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Realization and Verification of Data Conversion from Laser Scanner to FEM

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ABSTRACT
This paper deals with the data processing in the form of a point cloud scanned using a handheld 3D laser scanner. The aim of the paper was to use this data to create a representative FEM model and compare two different approaches, one them involved creating a CAD model and the other one did not. The data processing was carried out in the freeware systems MeshLab and Meshmixer and FEM analysis in the software ANSYS Workbench.

Keywords: 3D laser scanner, data processing, CAD model, MeshLab, Ansys Workbench.

INTRODUCTION

Nowadays, reverse engineering is encountered in various branches of engineering. This is a specific approach that enables to effectively link the measurement technique, laser or CT scanners, with a computer environment. This type of connection allows transforming the scanned data into the digital form and processing them with the computer. The way these data are processed is part of reverse engineering. Reverse engineering is known as the process of duplicating an existing component sub-assembly or product without using a drawing documentation or a computer model [2, 3, 16]. Reverse engineering has a wide use. It is mainly employed in the cases where the product documentation is missing or has never existed.

The laser scanning has a wide application in the field of the engineering industry. A laser stripe is projected onto a surface and the reflected beam is detected by CCD cameras. Three-dimensional coordinates are acquired through the image processing and triangulation method [4].

The cloud of points originates because of laser scanning. The external surface of an object is represented with a set of discrete points. Individual points are described in the file with their 3D coordinates. The density of the points on the surface is optional at certain intervals; for example, in the engineering industry it is roughly 1 to 0.2 mm between two points.

Triangulation is a method which uses location and angles between light sources and photo sensing devices to deduce position. A high energy light source is focused and projected at a prespecified angle at the surface of interest [1, 18]. It forms the basis for the algorithms that are applied to the cloud of points. After scanning the object with a laser scanner, it is necessary to process the obtained cloud of points. It is carried out by trigonometric calculation. The solution is to connect individual points together to a mesh that describes the geometry of the scanned object. Nowadays, there are several meshing algorithms that enable us to solve this type of problem.

POISSON SURFACE RECONSTRUCTION

In his paper, Michael Kazhdan "We show that surface reconstruction from oriented points can be cast as a spatial Poisson problem. This Poisson formulation considers all the points at once, without resorting to heuristic spatial partitioning or blending, and is therefore highly resilient to data noise. Unlike radial basis function schemes, our Poisson approach allows a hierarchy of locally supported basis functions, and therefore the solution reduces to a well conditioned sparse linear system. We describe a spatially adaptive multiscale algorithm whose time and space complexities are proportional to the size of the reconstructed model" [5].

This contribution is based on this algorithm too because the goal is to obtain a watertight and smooth surface. Therefore, the MeshLab software is used because it has implemented the Poisson Surface Reconstruction mesh algorithm.

PROCESSING OF SCANNED DATA AND MODELLING

After scanning an object into the cloud of points, a mesh is created from these points. As the reference object for this study a chrome-vanadium steel wrench, size 30 was used. It was scanned using the laser FARO Edge ScanArm HD in the company CEIT. A text file that contained the coordinates of cloud of points, defined in the cartesian coordinate system XYZ is received at the output from the scanner.

Figure 1 presents the whole workflow. After scanning the wrench using the laser scanner, the text file containing the positions of the points is imported to the freeware MeshLab software (see Fig. 2). A triangular surface model in the.stl format is created in this software (see Fig. 3). In MeshMixer, which is also freeware software, the information like the size of wrench and material from the surface of the model are removed by the smoothing tool (see Fig. 4 and Fig. 5). Afterwards, the two different approaches of further processing of the model are studied.

The first approach is a classic reverse engineering approach which includes the creation of the volume CAD model, because the .stl model is only the triangular surface model. Volume CAD model is created in the Ansys SpaceClaim software. After importing the .stl model into the SpaceClaim, the main boundary curves of the future volume model are created with the use of intersection of 2D planes and triangular surface model.

Using these boundary curves, the volume model is created by re-modelling the triangular surface model. The volume model must be created as close as possible to the triangulated surface model. Then the volume model is used in the FEM analysis.

