## Computational Simulations of the Anterior Vertebral Surface for Optimal Surgical Instrumentation Design

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The engineering design of surgical instrumentation to apply mechanical forces and linear moments on the human bones during the operations constitutes a rather difficult task. This is due both to the natural and pathological irregularities of the human bone morphology and surfaces and also to the individual variations from one patient to another. Usually, the forces are applied by the surgeon only on a determined part of the bone surfaces. This paper describes an innovative computational design method to digitalize, simulate, and fit mathematically the anterior vertebral body facet. We used real experimental data from 17 human cadaveric specimens to get and store a large amount of numerical surface digital values. The complete anterior vertebral body side was visualized and analyzed with grid data Subroutine, which was also used first to select the so-called natural regions of interest (ROIs). These ROIs correspond to those parts of the surface in contact with the surgical instrumentation, where the mechanical forces are applied. Subsequently, a numerical mathematical fitting-model was implemented for these ROIs. This was carried out with the development of a 3D geometrical least-squares optimization algorithm and appropriate software designed according to the proper numerical method selected. In doing so, the 3D superficies equations of the anterior vertebral body (L3, L4, L5, and S1) were determined after these fittings were mathematically checked as appropriate. Statistical parameters and determination coefficients that define the error boundaries and the goodness of this optimal fitting-model were calculated and NURBS error data in similar studies were commented. It was proven that the principal source of error was the micro- and macro-irregularities of human bone facets. The final surface equations, and their geodesics, were used to obtain accurate data for the spinal surgery instrumentation manufacturing. The industrial bioengineering result was the application of these equations for the design of a new spinal vertebral surgical distractor. This innovative distractor separates two adjacent vertebrae while keeping them parallel. That is, at their natural inclination, avoiding hammering the vertebrae to make the intervertebral space wider. The device mechanics also minimizes the necessary force to be carried out by the surgeon during the operation.

*Keywords: inverse approximation analytic method, anterior vertebral body, ROI, simulations, optimization, numerical fitting, least-squares approximation, spinal surgery, CAD*

## Automatic Vibrotactile Device for Interruption of Apnea in Premature Infants

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Apnea in premature infants is a common medical problem faced daily by neonatal intensive-care unit staff worldwide. The condition is defined as a pause in breathing that lasts for 20 s or longer and is traditionally treated by manual simulation administered by a nurse. This work proposes a design of an automatic apnea interruption system for infants, which utilizes a noninvasive vibrotactile (vibration feedback) unit to replace the traditional manual stimulation. The overall system consists of a vibrotactile unit and a device/user control interface that are used with a commercial patient monitoring device. The system monitors physiological signals associated with apnea, such as heart rate and blood oxygen level, and activates the vibrotactile unit in a closed-loop fashion. The system provides multimode haptic feedback for individualized patient treatment by allowing the care provider to adjust the magnitude and duration of the tactile stimulation from the user interface. As a preliminary evaluation, the system is tested for safety and performance using simulated data.



  