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Biomedical Applications of 3-D Optical Imaging and Image Processing

Syed Arif Kamal [*]
The Syed Firdous Growth and Imaging Laboratory, Department of Mathematics
University of Karachi, Karachi, Pakistan

This paper shall cover the activities of bioimging 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 rastersterography, which provide 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 provides 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, may 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 stereo-photgrammetric techniques.

Figure 1. Study of human back using moiré fringe topography (Credit: Shakeel Ahmed Ansari)

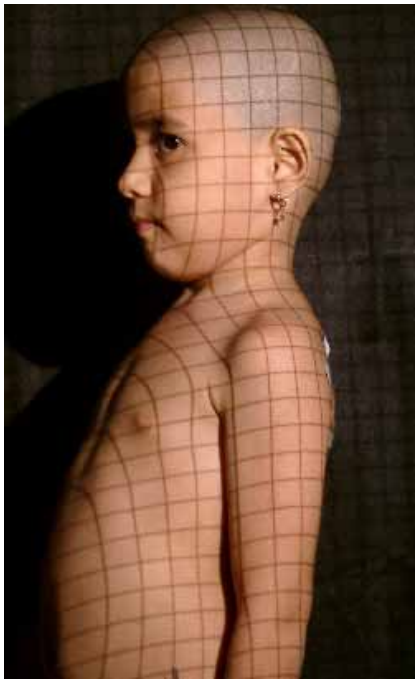

Figure 2. Study of human shoulder using rastersterography (Credit: Majeed Ahmed Khan)

3-D structure of macromolecules, significant in biology, may be studied by making their metallic replica and applying these techniques. 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, photogrammetry

[*] Professor Dr. Syed Arif Kamal, MS (Indiana), MA (Johns Hopkins), PhD, Project Director, the NGDS Pilot Project, the Syed Firdous Growth and Imaging Laboratory, Department of Mathematics, University of Karachi, *e-mail*: kamal(at the rate of)ngds-ku.org; *paper mail:* University of Karachi, Box 8406, Karachi 75270, Pakistan; *homepage*: http://ngds-ku.org/kamal