Metrology & Hallmark

https://gum.gov.pl/wye/content/volume-29/6158,Procedure-for-data-preparation-for-the-correct-evaluation-of-the-geometrical-str.html
13.04.2026, 12:41

Procedure for data preparation for the correct evaluation of the geometrical structure of the surface in functional analysis

Metrology & Hallmark

Authors Karol Grochalski, Szymon Wojciechowski, Dominika Podbereska, Michał Wieczorowski - Poznan University of Technology; Piotr Niesłony, Grzegorz Królczyk, Jolanta Królczyk, Marta Bogdan-Chudy, Roman Chudy - Opole University of Technology; Katarzyna Nicińska, Łukasz Ślusarski - Central Office of Measures

Abstract

Parametric results describing the geometric structure of a surface are influenced by many factors. One of the most important is the correct preparation of input data. This is related to the type of surface levelling, the selection of a suitable measuring section or the applied filtration. The data preparation procedure depends on the adopted measurement technique: contact or optical. Depending on the type of data acquisition, it is necessary to implement supplementary procedures. Each of the applied operations on data directly influences the obtained values of individual spatial parameters 3D and surface parameters 2D, such as roughness, waviness or base profile. In this paper, different surface levelling options and selected filtering methods were analysed. In the case of optical measurements, the influence of filling in non-measured points was also considered. The results obtained allowed us to develop of a data preparation procedure and to determine the influence of the different steps on representative parametric values. It was found that the most significant factor influencing the parameter values obtained is the removal of outliers. In this study, based on two measurement techniques: contact and optical, a procedure for sequential processing of input data was prepared to assess the impact of the steps performed on the resulting values of parameters describing the surface structure. The procedure is based on one of two main types of surface levelling: levelling with the least squares plane (LS) and levelling line by line (LbL), along with the impact of one filtering method – removal of outliers (RO). In the case of optical measurements, the impact of filling unmeasured points (NM) was also considered. It was found that the most significant factor affecting the obtained parameter values is the removal of outliers (RO). The relative differences between the data for

which this operation was not applied are 13 % for contact profilometry and approximately 1% for optical profilometry. On the other hand, the procedure of filling unmeasured points (NM) has the least impact – however, this is only applicable in the case of optical measurement techniques. The choice of the appropriate levelling method can affect the final results. Differences between these methods are generally small (up to 5 %), but in certain situations, they can be significant. The obtained results allowed for the development of a data preparation procedure and determining the impact of various stages on the representative
parametric values.

Bibliography

[1] Maruda R.W., Królczyk G.M., Wojciechowski S., Powałka B., Kłos S., Szczotkarz N., Matuszak M., Khanna N., Evaluation of turning with different cooling-lubricating techniques in terms of surface integrity and tribologic properties. Tribology International, (2020), vol. 148, s. 106334-1-106334-14.
[2] Leach R.K., Characterisation of areal surface texture. Springer-Verlag; 2013. https://doi.org/10.1007/978-3-642-36458-7.
[3] Thomas T.R, Roughness and function. Surf Topography: Metrol Prop 2013;2: 014001. https://doi.org/10.1088/2051-672X/2/1/014001.1.
[4] Mathia T.G., Pawlus P., Wieczorowski M., Recent trends in surface metrology. Wear 2011;271(3–4):494–50 8. https://doi.org /10.1016/J.WEAR.2010.06.001.
[5] Leach R.K. Optical measurement of surface topography. Springer; 2011. https://doi.org/10.1007/978-3-642-12012-1.
[6] Ghodrati S., Kandi S.G., Mohseni M., Nondestructive, fast, and cost-effective image processing method for roughness measurement of randomly rough metallic surfaces. J Opt Soc Am A 2018;35(6):998–1013. https://doi.org/10.1364/ JOSAA.35.000998.
[7] Kiran M.B., Ramamoorthy B., Radhakrishnan V., Evaluation of surface roughness by vision system Int J Mach Tool Manufact 1998;38(5–6):685–90. https://doi.org/10.1016/S0890-6955(97)00118-1.
[8] Su R., Wang Y., Coupland J., Leach R.K, On tilt and curvature dependent errors and the calibration of coherence scanning interferometry. Opt Express 2017;25(4): 3297–310. https://doi.org/10.1364/OE.25.003297.
[9] Su R., Kirillin M., Ekberg P., Roos A., Sergeeva E., Mattsson L., Optical coherence tomography for quality assessment of embedded microchannels in alumina ceramic. Opt Express 2012;20(4):4603–18. https://doi.org/10.1364/oe.20.004603.
[10] Krolczyk G.M., Maruda R.W., Krolczyk J.B., Nieslony P., Wojciechowski S., Legutko S., Parametric and nonparametric description of the surface topography in the dry and MQCL cutting conditions. Measurement Volume 121, June 2018, Pages

