Influence of 3D Scanner Parameters On Accuracy Evaluation of Deformation of Vehicle Selected Elements

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Abstract. In recent years, the elements reconstruction based on existing physical objects, plays an increasingly important role in research and everyday life. With the advancement of modern industry, more and more often reverse engineering is used, including automotive industry, modeling and deformation techniques of objects. One of such example is the reconstruction of the geometry of motor vehicles using 3D scans. Damages of motor vehicles cause local changes in the shape of the product and their size and character is directly related to the occurred reaction. However, to assess the damage extent and qualify the object for further repair, it is necessary to thoroughly know the condition of the object after the damage to select the appropriate technology and repair method. This is the case for reverse engineering, and 3D scanning using structural light. The aim of the study was to evaluate the influence of the parameters of the 3D scanner on the accuracy of reconstructing the geometry of the selected vehicle element – the rear door of the Skoda Octavia in two variants, non-deformed and deformed. The dimensions of door exceeded the range of the largest measuring area of used 3D scanner, so it was necessary to use the photogrammetric technique in order to generate a point model of the object that was used to compose the individual scans. Parameters of 3D scanner has significant effect on obtained results – in case of scanning small objects by big measuring field, discontinuities and unscanned areas can occur. For large objects any measuring field can be used, but increased resolution do not increase accuracy every time, and results depends on environment conditions, object surface preparation and skills of operator.

1. INTRODUCTION

In nowadays production processes of the equipment and during the assessment of defects and deformation of technical objects, it is often necessary to reproduce damaged products. Damage and wear of objects causes local changes in the shape of the product and their size and nature is directly related to the impact resulting damage or wear. The initial state of an object can be determined from the production documentation or the measurement of new object. However, in order to assess the degree of wear, depth of damage and to select the appropriate repair methods and technology, a thorough knowledge of the condition of the object after the failure is necessary. This possibility provides reverse engineering [6, 8, 9].

The simplest reverse engineering technique is to make measurements using mechanical measuring tools and create a digital model based on these measurements. When the shape of an object is very complex, such measurements are insufficient to provide data for the model [3]. Other methods of surface mapping are required. Nowadays, more and more methods of optical scanning (white or blue structural light) and laser scanning [1, 2,5] are used. These methods are very precise, enabling accuracy to be less than 0.01 mm, depending on the scanning technique used.

Depending on the scanner, important parameters, among many others, are [4,6,7]: scanner resolution, scanner accuracy, scan volume, repeatability, scanner resistance to environmental conditions, scanning speed.

For large objects, whose dimensions exceed used measuring field more than three times, a photogrammetric technique is required to increase the accuracy of the process of combining individual scans into a single scan [3, 4].

2. AIM OF THE STUDY

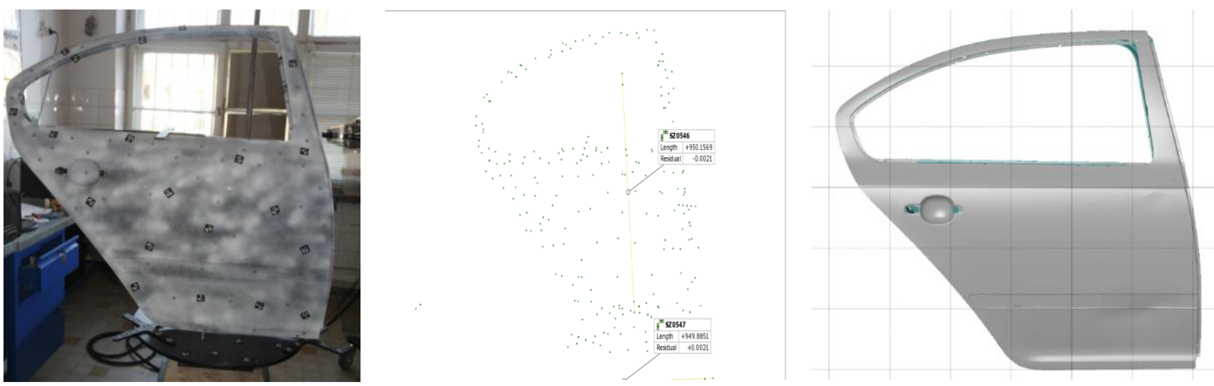
The aim of the study was to assess the influence of the 3D scanner's performance parameters on the accuracy of the selected vehicle element geometry – the rear door of the Skoda Octavia. The reconstruction of the door element with its dimensions far exceeded the range of average and smallest measuring field of used 3D scanner (fig. 1a), that's why it was necessary to use the photogrammetric technique in order to generate a point model of the object that was used to make the scans. Measurements were performed by three measuring areas: 1000x800x800 mm, 500x400x400 mm (as a base field) and 250x250x200 mm. The GOM GmbH ATOS IIe optical scanner was used during measurements.

2.1 Research program

The first problem was to determine the dependence between the individual parameters of the scanning process and to determine their influence on obtained results. For this purpose scanning of the object was carried out for various configuration of measuring equipment (field size, photogrammetric technique). The following elements were valuated:

- influence of measuring field size on a accuracy, field size: 1000x800x800 mm, 500x400x400 mm and 250x250x200 mm,
- repeatability of a measurements for a measuring field,
- influence of used photogrammetric technique.

Measurements were performed under the same conditions and by the same operator, each time after changing the lens of the scanning field, the device was calibrated.



