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SOME CONSIDERATIONS ABOUT 3D REPLICATION OF COMPLEX SURFACES

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Abstract: *In the present paper we propose the study of 3D replication of complex surfaces. We developed a study based on 3D Laser scanning of a mannequin head. The paper describes the entire process of 3D digitizing model to obtain 3D CAD model for implementation Rapid Tools. The process of obtaining virtual model is an integral part of Reverse Engineering technology. The hand-held system reviewed here is the VIUscan scanner, which is produced by Creaform; it's the one that makes the most sense from a practical point of view. The system ensures positional accuracy, even when the system is moved outside its range and its colour output is already of interest to many people at the school who deal with visualization and presentation in 3d formats.*
Key words: *complex shapes, 3D Laser scanning, Reverse Engineering, Rapid Tools, 3D CAD model.*

1. INTRODUCTION

Many technical fields require creating geometric models of existing objects that have no such model available [1]. This paper identifies the purpose and main areas of application of 3D CAD reproduction for objects with complex shapes. It also presents a technique for acquisition based on 3D laser scanning, the advantages and disadvantages of this method are highlighted. Reproduction is the virtual duplicate of an existing object, by acquiring the physical dimensions.

The purpose of RE technology - as is treated in this paper, is to successfully get a 3D CAD model of an object with complex geometry, where such a model does not exist.

2. MAIN PURPOSE AND FIELDS OF APPLICATION FOR VIRTUAL REPRODUCTION OF OBJECTS PRESENTING COMPLEX GEOMETRY

Using CAD models is the ideal method to build forms, features and functions of a real object. Data representations, which are arranged, form the basis for applications. The database is not accessed directly, but through algorithmic models available that allow improvement of complex functions, making them simple basic functions according to the algorithm defined.

There are various fields that require data on the geometry of real objects, in 2D or 3D, fields like: engineering(RE, RP, RT, quality control), medicine (plastic surgery and aesthetic medicine, orthopaedics and prosthetics, orthotics), architecture, conservation and inventory of historic buildings, archaeology, landscape architecture or other fields that would benefit from a 3D CAD model, with the advancement of 3D object surface acquisition techniques many fields started to implement 3D scanning. These data can be obtained through various procurements methods using various applications developed for this purpose.

Industrial production processes often involve obtaining plans and CAD models of a particular part or system. For example in the process of obtaining molds the need to achieve a certain part or subassembly associated with the mold [2].

The concept of virtual museum receives a great authenticity when it includes 3D replicas of real objects such as: sculptures, reliefs, artifacts, religious artifacts, furniture, paintings, frames or even the interior design of a the real museum. Now any museum in the world can make their collections accessible to millions of visitors through a virtual museum. Additionally museum may also attract public attention to the items owned by the museum, but are not exposed for reasons such as (lack of space, niche interest, low security, etc) [3].

Restoration involves building interiors or reproduction of architectural elements missing from the scene. This means obtaining 3D images of sculptures, architectural details, ornaments or fragments of plaster art furniture so that it can be reconstructed [4]

3D scanners can be used for digitizing 3D objects found during archaeological and palaeontology work, such as fragments of pottery or bones. Digitizing objects can be stored in databases accessible for scientific research in this fields [5].

3. CASE STUDY

In this paper, reverse engineering techniques are presented to acquire the complex surfaces for the head of a mannequin.

Because the mannequin head didn't had any technical information, it was necessary to acquire the size and shape in order to be able to advance to further operations regarding the mold. Also using the 3D model different simulations can be applied to find the optimal execution choice, and the optimal composite materials.

3.1 Presenting the 3D Scanning System

The 3D model for the mannequin head was obtained using laser scanning method. The 3D scanner used for this is the VIUscan (Figure 1), This scanner was acquired by the laboratory of Measurements and Reverse Engineering in the Department of Engineering Design and Robotics, from the Technical University of Cluj-Napoca.

The VIUscan scanner is produced by Creaform, located in Quebec, Canada. The system is laser based, which allows it to capture very high detailed surfaces. It also has 2 colour video cameras which captures colour information.

Fig. 1. VIUscan handheld 3D scanner [6]

The colour information is mapped to the geometry, producing 3D colour models. While we don't currently have 3D colour prototyping, colour information would be of immediate use to any field dealing with visualization or presentation (i.e. video, animation, engineering, web design, museum archiving etc.).

