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January 1-2, 1998
Karachi, Pakistan

Shaheed Zulfikar Ali Bhutto Institute of Science and Technology
90 Clifton, Karachi, Pakistan.
PROCEEDINGS

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RECENT ADVANCES IN
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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>i</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>ii</td>
</tr>
<tr>
<td>1. Information Accessing and Playing Video</td>
<td>1</td>
</tr>
<tr>
<td>T. Kanade</td>
<td></td>
</tr>
<tr>
<td>2. Image Compression Using Multi-Level Thresholding</td>
<td>2</td>
</tr>
<tr>
<td>A. Naqvi and A. Faraz</td>
<td></td>
</tr>
<tr>
<td>3. A Comparison of Moments Based Techniques for Object Representation</td>
<td>17</td>
</tr>
<tr>
<td>S. Z. Khan and S. B. Kesler</td>
<td></td>
</tr>
<tr>
<td>4. Computer-assisted Presentation by Analysis of Live-images</td>
<td>25</td>
</tr>
<tr>
<td>M. Toda, T. Yamaguchi, T. Iijima, T. Kawashima and Y. Aoki</td>
<td></td>
</tr>
<tr>
<td>5. 2-D Affine Invariants that can be Tuned to the Feature Domain</td>
<td>34</td>
</tr>
<tr>
<td>I. Rigoutsos</td>
<td></td>
</tr>
<tr>
<td>6. An Artificial Neural Network Approach to Camera Calibration and 3D-</td>
<td>35</td>
</tr>
<tr>
<td>World Reconstruction for Stereovision</td>
<td></td>
</tr>
<tr>
<td>S. Khan and Q. Memon</td>
<td></td>
</tr>
<tr>
<td>7. PC Based Optical Objective Test Marking System Using Neural Networks</td>
<td>41</td>
</tr>
<tr>
<td>A. Iqbal and H. M. F. Zafar</td>
<td></td>
</tr>
<tr>
<td>8. Model-Based Approach for Recognizing Human Activities from Video</td>
<td>50</td>
</tr>
<tr>
<td>Sequences</td>
<td></td>
</tr>
<tr>
<td>S. Dettmer, A. Seetharamaiah, L. Wang and M. A. Shah</td>
<td></td>
</tr>
<tr>
<td>9. Adaptive Wavelets for Pattern Recognition</td>
<td>60</td>
</tr>
<tr>
<td>A. Parodi and E. Morele</td>
<td></td>
</tr>
<tr>
<td>10. Adaptive Bilinear Inverse Filtering</td>
<td>67</td>
</tr>
<tr>
<td>F. Rauf and H. M. Ahmad</td>
<td></td>
</tr>
<tr>
<td>11. Modeling Estimating and Recognizing Human Actions</td>
<td>76</td>
</tr>
<tr>
<td>D. Metaxas, D. DeCarlo, I. Kakadiaris and C. Vogler</td>
<td></td>
</tr>
<tr>
<td>12. Analysis of Boundary Descriptions Using Parametric Techniques for Object Representation</td>
<td>77</td>
</tr>
<tr>
<td>S. Z. Khan and S. B. Kesler</td>
<td></td>
</tr>
<tr>
<td>13. 3-D Optical Imaging and Image Processing (Biomedical Application)</td>
<td>86</td>
</tr>
<tr>
<td>S. A. Kamal</td>
<td></td>
</tr>
<tr>
<td>14. Multimedia for Corporations</td>
<td>99</td>
</tr>
<tr>
<td>A. Qureshi</td>
<td></td>
</tr>
<tr>
<td>15. Automated Defect Detection in Steel Rod Manufacturing by Intelligent Image Processing</td>
<td>110</td>
</tr>
<tr>
<td>S. Swaminathan, S. M. Krishnan and L. Hayat</td>
<td></td>
</tr>
<tr>
<td>Author's Index</td>
<td></td>
</tr>
</tbody>
</table>
3-D Optical Imaging and Image Processing (Biomedical Applications)

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Keywords: moiré fringe topography, rasterstereography, edge-based moiré, trunk deformities

Abstract

This paper covers the biomedical applications of 3-D optical imaging techniques - moiré fringe topography and rasterstereography - in the study of posture and gait of children suffering from orthopedic and neurological disorders. Moiré fringe topography and rasterstereography are noninvasive, non-contact techniques which provide height and curvature maps of the body parts to be studied without using ionizing radiation. Techniques have been developed to project simultaneously moiré and raster grids and analyze height and curvature information separately using selective optical filtering for applications in gait analysis where the same position is difficult to reproduce. 3-D static and dynamic models of the human spinal column have been developed which generate spinal column in three dimensions and depict its movements during the four phases of gait cycle linking each phase with the subsequent one through edge-based algorithm. Combination of edge-based algorithm with moiré contours allows study of motion in the sagittal plane. These techniques could also be applied to study the three-dimensional structure of macromolecules by making their metallic replica. Some preliminary work was done on the flagella of salmonella typhus.

