Objective of the project:

The research project objective is to define the innovatory mathematical model of the five-axis kinematic structures (manipulators, robots), that use both translational and revolute kinematic pairs in their kinematic chain. The main sources that disturb the functioning of the mechanism would be taken into account in this model. These sources include: influence of the ambient conditions, especially the temperature, errors connected with the imprecise manufacturing and assembling of the manipulator arms and drives, errors caused by the dynamics of the mechanism and the errors attributed to the kind of tasks that manipulator performs. All of this influences cause the inaccuracies of achieving the required position and orientation of the mechanism's end effector.

Thanks to the developed model, it would be possible in the future to predict the geometrical accuracy of the manipulator being used. Quantitative description of the influence of mentioned disturbances may also be helpful in improving the accuracy of the manipulator by their reduction or compensation.

In practice, the five-axes kinematic structures that use both translational and revolute kinematic pairs are used among others in robotics, manufacturing techniques and metrology. Their significance is constantly growing as they present advantages of systems based only on the translational pairs and only on the rotational parts. So the depth recognition of their possibilities regarding the geometrical accuracy is the important case that may help in the future to improve the precision of functioning of the robots, manufacturing of the machine parts and performing of the measurements.

The basic research that will be carried out:

The project involves analysis of phenomena related to achieving by the end effector of a five-axis manipulators the programmed position and orientation, and after that modeling of this process using modern numerical techniques.

In order to determine the impact of the disturbances on ideal reproduction of programmed position and orientation the numerous experiments will be undertaken with the utilization of the most modern achievements of laser techniques, research station developed in the scope of this project and the novel theoretical solutions.

The influences having impact on the kinematic structure of the mechanism would be identified using the only one in Poland laser tracking system called LaserTracer. It would be used along with the multilateration methods. Also the precise laser interferometer would be available during performing of the experiments. The research methodology would be based here on the recommendations of the ISO 9283 standard and on the method developed by the Principal Investigator regarding the analysis of the residual errors of kinematic system.

The influences caused by the functioning of the manipulator's end effector would be estimated using the series of experiments based on measurements of material standards (of external and internal diameter) and also on measurements of standards described by the different, known value of Ra parameter. Before the experiments planned, these standards would be measured on precise optical measuring machines and the surface maps would be obtained as a result. They would be used then during the planned research cycle.

The numerical model would be prepared using the methods like Monte Carlo method, artificial neural networks and interpolation methods ("nearest neighbour" interpolation, bilinear interpolation and spline interpolation among others).

The experimental verification of developed numerical model would be performed using the WWC standard which was constructed in Cracow University of Technology and is utilized for checking many geometrical features in the same time (during one measurement).

Reasons for choosing the research topic:

The Laboratory of Coordinate Metrology (LCM) in which the project would be executed, for many years conducts research on assessment and improvement of accuracy of products manufactured in different branches of the industry. This is why the Principal Investigator started his interest in problems related to modeling of the accuracy of manipulators used in different disciplines of the science. He has noticed a common problems occurring during usage of this mechanisms, and the research undertaken within the scope of this project are the attempt to systematize the issues connected with the modeling of the accuracy of manipulators performing various tasks.

In the compliance with the name of the Laboratory, its workers deal mainly with the coordinate metrology, where the five-axis systems are now gaining the popularity. There are no detailed descriptions of functioning, accuracy and error sources connected with usage of this systems. So the results of the project would be the first of this type in the global scale, what could increase the prestige and a position of Polish metrology in the world.

The next reason for choosing this research topic was noticing by the Principal Investigator that in the long-term perspective, using of the developed detailed model of accuracy should allow preparing of the virtual model of measurement performed on a five-axis kinematic structures. Models like the mentioned one, but developed for less complicated measuring systems are successfully implemented and its application is always connected with the significant reduction of time needed for obtaining the proper result of the performed measurement. In effect, it would be possible to significantly reduce the time which is necessary for obtaining it, which could cause the reduction in quality control costs up to 30 times. And the quality control costs constitutes the big part of the total manufacturing costs.