

## Biomedical Applications of 3-D-Optical Imaging and Image Processing

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This paper covered the activities of bioimaging group of University of Karachi spanning over a period of 30 years, focusing on non-ionizing, non-invasive, non-contact, photogrammetric techniques — moiré fringe topography and rasterstereography, which provided permanent records height (third dimension) and curvature maps, respectively, of the human subject/test object under study (Figures 1 and 2). The work started in 1979 by developing a shadow-type-moiré system for the detection of scoliosis. The author developed methods to determine *the Cobb angle* from measurements performed on moiré topographs (and its generalization in 3-D, *the Asr Angle*). In the context of 3-D-static model of the human spinal column (put forward by author in 1982, complete version published in 1996), profile of spinal column in three dimensions was generated by moiré photograph of back, used to study posture, providing insight into the anatomical basis of back pain. A simultaneous recording from moiré and raster, using selective optical filtering, gave height and curvature maps of spinal column (thus generating 3-D profile of spinal column) in each phase of human gait (developed in 1996), which provided clues to many *orthopedic* and *neurological* disorders. A 3-D-dynamic model related spinal column in each phase to the next through edge-based algorithm. Edge-based moiré and edge-based raster allowed studies of changes in height and curvature maps of human back during a gait cycle. In the area of *sports-performance analysis*, unwanted motion in the sagittal plane, by a gymnast performing on vault, could be monitored using edge-based moiré. In the discipline of *speech therapy*, movements and curvatures of lips and mouth muscles could be studied using edge-based moiré and raster. In the field of *biometrics and security technologies*, a multi-level screening system was proposed (in 2008) to establish identity with a high level of sensitivity (top level) and specificity (bottom level) employing dynamic stereophotogrammetric techniques. These techniques might, also, be utilized to study 3-D structure of macromolecules, significant in biology, by making their metallic replica. Preliminary work was done on the flagella of salmonella typhus at the Albert Einstein College of Medicine (New York).

**Keywords:** Moiré fringe topography, rasterstereography, edge-based algorithm, stereophotogrammetry



Figure 1 *a, b* From left to right, study of human back using moiré fringe topography (Credit: Shakeel Ahmed Ansari) and human shoulder using rasterstereography (Credit: Majeed Ahmed Khan)

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