1. Photogrammetry in Medicine

Medical photogrammetry is the term used to cover all applications of photogrammetry in the broad field of medicine. The important advantages of photogrammetry over conventional methods for medical applications are:

- Photogrammetry is a noninvasive, non-contact and nondisruptive technique. It avoids risks involved in hurting, infecting, or distorting the human subject being studied.
- Photogrammetry can make it easy to measure objects otherwise inaccessible or difficult to measure.
- Photogrammetry enables to keep permanent records in the form of photographic images on paper, video-tape, diskette or CD-ROM.
- Body structures, which could not be seen or illustrated before, may often be studied by photogrammetry.
- Any desired degree of accuracy may be achieved by making a suitable choice of equipment and technique.
- Data obtained from photogrammetric measurements, especially if put in coordinate form, may be easily utilized by computer systems.
The different photogrammetric systems in use are stereophotography, holography, thermography, 3-D video laser scanning, edge-based and intensity-based algorithms, moiré fringe topography, rasterstereography and edge-based moiré. This paper deals with the biomedical applications of the last three techniques.

2. Three-Dimensional Imaging
   Techniques – Systems

In this section moiré system, raster system, simultaneous moiré and raster recording system and edge-based moiré system are discussed:

2.1 Moiré Fringe Topography Systems

Moiré fringe topography is a noncontact and noninvasive optical technique which provides a three-dimensional map of the human back without using X rays or any other ionizing radiation harmful for a growing child [4, 6, 31, 33, 39-42] and can be handled using various algorithms [45]. Moiré fringes are a series of interference fringes arising from the superposition of sets of parallel lines or threads, the sets being slightly inclined to one another. The width of the lines of the grid should be equal to the space between them. The various forms of moiré systems are described below:

2.1.1 Basic Form or Shadow Type Moiré Systems

The shadow type moiré fringe topography apparatus in use in Karachi consists of a wooden frame of external dimensions 57 x 133 cm (grid 52 x 108 cm). Black nylon fishing line of diameter 0.85 mm was wound vertically using a spring of pitch 0.75 mm. This method is simple and gives a lot of information, but it requires a large scale of equipment and it is difficult to maintain the standard of human bodies. Another moiré frame has been developed using "ARGENZA" cloth. In Malmö, Sweden the author worked on a moiré system in which the moiré grid was sandwiched between two glass panes.

2.1.2 Projection Type Moiré System

In projection type moiré fringe topography the human body is supported on a standard holder, and a grid image is projected on the back to form a transformed image according to the shape of the back. This image shall, then, be formed on a standard grid through a lens so as to generate contour line moiré fringe by superposing the transformed grid on the human back. This method gives a large amount of information. Accuracy can be changed by changing grids.

In both the shadow and the projection type the fringes are visible to the naked eye and hence can be used in setups where a permanent record in the form of a photograph is not required. The fringes could also be recorded on videotape. However, mispositioning cannot be corrected after the picture is recorded.

2.1.3 Grating Hologram Type Moiré System

Grating hologram type moiré fringe topography has the capability of adjusting the moiré fringes after recording. Grating hologram type of system consisted of projecting a moiré grid (Fig. 1a) on a child's back and photographing the distorted grid. The reference grid is reprojected at the same angle,
and with the same magnification on the photograph of the distorted grid to view moiré fringes. For gait analysis and simultaneous moiré and raster recording grating hologram type was found to be most useful.

In short, shadow type should be chosen if quantitative accuracy is desired, projection type if open space is needed and grating hologram type if posterior adjustment of the fringes is the requirement.