3.2 Phase 1 – Apply Coded Targets

The system requires that reflective dots that are placed on the subject, roughly 10-12 centimetres apart. This grid of dots allows the scanner to locate its current position relative to the object. In situations where dots can not be placed on the surface, special netting made of dots can be draped over the subject instead.

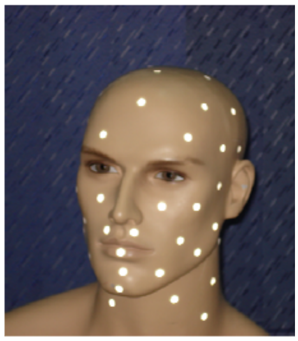

Fig. 2. Apply coded targets.

3.3 Phase 2 – Photo-grammetry Pictures

The grid of target frames allow the recording, interpretation and representation measurement of the object based on it is image. This allows the system to determine the position (location) in plane of the object and the 3D representation of it. This procedure is usually done through a software component instrument, in this case VXelements.

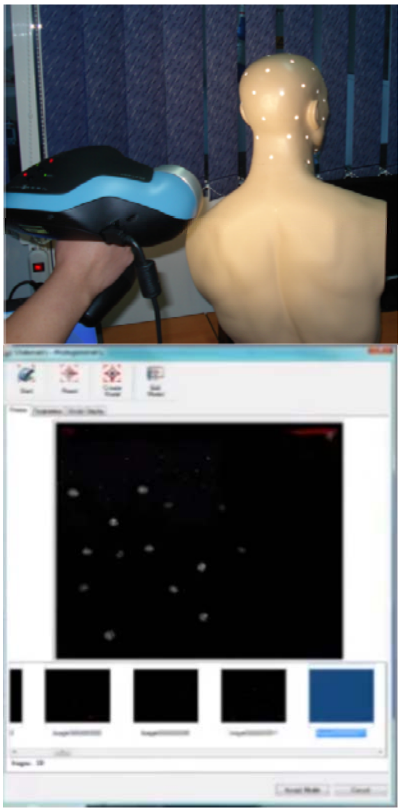

Fig. 3.. Photogrammetry pictures.

3.3 Phase 3 – Calculation and final 3D model of positioning targets

The process of combining the results of different positions photograms.

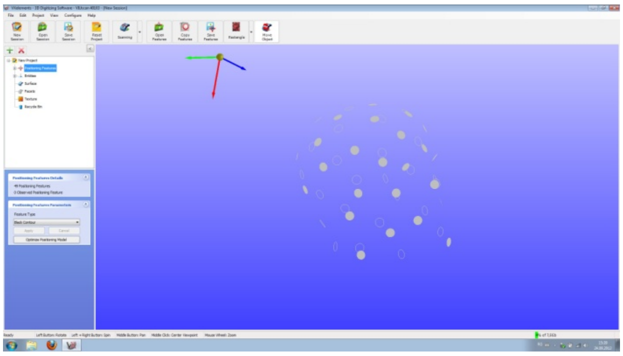

Fig. 4.. Final 3D model of the positioning targets.

3.4 Phase 4 – Laser calibration system

This operation is achieved by the auto adjusting function in the software VXelements. Adjusting the power and exposure time of the laser reflectivity is performed according to the surface / object that is being scanned. For the mannequin head the optimal values are: laser power: 65% and exposure time is 2 microseconds.

3.5 Phase 5 – Scan using the photo-grammetry positioning model

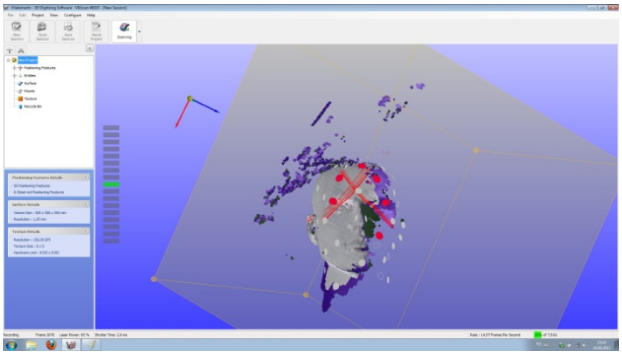

Fig. 5.. Scan using the photo-grammetry positioning model.

