

STEREOMETRIC IDENTIFICATION OF OBJECTS SHAPE

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Abstract

In this paper, the fundamentals of the reverse engineering with a definition of the methodology for optical identification of the object geometry are presented. The optical identification is done by a photo-camera and utilization of a stereometric method for determination of coordinates of the object. Coordinates of the object are used for its modeling and manufacturing with a numerically controlled machine (NC).

Key words: stereometric identification, reverse engineering, CAD

1. INTRODUCTION

Reverse engineering represents processing already existing product. In every day communication, it is known as making a copy of the product (e.g.3). Reverse engineering contains several phases:

- Identification of the object
- Modeling of the identified object
- Manufacturing of the object by a NC machine

2. STEREOMETRIC METHOD FOR IDENTIFICATION OF OBJECT

Measuring optical system is less used in the field of mechanical engineering. A positive feature of the system is its acceptable price and improvisation possibility. A measuring optical system contains digital cameras (stereo camera) with high resolution (3000 dpi) and a commanding with data processing computer.

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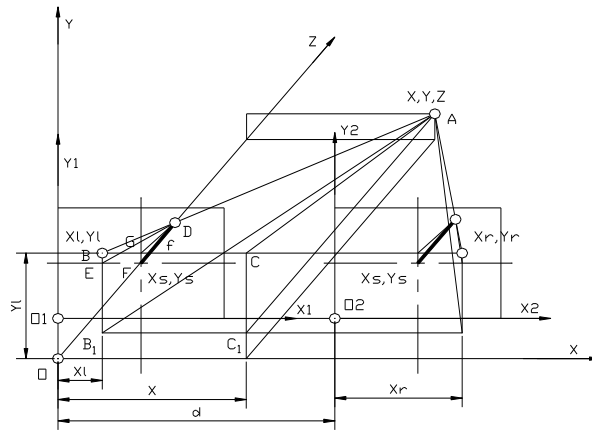


Figure 1. Method for developing of coordinates of stereo identification

Photos obtained in stereo pair with software are transformed into three-dimensional picture, which can be received by stereo glasses. Coordinates of the points are defined by a stereometric procedure from the three-dimensional picture or two stereo projections. The procedure is geometrical (e.g. 5).

The method for defining three-dimensional coordinates on one point of stereometric projections is explained on figure 1. Identified object is the point A with coordinates x, y, z set subjectively in the space with coordinate system $Oxyz$. Identification is performed by two cameras with focus distance f . Cameras are set on distance d . Projective ray is drawn from point A through point D and is projected on the left or on the right plane (photos) in point B with coordinates x_L, y_L and x_R, y_R . Projective planes are defined with axes x_1y_1 and x_2y_2 . The plane middle is defined by coordinates x_s, y_s . Projection of the point A upon xy plane is point C_1 . From triangle similarity $\triangle ABC$, $\triangle AB_1C_1$ and $\triangle DEF$, $\triangle DBG$ a system of three equations with three unknowns x, y, z is given by

$$\begin{aligned} z(x_s - x_L) &= f(x - x_L) \\ z(x_R - x_s) &= f(x_R + d - x) \\ z(y_L - y_s) &= f(y_L - y) \end{aligned}$$

By solving equation system are given

$$x = \frac{x_R x_s + x_s d - x_L d - x_L x_s}{x_R - x_L}$$

$$z = \frac{f(x_R + d - x)}{x_R - x_S}$$

$$y = \frac{fy_L - z(y_L - y_S)}{f}$$

Defined equation system is developed in software with possibility for determination of three-dimensional coordinates. Software consist ARX library, with direct connection of program language C++ and AutoCAD. Test object (test cube) is inflicted in field beside photograph object (figure 2). Focus distance f of photos in stereo pair is defined with geometric method. The method is rectified small displacements of 3D coordinates and is decelerated the distortion effect.

