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A method for detection of randomly placed objects for robotic handling

Panagiota Tsarouchi, Stereos-Alexandros Matthaiakis, George Michalos, Sotiris Makris, George Chryssolouris *

Laboratory for Manufacturing Systems and Automation, Department of Mechanical Engineering and Aeronautics, University of Patras, Patras 26500, Greece

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ABSTRACT

The image based systems still have open issues in order to meet the latest manufacturing requirements for simplicity, low cost as well as the limited maintenance requirements. In this direction, there is a method proposed for the recognition of 3D randomly placed objects for eventual robotic handling. The method includes a 2D vision system and is combined with data from computer-aided design (CAD) files for the generation of 3D coordinates. It is generic and can be used for the identification of multiple randomly placed objects. The method has been implemented in a software tool using MATLAB® and has been applied to a consumer goods case for the recognition of shaver handles.

Introduction

Important aspects of vision systems, in robotic applications, are the simplicity of the algorithm, the low cost and the reduced need for maintenance, while aspects such as the fast and effective identification still constitutes an unsolved problem. Even though adequately efficient and accurate algorithms have been developed, the processing speed still fails to meet the modern manufacturing requirements [1]. The problem becomes further complicated owing to the objects' properties, such as shape, material, colour, etc. Additionally, the requirements for simplicity and low cost are directly connected to the production rate that is expected to be increased with the introduction of robotic equipment in modern production lines [2].

The need for objects' recognition systems is met in multiple industrial applications, where different objects of variable shapes and sizes should be handled. An example of such an application is the consumer goods industry. This sector lacks in flexible, low cost and simple automation solutions that will eventually cope with high production rates and a variety of products (Fig. 1(a)). Currently, the high speed feeding and handling of objects imposes the need for dedicated equipment, namely feeder bowls. Such solutions are characterized as noisy, expensive and are dedicated to product specific equipment. Specifically, feeder bowls (Fig. 1(b)) cannot perform in more than one product, whilst for new products need redesigning.

An extended review on the sensor technologies and the research trends for assembly systems have shown that vision systems are suitable for objects' recognition, inspection and robot handling applications [3–8]. Vision-based robot control is investigated in [9–14], while a survey on the visual servoing systems is presented in [15–17]. Research has been done in the design aspects of the machine vision systems for industrial applications [18], and has led to improvements in reliability and product quality [1,19,20]. The vision system classification was investigated in [21–27].

The pattern recognition method has also been investigated in [14,28,29], while 3D vision systems have been presented in [30–38]. Such systems have the advantages of recognizing the objects' characteristics, but they are based on complicated algorithms and are prompt to failures in industrial environments. Methods for errors measurement in vision systems have been researched in [39], while techniques for the classification of objects and point descriptors are designated in [40–44]. Histogram-based image descriptors have been evaluated for the classification of 3D objects [45], while a comparison between the methods of local and full ranking point descriptors was reported in [46,47].

A low cost system is proposed for 3D randomly placed objects in order to meet the challenges of the semi-structured industrial environment. This system is based on simple algorithms for the recognition of 2D objects combined with CAD data for the computation of 3D coordinates. The use of CAD data, instead of a 3D vision system, reduces the complexity and the cost. The object pose recognition is based on observations with the physical object, while the measurement of 3rd coordinates, along the z axis, was made with the help of the object design files (CAD). The techniques

* Corresponding author. Tel.: +30 2610 997262; fax: +30 2610 997744.
E-mail address: xrisol@otenet.gr (G. Chryssolouris).

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Fig. 1. (a) Variety of products in consumer goods industry and (b) feeder bowls.

of the 2D vision system comprise basic image processing algorithms for the identification of the Points of Interest (POIs) and the object pose identification in the image. The method is applied to a consumer goods pilot case.

Method description

The proposed method includes (a) an offline system using the CAD files of the objects and (b) an online system for the recognition of object poses and 2D POIs (Fig. 2). The offline system is used for the observation of the candidate objects in order for the different poses and the POIs to be decided upon. Observations with physical objects allow the identification of the different object's n poses and the definition of the POIs. The distance from the object's lying surface and the POI along the z axis is measured in a CAD software platform for the n different poses. The z axis coordinate of each different POI is stored and used later on, in the online vision system.

