Basic Technologies and Models for Implementation of Industry 4.0

Karabegović, Isak

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3D Scanning in Industry 4.0

Adis J. Muminović[*1], Jasmin Smajić[2], Isad Šarić[1], Nedim Pervan[1]

Abstract: *Modern technologies are essential parts of Industry 4.0. From automation, robotics, digitalization and additive manufacturing (3D printing) up to 3D scanning and reverse engineering. 3D scanning has a wide range of usage in today product development and design processes. This paper will present several real case studies of 3D scanning in reverse engineering andnew product development and design processes. Paper explores importance of 3D scanning technology, as integral part of Industry 4.0. Seven case studies are explored in more detail. Five of these case studies are realized in Laboratory for Product development and design at University of Sarajevo – Faculty of mechanical engineering as a part of the projects realized in cooperation with several companies from Bosnia and Herzegovina, while two of them are realized in Protodevs company in Sarajevo. Artec Eva 3D scanner and Artec Studio software were used for most of the presented case studies.*

Keywords: *Industry 4.0,3D scanning, product development, reverse engineering*

1. Introduction

Through the history of industry and manufacturing there were several periods in which important changes happens. These changes are used to divide industry in several periods. These periods are called Industry 1.0, 2.0, 3.0 and 4.0 [1]. Today, manufacturing plants are mostly in the period of Industry 4.0 which is characterized by robotization, automation, digitalization and rapid manufacturing. In addition, Industry 5.0 is already started to take shape. Main characteristic of Industry 5.0 is digitalization of whole product development and design process and manufacturing process [2]. Development and design process is one of the most important parts of every industry period. This process is changed and adopted according to the demands and needs through history. The first technology which completely changed development and design process is technology of Computer Aided Design (CAD) [3]. Through development of modern CAD software packages in the early 1990s, designers and engineers had an opportunity to make real visuals of their ideas using computer software. Today, this software is developed up to the range where classical CAD software

[*1] University of Sarajevo - Faculty of Mechanical Engineering, Vilsonovosetaliste no.9, 71 000 Sarajevo, Bosnia and Herzegovina
[2]Protodevs Sarajevo, Vilsonovosetaliste no.9, 71 000 Sarajevo, Bosnia and Herzegovina
E-mail: adis.muminovic@mef.unsa.ba

like CATIA, SolidWorks, Inventor, etc., are divided from the software for design like 3Ds Max, Maya, etc. In addition, new modelling principles called Building Information Modelling (BIM) becomes most important parameter for integration of Industry 5.0. In comparison to CAD modelling which is focused on design, shape and materials, main focus of BIM is theinformation, which can be easily programed, automated and digitalized.
Two new technologies which currently have the biggest impact on product development and design process are additive manufacturing [4] and 3D scanning [5]. More details about how additive manufacturing influences product development and design process and Industry 4.0 in general can be found in paper [6]. The focus here is on 3D scanning and reverse engineering with special focus of presented case studies which are real industry examples realized through university cooperation with several companies from Bosnia and Herzegovina.

2. 3D Scanning in Industry 4.0.

3D scanning is not a new technology as people usually think. It exists more than 30 years but it was not used as much in industry up to the last five to ten years. Mostly due to the low quality and high price of the devices (3D scanners). Today it is used across a lot of disciplines and science fields. From digital character development for video games and movies up to mechanical engineering, archaeological science, cultural heritage preservation and digitalization. In the contest of Industry 4.0, 3D scanning is used in the fields of product development and design, industrial design, manufacturing quality control, stress and displacement analysis and movement (dynamics) analysis. There are several papers about potential of 3D scanning in industry 4.0 [7-9].

2.1. Product development and design

Product development and design is the main field where 3D scanning have the biggest influence and usage [10-12]. It is mostly used for reverse engineering processes of concept design made from clay or some other materials and for digitalization of old products which does not have technical documentation or 3D models.

