Improved Algorithm for Increasing Efficiency in Capturing and Orienting an Object with a 6-Axle Robot and a 2D Camera for Visual Inspection Aper

Boris Kostov and Vladimir Hristov

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Boris Kostov
dept. Electrical Motion Automation Systems
Technical university
Sofia, Bulgaria
kostovboris21@gmail.com

Vladimir Hristov
dept. Electrical Motion Automation Systems
Technical university
Sofia, Bulgaria
vdhristov@tu-sofia.bg

Abstract—In the present work, an improved algorithm for taking a part with a specific marker from a 6-axis robot is proposed, synthesized and put into operation by presenting it to a 2D camera for visual inspection and its correct orientation based on information received from the camera and placement. on another part with a pre-marked marker direction. The aim of the present development is to increase the efficiency of automated production of electronic products. From the proposed improvement of the algorithm for determining distortions, injuries or other damage to the part and improvement of the speed of the 2D visual inspection system, an improvement of the time for one lot been achieved, which has increased the efficiency of the system.

Keywords — industrial robot, 2D camera for visual inspection, orientation algorithm, speed improvement.

I. INTRODUCTION

In the present work, an improved algorithm for increasing the efficiency of automated production of electronic products by means of a 6-axis robot Mitsubishi Electric RV-2F-Q1-S15 (Fig. 1) is presented, which aims to take components and orient them correctly with a technical vision camera so that they can be mounted in a certain place in the electronic device in a more appropriate way [1].

Fig. 1. Robot Mitsubishi Electric RV-2F-Q1-S15- 6-axis[3].

The main tasks and steps that the robot performs are:

1. The first step is to take a board from a panel holder saturated with 3 columns of 10 rows of boards and to present the board at a certain focal length. The camera takes a frontal photo of the board to determine if it is the correct model of the board and whether it is facing up with the sockets, if the board is turned 180^0 it is rotated in front of the camera and a photo is taken again. If the board is the correct color and is facing the camera lens with the slots, then it is served sideways for a photo, which determines whether the slots are empty, if empty the board is placed on a table.

2. The second step is to take a chip from a socket located at the end of a vibrating table. Place it in front of the camera at a focal length according to the gripping point and the height of the chip. The camera takes a picture of the chip to find a marker (pin) against which the chip orients itself for the next two pictures of the legs. In the third photo, the chip is oriented at 90^0 compared to the second photo. The legs are photographed to determine if they have any mechanical damage. If they have any damage, the chip is thrown in a box for unusable chips.

3. Third step - the robot places the chip oriented and compensated for the error caused by the grip of the gripper's fingers.

4. After all 16 slots have been successfully saturated, the robot takes the board and returns it to the panel holder.

Points 1 to 4 are repeated until all boards are saturated with chips. A total of 30 boards of 16 chips. The saturation of all boards must be less than 5 minutes.

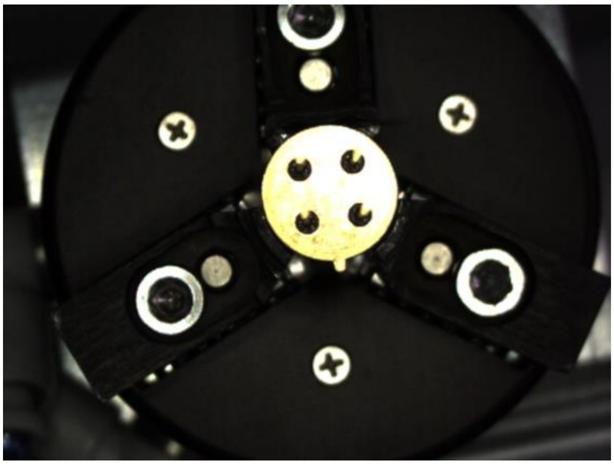

Fig. 2. First photo with unoriented detail.