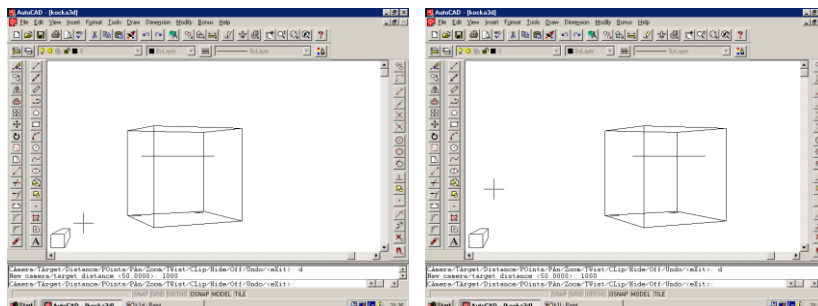
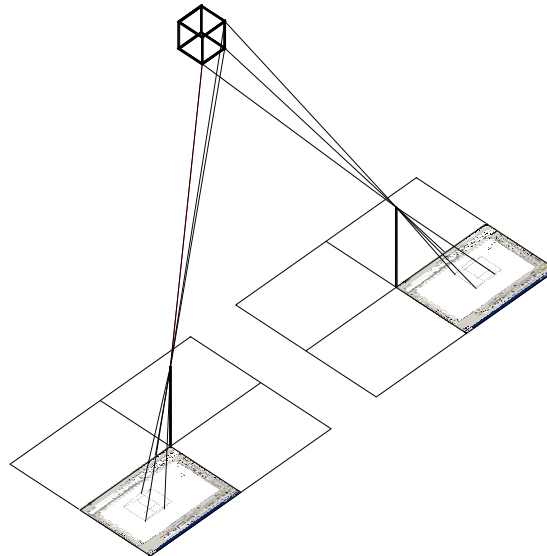


Figure 2. Method for rectification of 3D coordinates

In this paper, an experiment of the product identification is presented. A product has been chosen – computer mouse. Stereometric identification of the object is done a camera *Pentax 80* with maximum focus distance 80 mm (Figure 3). Stereometric data processing is created on *Silicon Graphics Computer* using stereo glasses. A scanner *Vexcel - VX3000*, scans negatives of the photos by resolution 3000 dpi.

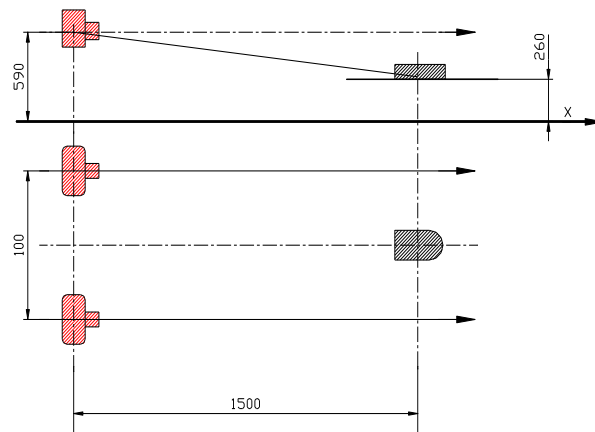


Figure 3. Stereo identification of the computer mouse

Plastic bottle is chosen in the second experiment. Stereometric identification of the object is done a digital camera *Sony DSC-P32* and *PComputer*.

Coordinates are defined by photogrammetric procedure. Photogrammetry is a skill of defining real dimensions of the photographed object from two photos. Computer processing of the photos in digital forms creates acquisition of data at digital systems. Digital pictures signify a matrix of pixels with different values, which can be obtained by far detection method or by CCD (*Charge Coupled Device*) camera photographing as well as indirect, by scanning analogous photographs. The process of digital photogrammetry can be presented in three steps:

- Triangulation
- Stereorectification
- Generating DTM and orthorectification

Triangulation is measuring with help of connected triangles where the points and edges are defined by trigonometric procedure. Identification is done by amateur camera where the entrance real elements (determined by camera calibration) are not known, a great

number of values are accepted as ideal, which in any case do not correspond to the real situation. All this has great influence on the right solution in the process of triangulation.