The second approach does not include the creation of volume CAD model. The .stl model is imported to the ICEM CFD module which is implemented in the Ansys Workbench and it is an effective tool for generating FEM meshes. This tool is used to create the surface mesh from the triangular surface model. Afterwards, this surface mesh is used to compute the volume mesh. Then, the volume mesh is used in the FEM analysis. [11–14].

FEM ANALYSIS

The FEM models from these two approaches are simulated in the Ansys Workbench software in the Static Structural module [9, 19]. The purpose of this paper was to compare the simulations of these two approaches; therefore, the simple and the same boundary conditions are set on the these

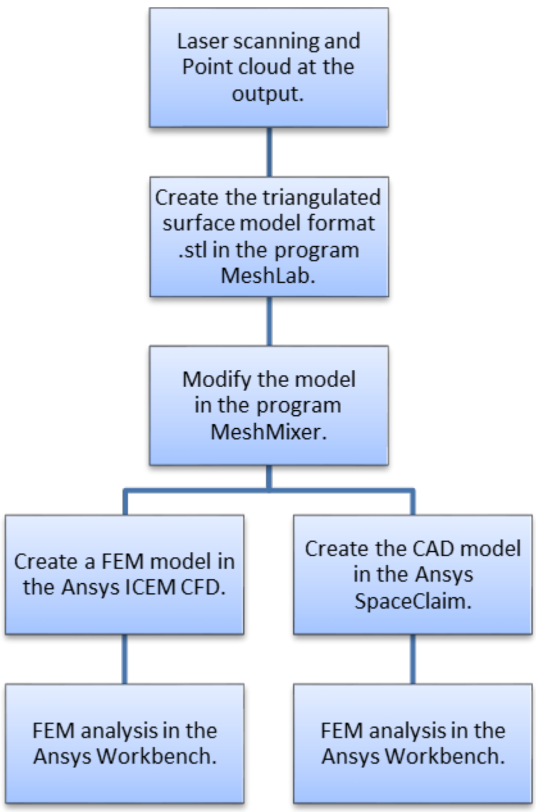

Fig. 1. Scheme of process suggestion

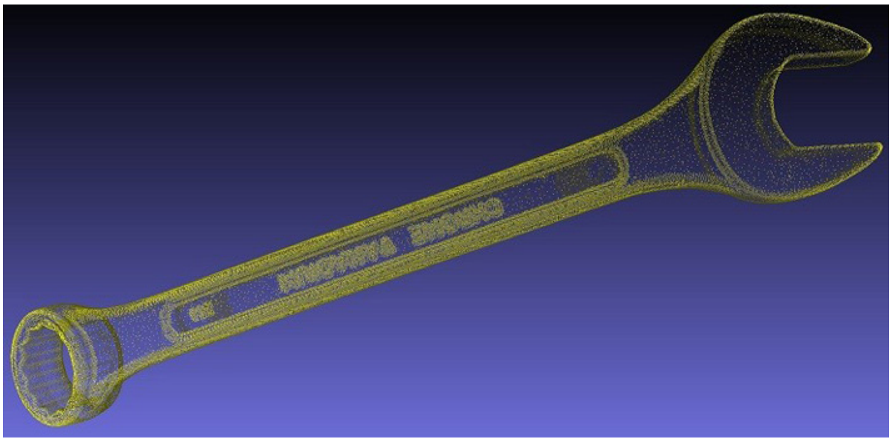

Fig. 2. Point cloud

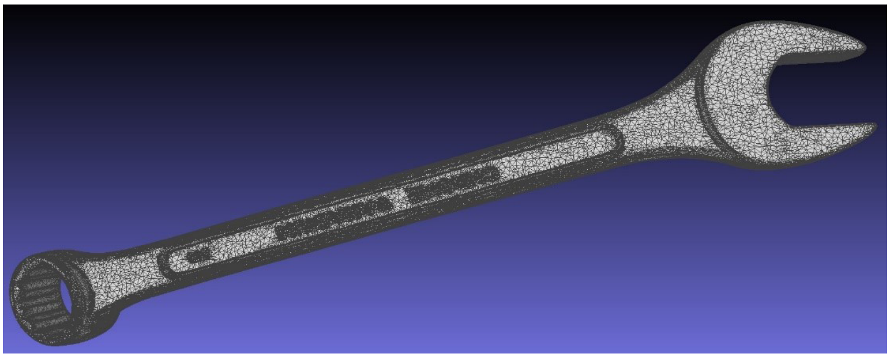

Fig. 3. Triangulated surface model

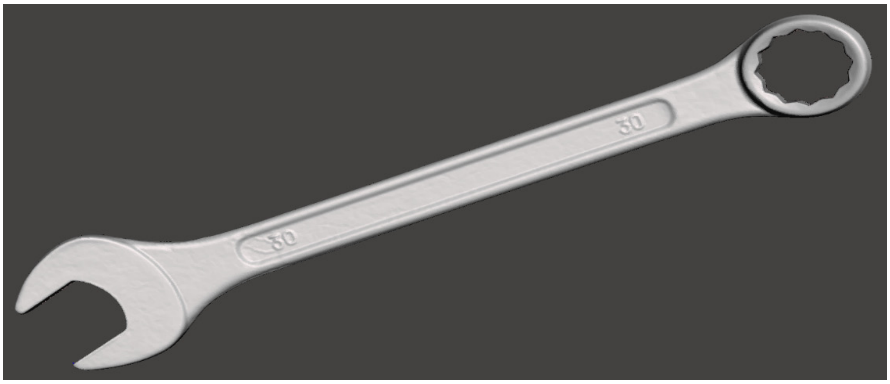

