DIGITIZING LARGE-SCALED OBJECTS AND REVERSE ENGINEERING

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Abstract
The aim of this paper is describe the application procedure of a non contact laser scanning and preparation of an operating procedure to digitize a selected large-scaled object. Cooperation and communication of 3D data in real-time allows simultaneous activities and the participation of other departments of the organization in the design and technical preparation of production of the product, resulting in a significant reduction in the number of structural discrepancies (inaccuracies). Applying this procedure in practice allows for quick development of an offer matching with demands and needs of customers.

Keywords: *reverse engineering, 3D scanning, large-scaled objects, non contact laser scaning, 3D data*.

1 Introduction

Reverse engineering is a process when copies of an existing component, configuration or a product are made with no drawings, documentation or a computer-based model is available [2]. Parts of a reverse engineering are all activities enabling determination of a functional approach to a product or idea and technology that have originally been used in product development. It is applied to master the draft process, as a starting point for redesigning process so it is possible to monitor and to assess mechanisms enabling functionality of a product, to analyze and to study internal operations of a mechanical product and to compare existing solution with own ideas and to propose a solution [2].

Reverse engineering is taking apart an object to see how it works in order to duplicate or enhance the object. The practice, taken from older industries, is now frequently used on computer hardware and software. Software reverse engineering involves reversing a program's machine code (the string of 0s and 1s that are sent to the logic processor) back into the source code that it was written in, using program language statements.

Software reverse engineering is done to retrieve the source code of a program because the source code was lost, to study how the program performs certain operations, to improve the performance of a program, to fix a bug (correct an error in the program when the source code is not available), to identify malicious content in a program such as a virus or to adapt a program written for use with one microprocessor for use with another. Reverse engineering for the purpose of copying or duplicating programs may constitute a copyright violation. In some cases, the licensed use of software specifically prohibits reverse engineering

2 3D ZScaner 800 hand scanner

ZScaner 800 provides for optimized and easily integrable 3D software for digitalization enabling [4]:

- Managing the work easily,
- Visualization of a 3D model in real time,
- Algorithms for surface optimization,
- Compatibility with Microsoft Windows,
- Software integration through dynamic libraries
- export of files to standard formats.

A camera of high resolution increases an accuracy of scanning up to 40μm and able to record changes of the surface only greater than 50μm. Fully automated function independently sets a level of resolution depending on a type of a scanned surface and through pushing a key we can simply activate a mode with high resolution.

ZScanner is an autonomous moving 3D scanner, whereby no external fixation mechanisms are needed, so the system enables free movement of an object during scanning and an image of a scanned surface can be monitored in real time. If the hardware allows it, it enables obtaining data during an only scanning comparing with numerous discontinuous scanning, that shortens time needed for whole process of scanning.

3 Large-scaled object scanning procedure

The object selected to be digitized is two-engine general-purpose rotor wing with five blade main engine for civil and military application coded as Mi-17 for machines to be exported. The machine was produced till 80ss. In digitizing this object there is a need to create an exact model of this helicopter. The attention is focused on a model of a cockpit from outside as well as inside up to the load space. A digitized part has a diameter about 2,4m and a length of 3,8m. The position targets had been applied before scanning and the windows had been made non-transparent with a flatting spray. Then a picture of an object was taken to avoid an exchange of individual parts when assembling. The object was divided in 3 main groups: a cockpit from outside, a cockpit from inside and a partition wall between a crew and cargo. These three main groups were divided into 32 smaller parts.

Fig. 1 *Cockpit front side with position targets*

Fig. 2 *Cockpit inside*

An outer shape of a cockpit was scanned as the first aiming to avoid inaccuracies in assembling individual scanned surfaces. It was important to scan the orientation points properly into a scanned surface for this first surface in order to avoid a local shift of individual parts. A model of a cockpit framework from outside was created. Then this procedure was repeated on a cockpit from inside and on a partition cross wall. A wireframe model of a whole cockpit was compiled from individual partial models on which then the particular scanned parts were located. As a helicopter cockpit is riveted, individual rivets and their arrangement served as orientation points to arrange them into whole object.

4. Creation of a 3D model from scanned data

The Geomagic studio program was used to arrange individual scanned parts that provides for a complete set of instruments for each transformation of 3D scanned data in highly accurate surfaces, polygonal networks and genuine CAD models. The program enables arrangement of clouds of points or a polygonal network, connecting individual surfaces and generation of exact surfaces (patchworks). In Fig. 3 there is a display of a working environment of Geomagic studio with an arranged model of a helicopter. On a model we can see particular surfaces that were needed to arrange an object.