Stereoscope effect is achieved by rectified photographs in epipolar presentation (Figure 4). Three-dimensional coordinates are transforming into two-dimensional coordinates with four systems of polynomial (e.g. 4).

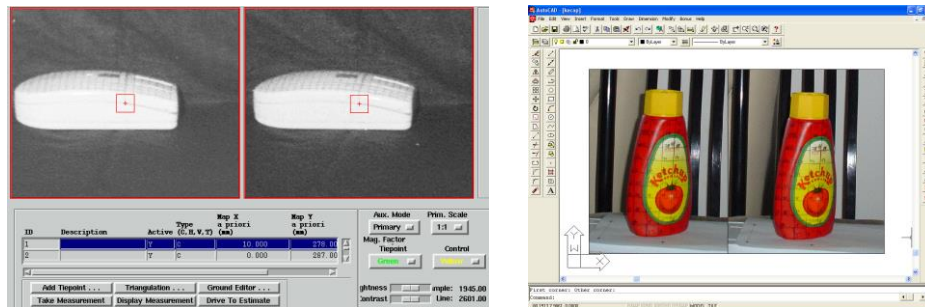


Figure 4. Stereoscope effect

DTM (*Digital Terrestrial Model*) is generated through automatic acquisition of TIN (*Triangulated Irregular Network*) and/or DEM (*Digital Elevation Matrix*). There with space coleration algorithm is used, processing the pixel through the whole process. Primary correlation measurement uses differences in the contrast and illumination between photos (e.g. 1,2).

Orthorectification is completely automated process of the central projection and third dimension effects elimination. The process is transformation pixel by pixel from photo to space elements.

Coordinates of identified object are determined precisely with a micron value.

3. MODELING AND MANUFACTURING OF OBJECT (PRODUCT)

Object modeling is performed with commercial software. Object coordinates are imported in the software and a solid model of the object is created (Figure 5).

3D coordinates of modeled object are put in NC machine computer. To get NC code of modeled object an algorithm is created. NC code with simulation of the object production in the NC machine computer is verified. Then production of the object follows. Similarity of manufactured and original object is verified by comparison.

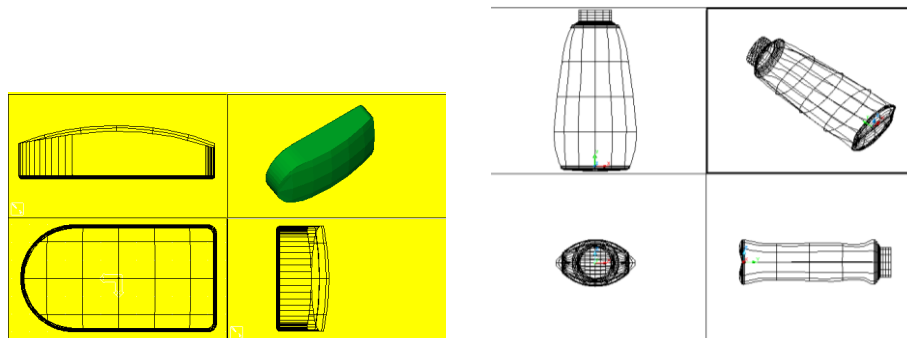


Figure 5. Modeling of the object

4. CONCLUSION

Significance and development of stereometric projecting comes out of the great number of papers presented in the world. Stereometric projecting is a part of the geometry being developed a long time ago, but it is respectably improved in the last years for its great application in industry and everyday life.

The stereometric technique is built in the reverse engineering. Identification or object dimension determining is performed by a stereometric method. Economy is priority of this procedure. The process doesn't depend of object size, where as other methods of identification by touch machines and laser are limited. Identified object (product) with help of determined coordinates is modeled. Then modeled object or product is manufactured in NC machine.

5. REFERENCES

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