The 3D scanning is conducted on the principle of triangulation, which is a method that uses laser triangulation sensors. The name is suggested by the fact that the laser beam emitted and reflected along with the base beam (distance between the CCD camera and the laser emitter) form a triangle.

This principle is applied to study the solution with two cameras (Figure 6). Here the laser beam is emitted in the form of a cross instrument and is reflected from the surface of the mannequin for the two collector lens located on the scanner to a known distance. The lens focuses the image reflected by the laser spot, this is detected and collected with CCD cameras (Charged Coupled Devices).

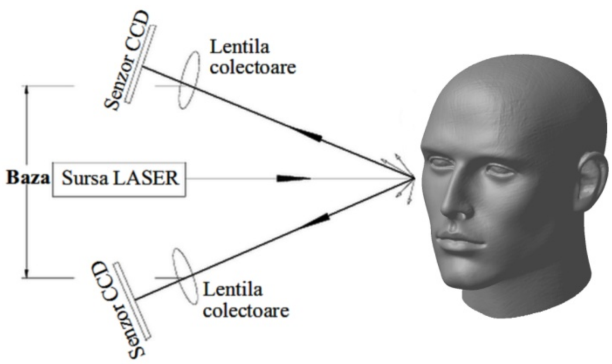

Fig. 6.. Triangulation principle used by the scanner VIUscan

3.6 Phase 6 – Registration

Registration is the process of combining the results from different positions of the laser scanner or transforms these results into a common coordinate system (Fig. 7). This enables the transformation of two or more data sets into one without using sight targets. The condition of making such arrangements for registration is that data sets resulting from the scan have overlapping areas.

Unlike other scanning systems, VIUscan doesn't scan information in the form of a cloud of points (which then has to be processed using meshing techniques which is a very time consuming operation), but rather uses it's own technical system that converts the surface as the models is being scanned.

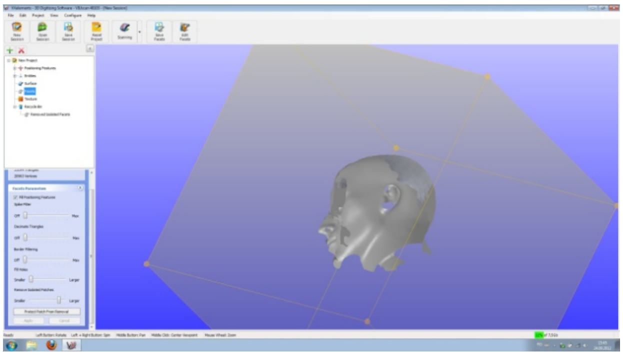

Fig. 7.. Registration for the scanned surface

3.7 Phase 7 – Post-processing

The determination of the scanned surface was numerically defined using different modules of the CATIA V5R21 software. The surface taken into account is the outer surface of the mannequin, this 3D model was imported as a *.STL file in CATIA (Fig. 8).

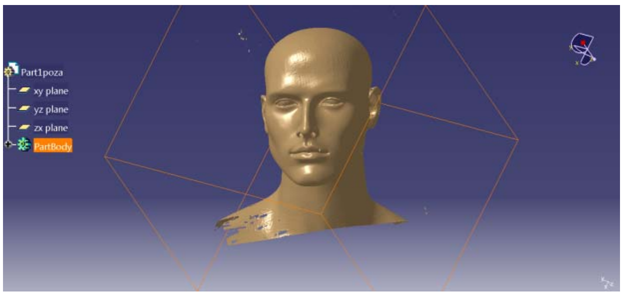

Fig. 8. Imported *.STL in CATIA

The STL (Stereolithography) is a triangular representation of 3D geometric surfaces. The surface is divided into a set of oriented triangles (facets). Each facet is described by the surface normal direction and three points representing triangle tops. The *.STL file format only describes the 3D object geometry, there are no other information such as, colour, texture or other CAD models attributes.

CATIA V5R21 has modules dedicated to post processing point clouds or imported surfaces into 3D polygonal networks (meshes), which can be used in design, analysis and manufacturing.

CATIA can process large data sets, taken from different types of scanners, offers the possibilities to optimize the scanned data (the elimination of anomalous noise disturbing points, etc..). The alignment of multiple sets of data points can be easily archived. Other features are: generating polygonal networks, modify the meshes, editing and cleaning network error, repair and sharpening edges, and export different 3D model formats.

