REVERSE ENGINEERING VISION TECHNIQUE APPLYING IN TRANSPORT SYSTEMS

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Abstract

The paper is focusing on a designing conception of the 3D type operation workspace (digital map) of a transportation device (based on an overhead crane), included possible obstacles influences at movement trajectory shaping of goods as subject of replacements. System proposal conception is built based on a reverse engineering vision type technique.

Contact less an object geometry mapping methods, laser triangulation system with CCD camera, Indirect measuring the height of the detail with use of the vision system, the 3D scanning testing system, Example of a real object (left side) with the CAD model (right side) received with laser scanning method, Laboratory double girder crane, selected research activities carrying out with the crane use, the crane workspace mapping block scheme are presented in the paper. Presented in paper scanning conception of the possible transportation limited 3D type workspace is requiring further research focusing on automated mapping system the material handling devices. The research must include also selected possible obstacles (including containers) shape, surface features and colour, as well as environment possible noise (e.g.: non sufficient lighting, limited visibility, workspace dimensions).

Keywords: *operation space reconstruction, transportation, reverses engineering*

1. Introduction

During last years the goods are more and more world-wide transported as a unified units (containers) based on the TEU (*Twenty feet Equivalent Unit*). In 1985 the world economy generated global transport on the level of 50 million TEU and in 2005 the number of transported containers grows about over the 700% [3]. Today in terminals the reloading of containers from one to other transport device (mode) or from to storage area, with taken under consideration: time, cost, safety and availability of technical infrastructure, is a crucial problem in total transportation chain [1, 3, 7, 8]. The containers are mostly a subject of replacement with use overhead cranes. One of the critical replacement factors is a problem of identification the possible obstacles (expressed via their coordinates, geometry) in the transportation device 3D type operation workspace to optimal movement trajectory shaping of goods as subject of replacements.

Today operators mostly control cranes. The coming future automated cranes must operate autonomously on-line with use known operation workspace based on a digital map. To create dynamical crane operation 3D type workspace, the known solution is to use the CCD type camera to create operation space image (Fig. 1) or use a reverse engineering vision type technique [5].

Reverse engineering (RE) is the process of discovering the technological principles of a device or object. With use the RE approach the creation of three-dimensional digital models of physical objects with their geometrical structure is possible.

The paper is presenting the design conception the 3D type operation workspace (digital map) of a transportation device (based on a overhead crane) with possible obstacles influences at movement trajectory shaping of subject.