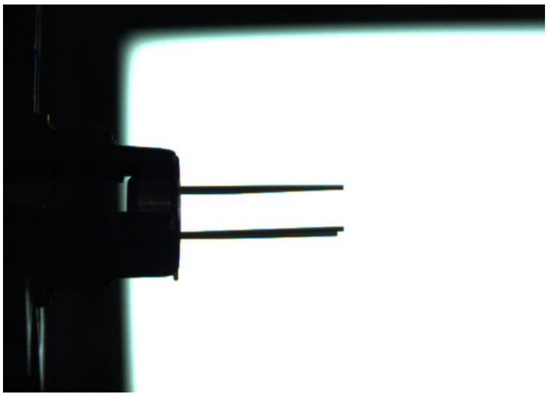

Fig. 3. Second photo, in which the detail is oriented.

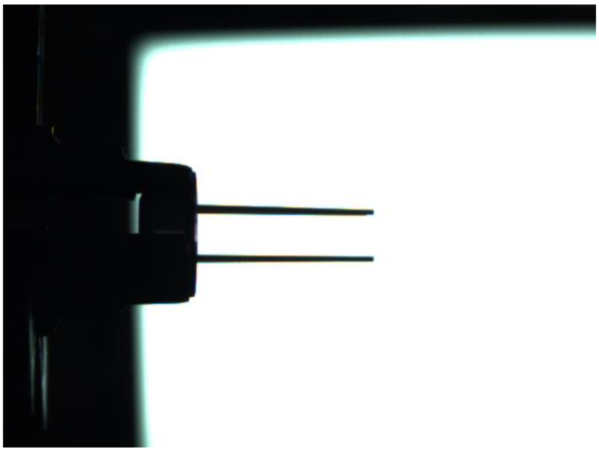

Fig. 4. Third photo, in which the detail is oriented and rotated 90° compared to the second.

The purpose of the present work is to repeatedly improve the speed and quality of saturation of the board. With which to contribute to greater productivity (efficiency) with better quality [2].

The selected camera is In-Sight 2000 - C, Figure 5, because it has high speed - 24 fps (color), high resolution - 1280x960, autofocus, built-in lighting and many tools for quality monitoring such as pixel counting, distance measurement, angle , color reading, text and font recognition, OCR and many more [4].

The camera works with many basic communication protocols such as EtherNet / IP, PROFINET, SLMP, SLMP Scanner, Modbus TCP, TCP / IP, UDP, FTP, Telnet (Native Mode), RS-232 and many industrial communication protocols such as OPC UA, EtherNet / IP with AOP, PROFINET Class B, iQSS, Modbus TCP, SLMP / SLMP Scanner, CC-Link IE Field Basic [4].

Fig. 5. In-Sight 2000 - C camera for visual inspection.

II. Analysis of work and shortcomings of the built system.

In the process of testing the constructed system, Fig. 8 and Fig. 9, it was found that the speed at which the anthropomorphic robot works does not correspond to the speed for processing the data obtained in the 2D visual inspection system. It has been experimentally established that after taking a picture of the object, the camera in 7% of cases does not process the picture with the required speed and sends the robot old data from a previous object. This false data leads to the qualification of a suitable part as unsuitable or to the qualification of an unsuitable part as suitable, which in turn leads to distortions and injuries of the part during its installation. Another problem that was found in the process of work is that in 3% of cases, the camera does not send any data to the robot, which leads to the inability of the robot to continue the cycle and the need to restart the cycle. All this leads to an increase in unusable details, which impairs the efficiency of the system, which is undesirable. There are shortcomings in the built and set algorithm of the system operation in the following outlined part of Figure.6:

