Application a machine vision system in labelling machines

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Abstract. Machine Vision systems are becoming more and more significant recently. Set of cameras connected with a PC computer have a great potential in solving many problems that can occure in the industry. Labeling machines are reasonable application example of these systems. Within this work the construction of labeling machine was presented and concept of using cameras to check label quality, provide help with pre-setting of the machine and monitor the whole labeling process was discussed. This paper describes the proposal of the solution, that will be universal and possibile to apply on every labeling machine with the similar construction to one described below. Moreover, this application could be considered as an inspiration to develope new vision system based structures with other kind of machines, by using same solutions as those shown in this paper.

1. Introduction
Nowadays almost every product has it’s own label. It provides the possibility to locate the brand name, logo and basic informations about the particular item. Sometimes producent is even obligated to do this, like in the case of the information about some food product’s composition. For this reason, labelling is inherent production process. However, the industry requirements are often very strict, so the label must be applied very precisely, even if the shape of the product or the label itself is extraordinary. This generates many problems, what results with the need of the individual approach in some cases.

It is difficult to determine the duration of the labelling machine calibration. It is highly related with the exact shape of the container and label. For simple cases (rectangular shaped label and plain surface of the label place) it can take up to two hours, but not less than an hour. However if the surface of the object is irregularly curved (in different directions and with variable radii) the pre-settings can last few days, even for the operator, who knows the construction of the labelling machine.

The defects, that are unacceptable, can be categorized. It is easy to determine the type of the defect that has occurred. recognizing the defect type is crucial in determining the setting which needs to be changed for compensating this defect.

In this article, we would like to propose the machine vision system structure, that will fit every labelling machine with the similar construction to the one described below. It will control the quality of the whole labelling process, and recognize the type of the defect. Moreover, knowing the connections between some particular settings and the defects, it is possible to prepare some tips for the operator.
2. Construction of the labelling machine

To fully understand the whole machine vision system described below, it is important, to learn about construction of the device that this system is prepared for. The labelling machine that is shown below, is the simple version, that can be extended by, for example, additional labelling head, so it could apply labels on the both sides of the product. In this section however is described only basic version of the machine, because it contains all elements and it is enough to understand the construction of the extended versions.

The construction of the labelling machine is shown in the Figure 1.

![Figure 1. The construction of the labelling machine. 1-Transporter; 2-Side positioners; 3-Top positioner; 4-Separator; 5-Labeling head. This is the model of the labelling machine produced by the Autojet company. For more information, please check [1]](image)

Principal of operation in this machine is very simple. Items that are going to be labeled are driven by the transporter (1), that is moving constantly from the left to the right side. Containers don’t have to be placed at regular intervals, because separator (4) provides regular gaps between the products. If there will be two items placed one right after the other, the separator will hold the second one of them for a while, and release after previously determined time. While an item goes further, it gets between the side positioners (2), that are fixing it in the right position until they reach the top positioner (3). It presses the products to the transporter, what is necessary to ensure stability during the labelling process. Next step is labelling itself. Item is detected by sensors and then labeling head (5) is giving the label. while the item passes next to the label, it sticks to him. For better adhearing, just applied label is pressed to the container with a brush. Then, already labeled containers are leaving from under the top positioner, and can be collected as the final products.
3. Calibration of the labelling machine

After assembling whole labeling machine and uploading the program, there is a need to calibrate it. This procedure is necessary to accomplish required performance and quality of label application. Skipping this step will result with incorrectly applied labels (with defects described in section 4) in best case, but it can also damage the products or the machine itself.

The labelling machine with featured pre-setting gear is shown in the figure 2 below. Marked elements are the basics instruments for calibrating the labelling machine, but that is not all that could be changed. However, beside those described below, there are settings that are usually made once and there is no need to change them during the exploitation of the machines, which is why they have been omitted.

Figure 2. Instrumentation for pre-setting the labelling machine: 1 – control panel, there the operator can change some delay times, and speed of the whole process; 2 – knobs for changing the height of the side positioners; 3 – knob that can move the side positioner toward the transporter and backwards; 4 – knobs for changing the height of the top positioner; 5 - barrier holders; 6 – labelling head height knob; 7 – screw for changing the labelling head angle; 8 - knob that can move the labelling head toward the transporter and backwards; 9,10 – knobs for changing the position of the brush. This is the model of the labelling machine produced by the Autojet company. For more information, please check [1]

4. Labeling Defects Classification

According to what was mentioned in the introduction, in this section, all labeling defects are presented and categorized. All defects that can occur due to the incorrect labeling process are mentioned below, however, defects made during other processes that the item or label were subjected (like for example stains of the ink on the label caused by damaged printer), do not appear in this section.

Figures 3-8 depict all types of labeling defects. Possible causes of each defect and tips helpful with compensating it are posted in the figure descriptions.
Figure 3. **Label absence** – unsuccessful labelling process. Item did not get at least one of the labels it should get. **Possible cause:** empty label roll, labelling head too far from the product. **Compensation:** 1. Check label content; 2. move labelling head towards the transporter.

