# Development of Spine-Shaper for 3D Position Estimation of the Human Spine Using a Three-Dimensional Sensor

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## Abstract:

This study aims to develop a system that estimates the three-dimensional position of the human spine using the 3D surface structure of the back, offering a non-invasive alternative to traditional X-ray imaging. A non-contact 3D sensing setup was constructed to measure dorsal surface geometry, and software was developed to infer spinal alignment from this data. The focus is on estimating the spinal sulcus point—an anatomical landmark indicating spinal location—using slice data from the back surface. A multi-input classification model based on a one-dimensional convolutional neural network (1D-CNN) was designed to predict the sulcus index from z-curve profile data. The dataset comprised 1,000 samples, each containing 200 z-values, a target index for the spinal sulcus, and a range value representing curve shape. Z-values were normalized between 0 and 1, and the range value was one-hot encoded as an auxiliary input. The target was treated as a class index, enabling softmax-based classification. The model included 1D convolutional layers, dense layers, and dropout regularization, with sparse categorical crossentropy as the loss function and the Adam optimizer for training. Performance evaluation using mean absolute error (MAE) showed an average error of 1.73 pixels, or approximately 1.56 mm, demonstrating high precision. The final system integrates sensing, analysis, and output modules, automatically displaying estimated spinal positions and curvature angles. This work confirms the feasibility of precise, non-contact spinal alignment estimation and suggests potential for clinical use as an alternative or complement to conventional radiography.

## Keywords:

Non-contact spinal measurement, 3D surface analysis, 1D-CNN classification, Spinal sulcus localization, X-ray alternative diagnostics.