ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering

Tome XII [2014] – Fascicule 1 [February]
ISSN: 1584-2665 [print]; ISSN: 1584-2673 [online]
a free-access multidisciplinary publication
of the Faculty of Engineering Hunedoara

1. Michal WIECZOROWSKI, 2. Bartosz GAPINSKI, 3. Miroslaw GRZELKA,
4. Lidia MARCINIAK-PODSADNA, 5. Robert KOTERAS

ROBOTISATION OF MEASUREMENT ON OPTICAL COORDINATE SCANNER

1-4. Poznan University of Technology, Institute of Mechanical Technology
Division of Metrology and Measurement Systems, Piotrowo 3 st, PL-60965, Poznan, POLAND
5. Volkswagen Poznan Sp. z o.o., Warszawska 349 st, PL-61060, Poznan, POLAND

Abstract: The aim of this paper is to present the use of robotisation in automation of measurements on optical 3D scanners. It allows reducing costs by shortening time of measurement execution. Data which describe the shape of measured surface allow for their subsequent use in analysis of manufactured parts quality. Automation of the measurement process using an industrial robot eliminates random errors made by serving staff. As a result of locating individual measurement data with reference points rather than on the basis of relative position of scanner and measured object, the method of measurement is not sensitive to errors of manipulator positioning.
Keywords: optical 3D scanner, robotisation, optimization, coordinate measuring technique

1. INTRODUCTION

Efficient quality control process is essential for the proper functioning of any modern manufacturing enterprise. One of the R&D activity in this area is to eliminate unreliable human factor [1]. Optical 3D scanners became a modern branch of the coordinate measuring technique that is being constantly developed [2,3,4]. These devices operate on the basis of various methods of non-contact digitalization of the measured object. They are widely used in quality control analysis of part geometry and form deviation as well as in reverse engineering [5]. In substantial majority of cases optical scanners are the devices that need to be operated directly. Thus, manual execution of measurement involves the problem of committing additional error introduced by human.

2. THEORETICAL BASIS

This measuring system consists of a measuring 3D scanner which is supported by a dedicated computer and advanced software to process measurement data, its analysis and reporting. The measurement is based on the triangulation principle [6, 7], as the scanner head consists of a projector and two cameras. The projector projects a structured light onto the object while cameras record sequences of fringes. That allows to obtain the image from which software calculates the 3D coordinates of each pixel. Depending on the measurement conditions, and the resolution of cameras CCD matrix more or less numerous clouds of points are obtained. Only occasionally the data obtained during one projection is sufficient to evaluate the measured object.

Therefore, it is necessary to make consecutive measurements in order to achieve sufficient information about geometry of an object. In order to stitch the results of measurements (point cloud) of each projection into one coordinate system, markers placed on the object or its surrounding are used. Relative positions of the markers, which are applied as reference points, can determine the relative position of each scanned fragments.

Once data collection is accomplished, proccesing of the point cloud is conducted. This processing allow to possess proper form of data in respect to the measurement task. Measurement report may show the values of individual features or color map of deviations in relation to the nominal. When measurement and analysis are planned appropriately, as well individual workpiece as supervision of the whole production process might be conducted [8, 9, 10].

3. CONCEPT OF AUTOMATION OF OPTICAL MEASUREMENT

Measurements using optical scanners typically require manual operation. In the standard system the operator changes related position of both a scanner and a measurement object, as well as changes measurement parameters, and data analysis. In the case of partial automation the measurement can be conducted using measurement macros to analyze data automatically. Some extension of the measuring functions can be extended by introducing a rotary. This allows to automate setting motions of the scanner. All of these solutions, however, do not provide full automation of the measurement process.

In order to automate the process of measurement on the optical 3D scanner, a solution that uses an industrial robot was developed. During the conceptual work, a plan to implement robotized station for investigations in full automated mode has been made for the purpose of the highest measurement results repeatability. The idea was to develop a universal station to be used in many branches of many industries. Both the conceptual and implementation works were carried out on the basis of the available space in the research laboratory. It was necessary also to develop technical solutions to ensure safe operation of the robot in its working area. The measuring cell with access control system were constructed. Such a project in industrial environments has several advantages - allows to:

- reduce the cost of development of technical documentation.
- reduce the cost of components starting thanks to the experience of maintenance services workers.
- reduce the cost of specialized training.
- opportunity of using spare parts from different devices of the same type available in the company.

At the conceptual stage it was found that for proper and effective realization of the measurement task system with 7 axis will be used. 6 axis of the robot, and a table with one axis of rotation. This solution enables the study of spatial objects of considerable size. Single parts, produced for example by stamping sheet metal, can be tested by scanning the surface on one side. However, in real life we need to scann a part on each side. When installing a complex object on the rotary table the access to many surfaces can be achieved, as long as they are not obscured by a handler configurations. The concept of the 7 axis set reduces the time required to change the position of the measured part and allows full automation of the measurement process.