Fig. 4. Triangulated surface model with the characteristic information on the surface

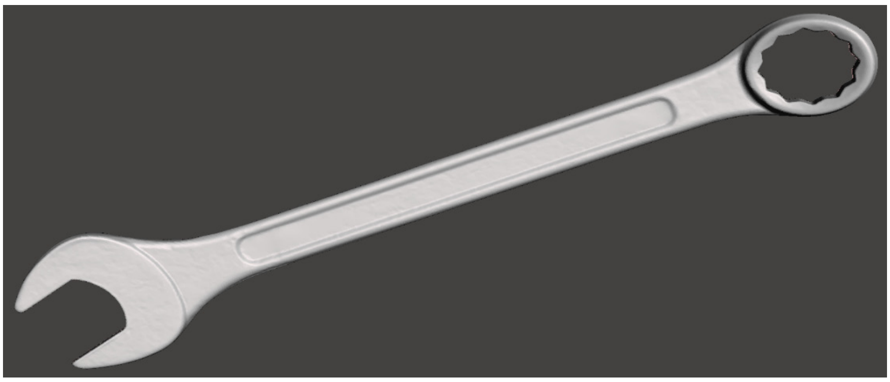

Fig. 5. Triangulated surface model without the information on the surface

both FEM models. In Figure 6, it is shown that the two parallel surfaces of the wrench are fixed and the pressure 0.59 MPa is applied on the other side of the wrench in the direction of the movement.

In the first approach, a computational mesh was created from the volume model before the simulation itself. The computational meshes contained about 350 000 elements in the both cases (see Fig. 7).

Both simulations were completed successfully and the results are shown in Figure 8 and Figure 9.

The results are different. The maximum value of the von Mises stress in the 1st approach is placed at the different locations than the maximum value of the von Mises stress in the 2nd approach and the deviation of the results is 29.7%. The reason why the results are different may be the fact that