In the next part of the paper several examples of product development and design case studies using 3D scanning are presented. These examples are selected examples which are realized in Bosnia and Herzegovina thought University of Sarajevo – Faculty of Mechanical Engineering cooperation with several companies from Bosnia and Herzegovina.

- **Shoe silicon protection**

This is an example where 3D scanning was used in the development of shoe silicon protection product. Goal of the product is to protect the shoes during usage. To develop protection which will ideally fit the shoes and which will not deform during waking, 3D scanning is used to make a digital representation of the shoe in its deformed shape (Figure 1). Using digital data of deformed shoe, silicon protection was designed in its deformed shape. After the application, protection will stretch and ideally fit the shape of the shoe. In addition, it will deform during walking to fit the shape of the shoe in all stages of walking. This project was realized in cooperation with the company Solvio doo from Bosnia and Herzegovina and it was realized for client from United states of America (USA).

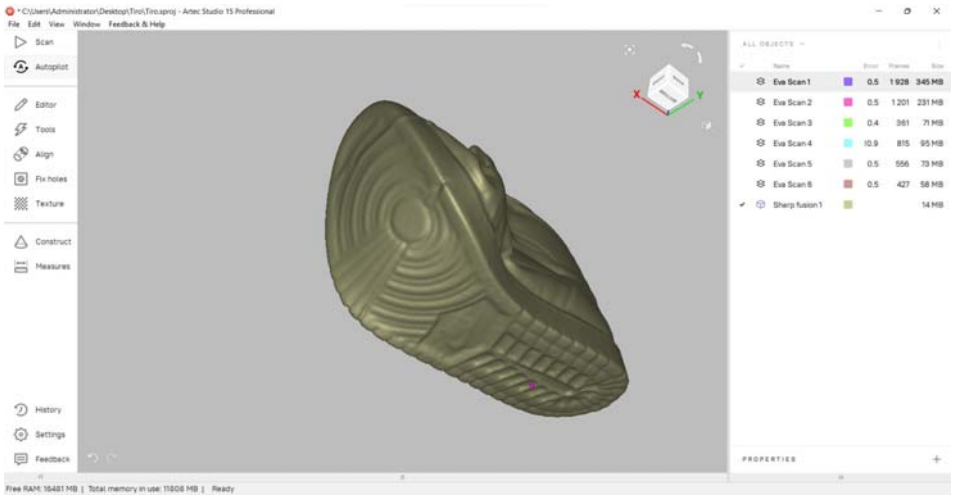


Figure 1. 3D scanned shoe

- **3D scanning in furniture industry in Bosnia and Herzegovina.**

Furniture industry is the field where 3D scanning has a lot of applications [13]. First example is the case where 3D scanning is used for digitalization of initial concept designs which is created by industrial designers, product designers or architects. First initial concepts designs are created by hand. This hand created products are than 3D scanned with the goal to create STL 3D model (point cloud) and then to create CAD (Computer Aided Design) 3D models ready for manufacturing. Figure 2 shows example of 3D scanning of a lounge chair which is created by product designer. Product designer created initial design digitally using computer software, whereas mechanical engineers used that digital design to manufacture first real example of the lounge chair. After manufacturing,

designer was not satisfied with the shape and look of the chair so he used hand tools for grinding and polishing to create new modified design. The new design did not match with already created CAD models so manufacturing of more chairs was not possible. It was necessary to 3D scan the new design and to use 3D scanned models to create new CAD models ready for manufacturing.