On the basis of developed concept, the research station that consist of the six axis industrial robot KUKA and optical 3D scanner ATOS II GOM was constructed (Fig.1).

Installation of the measuring device was not only limited to setting the robot with the scanner. It was also necessary to develop additional components that allow for attachment of the robot at the proper height from the floor level. Moreover, construction of a special adapter for mounting the scanner head to the handle of a robot arm was also considered (Fig. 2). Its dimensions also extend the operating range and allow for easy measurement of the part from the bottom side.

As agreed at the stage of design, in order to achieve useful measuring device it is required to ensure device with 7 rotational axis. Six axes are provided by the robot which manipulate the scanner head while the seventh one is introduced by a rotary table. The construction of the table need to both enable putting on it all measured items and do not obscure the view of observed object which is measured by the measuring system. Due to faster and easier installation and integration with controller, to drive of the rotary table was selected from KUKA robot. This solution allows to reduce number of spare parts, as well as shortening the training time for service. All proposed technical solutions have been tested on trial sheet metal parts. This resulted in the introduction of many improvements and modifications. The study also confirmed the usefulness of measuring stations for both laboratory analysis, and mass industrial measurement.

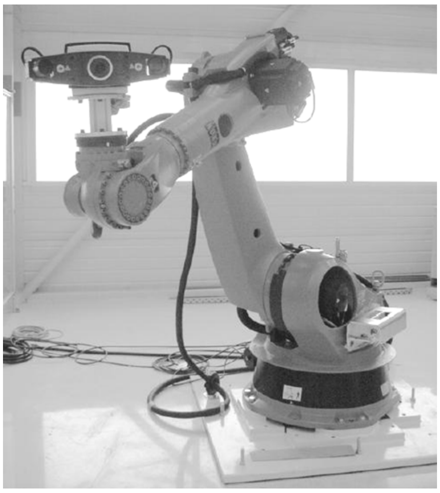

Figure 1 – KUKA Industrial robot with optical 3D scanner GOM Atos II

Figure 2 – Mounting adapter for optical 3D scanner on a robot arm

Connection of particular measurements obtained using the ATOS scanner is normally done on the basis of reference points. These points are marked on holder in such a way that provides referencing the object which is measured. This strategy reduce the time required to incorporate the reference point on the measured object. The measurement plan need to consider that at least three reference points registered in any of previous shots have to be visible in measurement view. During testing it was found that this solution is limited only by the size of the scanner measuring volume. If, applied size of the measurement volume ensure simultaneous covering the fields of measurement object and collection of reference points, then there is an opportunity to exchange parts in the handling device without introducing additional markers on the surface of measured element. In addition, the binding of reference points without linking them with the construction of the robot eliminates the robot positioning errors. In industrial reality, this allows to use used robot for research as well as for testing before deciding on the automation of the scanning process.

Figure 3 – Calibration cross for optical 3D scanner

In order to ensure proper operation of the scanner its calibration is necessary. This can be done using the calibration cross or plate (Fig. 3). In the standard system the calibration is performed by the operator. It should be an experienced person to proceed the calibration with metrological correctness. In this particular robotic measurement station the program for automatic calibration of a scanner was developed. It allows to automatically set the scanner head in the proper measurement position in relation to measurement object. An additional benefit is the ability to calibrate the scanner for example during a break time in the measurement, or one of the standard working day interruption without involving the operator.

During conceptual design study of robotized measurement station, CAD software was also involved. It is the optimum solution to reduce design time and cost of several alternative construction analysis. Moreover, simulation of the robot action in order to detect possible conflicts, etc. was also possible. The virtual model of whole construction additionally allows to send 3D models of particular components to its manufacturer in order to facilitate the production. This applies to all elements such as walls, securing a workspace, as well as profiles used for the construction of the rotary table and handles.

4. ADVANTAGES OF ROBOTIZED MEASUREMENT STATION

Coordinate measuring technique gives very wide range opportunities to control elements of different shapes. Coordinate optical devices allow for a significant acceleration of the measurement process by contactless measurement and in many cases are the only way to carry out one hundred percent control directly on line. With manipulator, which is the industrial robot, it is possible to introduce measurement strait into the production pace. As a result of this action, reduction of the amount of products that do not meet quality criteria with immediate information about the problem in the manufacturing process was possessed.

The specification of measurement using an optical 3D scanner determine obtaining whole the geometry of measured object. The corresponding database is capable of storing all of those data. With this solution, we get a huge base of knowledge about our products and in the course of the subsequent analysis can obtain additional information about the object. This allows the analysis of geometric features not discussed during the measurement.