2.2 Rasterstereography System

Rasterstereography is very similar to stereophotography. Difference is that one of the cameras is replaced by a slide projector projecting a raster (Fig. 1b) on the human back [26, 37]. Because of the curvature of the body the raster is distorted. Study of this distortion provides information about the topo-logical properties of the surface under study. The remarkable feature of rasterstereography is that it does not require a specific arrangement of apparatus to obtain meaningful rasters whereas only a specific geometry of the moiré set up would provide contours with the desired mathematical properties.

2.3 Simultaneous Moiré and Raster Recording System

For simultaneous moiré and raster recordings we used a 35 mm camera, 2 slide projectors, a moiré grid (Fig. 1a) and a raster grid (Fig. 1b) [26]. Moiré grid was prepared in red color and raster grid prepared in blue color. Both the grids were simultaneously projected on the body using 2 slide projectors as shown in Fig. 2. After a color photograph was obtained a red filter matching with the color of the original moiré grid was placed on it. The red moiré grid became invisible and the blue raster grids appeared black. These were, then, fed in the scanner for analysis using rasterstereography algorithms. Similarly, a blue filter matching with the color of the raster grid was placed on the picture. Raster was suppressed and the moiré grid appeared black. Then a standard moiré grid was projected at the same angle to produce moiré fringes. Success of this procedure depends critically on proper matching of the colors.

Figure 1: Grids for (a) moiré fringe topography and (b) rasterstereography
2.4 Edge-Based Moiré Algorithm

This is a combination of edge-based algorithm and moiré pattern [15]. Since moiré contours provide height maps in a plane perpendicular to the image moiré patterns would change if the object is moving towards or away from the observer. Consider the moiré patterns of back of a person. If that person starts moving the moiré patterns shall also move. If the person is moving away from the observer the patterns would start converging and appear to sink in the scapulae. Motion away from the observer, therefore, corresponds to a sink field in the moiré patterns of the convex surfaces (Fig. 3a). For a person moving towards the observer new diverging patterns will appear from the scapulae (Fig. 3b). Motion towards the observer, therefore, corresponds to a source field in the moiré patterns of a convex surface. For a concave surface the roles shall be reversed. For a concave object moving towards (away from) the observer the patterns appear to converge to (diverge from) a point where depth has a local maximum corresponding to a sink (a source) field.

3. Three-Dimensional Imaging Techniques — Parameters For Study

In order that the information obtained from these photogrammetric techniques be scientifically and clinically relevant one must consider the following.

3.1 Image Quality

Image quality depends on a number of factors. Some of the considerations are:

3.1.1 Sharpness of Image

To obtain sharper fringes for our fishing line shadow type moiré system we used parallel light from a slide projector and applied talcum powder on child’s back. Image quality depends critically on the choice of light source. We are in the process of evaluating fringe quality using torch light, gas light, candle light and collimated candle light.

3.1.2 Distortions

The more are the optical elements in the system the more is the distortion. Therefore, one would realize that as compared to shadow type the distortion error in projection type and grating hologram type is a factor of 2-3 in the depth and in sides. Distortions in our grating hologram type system have been minimized.

3.2 Reproducibility

Our group found the moiré technique to be 99.5% reproducible [14, 23]. Tests were conducted using Swedish system (pitch 2 mm) with moiré grid sandwiched between two glass panes.

3.3 Accuracy and precision

Accuracy and precision of our fishing line shadow system (pitch 1.5 mm) have been estimated as 99.61% and 91.21% respectively [33].

3.4 Sensitivity and specificity:

99% sensitivity of moiré fringe topography is reported in the literature in the context
of scoliosis screening. However, sometimes because of mispositioning subjects a large number of false positives are generated [1]. To reduce these false positives (that is, increase specificity of moiré) we took moiré topographs on a level surface [29, 30], sometimes used an alignment system [7] and corrected leg-length inequalities. Further, referral was based on more than one test and not on a single test.

4. Applications In Biomechanics, Orthopedics And Neurology

The word "orthopedics" means straight child. In fact, bad posture and gait are the first impressions which one gathers about a prospective candidate during a job interview. It becomes of prime concern for military and paramilitary occupations. To cater for a better body and self image it is necessary that we develop children having straight spines and well-balanced gait. During the last few years there has been an increasing awareness about heavy school bags producing spinal problems. Articles and cartoons projecting these problems have appeared in the dailies. There is a need to develop scoliosis screening tests which are quick, reasonably sensitive and specific as well as easy to conduct on school/basic health unit premises [2].