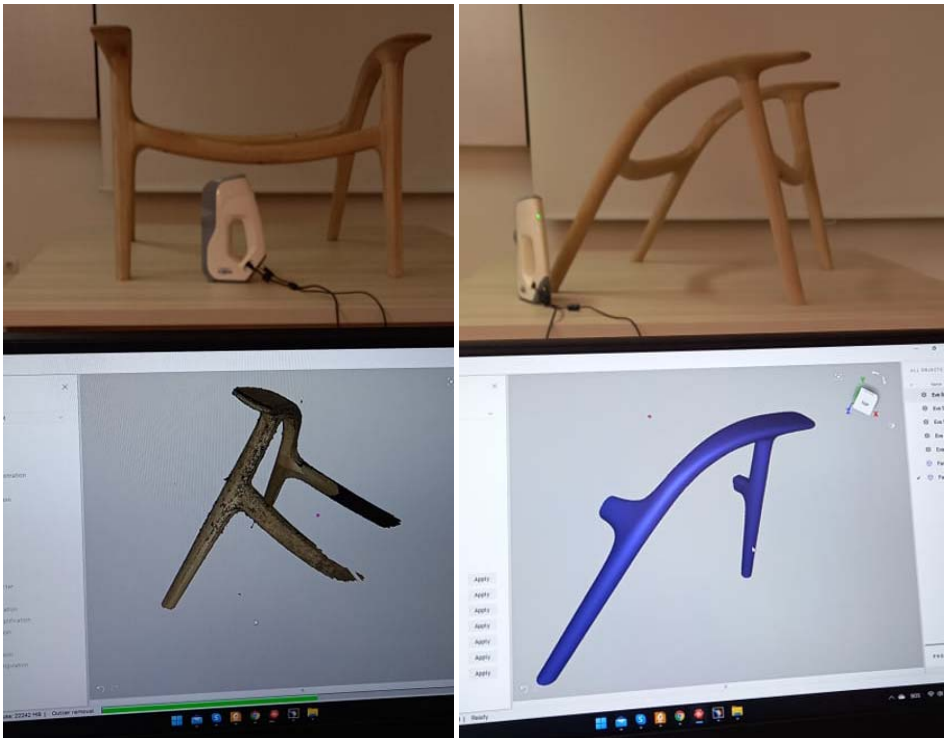


Figure 2. 3D scanning of lounge chair

Figure 3 shows final shape of the lounge chair after manufacturing. This project was done in cooperation with the company Aptha Corporation from Bosnia and Herzegovina. Designer of the chair is Stefano Bigi from Italy and chair is manufactured in Bosnia and Herzegovina.

Second example of 3D scanning in furniture industry is the case study where it was needed to create 3D CAD model of already manufactured parts of the chair. Client sent already manufactured parts, without any technical documentation and ask for massive reproduction of the same part.In this case, it is the frame of the chair which needs to be manufactured using welded pipes (Figure 4). This project was done in cooperation with Standard Furniture company from Bosnia and Herzegovina. Similar example is presented in Figure 5.

Figure 3. Final shape of lounge chair [7]

In this case it was also necessary to reproduce already manufactured part which was send by the client without any technical documentation. To be able to reproduce the same part, first step was to 3D scan initial part and to create 3D CAD models. Created CAD models were then used for tool die manufacturing using robot. After that, manufactured tool die was used to reproduce the same part massively. Whole process of reverse engineeringis presented on Figure 5. This project was realized in cooperation with the company Wood Team doo from Bosnia and Herzegovina.