Automation of the measurement process using an industrial robot eliminates random errors committed by the staff. It refers as well to the measurement process as to recording and archiving data. If the measurement process is planned and tested by experienced staff than even operator with lower qualifications would be able to conduct all action connected to the measurement start – up and exchange of the workpiece strait after short training reliably and safely. Saving measurement data and their initial assessment can be fully automated and require no maintenance staff. Thus, its implementation for metrological inspection of production lower financial costs could be incurred on stuff training which would be caused by the need of maintain limited number of highly skilled personnel with high professional qualifications.

Automated optical system may be used in any process if inspection. However, the most cost-effective application of the robot is connected with serial measurements which ensure repeatable measurement process. Frequent changes of the systems optics configuration and the creation of new measurement programs is time consuming. Conversions measurement system according to the change of measurement parts is another process to allow efficient use of available equipment. This situation causes an increase in the actual cost of operating the measurement. In carrying out the measurement series of elements using the same auxiliary equipment, instrumentation outages are caused only by the exchange of test pieces.

5. CONCLUSIONS

Developed concept of the measuring robot with an optical 3D scanner and its launch allow concluding the validity of the action taken. Research has shown many advantages of such solution. These include a significant reduction of time for serial measurements, to achieve high measurement repeatability and the ability to hire staff with lower qualifications to operate the measuring station.

Appropriate development of measuring station allows for safe operation of the robot. It was necessary to distinguish and separate area of the shop floor in order to ensure secure the robot working area against being in it any person during its operation time. Designed restriction to the access with electro technical and electronic protection is ready to replicate project of safety in danger zone in accordance with the law. The ease of access to the robot working area and the convenience of its use as well as simplicity of mounting workpieces to be measured were highlighted.

Conducted investigations confirmed the usefulness of measuring stations developed both for laboratory analysis and mass industrial measurement. The method of measurement is not sensitive to errors of manipulator positioning, which is achieved by locating reference points on the construction of the rotary table and handles for workpieces which are unrelated with the construction of the robot. The use of automated measurement equipment allows for the elimination of random errors made by service and automatic archiving of measurement data. This allows to obtain additional information about the realized production based on historical data.

During the conceptual phase of the project, its implementation and tests, the complete technical documentation was drafted. Financial resources and time invested in its production could not be considered as loss when starting to launch the station. This documentation will in fact enable reproducing all or part of the measurement station and significantly reduce the cost of subsequent deployments. Not without importance is also the practical experience gained by the staff implementing the first robotic measuring station with an optical scanner. They will make another run faster and with fewer mistakes.

6. REFERENCES

[1] Wieczorowski, M., Koteras, R., Grzelka, M., Gapiński, B., Znaniecki, P., Krasicki, P., Radke, M.: Automation of measurements using optical scanner, Book of Abstracts III Międzynarodowa Konferencja Naukowo-Techniczna Manufacturing 2010 Współczesne problemy wytwarzania i zarządzania produkcją 24–26.11.2010, Poznań, Polska, 201-202 (in Polish).

[2] Grzelka, M.: Possible applications of the optical coordinate scanner GOM ATOS II, Coordinate Measuring Technique, Problems and implementations, 2008.

[3] Bradshaw, G.: Non-Contact Surface Geometry Measurement Techniques, Image Synthesis Group Trinity College, Dublin IRELAND Gareth Bradshaw, Trinity College, Dublin, 1998/1999.

[4] Wieczorowski, M., Ruciński, M., Koteras, R.: Application of optical scanning for measurements of castings and cores, Archives of Foundry Engineering, 10(2010), 265-268.

[5] Wieczorowski, M.: Industrial application of optical scanner, Zeszyty Naukowe Akademii Techniczno-Humanistycznej w Bielsko Białej, 22(2006), 381-390.

[6] Galanulis, K., Reich, C., Thesing, J., Winter, D.: Optical Digitizing by ATOS for Press Parts and Tools, GOM, Braunschweig, 2005.

[7] Klette, R.: Image Analysis & Object Surfaces, CS-TR-152/CITR-TR-9, The University of Auckland, Tamaki Campus, Computing & Information Technology Research, Computer Vision Unit, Auckland, New Zealand, August 1997.

[8] Wieczorowski, M., Koteras, R., Znaniecki, P.: Wykorzystanie skanera optycznego w kontroli jakości karoserii samochodu, PAK, 56(2010)1, 40-41 (in Polish).

[9] Hartym, R.: Dimensional accuracy of investment casting for the burned pattern process, Archives of Foundry, 6(2006)18, 231-236

[10] Setan, H., Sharuddin, M. I., Ismail, M.: Applications of Digital Photogrammetric Systems for Dimensional Measurement and 3D Modeling, 3th FIG Regional Conference, Jakarta, Indonesia, 3-7.10.2004.

ANNALS of Faculty Engineering Hunedoara – International Journal of Engineering