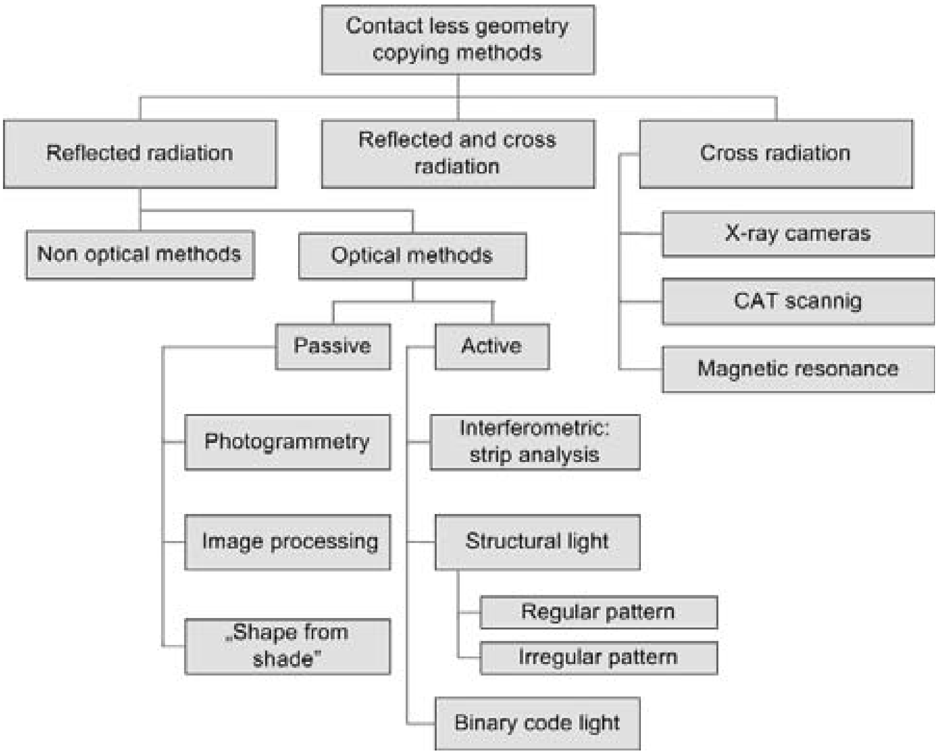

Fig. 1. Contact less an object geometry mapping methods

2. Vision technique in the operation workspace mapping

Applying the known vision based techniques to three-dimensional transport device operation space with possible objects presentation, as the digital map (e.g.: photogrametry), is not so useful because object-marking needs and the time periods needed for the inspection and computer images analysis. Resulting the known literature analysis [4, 5] the laser technique has been proposed for object scanning.

Methods of scanning with dispersed bundle (line emitter) [6] are based on technique of the triangulation that uses the projection approach with the calibration for one of triangulation directions [2]. In layouts of the laser triangulation the explored surface is a subject of scanning, while the laser line has been recorded via the CCD type camera (Fig. 2). Also to solve existing inconvenient a conception proposal system focusing on object height measurement of possible obstacles in operation space has been workout (Fig. 3).

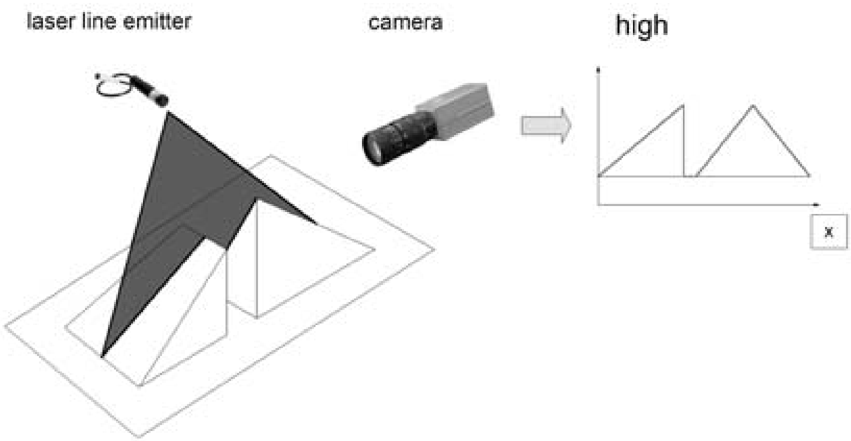

Fig. 2. Laser triangulation system with CCD camera

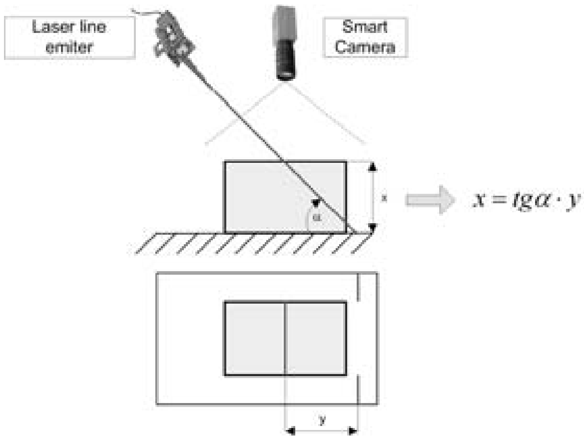

Fig. 3. Indirect measuring the height of the detail with use of the vision system

The height x of the object (Fig. 3) is being measured in the indirect way with using the laser line emitter. The x value is determined with the help of mathematical formula. The height of the object is the function of glancing angle of rays to the laser line and of the distance between dispersed laser lines.

