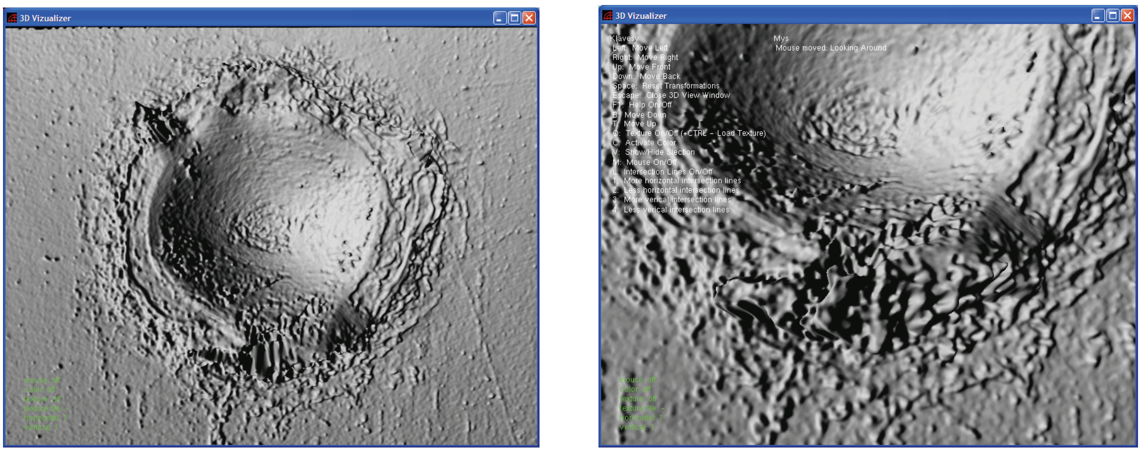


Fig. 3: Main window of the editor.



a) b)

Fig. 4: 3D visualization of the real sample (the same sample as in fig. 2d) a) view from distance, b) part of the sample in detail.

The major part of the main window creates the top view on the sample. On the left and bottom side of the window vertical and horizontal intersections are displayed. They enable users to explore the depth of the pit in detail. The small window which overlays the top view shows height scale. User can see, how deep is the concrete part of the pit while moving the cursor over the sample. Also various sizes can be measured, the ruler is able to measure height, width and deep of the sample. The right part of the window and the main menu serve for controlling the editor. User can set a type of material and laser, select part of the sample and save them, he can also view the sample in 3D, detect pulses in the sample, etc.

Nowadays first experiments with ceramics and steel are prepared. We dispose with about fifty measured samples (various count of pulses into one point and burning during movement using various speed of laser for mentioned materials).

After managing static experiments we plan to include into the simulation dynamics characteristic of the laser – speed of the movement, time period necessary to cooling the laser down etc. Moreover the simulator should be able to optimalize results of the simulation (especially the depth of the burned relief).

5 Conclusion

The project is multiprofessional, it is cooperated by several university departments with support of a hi-tech firm working in the branch. Our IT part falls into the applied research. Although the project runs less than one year, we already have first promising results especially in range of data processing and visualisation.

Acknowledgement

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References

[1] ALEXIADES, V., SOLOMON, A. D.: *Mathematical modelling of melting and freezing processes*. ISBN 1-56032-125-3. Taylor&Francis, 1993.

[2] WRIGHT, R.S., LIPCHAK, B.: *OpenGL SuperBible (3rd Edition).* ISBN 0672326019. Sams, 2004.

[3] OpenGL [online], [cit. 2007-09-01]. <http://www.opengl.org/>.

[4] Java OpenGL [online], [cit. 2007-04-21]. <https://jogl.dev.java.net/>.

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