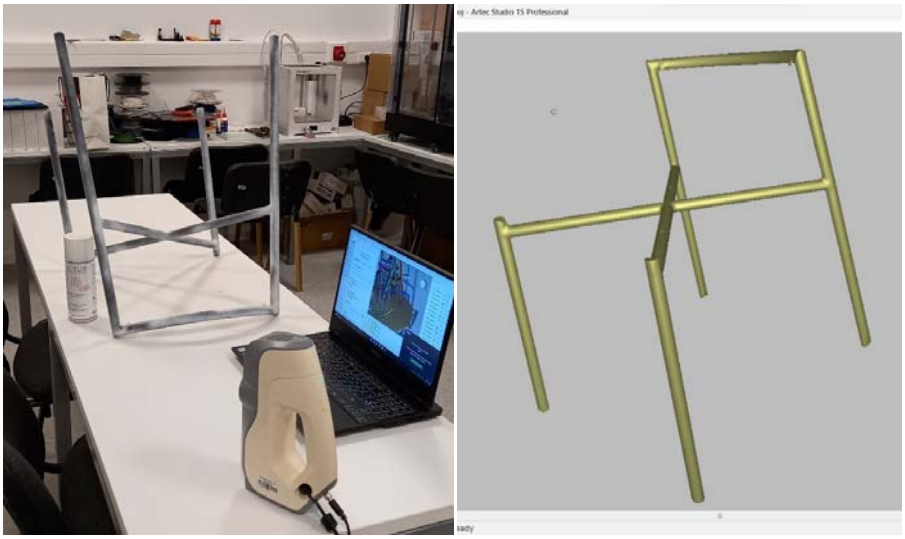
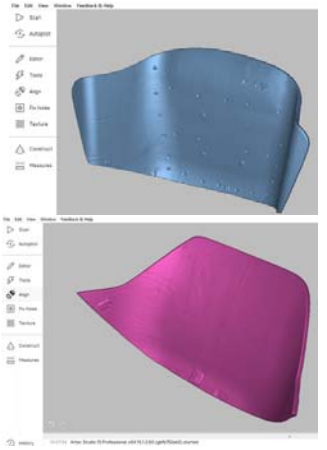


Figure 4. 3D scanning of chair frame

Initial manufactured parts.

3D SCANNING

3D scanned STL models (Artec Eva 3D scanner and Artec Studio software).



CAD 3D models SolidWorks software.

Tool die manufacturing using created CAD models: manufacturing using robot (left), manufactured tool die (right.)

Reproduction of the same part: new part (left), initial part (right).

Figure 5. Process of reverse engineering of chair parts

The fourth example is the case where it was needed to develop and design a new park bench using old design from Austo-Hungarian old style (Figure 6). Old bench part was 3D scanned. Scanned data are then used to design a new bench without back support. CAD models are developed using 3D scanned data

asreferences. These CAD models are adjusted for casting in sand. To create a mold for casting, these CAD models are manufactured using additive manufacturing (3D printing). This case study is a great example how additive manufacturing (3D printing) and reverse engineering (with 3D scanning) can significantly influence and modernize old manufacturing process like sand casting.

Figure 6. Park bench after 3D scanning, 3D printing and send casting

- **3D scanning in automotive industry**

Automotive industry is the field where 3D scanning is used the most, from new products development to quality control of manufactured parts. Following case study was a 3D scan of motorbike frame. It was necessary to create digital 3D model of manufactured bike frame for the purpose of next steps of the project, where it will be necessary to design other bike parts which needs to fit to the frame. Using digital 3D scanned model it is possible to create other external plastic parts and to connect it to the frame perfectly.This project was realized in cooperation with one company from Bosnia and Herzegovina. Name of the company cannot be mentioned here because of confidential agreement. 3D scanned bike frame is shown on Figure 7. This example shows that 3D scanning

is especially great tool for digitalization of complex shapes and forms. Manual development of 3D CAD model of this complex shape will be time consuming and very expensive. Using 3D scanning, 3D model (STL format) is created easily and fast. This type of 3D models in STL formats can be used only as reference geometry 3D models.

