**The Syed Firdous Memorial Lecture** delivered during *the First Conference on Athromathematics in the Memory of (Late) Syed Firdous*, Department of Mathematics, University of Karachi, Karachi, Pakistan and Government College, Hyderabad, Pakistan, September 4, 5, 2013 (Thursday, Sept. 5, 2013; 1240h-1250h, Assembly Hall, Govt. College), Technical Session Anthro13-IV, Abstract#Anthro13-16, p 22

# From Simple X rays to Bone Scanning using Backscatter-X Rays: A Journey of 113 Years

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Willam C. Rontgen received **Physics Nobel Prize of 1901** for the discovery of *X rays*. Imagine medical science, in particular, orthopedics, without bone imaging. Patients would be dependent on bone fixers to manipulate our bodies. Then, the next change of paradigm came through the award of **Medicine Nobel Prize of 1979** for introducing *CT-scanning technology*. Anthromathematics and image processing played key roles in this discovery, as radiative-transfer equation (a differential equation describing the intensity distribution) was solved and interpreted to develop this medical-imaging technology. On **May 30, 2013**, *bone-structure scanning* was suggested using the backscatter-body-scanning system, introduced for security screening at airports http://www.ngds-ku.org/Presentations/Security.pdf — this could be combined with stereophoto-grammetric techniques for the study of structure of spinal column by generating height and curvature maps of backbone using moiré fringe topography http://www.ngds-ku.org/Papers/Moire.pdf and rasterstereography http://www.ngds-ku.org/Papers/Rasterstereography.pdf

Human stereophotogrammtry has its roots in *anthrogeometry* (mathematics of interpretation of distances and curvatures on the human skin or surfaces of bones and organs). The term was introduced on April 10, 2013, during a seminar at FUUAST entitled *Anthromathematics***:** *Mathematics of the Third Millennium*. In orthopedics, moiré and raster techniques are used for static and dynamic studies of the human spinal column (posture, gait and scoliosis). These techniques employed ordinary light for *active scanning*. Hence, their scope was limited to surface studies (human skin) and could not be used to study bone structure. In the backscatter-X-ray scan, radiation went through clothes and was Compton scattered from skin to produce body image. For medical applications, the intensity was adjusted so that X rays were scattered off the bone generating its picture instead of skin. For 3-D-spinal-column-surface analysis (height map), radiation was filtered through a shadow-type-moiré frame (X rays blocked by frame threads) to produce a 3-D-moiré pattern of the spinal column. However, both X-ray- and moiré-scanning mechanisms provided gross information, as they did not go to the next level of analysis (suggested by our group on December 27, 2012), in which crystal-structure concepts (form factor and structure factor) http://www.ngds-ku.org/Presentations/BZU1.pdf were applied to static and dynamic modeling of the human-spinal column. *Passive-image (post-recorded) correction* (for misalignment or rotation) was not possible in the *shadow-type-backscatter moiré*, which offered the possibly of only *active-image correction* — operator (viewing real-time scan on the monitor) asked the patient to change position. However, in *grating-hologram-type-backscatter moiré* the former was possible. A projected-raster grid (X rays blocking raster patterns) generated 3-D-curvature map of the spinal column. Simultaneous backscatter (-moiré and -raster) recordings http://www.ngds-ku.org/Papers/J16.pdf could be employed to visualize spinal column during gait analysis. Holographic images could be generated by recording and processing multiple images in the semi-circular angular range. *Holographic-backscatter moiré (raster)* seemed to have the potential to generate real-life images of bones. As regards radiation damage, intensity of backscatter-X rays was stated to be low as compared to regular-X rays. As backscatter-X rays reflected off the bone surface and were not absorbed in its material, it might be, reasonably, assumed that there would not be so much damage as from regular-X rays, provided eyes and gonads are, properly, shielded. However, discretion was advised, when using these tech-niques in infants, children, elderly people, pregnant women and cancer patients. Using techniques from physics (image projection/recording), computer science (edge-based and intensity-based algorithms) and information technology (image processing), sterophotogrammetric imaging of humans using moiré fringe topography, rastersetereography, simultaneous moiré and raster, edge-based moiré, edge-based raster, *edge-based-holographic-backscatter-simultaneous moiré and raster* may form the basis of ***anthroimaging*** — 3-D imaging of human-skin, -bone and -organ surfaces (sectional-semicircular views) as well as their infinitesimal movements. This lecture was dedicated to the memory of our loving colleague, born on September 4, 1952 in Jacobabbad, Sindh (Pakistan) and educated at University of Sindh, the affiliating institution of Government College, Hyderabad. At the time of his death Syed Firdous was serving as Associate Professor and Head, Mathematics Department, SM Government Science College, Karachi as well as Member, Board of Studies of Mathematics, University of Karachi (UOK). Department of Mathematics, UOK honored him by naming Growth-and-Imaging Laboratory after him, arranging his memorial lecture during *the First Conference on Mathematical Sciences* (2010) and dedicating this conference in his memory.

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