Abstract

This implementation-oriented doctoral dissertation presents the development of a system for screening postural defects in children and adolescents, intended for the early detection of scoliosis. The system comprises the ORT software application and the ORT-100 hardware solution, designed for the automated analysis of back asymmetry and the sagittal (anteroposterior) curvatures of the spine.

The dissertation provides an overview of methods and technologies used for scoliosis diagnosis both in contemporary practice and historically. It explains the principles of screening examinations in children and adolescents in the context of early scoliosis detection. The concept of measuring the angle of trunk rotation using a scoliometer, including its electronic variants, is discussed in detail. In addition, a model for postural assessment employing an orthometer is presented.

The author describes the procedure and results of studies conducted at three experimental setups:

- a rotational test stand for the accelerometer system,
- a rotational test stand for the orthometer,
- a measurement stand for length and rotation-angle measurements.

The studies aimed to apply established regression methods and to develop approaches that increase the accuracy of angle measurements based on accelerometer and gyroscope readings for the orthometer device. For measurement estimation, polynomial regression methods were employed, as well as machine-learning algorithms, including neural networks, the random forest method, and the k-nearest neighbors (K-NN) algorithm. The application of these methods enabled a substantial reduction in measurement errors whose magnitudes depended on the rotational velocities. In addition, the studies facilitated improvements to the spinal-segment length measurement implemented in the orthometer.

The dissertation presents methods for the automated determination of back asymmetry and sagittal spinal curvatures, based on orthometer measurements. In conjunction with parameters entered into questionnaires completed by medical personnel, their application within an expert system is demonstrated. The system was developed using clinical decision rules to identify the risk group for idiopathic scoliosis and to determine the type of postural defects on the basis of an expert decision tree.

The results of implementing the developed methods in a system for automated analysis of back asymmetry and sagittal spinal curvatures are presented. The dissertation describes in detail the design assumptions and normative requirements for the ORT system, specifying the process of software design and development. It also presents the system components as well as the course and results of studies carried out at a rehabilitation center.