Figure 4. **Angle error** – applied label is twisted. **Possible cause:** incorrect labelling head angle. **Compensation:** 1. change the labelling head angle. (angle of the label is varying accordingly to the labelling head angle)
Figure 5. Folded label – The label is creased. Possible cause: unsynchronized speeds of label and the transporter, incorrect brush setup, incorrect labeling head setup. Compensation: 1. check the transporter and labeling speed (synchronize them if necessary); 2. monitor the process of labelling to figure if the label is being folded during it’s application or when pressing with a brush, then change adequate equipment setup.

Figure 6. Mechanical damage – label is torn, or some part of it is missing. Possible cause: any element of the machine is interfering with the product path. Compensation: 1. Monitor the process of labelling to find the exact spot, where label is being damage. 2. move the equipment so i won’t interrupt

Figure 7. Inaccurate adhering – label does not adhere to the product with all of its surface. Possible Cause: position of the item is not fixed, incorrect brush setup, incorrect labelling head setup. Compensation: 1. check if the top positioner is holding the item in required position. (if necessary, move the top positioner down so it reach the container and press it toward the transporter) 2. move the brush towards the product, so it could stronger press the label (try different angles). 3. move the labelling head toward the transporter
Defects described above often occur simultaneously. However they should be consider separately, so the compensating procedures proposed above will help in such cases as well. The situation is more complicated if the defects are not recurrent. If some defect occur once, there is high probability that it wasn’t caused by the labeling machine, but by the faulty product or label. In those cases it is necessary to take off incorrectly applied label and check if the problem appears repeatedly for the same product. This will allow to distinguish and eliminate faulty items. If the problem is not connected with particular item, it can be caused by low quality labels.

5. Machine vision system

Machine vision (system vision) it is an using computer vision in industry. While computer vision is focused mainly on image processing at the level of hardware, machine vision most often requires the use of additional hardware I/O (input/output) and computer networks to transmit information generated by the other process components, such as a robot arm. One of the most common applications of machine vision is inspection of the products such as microprocessors, cars, food and pharmaceuticals. Machine vision systems are used increasingly to solve problems of industrial inspection, allowing for complete automation of the inspection process and to increase its accuracy and efficiency. As is the case for inspection of products on the production line, made by people, so in case of application for that purpose machine vision systems are used digital cameras, smart cameras and image processing software.

A typical machine vision system consists of several components of the following (Figure 9):

- one or more digital or analogue camera (black and white or colour) with optical lenses,
- interface the camera to digitize the image (the so-called frame grabber),
- processor (this is usually PC or embedded processor such as DSP),
- lens for taking close-ups,
- adapted to the system, specialized light source (such as LEDs, fluorescent lamps, halogen lamps, etc.),
- software to the imaging and detection of features in common image (image processing algorithm),
- sync-sensor to detect objects (this is usually an optical or magnetic sensor), which gives the signal for the sampling and processing of image,
- the regulations to remove or reject products with defects.
Software machine vision system for both commercial and open-source consists of many different image processing techniques, such as:

- counting pixels (counting the light and dark pixels),
- binarization (colour conversion from the shades of gray in two colours: white and black),
- segmentation (used to locate and/or counting objects,
- "hard" to identify the image (to locate an object that can be rotated, partially hidden by another object or change its size),
- barcode reading (decoding of bar codes, read or scanned by machines),
- text recognition (automatic reading of text - letters and numbers, such as serial numbers),
- measurement (measuring the size of the object),
- edge detection (edge detection object),
- template matching (finding, matching, and/or counting specific patterns),
- others.

In most cases, the machine vision system uses a combination of these processing techniques in order to perform a complete inspection. For example, a system that reads bar codes can also check the surface of an object to detect scratches or other damage, and to measure the length and width of the manufactured component.

Figure 10 shows general structure of the program with sample result windows using Adaptive Vision Studio software for labelling defects. One of the steps of realizing algorithm of recognition the label shows Figure 11.

There are many video programs available on the market, and the selection of the right software significantly affects the reduction of integration time, its costs and - in the future - the possibility of performing modifications. The main factor determining the program selection is the complexity of the vision application. For simple applications, such as bar code reading, simple measurements or checking the completeness of parts, software with graphical interface is sufficient. Sometimes, however, even for such applications it is necessary to use video libraries, because with variable lighting conditions, background or uniqueness of code execution (often occurs when knocking out the DataMatrix code on metal parts) only the use of specialized algorithms allows correct execution of the application.

The end user is the second factor determining the choice of software. If you want to be able to modify video procedures yourself, add new products to check, the most convenient solution is also to use a graphical interface program. Thanks to the ability to create access levels, no unauthorized person will be able to interfere in the program, and after the training, maintenance staff will be able to implement modifications themselves.
Figure 10. The general structure of the program with sample result windows

Figure 11. One of the steps of realizing algorithm of label recognition

References
[1] ***http://www.autojet.com.pl/