225-239.
[11] Nieslony P., Krolczyk G.M., Wojciechowski S., Chudy R., Zak K., Maruda R.W., Surface quality and topographic inspection of variable compliance part after precise turning. Applied Surface Science Volume 434, 15 March 2018, Pages 91-101.
[12] Maruda R. W., Wojciechowski S., Szczotkarz N., Legutko S., Mia M., Gupta M.K., Nieslony P., Krolczyk G.M., Metrological analysis of surface quality aspects in minimum quantity cooling lubrication. Measurement, (2021), vol. 171, s. 108847-1-108847-12.
[13] Nieslony P., Cichosz P., Krolczyk G.M., Legutko S., Smyczek D., Kolodziej M., Experimental studies of the cutting force and surface morphology of explosively
clad Ti–steel plates. Measurement., 78 (2016), pp. 129-137, 10.1016/jmeasurement.2015.10.005.
[14] Józwik J., Mika D., Diagnostics of workpiece surface condition based on cutting tool vibrations during machining. Adv. Sci. Technol. Res. J., 9 (2015), pp. 57-65, 10.12913/22998624/2365.
[15] Mikołajczyk T., Nowicki K., Bustillo A., Pimenov D.Y., Predicting tool life in turning operations using neural networks and image processing. Mech. Syst. Signal
Process., 104 (2018), pp. 503-513, 10.1016/j.ymssp.2017.11.022.
[16] Wojciechowski S., Krajewska-Śpiewak J., Maruda R.W., Krolczyk G.M., Nieslony P., Wieczorowski M., Gawlik J., Study on ploughing phenomena in tool flank face – workpiece interface including tool wear effect during ball-end milling. Tribology International, (2023), vol. 181, s. 108313-1-108313-20.
[17] Wojciechowski S., Krolczyk G.M., Wiąckiewicz M., Study on metrological relations between instant tool displacements and surface roughness during precise ball end milling. Measurement, 129, (2018), s. 686-694.
[18] Przestacki, Szymanski P., Wojciechowski S., Formation of surface layer in metal matrix composite A359/20SiCP during laser assisted turning. Composites Part A: Applied Science and Manufacturing, 91, 1, (2016).
[19] Lu E., Ren W., Dai H., Zhu X., Investigations on electromagnetic wave scattering simulation from rough surface: Some instructions for surface roughness measurement based on machine vison. Precision Engineering Volume 82, July 2023, Pages 156-168.
[20] Li S., Peng G., Xu D., Shao M., Wang X., Yang Q., A multifeature fusion model for surface roughness measurement of cold-rolled strip steel based on laser speckle. Measurement, Volume 227, 15 March 2024, 114319.
[21] Al-Kindia G.A., Shirinzadeh B., An evaluation of surface roughness parameters measurement using vision-based data. International Journal of Machine
Tools & Manufacture 47 (2007) 697–708.
[22] Zhang H., Liu J., Chen S., Wang W., Novel roughness measurement for grinding surfaces using simulated data by

transfer kernel learning. Applied Soft Computing Volume 73, December 2018, Pages 508-519.
[23] Weckenmann A., Krämer P., Assessment of measurement uncertainty caused in the preparation of measurements using computed tomography. XIX IMEKO World Congress, Fundamental and Applied Metrology, September 6−11, 2009, Lisbon, Portugal.
[24] Whitehouse D., Surfaces and Their Measurement Elsevier Ltd.; 2004. 432 p.
[25] Yuan Y.B., Qiang X.F., Song J.F., Vorburger T.V., A fast algorithm for determining the Gaussian filtered mean line in surface metrology. Precision
Engineering 2000; 24:62–9.
[26] Yuan Y.B., Vorburger T.V., Song J.F., Renegar T.B., A simplified realization for the Gaussian filter in surface metrology, X International Colloquium on Surfaces 2000, Chemnitz, Germany, 2000. pp. 133–141.
[27] Numada M., Nomura T., Yanagi K., Kamiya K., Tashiro H., High-order spline filter and ideal lowpass filter at the limit of its order. Precision Engineering 2007; 31:234–42.
[28] Hanada H., Saito T., Hasegawa M., Yanagi K., Sophisticated filtration technique for 3D surface topography data of rectangular area. In: Proceeding's 10th International Conference "Metrology and Properties of Engineering Surfaces". 2005. p. 191–8.
[29] Jiang X., Zeng W., Scott P., Ma J., Blunt L., Linear feature extraction based on complex ridgelet transform. In: Proceedings of the 10th International
Conference on Metrology and Properties of Engineering Surfaces. 2005. p. 85–92.
[30] Jiang X., Scott P.J., Whitehouse D.J., Blunt L., Paradigm shift in surface metrology. Part II. The current shift. Proceedings of the Royal Society A 2007;463: 2071–99.
[31] Barrios-Muriel J., Salgado D.R., Cambero I., Alonso F.J., González A.G., An approach for Surface Roughness Filtering as an alternative to ISO Standard. Procedia Manufacturing 41 (2019) 674–681.
[32] Zakharov O.V., Lysenko V.G., Ivanova T.N, Asymmetric morphological filter for roughness evaluation of multifunctional surfaces. ISA Transactions, https://doi.org/10.1016/j.isatra.2023.12.016.

ISSN 3071-7647
Language english
Year 2024
Volume 29
Published 8

Application generates the quote in the selected format.

Generate quote from this publication

Generate the quote

Download

Downloads

Procedure for data preparation for the correct evaluation of the geometrical structure of the surface in functional analysis 1.7 MB

Previous Page