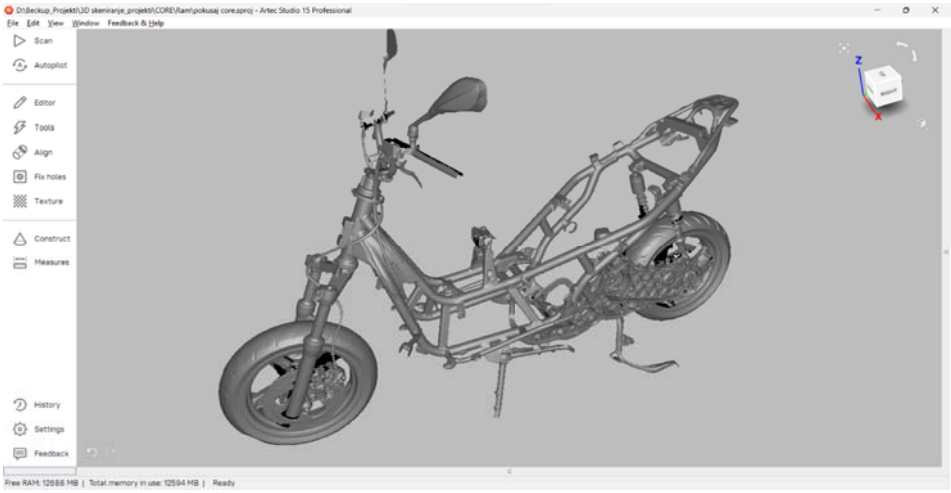


Figure 7. 3D scanned bike frame

- **3D scanning in maintenance industry**

3D scanning and reverse engineering is a great tool for maintenance industry, especially in the cases when broken parts of old machines need to be manufactured and when there isn't any technical documentation. 3D scanning can be used for digitalization of old parts. Scanned data are then used for reverse engineering with the goal to create CAD models ready for manufacturing.Figure 8 shows example of broken metal ventilator blades from old machine. Client needed a new ventilator blade but he didn't have any technical documentation of the part. In the first step, old broken ventilator is 3D scanned, and after that CAD model is developed using 3D scanned data. Developed CAD 3D model can be used for future manufacturing purposes.

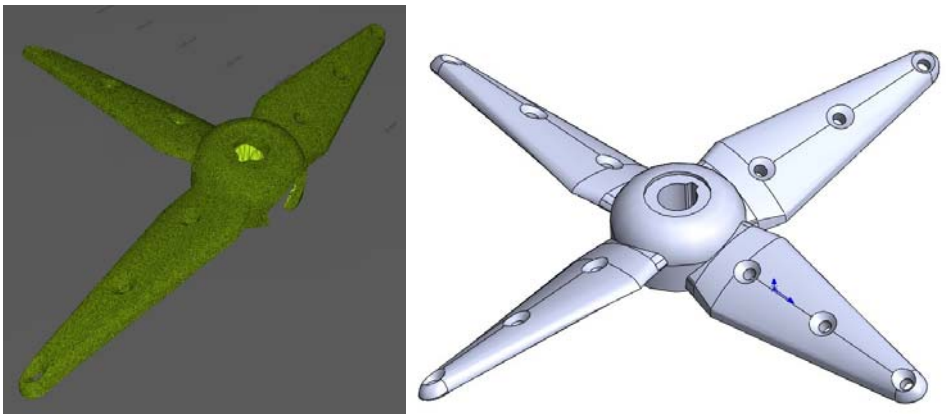


Figure 8. 3D scanned old ventilator blades (left), CAD model (right)

3. Conclusion

From above presented case studies it can be concluded that 3D scanning and reverse engineering has become integral part of today industry. It is used in almost all aspect of development, design, manufacturing and quality control. In the case of Bosnia and Herzegovina it is used a lot in furniture industry, especially for reverse engineering and new product development and design. In addition, in the case of park bench it can be seen how reverse engineering together with 3D scanning and 3D printing can bring significant improvement to old manufacturing processes like sand casting. Using 3D scanning and 3D printing, sand casting can be improved, modernized and digitalized. Manufacturing of initial first part for mold preparation is significantly cheaper and easier to make using 3D printing in comparison to the old hand manufacturing by skilled workers from wood material (in most of the cases).
In addition, from above presented case studies it is clear that knowledge about 3D scanning, reverse engineering and additive manufacturing (3D printing)has become one of the most important skills for today's engineers and designers.

ACKNOWLEDGEMENTS
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