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Calibration of 2D and 3D Optical Measuring Instruments in Industrial Environments at Submillimeter Range

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Abstract : Modern manufacturing processes have led to the miniaturization of systems and, as a result, parts at the micro-and nanoscale are produced. This trend seems to become increasingly important in the near future. Besides, as a requirement of Industry 4.0, the digitalization of the models of production and processes makes it very important to ensure that the dimensions of newly manufactured parts meet the specifications of the models. Therefore, it is possible to reduce the scrap and the cost of non-conformities, ensuring the stability of the production at the same time. To ensure the quality of manufactured parts, it becomes necessary to carry out traceable measurements at scales lower than one millimeter. Providing adequate traceability to the SI unit of length (the meter) to 2D and 3D measurements at this scale is a problem that does not have a unique solution in industrial environments. Researchers in the field of dimensional metrology all around the world are working on this issue. A solution for industrial environments, even if it is not complete, will enable working with some traceability. At this point, we believe that the study of the surfaces could provide us with a first approximation to a solution. Among the different options proposed in the literature, the areal topography methods may be the most relevant because they could be compared to those measurements performed using Coordinate Measuring Machines (CMM's). These measuring methods give (x, y, z) coordinates for each point, expressing it in two different ways, either expressing the z coordinate as a function of x, denoting it as z(x), for each Y-axis coordinate, or as a function of the x and y coordinates, denoting it as z (x, y). Between others, optical measuring instruments, mainly microscopes, are extensively used to carry out measurements at scales lower than one millimeter because it is a non-destructive measuring method. In this paper, the authors propose a calibration procedure for the scales of optical measuring instruments, particularizing for a confocal microscope, using material standards easy to find and calibrate in metrology and quality laboratories in industrial environments. Confocal microscopes are measuring instruments capable of filtering the out-of-focus reflected light so that when it reaches the detector, it is possible to take pictures of the part of the surface that is focused. Varying and taking pictures at different Z levels of the focus, a specialized software interpolates between the different planes, and it could reconstruct the surface geometry into a 3D model. As it is easy to deduce, it is necessary to give traceability to each axis. As a complementary result, the roughness Ra parameter will be traced to the reference. Although the solution is designed for a confocal microscope, it may be used for the calibration of other optical measuring instruments by applying minor changes.

Keywords : industrial environment, confocal microscope, optical measuring instrument, traceability
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