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Crystal-Structure Concepts Applied to Static and Dynamic Modeling of the Human Spinal Column

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Spinal column is a 3-D structure. Ordinary anteroposterior (AP) X rays (external auditory meatus to hip joint, in the attention position) show the spinal projection in frontal plane, not capable of displaying kyphosis or lordosis. Spinal models in 3 dimensions have the ability to generate full view from projections of spine in the frontal and the sagittal planes obtained from AP- and lateral-X-ray pictures or moiré topograph (http://www.ngds-ku.org/Papers/J04.pdf) of back in the attention position. From moiré measurements, a parabolic curve is generated[b], $x = x(\xi)$, $y = y(\xi)$, $z = z(\xi)$, (http://www.ngds-ku.org/Papers/J18.pdf) best fitted to discrete measurements performed at various locations represented by the parameters, ξ_i; $i = 1,\ldots,33$, corresponding to 33 vertebrae of backbone, consisting of cervical, thoracic, lumbar and sacral regions. Coördinate system is rotated through a suitable angle to make the cross term (yz) vanish. The coefficients of squares of y and z, then, represented half of curvatures and degree of correction of spinal deformity was defined in terms of these curvatures, taking into account the normal curvatures of the spinal column. This 3-D-static model was found to be useful in the study of posture of children and invariance under deformations. The dynamic model http://www.ngds-ku.org/pub/confabst0.htm#C42:, a generalization of 3-D-static model, included movement of the human spinal column during a gait cycle. The human spinal column in 3-D was generated from moiré topographs of back in the anatomical position as well as during the first, the second, the third and the fourth phases of gait cycle http://www.ngds-ku.org/Papers/J16.pdf. Spinal column in the anatomical position was subsequently linked to position during the first phase of gait cycle through the edge-based algorithm. Similarly, position in the second phase was linked to the first phase through the edge-based algorithm and so on. Considering the human spinal column as a crystal structure, the center-of-mass of each vertebra, expressed in terms of positional coördinates (x, y, z) in the body-coördinate system, could be visualized as 'form factor', familiar to solid-state physicists. The surface structure of each vertebra could be studied using moiré fringe topography (providing 3-D-coördinate information) and rasterstereography (providing curvature information). Combined with rotational (in terms of Euler angles) as well as inter-vertebral-spacing information, such an analysis may be considered equivalent to 'structure factor', determined by crystallographers. Future work should focus on developing a coördinate system (suggested by Mehwish Nazir Alam, BS, Mathematics, University of Karachi, class of 2012), which should reduce the degrees-of-freedom of spinal column from (33)(3 + 3 + 1)[$] to, possibly, one by applying the techniques similar to those employed in reducing degrees-of-freedom of two-body problem http://www.ngds-ku.org/pub/confabst0.htm#C45: from 12 to one. The problem of human spinal column, one of the leading problems of orthopedics (study of bones, joints and skeletal deformations), therefore, falls in the domain of 'algebraic topology' — realizing that orthopedics emanates from 'anatomy', study of body structures, whereas 'algebra', is the study of mathematical structures and 'topology', deals with invariance under deformations http://www.ngds-ku.org/Papers/J30.pdf. A new branch of mathematics, 'anthrotopology', may be needed to describe and handle mathematical framework related to trunk deformities.

Prof. Dr. Syed Arif Kamal presenting his paper during the First Session, in which a new branch of mathematics was introduced, named as *anthrotopology*

Keywords: Human spinal column, static model, dynamic model, posture, gait, structure factor, form factor
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[$]The product (33)(3 + 3 + 1) represents (number of vertebrae)(positional degrees-of-freedom + rotational degrees-of- freedom + inter-vertebral-spacing degree-of-freedom)