(a) (b) (c)

FIGURE 1 Measured object: a) main view, b) geometry of uncoded reference points, c) reference models

2.2. Method of the results

To determine the appropriate tolerance limits, all obtained results were analyzed for the maximum difference between the results of the measurements and the model, and the optimum range of the data was chosen which includes the full spectrum of the differences. The accepted limit was 0.1 mm, then the range was divided as following: 0÷ 50%, 50÷100%, 100%÷150% and over 150% of differences accepted as a base. The results were presented >2,00 mm; 1,51 ÷ 2,00 mm; 1,01 ÷ 1,50 mm; 0, 51 ÷ 1,00 mm; 0,01 ÷ 0,50 mm; -0,50 ÷ 0 mm; -1,01 ÷ -0,50 mm; -1,51 ÷ -1,00 mm;-2,00 ÷ -1,50 mm and <-2,00 mm.

Tolerance is defined as the range of values in which differences in distance between the dimensions of the individual homologous points of the underlying model and the measurement compared. Area value is an absolute value that corresponds to the sum of the surfaces of the individual planes constituting the model of the object. The ratio of the surface area of a given range to the total area of the object is expressed in percent.

3. RESULTS

Fig. 2 presents the first case – influence of measuring field size on the accuracy of deformation assessment. The deviation map presents the measurement – each point is described in three dimensions (X, Y, Z), and the fourth value represents the deviation. The baseline model and the results obtained during the individual studies were compared

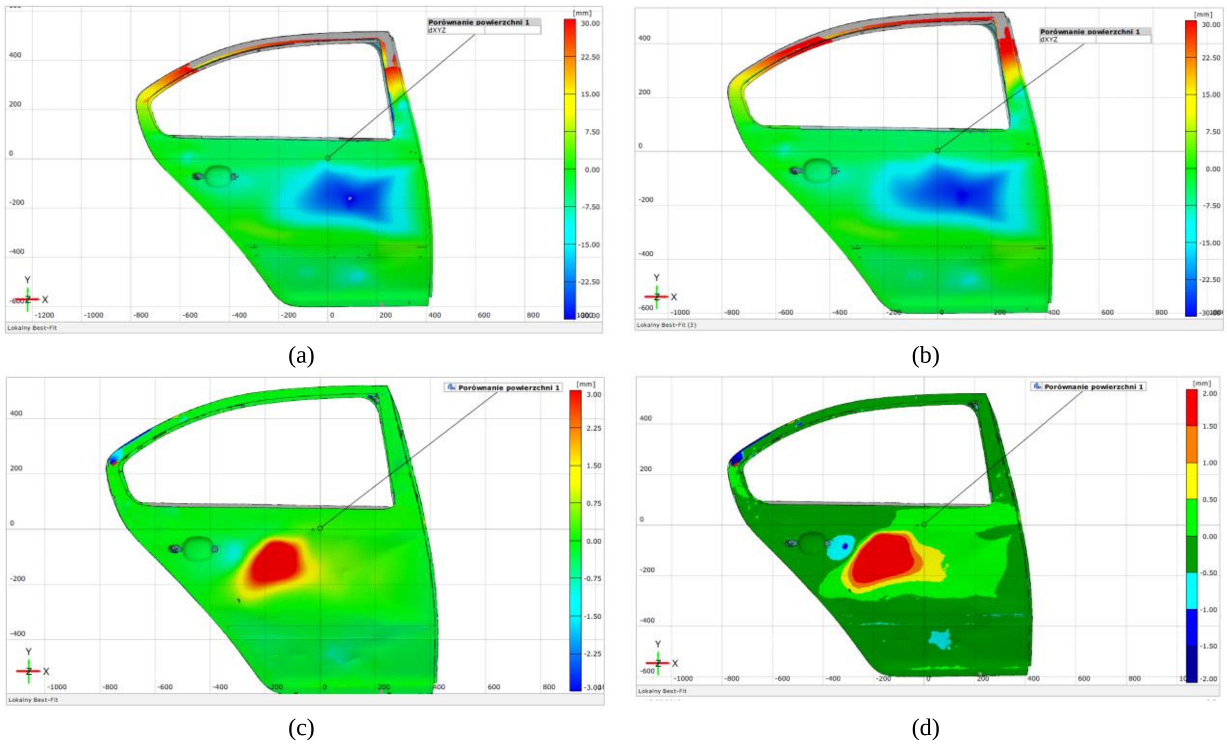


FIGURE 2 Deformation evaluation with 250 mm base field: a) measurements comparison with base model – 250 mm field, b) measurements comparison with base model – 1000 mm field, c) differences between 250 mm and 1000 mm field, d) differences between 250 mm and 1000 mm field – boundary sections

Based on the analysis of the obtained results, one can notice a considerable influence of the size of the measurement field on the assessment of deformation (Figures 2a and b). The comparison of deformation values was determined by means of field 250 and field 1000 (Fig. 2c, d.). it was found that the biggest differences in results occur in the middle part of the door (positive difference), while negative deviations occur mainly in the left corner of the object and on the upper door frame. Positive differences in dimensions occur mainly on the convex surfaces of the front of the door, which are remnants of the slats attached here, and in places with small radiuses of the outer plating. They are noticeable on the inside of the door on the lower part and on the frame. As for the comparison of the base model with the results obtained without the use of photogrammetric technique, with the same values of the scale and the comparison parameters of the results, there are considerably greater differences between the models.

4. CONCLUSIONS

- The studies and results demonstrate the full suitability of the ATOS IIe scanner for the geometry of vehicle components. However, the accuracy of the mapping images depends of the object's scanning techniques and scanner performance.
- For large objects, any available measuring area of the selected scanner can be used. The key issue is to determine the purpose of the measurement and to reach a compromise between the scanning time and the accuracy of the measurement.

- In case of small objects scan, the uses of large area measurement fields are associated with an increase in inaccuracy of scanned object. This may also cause difficulty in mapping the details of the test item.
- An important consideration in measuring accuracy, especially in high accuracy measuring fields, is the proper preparation of the object and proper fitting during measurements.

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