Shape Survey of Symmetric Bodies Through the Moiré Interferometry.

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ABSTRACT.
This research work reports a study of shape determination of bodies with regular geometry as cubes, cylinders, and spheres by employing a moiré method. The selected method is named geometric projection moiré, which consists in projecting a grid onto a background and in a second step to project the same grid onto the object in study before the background. Both images were captured by a digital camera and the archives transferred to a PC for further processing. Generated fringes are then multiplied pixel to pixel as well as contrast increased and equalized by means of "COREL PHOTO-PAINT" software. Fringes are transformed into sharp contour lines by means of the "RIISING SUN MOIRÉ" software. The dimensions of the object are proportional to the number of fringes generated onto its surface. The procedure of image analysis involved the software named "COREL PHOTO-PAINT", and "RIISING SUN MOIRÉ". Geometrical measurements of cubes, cylinders and spheres of ten different sizes were obtained by means of a digital caliper and compared with those generated by the optical method under study. The paper presents conclusions based on probable error sources as well as future automation process development.

Key words: Moiré Techniques, shadow moiré, fringe multiplication, perfilometry.

INTRODUCTION.

Problems involving shape survey are of very common occurrence in agriculture science. As examples it could be mentioned several topics where the shape or geometric profile of bodies are of major interest as fruit sorting, plant architecture, plant - machine mechanical interaction, mechanical behavior of vegetative materials, dimensioning of machine elements, shape study applied to animal husbandry, etc. The name moiré has its origin in the French language, referring to wave like pattern. The phenomenon is generated when screens of certain mesh density are superposed, producing wave like patterns or fringes, which move when its relative positions are displaced (Sciammarella, 1982). The literature discloses the name of Lord Rayleigh, 1874 (Oster et al, 1964) which proposed the application of a moiré technique in testing diffraction grids. Mulot (1925) employed this technique in studying deformations of mica layers. Later on, Tollenar (1945) found that moiré fringes serve to magnify displacements, being suitable to photoelastic analysis. Recent reports present comprehensive classifications of the methods termed as moiré. The objective of this work is to compare the volumes of symmetric bodies obtained from direct measurement with digital caliper with those obtained from the moiré method, validating, this way, the proposed technique to non symmetric bodies. The experimental phase employed cubic, cylindrical as well as spherical specimens of ten different sizes. A statistical analysis was performed to consider error generation. Recent literature discloses relevant research works on machine vision for shape detection, sorting, surface defects detection, fruit on line orientation, grading process and others.

METHODS.

Specimens were made of black rubber and covered with white opaque painting to improve contrast conditions. This way ten different sizes of cubes, ten cylinders and ten spheres were prepared for the tests. Table 01 shows the dimensions of the specimens, Figure 01 shows the dimensions of the grid and Figure 02 illustrates the employed experimental setup. A regular Kodak slide projector was employed as a light source and a Sony digital camera used to capture the images. A 3.58 mm period by 3.58 mm thickness grid was used for the tests. The grid was firstly projected onto a background and its image recorded by the digital camera. In a second step the same grid was projected onto the object in study before the background and that new image again recorded by the digital camera. Both images were then transferred to a PC for further processing. Generated fringes are then multiplied pixel to pixel as well as contrast increased and equalized by means of "COREL PHOTO-PAINT"
software. Fringes are transformed into sharp contour lines by means of the "RISING SUN MOIRÉ" software. The dimensions of the object are proportional to the number of fringes generated onto its surface. The "Corel Photo Paint" software was then employed to equalize and to improve fringes contrast.

Table 01. Dimensions of cubical, cylindrical and spherical rubber specimens. Digital image analysis

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Cube (cm)</th>
<th>Cylinder (cm)</th>
<th>Sphere (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.02</td>
<td>17.61</td>
<td>19.22</td>
</tr>
<tr>
<td>2</td>
<td>25.16</td>
<td>26.06</td>
<td>26.55</td>
</tr>
<tr>
<td>3</td>
<td>29.81</td>
<td>30.79</td>
<td>31.41</td>
</tr>
<tr>
<td>4</td>
<td>35.10</td>
<td>38.33</td>
<td>37.56</td>
</tr>
<tr>
<td>5</td>
<td>39.91</td>
<td>43.51</td>
<td>44.09</td>
</tr>
<tr>
<td>6</td>
<td>44.73</td>
<td>50.03</td>
<td>49.05</td>
</tr>
<tr>
<td>7</td>
<td>49.33</td>
<td>56.01</td>
<td>55.81</td>
</tr>
<tr>
<td>8</td>
<td>54.26</td>
<td>62.49</td>
<td>62.47</td>
</tr>
<tr>
<td>9</td>
<td>59.29</td>
<td>68.84</td>
<td>68.87</td>
</tr>
<tr>
<td>10</td>
<td>64.95</td>
<td>74.65</td>
<td>74.68</td>
</tr>
</tbody>
</table>

Figure 02. Dimensions of the grid employed in the tests.

Figure 03. Experimental setup.

RESULTS.

Figure 03 shows the fringes generated on the tested cubic specimens, Figure 04 shows the fringes on cylindrical specimens and Figure 05 shows the fringes on the spherical specimens, meanwhile. Table 02 displays the values presented on Table 01 together with the physical dimensions data obtained with the moiré method. From that last table it is noted that the maximum and minimum errors is near 7.0 % and 0.15 % for cubic specimen, 2.06 % and 0.02 % for cylindrical specimens and 7.72 % and 0.43 % for spherical specimens.
Figure 03. Fringes generated on cubic specimens.
Figure 04. Fringes generated on cylindrical specimens.
CONCLUSIONS.
Based on what it has been exposed before, the following conclusions can drawn:

- Error between both methods could be brought to a minimum value if a more dense grid and coherent light were used.
- Projection moiré can be considered a suitable and practical method for shape survey of bodies.
- Future studies should consider processing time to support further applications as fruit sorting.

REFERENCES.


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Mulot, 1925 Apud Lino, 2002.