The 3D scanning testing system conception is presented in Fig. 4. The essential elements of the measurement system are laser triangulation set with one immobile CCD type camera and two rectangular plates assembled under 90 degree (Fig. 4).

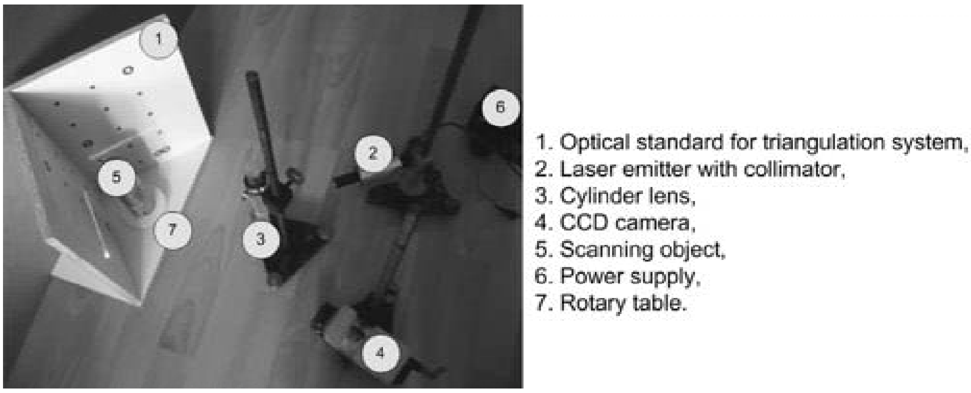

Fig. 4. The 3D scanning testing system

The arrangement of the measurement of the distance consists emitter (source of the laser light) and the receiver (CCD camera with lens). The laser emitter emits laser line with the cylinder lens set and a distance between laser emitter and CCD camera is constants. Light beam reflect from the object and return to detector of the CCD camera (calculation displacement *r*). Knowing lens focal and place of falling down of a beam light on the detector (*dx*), it is possible to appoint the distance from the object with the help of equation (1):

$$r = \frac{b}{\frac{dx}{f} + \frac{1}{tg\alpha}}, \tag{1}$$

where:
r - object distance,
b - rangefinder base,
f - focal length,
α - beam transmitter angle inclination,
dx - laser point on CCD detector.

Final effect of copying the geometry with the 3D scanner is so-called as *cloud of points* and after software processing is presented as *.stl type file format (stereolithography). This format is fully convertible to 3D object type computer added presentation and modelling (Fig. 5).

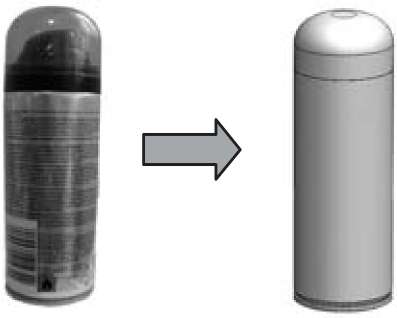

Fig. 5. Example of a real object (left side) with the CAD model (right side) received with laser scanning method

3. Research environment

The presented laser mapping system will be a subject of a practical experiments with using the double girder overhead travelling crane with Q = 150 [kg] hoisting capacity localized in the Automated Transport Laboratory of the AGH University of Science and Technology [7, 8] – Fig. 6 and 7.