CATIA offers a number of surface modelling tools to create simple or complex 3D surface models, Different models of the mannequin head were created using surface modelling techniques from the *„Digitized Shape Editor"*, the models created here have no thickness or mass properties.

In *„Digitized Shape Editor"* the 3D model that was generated by the VIUscan is imported as a *.STL file format. Maintain the integrity of the scanned area is very important (in the import dialog the sampling and scale factor parameters should be set to 100% for the sampling and 1 for the scale factor). In the dialog box, by activating the *„Statistics"* dialog box, CATIA provides information about the imported surfaces (in this case the number of triangulation is 865456 and the number of points is 437590. (Fig. 9).

Next step is the filtering operations and disposal of isolated surfaces (Fig. 10) Isolated surfaces are surfaces captured outside the scan form. This step is done using the *„remove"* tool; this offers different possibility of selection shapes in order to capture the isolated surfaces.

After the scanned surface was cleaned in *„Digitized Shape Editor"*, the surface is discretized in the *„Quick Surface Reconstruction"* module. The *„Automatic*

Surface" (Fig. 11) tool is used on the cleaned surface.

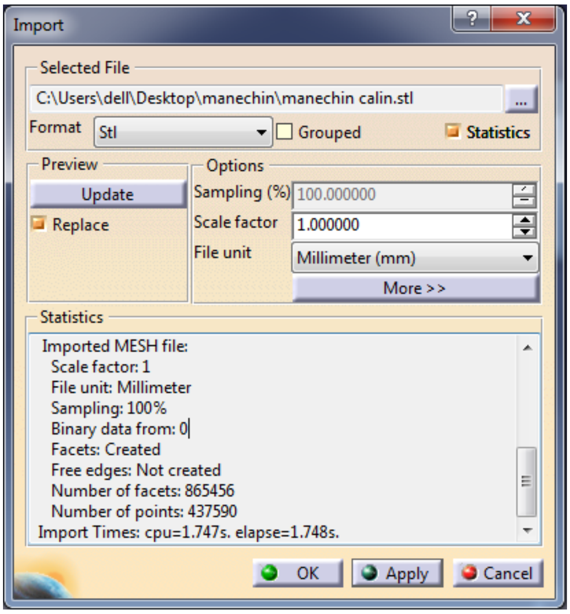

Fig. 9. Statistics regarding the imported surface

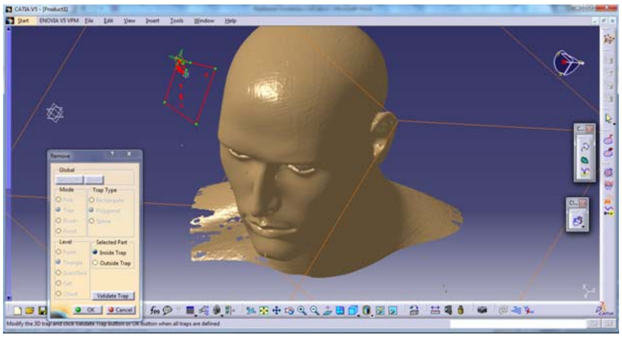

Fig. 10. Removing the isolated surfaces

This step is necessary to bring the surface into a specific surface format used by CATIA, in order to have access to further operations such as finite element analysis. Complete processing of data containing a high amount of points to define complex geometry surfaces, requires the development of powerful algorithms to achieve correct triangulation.

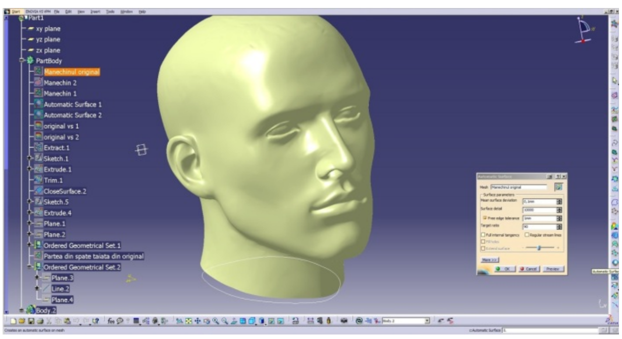

Fig. 11. Converting the cleaned surface into CATIA specific surface format

Optimal parameters for achieving a good CATIA surface are in this case: the surface deviation: 0.1 mm, the surface details: 10000, if a lower value is entered for details, the surfaces will have different meshing errors in complex areas such as the mannequin ears, those areas need a high about of triangulations in order to maintain the shape without having deviations occur on the CATIA surface (Figure 12)