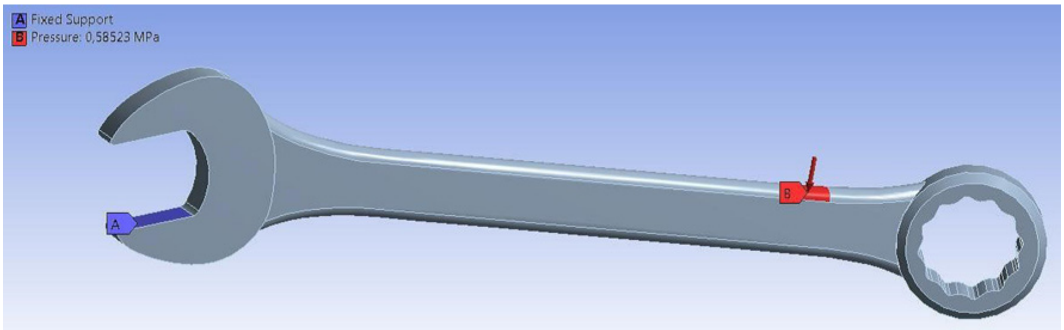

Fig. 6. Location of boundary conditions

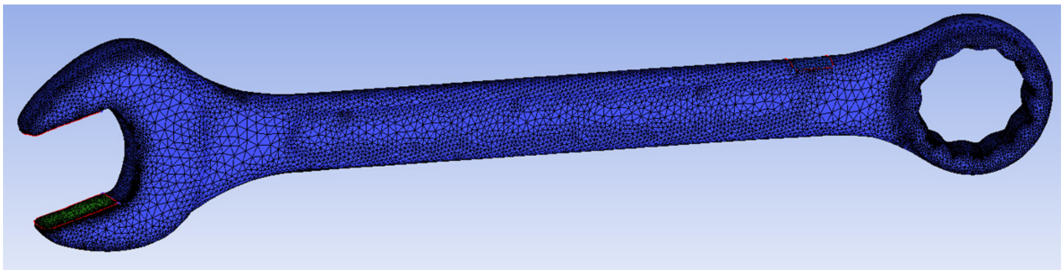

Fig. 7. Computational mesh

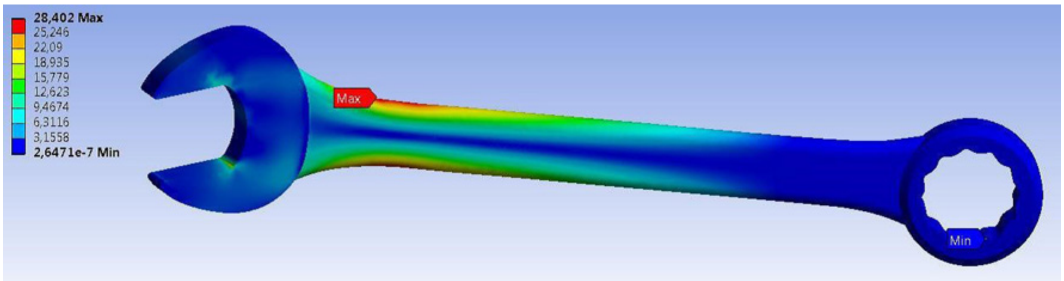

Fig. 8. Result of 1. Approach – Equivalent von-Mises stress

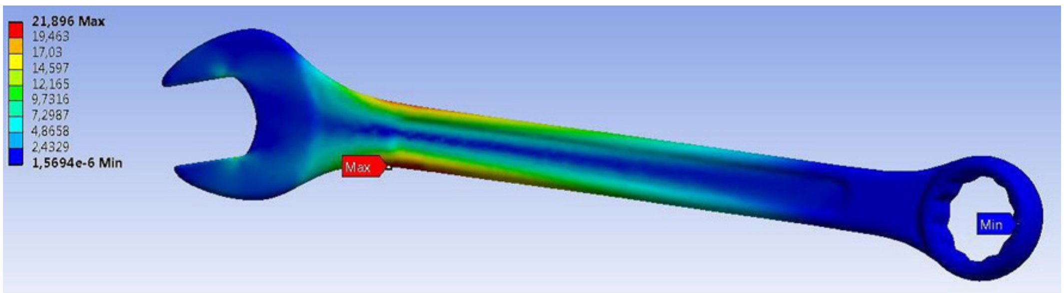

Fig. 9. Result of 2. Approach – Equivalent von Mises stress

the geometry of volume of the CAD model which is the first approach is a little different from the reference wrench because it is created by remodelling from the triangulated surface model. Therefore, it cannot be 100% same as the original triangular surface model. A complete comparison of the approaches would require the comparison with an experiment at which deformations would be measured on a loaded object [10–17].

CONCLUSIONS

The two different approaches were compared; the first one included the creation of the volume CAD model and the other one did not. The results of the FEM analysis are different but the 2nd approach may have better results because that geometry is almost an exact copy of the real reference wrench. The 1st approach has a little different geometry in compare to the original. This problem is looked at from the viewpoint of the FEM analysis, rather than classic reverse engineering. [5–8]. Classic reverse engineering needs to create the volume CAD model because it is used for other applications, not only for the the FEM analysis.

In terms of the FEM analysis, the 2nd approach is better because it does not require creating the volume CAD model. When the volume CAD model is needed, the 2nd approach is useless. However, in the situations where only the FEM analysis is needed, the 2nd approach is faster than the first one.

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