Fig. 6. Laboratory double girder crane

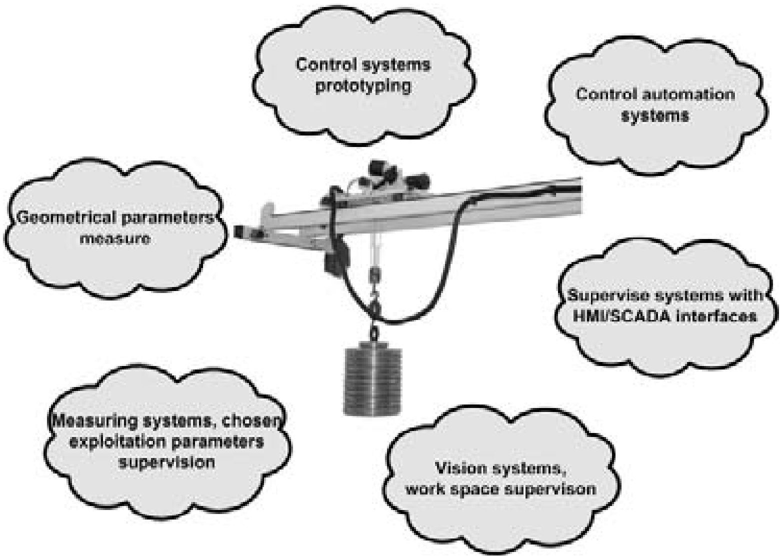

Fig. 7. Selected research activities carrying out with the crane use

The laser mapping system is presented on the block scheme on Fig. 8. The crane workspace also is supplemented with special light diode elements supported object recognition during mapping process.

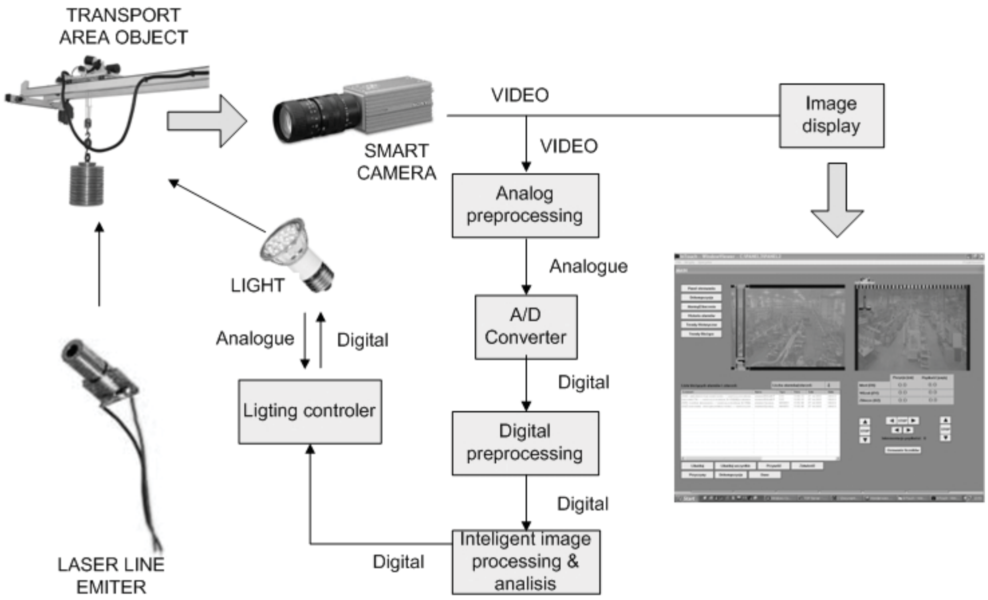

Fig. 8. The crane workspace mapping block scheme

4. Conclusions

Presented in paper scanning conception of the possible transportation limited 3D type workspace is requiring further research focusing on automated mapping system the material handling devices. The research must include also selected possible obstacles (including containers) shape, surface features and colour, as well as environment possible noise (e.g.: non sufficient lighting, limited visibility, workspace dimensions).

Applying in transportation activities the computer aided vision techniques based on so-called reverse engineering enable work out new tools, which will help to improve management effectiveness of material handling devices.

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