Schools should organize posture, gait and scoliosis screening programs (which must include moiré examinations of back) as part of general health care. All children between the ages of 5 and 10 should be screened yearly for scoliosis [4, 27-30, 34-36, 43]. Scoliosis screening of school-age children is compulsory in Japan.

The moiré technique is being used for the study of both posture [24, 25] and gait [15, 26, 37, 44], detection of trunk deformities [2, 4, 27-30, 34-36, 43] and neurological
disorders [21, 22] as well as static and dynamic modeling of the human spinal column [5, 8-12, 16, 17]. Static modeling consisted of generating a profile of the human spinal column (in three dimensions) from moiré topograph of back with the person in the anatomical position [16]. Dynamic modeling consisted of generating profiles of spinal column in the first, the second, the third and the fourth phases and connecting each phase with the subsequent phase through edge-based algorithm (after phase 4 comes phase 1 of the next step) [17].

Applications of moiré techniques in kinesiology, biomechanics, orthopedics and neurology include study of full-length moiré of back and front. Both halves of the human body may be compared regarding structural asymmetries. Straightness of the spinal column (in frontal plane) may be determined by computer model of spine generated from moiré topograph of back [44]. This may also be evaluated by obtaining moiré topographs of shoe soles and footprint molds obtained while the child is standing in the anatomical position. Study of footprints on sand while the child walks (normal or stereo pictures) during a complete gait cycle could also indicate problems in gait. Similar studies of curvatures on shoe soles and footprint molds could be performed using rastersteroigraphy.

No screening and follow-up program could be effective without community support. Awareness of good posture and prevention of spinal curvatures may be produced through parent-teacher meetings or during special child guidance courses arranged on school campuses. Media (Internet, TV, radio, newspapers, magazines) can also play a role. A humble effort is being done in this direction [13, 18-20].

5. Applications In Molecular Biology

The flagella of salmonella typhus were obtained by biochemical methods and their images were stored as UNIX Files from the electron microscope images. These were converted as VAX/VMS images through VAX-Ultrix software. The images were then aligned using the image-processing algorithm "SPIDER" (System for Processing Image Data in Electron Microscopy and Related Fields). The motifs were aligned first in a coarse manner and then fine-tuned by finding cross correlation coefficients of the aligned
images. The similarities showed up in mean and the differences in standard deviation. This way main features of the flagella were highlighted from the mean of, say, 100 images. The alignment improved significantly if the images were Fourier filtered prior to alignment. Another way to study the structure of these flagella is to make their metallic replica using fast freeze method and then look at their surface properties using stereophotogrammetric techniques like moiré fringe topography and rasterstereography. This work was performed in Departments of Structural Biology and Biophysics of Albert Einstein College of Medicine, Bronx, New York (USA) while the author was a visiting research fellow there.

6. Conclusion

In the coming years moiré and raster techniques will supplement and possibly decrease the conventional X rays. These techniques may find immediate applications in computerized construction of artificial limbs as well as braces to treat scoliosis. Unlike holography moiré techniques donot require the subject (or object) to be still. Hence, these techniques could be used to describe infinitesimal motion of the object. An immediate visual illustration of the magnitude and the direction of motion is available by combining edge-based algorithm and moiré contours. This technique, therefore, makes it possible to have a three-dimensional map (position) and a three-dimensional motion profile (velocity) without involving differentiation. Using edge-based moiré algorithm chest-wall as well as stomach movements may be monitored and quantified. Dynamic model of the human spinal column as well as edge-based moiré may be used to study gait in neurological and muscoskeletal disorders. The moiré technique combined with rasterstereography may prove to be useful in providing noncontact, non-destructive, noninvasive, safe and reliable methods to study trunk asymmetries. Computations may be simplified using multigrid techniques [38]. Edge-based moiré algorithm may also be applicable for studying mechanical structures and small motions (vibration testing) using image processing.

Moiré and raster techniques, therefore, offer much scope in the medical sciences and shall become some of the most important nonradiological scanning techniques of the third millennium.

References

2. Ahmad, B. & Hashmi, U. F., "To develop different techniques to study spinal deformity", MSc. Project, 1990, University of Karachi (unpublished) - supervised by Dr. S. A. Kamal

positions". In: Surface Topography and Body Deformity (Proc. 5th Int. Symp.), (1990) loc. cit., pp. 77-78


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