The image based recognition system runs online in order to detect the object's poses and compute the 2D POIs coordinates. The transformation between the image plane and the world reference frame (WRF) of the estimated 2D POI follows. Since the 2D POI coordinates have been estimated, the 3D POI coordinates are generated with the help of the offline system.

The online system starts with basic image processing techniques and principles, via the combination of algorithms for object pose detection and POI recognition. The geometrical features, such as the pose, orientation, coordinates of the POIs, etc. are computed via the binary image processing and the contrast value measurements in the blue band of the RGB image. In the RGB image, the value of 255 is considered being 100% visible in terms of blue colour and 0 of being fully transparent, based on a single 8-bit byte system. The object's shape is approximated with an ellipse and some of its geometrical features are computed with the help of the ellipse, comprising the major, minor axis, edges, middle points, orientation, etc. Other features that have been taken into account are the centroid and middle points, which are estimated by diving the distance of the major axis.

The next step concerns the automatic object's pose detection. This method is based on the maximum distance between the k middle points and the centroid point. The poses are decided upon the distances of these k points (Eq. (3.1)), as well as their contrast values in the blue band. The POI automatic recognition is computed on the basis of the highest contrast values, compared with those of the middle points, depending on the object.

$$DIFF_k = |C_{MP}^k - C_{CP}| \tag{3.1}$$

where:

- $DIFF_k$ is the absolute difference of the contrast values between the k middle points and the centroid;
- C_{MP}^k is the contrast value of the kth middle point;
- C_{CP} is the contrast value of the centroid point.

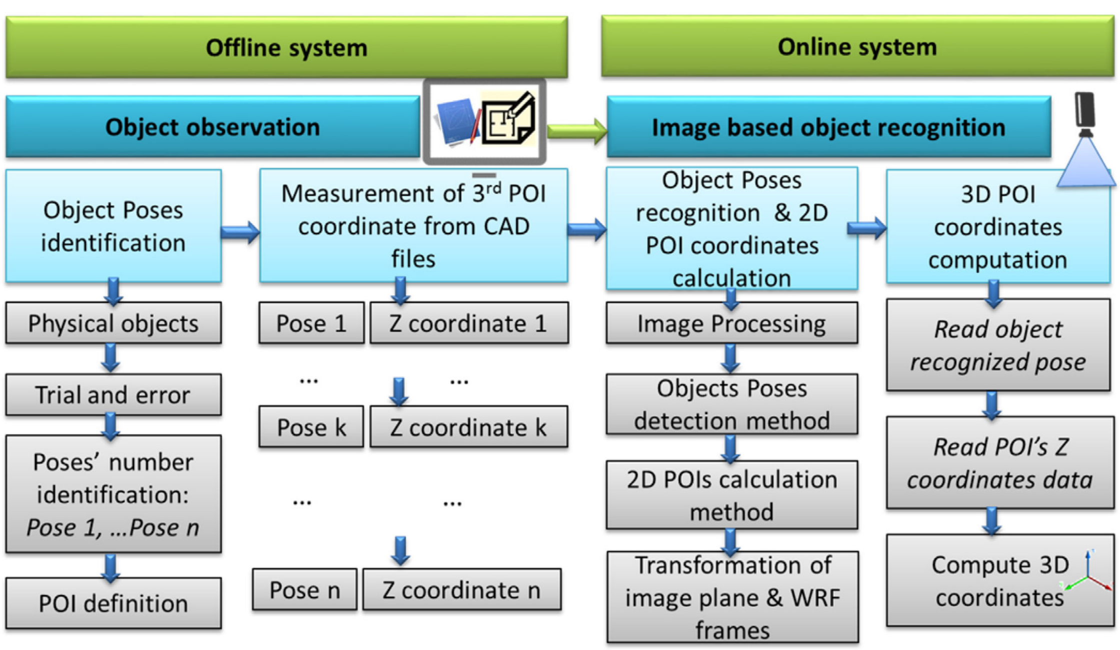

Fig. 2. Method overview.