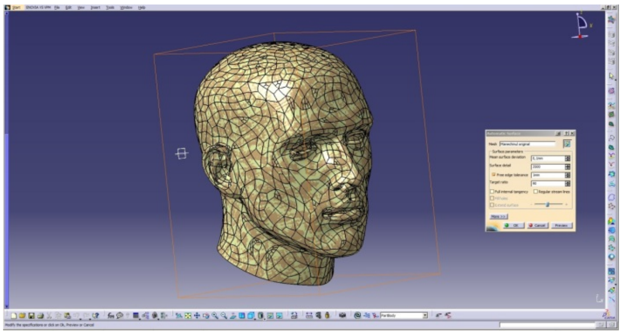

Fig. 12. Adjusting the parameters for discretization

With the resulting mesh surface (Fig. 13), CATIA can provide finite element analysis of the active surface of the mold.

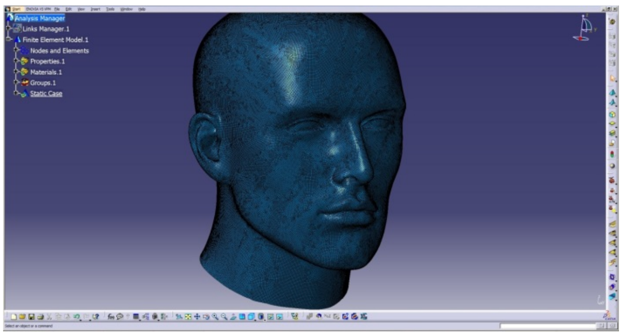

Fig. 13.. Final 3D discretization mesh

4. CONCLUSION

3D scanning industry is considered by many to be far from it is maturity, it doubles every year. In industry, the acquisition of 3D shapes used in reverse engineering, which enables the creation of a numerical model of an object in order to create prototype or manufacturing tools (export collected data to the CAD).

If the object has many hidden areas, sharp angles, black surfaces or height differences on a relatively small area, the scanning process will take longer to achieve.

This paper presents a RE technique applied to a mannequin head with a special geometry, highlighting the multiple advantages compared to traditional CAD design :

a. *The speed*, given the tendency to obtain products free-form compared to CAD-CAM design, which becomes more difficult in these conditions;

b. *Reduced implementation time of a product or a 3D model in digital form*, followed by remodelling ,prototyping or rapid manufacturing;

c. *The technical is accessible* in terms of cost;

d. *Speed up the verification and control prototype*; methods like (measuring calliper, micrometre, etc..), require the object to be measured and redesigned into a CAD program;

e. *data obtained by scanning can be translated to multiple file formats,* such as *.DXF, *.OBJ, *.3D Studio Max, *.IGES, *.ASCII, *.STL, etc.;

f. *determine the precise geometric model deviations using the master 3D models*; this allows detecting errors in the manufacturing process;

g. *regular inspection* of parts to analyse how close they are to the original product;

h. *having a high speed to access and continuously improve the digital information*;

i. *design environment is much more intuitive than other standard CAD system*.

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CÂTEVA CONSIDERAȚII PRIVIND REPRODUCEREA 3D A SUPRAFEȚELOR COMPLEXE

În lucrarea de față ne propunem studiul reproducerii 3D a suprafetelor complexe. Am dezvoltat un studiu bazat pe scanarea laser 3D a unui cap de manechin. Lucrarea descrie întregul proces de digitizare 3D pentru a obține modelul 3D CAD pentru realizarea de scule rapide. Procesul de obținere a modelului virtual este o parte integrantă a tehnologiei Reverse Engineering. Sistemul de scanare, VIUscan care este produs de firma Creaform, este cel mai pretabil din punct de vedere practic. Sistemul asigură o precizie de poziționare, chiar şi atunci când sistemul este mutat în afara domeniului său de acțiune, iar redarea culorii este deja de interes major pentru mulți oameni din domeniul educațional care se ocupă cu vizualizarea şi prezentarea în format 3D.

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