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Development of precision information-measuring complex for optical metrology of nanosystems

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Goniometer Г5 is a precise laboratory instrument for measurement of angles between plane polished faces of optical parts, as well as for some other types of measurements. Its accuracy is 5 angular seconds. This device is very common in the post-Soviet space and is used in the optical industry and in scientific research. It is a convenient base for the creation of experimental installations to measure angular distributions of light. The main difficulty lies in visual reading angles on a specific scale and in manual positioning of the sample.
The authors developed a complex of automation for this goniometer. The complex includes a machine vision system, drives for positioning and special modules for controlling polarizers or other optical elements.
The machine vision system physically consists of a camera and a computer. The camera is attached to the goniometer goggle. The image of the scale is being processed by a program created by the authors in the LabVIEW environment. The main essence of the algorithm is to determine the fractional and the integral part of the angle. The former is achieved by analyzing the distribution of brightness along the specified segments, and the latter by the standard algorithm of optical character recognition. The scale reading error is about 2.5 arc seconds, which means full use of instrument accuracy. It takes generally about 1 second to determine one angle.
Mechanical actuators are made on the basis of stepper motors NEMA8 and NEMA23. The motors rotate goniometer table and alidade through gearboxes and belt transmissions. The elasticity and unevenness of the transmissions are not fundamental because the real position of the elements of the goniometer is determined by its scale. These actuators allow you to position the table and the alidade with a few arc seconds of discretion.
Finally, standardized nozzle fittings for goniometer tubes were developed. Each such nozzle is a turntable unit with a stepper motor and an optical encoder. It is used to position polarizers and phase plates with ~0.5 degrees accuracy.
At each stage of automation, a large number of control programs have been created in LabVIEW. In addition, each new research task required the creation of new programs for the experiment and the processing of results.
The described installation can be quickly reconstructed to the desired task. It can measure angular radiation distributions of sources or scattered light, work as an ellipsometer or Stokes polarimeter. The authors successfully conducted a series of studies on it, among which were the measurement of the indicatrix of scattering of milk glass, suspension of nanoparticles, ellipsometry of thin film multilayered structures, measurement of curves of plasmon resonance of biosensors, and others.

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