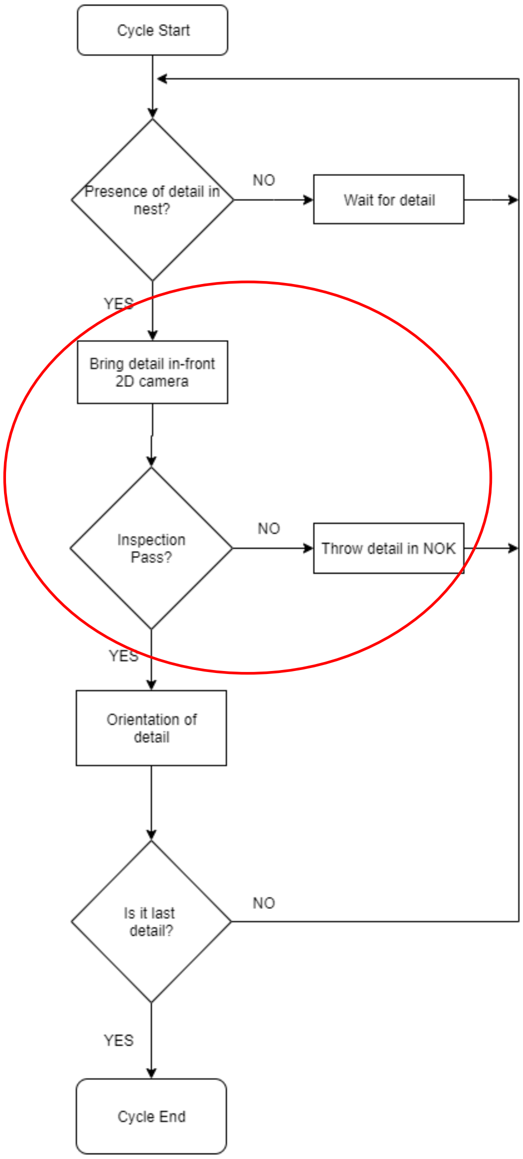

Fig. 6. Block diagram of the constructed algorithm of work.

III. Prepare Your Paper Before Styling

The aim is to increase the efficiency of the system by eliminating the identified shortcomings. To improve the speed and volume of system operation. To eliminate all shortcomings caused by delays related to calculations implemented in the 2D visual inspection system.

The tasks to be performed are:

- Simplification of the algorithms used in the 2D system for visual inspection, in order to increase the speed;
- Transferring algorithms to the robot, again in order to increase speed;
- Elimination of the shortcomings in the speed of the 2D system for visual inspection and the implementation of 100% successful tests after the improvements.

If the improvements are successful, this will significantly increase the performance of the system, because each board is saturated with 16 parts, the time lost per part is 1.27 seconds. Therefore, the saturation of one board would be accelerated by 20.32 seconds per board or 10.16 minutes per lot.

IV. Improved Algorithm for Operation of the 2D Visual Inspection System.

Figure 7 shows a block diagram of the improved algorithm of operation related to the processing of information by the 2D visual inspection system.

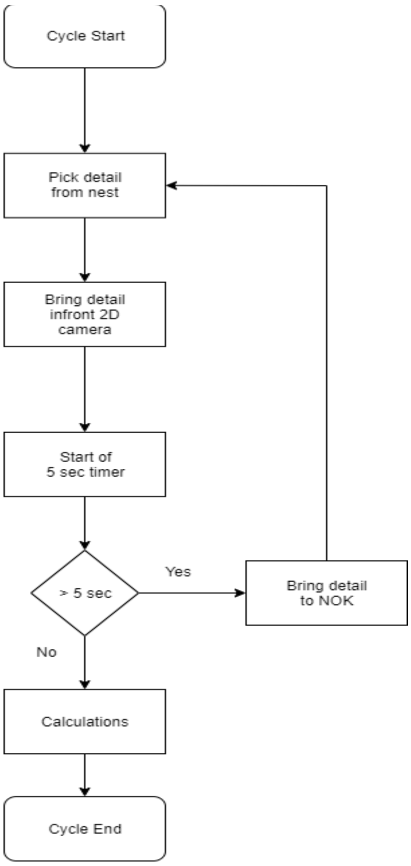

Fig. 7. Block diagram of the improved algorithm of operation of a 2D visual inspection system.

The sequence of the proposed operation algorithm includes the following steps:

- Taking a part from the socket of a tube holder;
- Presenting a detail in front of the photo camera;
- Start a 5 second timer;
- If 5 seconds have elapsed, it means that the camera has not sent data to the robot, qualifying the part as unusable and throwing it in a NOK box;
- If less than 5 seconds have elapsed, the camera sends raw information to the robot;
- Calculations and checks are performed by the robot.

The calculations that are performed in the robot are built in separate steps for the individual photos.

After the first photo, the photo from which the orientation of the object is determined, the following calculations are per if

$$PRotationB < 0°$$

then:

$$PRotationB = PRotationB * (-1)$$

otherwice:

if

PRotationB > 360°

then:

PRotationB = 720° - PRotationB

otherwice:

PRotationB = 360° – ProtationB,

where: PRotationB is the raw angle obtained by the camera.