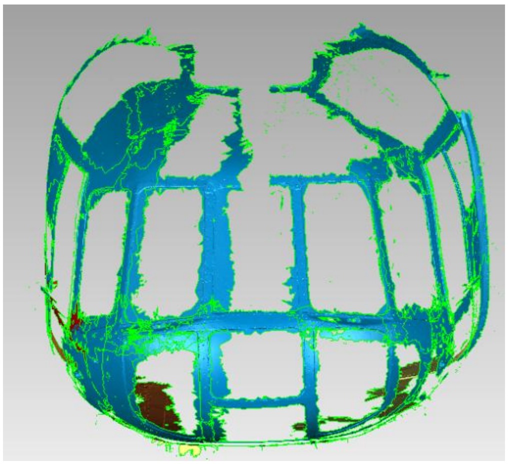

Fig. 3 *Working environment of the Geomagic studio program*

In the first step of arrangement we connected three basic parts and checked a position and overlapping of individual parts. After having arranged a framework of a model, then the next parts were arranged into sub-sets and they were placed into an initial outline model. The object was compiled from individual polygonal networks that needed some adjustments. A merging individual surfaces function was used to avoid duplicate surfaces on an object. After merging a suture order was used to seam up individual surfaces so a unique polygonal network was created. As such network contains more than 7 millions of polygons and a resulting set of data reaches more than 800 MB, this network was simplified. Through a large set of orders for a work with polygonal networks we managed to reduce a number of polygons to a half and to reach a size of a file below 320 MB.

A scanned model was compared with a group of points obtained through an independent measurement with a theodolite. A method of a contactless laser scanning and an accurate preparation of a working method enabled a formation of a helicopter model with a maximum variation of 2,84 mm. In Fig. 4 and Fig. 5 there are a display of a cockpit models from Geomagic studio. Cooperation and communication over 3D data in real time enables simultaneous activities and participation of other branches of the organization in drafting processes and in a technical preparation of a large-scaled product manufacturing, resulting in a significant decrease of design non-conformities (impreciseness's) and a time shift in their detection till initial phases of a product lifecycle.

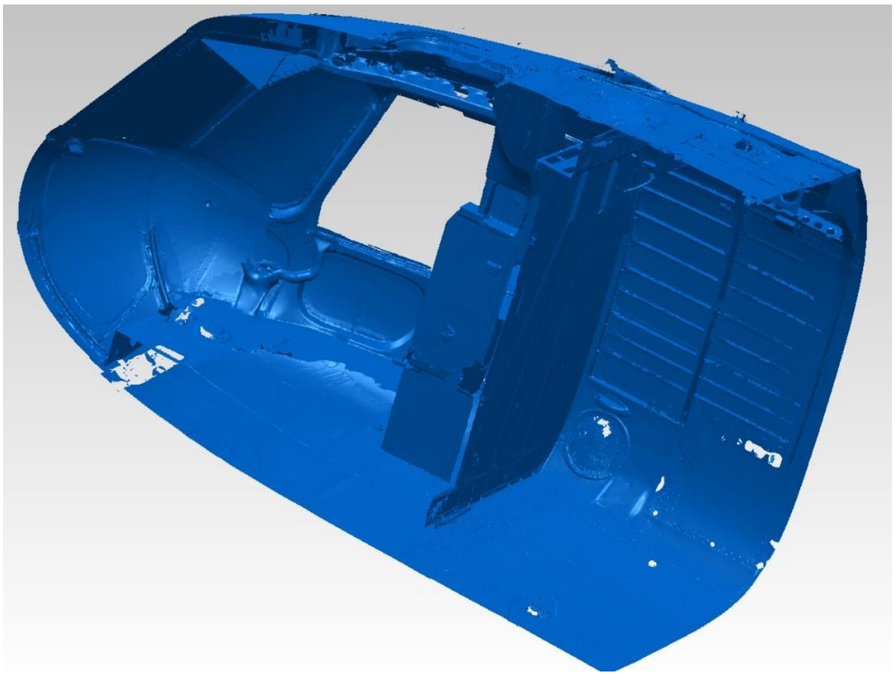

Fig. 4 *Cross section of cockpit – export data from Geomagic studio program*

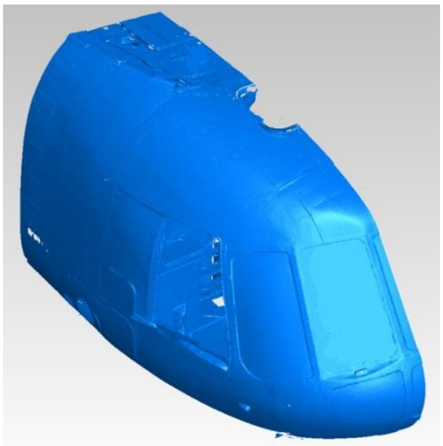

Fig. 5 *Left side view - export data from Geomagic studio program*

5. Conclusion

Application of 3D scanners in process of digitizing of large-scaled objects achieves at present time a high level from accuracy of data transfer point of view between real and virtual environments. In such a way a complex meeting of requirements for a transfer of real dimension characteristics of scanned components or models in their data forms is possible. Each point of a surface of a real component corresponds to a respective virtual point with precisely defined coordinates in 3D space, of any chosen coordinate system. In such a way we can exactly empirically describe a surface and a shape of any large-scaled object. A general result depends on a chosen method and digitizing procedures and general accuracy is dependent on sensitivity and accuracy of measuring device. The paper characterizes a methodology of scanning of large-scaled objects on a chosen example of two-engine general-purpose helicopter with five-blade main engine for civil and military application designated as Mi-17. This methodology was applied on other similar objects. The achieved results prove that a chosen type of a scanning device and a procedure of its application were appropriate for scanning of this large-scaled object that was proven also by achieved technical and economic indicators of the draft and a production of a damaged component of the object. The fact, that application of such procedures enables a fast development of an offer meeting the customers’ requirements is also important.

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