3D Reconstruction of External Anatomical Structures using Computer Vision

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Contents:

• Introduction to 3D Vision;
  – Methods for Human Body Reconstruction;

• Used Methodology;

• Experimental Results;

• Conclusions;

• Future Work.
3D Vision:

- 3D reconstruction of objects from images has been one of the major research topics in Computer Vision.

- Modeling the human body was initially needed in the automotive and aeronautics industries for ergonomic purposes:
  - models used were consisted by articulated skeletons;
  - the body was represented using simple geometric primitives, such as cylinders or parallelepipeds.

- Actually, 3D models of the human body are very realistic and of great interest in a variety of application fields:
  - cinematographic industry;
  - virtual reality;
  - clothing industry;
  - biomedical applications…
Some methods for 3D reconstruction of the human body:

- **Commercial scanners**: generally expensive but easy to use and the models obtained are of great accuracy;

- **Stereo-based methods**: commonly used and well studied, but usually are not adequate for objects with smooth surfaces;

- **Volumetric methods**:
  - more efficient than stereo-based methods, because they work on the 3D objects space and do not require a matching process between images;
  - based on the visual-hull concept.

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Used methodology:

1. **Acquisition of two image sequences:**
   - first: moving freely a planar chessboard calibration pattern;
   - second: with the object on a turntable device, with the calibration pattern beneath it, and keeping the camera untouched, the images are acquired spinning the turntable device until a full rotation is performed.

2. **Camera calibration**: Zhang’s method;

3. **Segmentation** of the second image sequence;

4. **3D reconstruction**: using the volumetric method *Generalized Voxel Coloring - GVC*;

5. **Polygonization and smoothing** of the obtained 3D model: *Marching Cubes* algorithm.
Results:

Image acquisition

- **Two objects were experimentally used**, distinct in size and in shape complexity: a hand and a human torso.

- Some image of the sequences - **hand case**:
Results:

Image acquisition

- Some image of the sequences - torso case:
Results:

Camera calibration

- Error in the 2D reprojection of the used 3D calibration points:

<table>
<thead>
<tr>
<th>Object images</th>
<th>Error standard deviation (in pixels)</th>
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<tr>
<td></td>
<td>x</td>
</tr>
<tr>
<td>hand</td>
<td>0.4891</td>
</tr>
<tr>
<td>torso</td>
<td>0.1547</td>
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- Graphical representation of the extrinsic parameters obtained:
Results:

Background/object segmentation
Results:

3D reconstruction and polygonization (smoothing)
Results:

Characteristic measurements

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Conclusions:

- the 3D reconstruction of accurate 3D models of external anatomical structures from images is difficult and complex;
- the quality of our results are highly dependent on:
  - the accuracy of the camera calibration process;
  - the objects silhouettes segmentation;
  - the complexity of the objects shape;
  - the reflectance of the objects surface.
- our methodology can obtain adequate 3D static reconstructions of human external structures from images in controlled environments;
- computationally the GVC volumetric method is very demanding and consequently slow, which can be unsuitable for interactive and/or real-time applications.
Future works:

- **improvement** of the camera calibration step / consideration of **self-calibration** methods;

- development of **adequate photo-consistency criteria** for objects with surfaces of (almost) **uniform colours**, as is the case of human anatomical structures;

- implementation of **3D reconstruction methods** for objects whose shape is varying along the image sequences (**non-rigid objects**);

- implementation of a **coarse-to-fine approach** (e.g. using **octrees**) / development of **parallel implementations** to speedup the 3D reconstruction process.
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Thank you!

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