After the second and third pictures, a number of calculations are made to determine whether there is any distortion or damage to the part [5]:

If Abs(Vision3UpLP) > StraddleSGL Or Abs(Vision3UpLM) > StraddleSGL Or Abs(Vision3DwLP) > StraddleSGL Or Abs(Vision3DwLM) > StraddleSGL

If (Vision3UpLP - Vision3UpLM) > StraddleFBL Or (Vision3DwLP - Vision3DwLM) > StraddleFBL

If (Vision3UpLP + Vision3DwLP) > StraddleUDL Or (Vision3UpLM + Vision3DwLM) < -StraddleUDL

If Abs(Compensation3) > Abs(GripDeviation),

where:

'StraddleSGL = 0.9 -> 1. Straddle Single Leg

'StraddleFBL = 0.6 -> 2. Straddle for leg deviation (FBL - Front-Back Leg)

'StraddleUDL = 1.1 -> 3. Maximum inside/outside straddle (UDL - Up-Down Leg)

'GripDeviation = 5.0 -> 4. 'Max angle for Grip Deviation

These criteria are intended to determine whether the part is suitable or unsuitable for subsequent operations formed:

Fig.8 Robot Cell From Front Side - Industrial Zone.

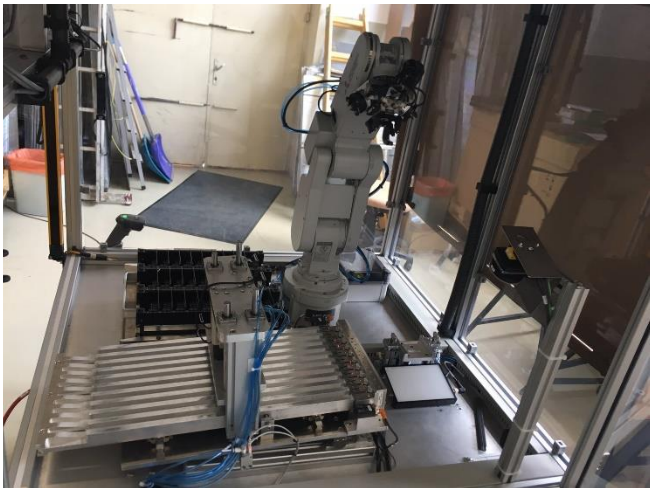

Fig. 9 Robot Cell From Inside - Industrial Zone.

V. Analysis and Conclusions

The performed simulation researches show that the introduction of improvements in the algorithms, moving the calculations and simplifying them in the 2D visual inspection system would lead to the improvement of the speed of the robot - camera system.

The improvements made in the algorithms and the addition of new ones are aimed not only at increasing the volume of system operation, but also at improving the quality of the products and reducing the waste of finished products.

After the commissioning of the improvements in a real industrial environment, the simulation studies were confirmed by the experimental ones, as the performed experimental studies show that the time for one lot is improved by 10 minutes, which leads to an increase in system efficiency by 17.296%. The average saturation time of a circuit board, after deducting the time to discard an unusable part in the unusable part compartment, is 3 minutes and 53 seconds. The average saturation time of a panel holder with a capacity of 30 boards after deducting the processing time of an unusable board, which includes returning the unusable board to the appropriate socket of the panel holder and replacing the board with a new one, is 1 hour 56 minutes and 30 seconds. Before the introduced improvements, the execution time of one lot was 2 hours 16 minutes and 39 seconds, which is exactly 17.296137339055797% slower.

The reason for the introduction of improvements in the system was the large series of products and the need to facilitate labor and increase productivity.

The algorithm, which was created and applied in the real industrial environment, meets the main goals - increasing the productivity and quality of the installation of electronic components and the lower cost of production of products. With the help of this algorithm, the work of two 6-hour shifts has been successfully replaced by an industrial robot with a 24-hour work schedule. The MELFA BASIC V language implemented in the Mitsubishi Electric Co. RT ToolBox3 software was used for programming [6,7].

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